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Passive Optical LAN as an emerging LAN Architecture

Shubha Chaturvedi 1, Gautam Chaturvedi 2,

[1] Department of Computer Science,
Sophia Girls College, Ajmer, Rajasthan, India
shubha.sophia28@gmail.com

[2] H.O.D, Department of Computer Science,
Sophia Girls College, Ajmer, Rajasthan, India
chaturvedigautam@yahoo.com

Abstract: In a rapidly changing technological environment, though the Local Area Network helps an organization gain a competitive edge, both domestically and internationally, but due to the fast changing technology, the environment of organizations, and the growing role of information is challenging firms both large and small to replace their copper-based networks with fiber optics. Fiber-based **Passive Optical LAN (POL)** technology is a point-to-multipoint network architecture optimized for local area network (LAN) environments to provide a fiber-to-the-desktop solution. (1) and has emerged as a particularly promising alternative for enterprises in need of a secure, converged network with increased bandwidth. Passive optical LAN (POL) technology platforms optimized for enterprise LAN environments have become available only in the last couple of years. Therefore in this paper authors have summarizes the potential use of POL for further use. We'll then discuss traditional LAN architecture, Passive Optical LAN components and further implications on network management, real estate, and energy consumption.

Keywords: Passive Optical Lan (POL), Local Area Network(LAN), Virtual Desktop Infrastructure (VDI),Optical Network Terminal (ONT), Optical Line Terminal (OLT),

INTRODUCTION TO WHY PASSIVE OPTICAL LAN?

A passive optical network (PON) is a system that brings optical fiber cabling and signals all or most of the way to the end user. A passive optical LAN is an ideal solution for new infrastructure projects and the upgrade of existing infrastructure for a number of reasons (2, 4):-

1.1. Guaranteed Bandwidth:

Today's enterprise traffic patterns fueled by server and data center consolidation, virtual desktop infrastructure (VDI), bring your own device , mobile, and cloud computing, are better served by a centralized switch model compared to traditional workgroup technologies with layered active switches.

1.2. Future Proof:

Passive Optical LANs offer a future-proof upgrade path to safer, greener, higher security and higher bandwidths over the same fiber infrastructure.

1.3. Savings:

Passive Optical LANs replace the active Intermediate Distribution Frame equipment (aggregation Ethernet switches) with passive components; reduce space, energy and cooling requirements, as well as lower installation costs. Passive Optical LANs replace traditional copper wiring with fiber saving space and weight. Passive Optical LANs require simpler management and offer advanced capabilities that can be easily integrated with campus-wide provisioning and management applications. We demonstrate enterprise traffic patterns using network traffic captured in a large enterprise campus.

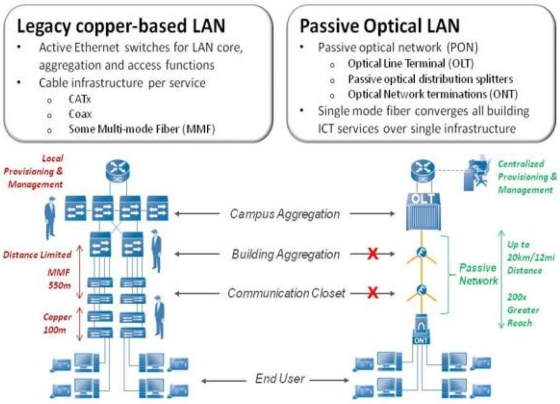

Figure 1: Passive Optical LAN provides a variety of advantages over legacy Ethernet networks.

2. Advantages of POL

2.1 Technical Advantages

Passive Optical LAN is a new application of a proven access network solution. It is a better way to structure a LAN, because:

- It flattens the Local Area Network
- It simplifies network moves, adds, and changes
- Is not limited by the distance and bandwidth constraints of twisted pair networks
- Is secure by design, based on optical fiber and built-in encryption

2.2. Economic Advantages

Passive Optical LAN provides substantial savings legacy LAN designs.

- Can eliminate wiring closets.
- Eliminates the need for electronics, power, and cooling infrastructure.
- Uses smaller, lighter, less expensive cables to reduce pathway and space requirements.
- Virtually eliminates the need to refresh cabling infrastructures.
- As technology evolves, only the active endpoints need a refresh.

3. Who can benefit from POL?

POL is best suited for larger LAN deployments, where the scalable and immediate cost savings and longer-term operational benefits compound most greatly. Verticals that could most benefit from POL include:

- Department of Defense military bases/posts
- federal and municipal government agencies and entities
- large hospitality facilities/hotels/resorts
- higher and lower education campus networks
- media companies
- cruise/Naval ship communications
- industrial/manufacturing plant networks
- Airports and stadiums.

4. Reassessing Active Switch-based LAN Architecture [4]

Traditional LAN infrastructures are based on layered active switches commonly referred to as two-tier or three-tier design. In a typical enterprise LAN setup, a group of individual computers connect to a hub or an access layer switch. The access layer switch forwards the network packages initiated from individual computers to the distribution layer switch. Finally the package gets forwarded to the core switch and routed to the destination. If the destination is connected to the same switch, network traffic will be routed to the destination without going through upper layer switches.

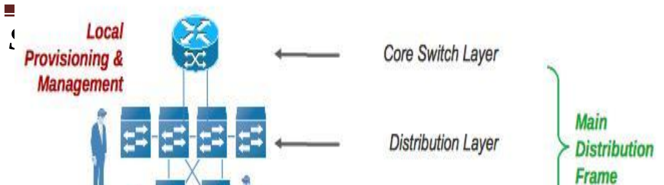

Figure 2 Traditional LAN Architecture which illustrates this layered architecture and typical organization of the devices.

This layered architecture is further complicated by building structures when being implemented. To map the different layers to building or campus structures, the concepts of Main Distribution Frame and Intermediate Distribution Frame are commonly used. Main Distribution Frame usually refers to the main computer room for servers, and core switches. Intermediate Distribution Frame is a remote room or closet with access layer switches. The design of Intermediate Distribution Frame is limited by a few factors including cable length limit, power consumption, cooling, and density of end users. Those factors have been incorporated into building designs by architects to compete with the maximum usable square footage of each building. The fundamental limitation in this layered architecture is mainly due to the characteristics of the copper cable which is commonly used to connect the workstation and access layer switches:

4.1 Length limitation of copper cable:

Since the high-frequency signal transmitted in the copper wire degrades with length; the maximum length for a copper cable link between two active devices is 100 meters (328 feet). In a typical installation, this would translate to 90 meters (300 feet) of solid “horizontal” cabling between the patch panel and the wall jack, plus 5 meters (16.5 feet) of stranded patch cable at each end between each jack and the attached device. Exceeding the patch cabling length or maximum cable length will cause signal loss.

4.2 Bandwidth of copper cable:

The speed of data transfer used by copper LANs has increased significantly from 10 Mbps a decade ago to 1 Gbps with 10 Gbps on the horizon. However, in order to accomplish those speeds, the systems have evolved from 10 MHz radio frequency in CAT 3 cable to 500 MHz today in CAT 6A. Each evolution was also accompanied a physical cable upgrade. In addition, when high radio frequencies are being transferred, more sophisticated cable construction is needed for physical cables. Some may need special processes such as noise-canceling to filter out the cross-talk interference when the outgoing signal and incoming signal are not balanced.

4.3 Physical structure of copper cable:

In today's LAN deployment, workers spend significant time laying out the Ethernet cables nicely and tightly. Nevertheless, Ethernet cables get messy and bulky very easily. The first impression for most switch closets or machine rooms is that it is full of Ethernet cables. Moreover, the weight of copper cable can be significant as well. A 1,000 feet CAT6 cable in average weights 24 pounds and CAT 6A cables are about 49 pounds per 1,000 feet, while fiber optic cables are less than 12 pounds per 1,000 feet. For a same length of cable, fiber optic cables use 50% less plastic than a traditional copper LAN and no copper

4.4 Installation rules of copper cable:-

Installation of copper cable is a rather delicate task with lots of consideration including wiring routes and clearance from power wires. The high frequency signal transmitted via copper cable is very sensitive to noises generated by other cables or devices. There are many rules regarding copper Ethernet cable deployment. For example, Ethernet cables must be kept a certain distance away from all power wires, and must be orthogonal to power cables when crossing power wires. This makes the cost of copper cable installation rather expensive.

Figure 3: A Switch Closet of a Small Company. The left side picture shows the main switch rack with huge bundles of cables intertwined with each other. The right side picture shows the huge bundle of cables going to riser channels and lateral ceilings from the rack.

5. Passive Optical LAN as a Superior LAN Architecture

Passive Optical LAN overcomes all the limitations found in traditional copper-based Ethernet implementations: the optical fiber cable used in Passive Optical LAN can travel for a distance of up to 20km ~ 30 km; the fiber cable structure is much lighter than copper-based cables; the use of bend-insensitive fiber radically diminishes bend radii therefore diminishing cable tray and pathways requirements; the passive nature of the intermediate splitter eliminates the need of power and cooling; the single management console provides consolidated access to all devices and network ports in the network.

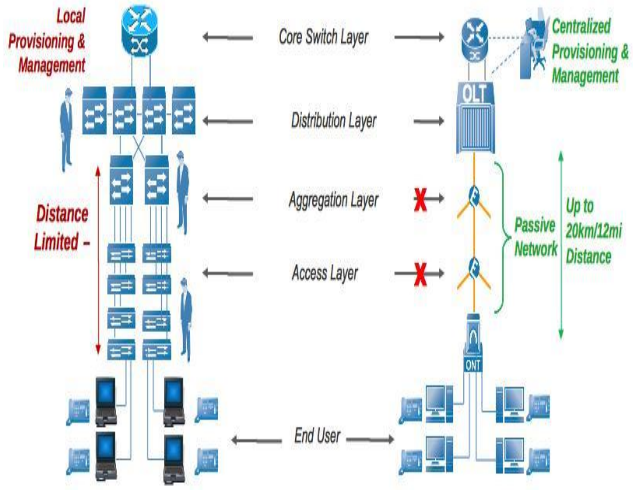

Figure 4: Traditional LAN Architecture vs. Passive Optical LAN Architecture.

6. Components in Passive Optical

The main components in Passive Optical LAN architecture are **Optical Network Terminal (ONT), passive splitter**, and **Optical Line Terminal (OLT).** The ONT connects computer devices into the Passive Optical LAN network via the Ethernet ports on the unit. Electrical signals from computer devices get converted to optical signal in the ONT. Optical splitters simply split the light signal multiple ways to ONTs and transmit the multiplexed signal to the OLT. The OLT aggregates all optical signals from ONTs and convert them back to electrical signals for the core router. The OLT may also have a range of built-in functionalities such as integrated Ethernet bridging, VLAN capability, end-user authentication and security filtering etc. Figure 4 above shows the corresponding layers in traditional LAN architecture and in Passive Optical LAN architecture. Switches in the access layer and building aggregation layer are replaced by a passive optical splitter and those two layers do not exist anymore in Passive Optical LAN architecture. An OLT may support 8 ~ 72 fiber ports with each port connecting a fiber cable to the splitter. The splitter can support different splitting ratios with 1:32 or less being the recommended split ratio. Therefore, each OLT port supports 32 ONTs. Different ONT configurations are available ranging from 2 to 24 Ethernet ports, multiple analog voice ports, coaxial video ports, and even wireless support. If only 4 devices are attached to each ONT, an OLT with 72 ports will be able to support 9216 devices. In field deployment; splitters can be placed in DF closets, or can be placed in ceilings or beside electrical panels, since no cooling is required for splitters. Depending on application and usage, vendors usually provide a wide range of ONTs to meet different needs.

7. Conclusion:

This paper offers a study of the Passive Optical LAN technology and its implications for cabling infrastructure projects. . We demonstrate that the passive optical architecture is vastly superior to traditional copper cable-based LANs in terms of deployment flexibility, easiness of management, environment friendliness, capital, and operating costs. Recent advances in the manufacturing and commercialization of passive optical components are now extending these capabilities to edge and campus networks. Buildings that have been traditionally wired with CAT5/6 copper are facing a fantastic opportunity from the emergence of Passive Optical LAN technology along the same lines: reduced infrastructure footprint and cost, reduced power requirements, future-proof bandwidth, greener infrastructure, safer, higher security and higher reliability.[4]

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Authors Profile

1.Shubha Chaturvedi

Working as lecturer in Computer Science Department at Sophia Girls College, Ajmer.

2. Gautam Chaturvedi

Working as H.O.D in Computer Science Department at Sophia Girls College, Ajmer.