Fiber-Deep, Software-Defined Network Designs and 5G

CORNING

A New Network Solution

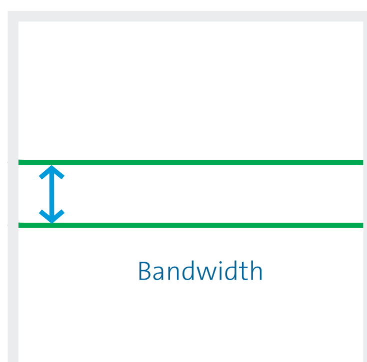
With the explosion of wired and wireless devices into both personal and business lives, along with the rapid approach of 5G technologies, one thing is certain. The network infrastructures in place today will not be able to keep up with the increase in bandwidth requirements these devices and their technologies will require. Since the release of the smartphone and 4G, mobile device penetration has increased from 60 percent in 2012 to over 120 percent today. In addition, the demand for bandwidth increased 45x during this same period. Those statistics are projected to double again by 2020. Existing network design topologies can't scale to support that increase in demand, making refresh times shrink and refresh costs skyrocket.

The answer lies in the deployment of a single converged network platform (SCNP), which can provide fiber-rich designs and low-voltage power, plus software-defined Gigabit bandwidth, out to the edge where it is needed. A simple, elegant, economical, and future-ready 5G infrastructure.

Future networks will still have to support the typical IT services common today, but on a much larger scale. While we aren't yet sure of the exact form 5G will take, we are beginning to see it with the advancement of the Internet of Things (IoT). With the IoT, millions of new devices are being developed to support millions of new applications, such as building automation (wireless controls for lighting, heating/air conditioning, water heating, elevators, etc.), building security, and commercial and retail-specific applications, just to name a few. The IoT will be supported by a combination of network types – Wi-Fi, DAS, small cells, digital solutions – all forming a heterogeneous network connected by a rich fiber infrastructure. Imagination is the only limitation to the possibilities. According to Qualcomm, by 2020 IoT devices will be deployed at a density of one million per square kilometer. That is an enormous amount of data being captured and processed, and a high-speed, low-latency network is the only solution.

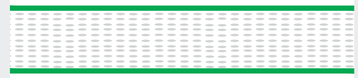
Yesterday's Network

In the beginning it was all about moving data, emails, and pictures from one place to another. Network speed was all about the size of the pipe, or bandwidth, which is measured in Mbps.



At its origin, information was broken down into small packets for transport, and then reassembled back into its original form at the receiving location. If packets got mixed up or went missing, there was an error correction protocol which filled in the blanks so the reassembled product was complete and ready for the user.

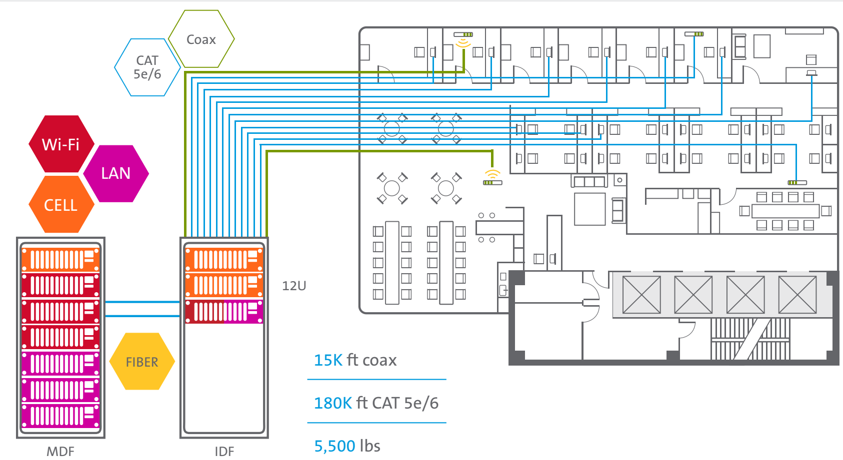
The network design of yesterday typically required a fair amount of real estate in the form of a main distribution frame (MDF). The MDF housed the core elements of the network (computers/servers, switches, media converters, routers, and patch panels) which spidered out to a number of intermediate distribution frames (IDFs) via fiber to service a designated area. At the IDF, data was converted to copper via more routers/switches and patch panels, before going out to the individual final connection points.



Fixed Bandwidth Allocation Throughout Network

All of this equipment laced together from beginning to end defined the data plane. The control of data flow through the data plane was fixed, or defined within the individual switches and routers in that data plane. So even a large pipe eventually looked like the narrow, fixed lanes of a highway, with each user or application getting a specific fixed portion of the overall bandwidth.

Legacy Network Infrastructure



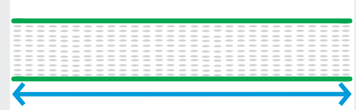
Legacy Network Infrastructure

A legacy infrastructure approach is characteristically:

- Separate layers for each service
- Lots of copper and coax
- Switches, routers, and patch panels are fixed at the ports and bandwidth defined
- Lots of real estate needed to support cabling restrictions
- Power and A/C required for all of the real estate
- Minor changes can be expensive rip-and-replace solutions

This approach worked well until the mid-2000s, when video and voice entered the scene with the advent of Skype, YouTube, and VoIP. This was the beginning of streaming or real-time services.

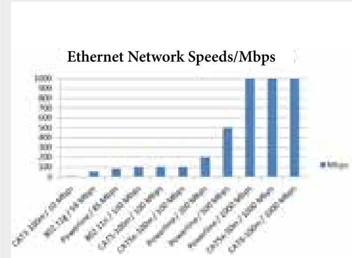
Video and voice services require a much higher quality of service (QoS) for optimal user experience. Both services moved a lot of data packets, which required a lot of bandwidth, but if those packets got mixed up or lost, the error correction protocols created "jitter" (garbled, scrambled, jumpy, etc.) and a poor user experience. In this scenario, latency or the time it takes to get from point A to point B also becomes important. Now both bandwidth (width of the pipe measured in Mbps) and latency (length of the pipe measured in milliseconds) are critical variables in the network.



Latency (Quality and Speed of the Pipe)

Tomorrow's Network

With the explosion of device connections occurring, the network will have to provide ever-increasing high-speed, low-latency bandwidth to the individual users. Yesterday's copper infrastructure is not the answer because of both speed and distance limitations. The answer will require much greater speed and QoS with a greatly reduced distance limitation, which is possible with a fiber infrastructure. It will also require a centralized control plane with one master and many secondary data planes to provide faster reconfiguration and proactive management of data, or a software-defined network. Connections defined by the control plane will create a path through various data planes, enabling QoS and efficiency. These paths are known as flows.



Ethernet Network Speeds

Optical fiber continues to improve as newer multiplexing methods are developed and deployed, with overall capacity and speed currently growing 10x every four years. Software-defined networks remove the fixed controls associated with the "dumb devices" (routers, switches, patch panels, etc.) with a software-defined, dynamically controlled application that allows for on-the-fly changes to porting, bandwidth allocation, and much more. These changes can occur either automatically or through an application resident on a laptop or smart device.

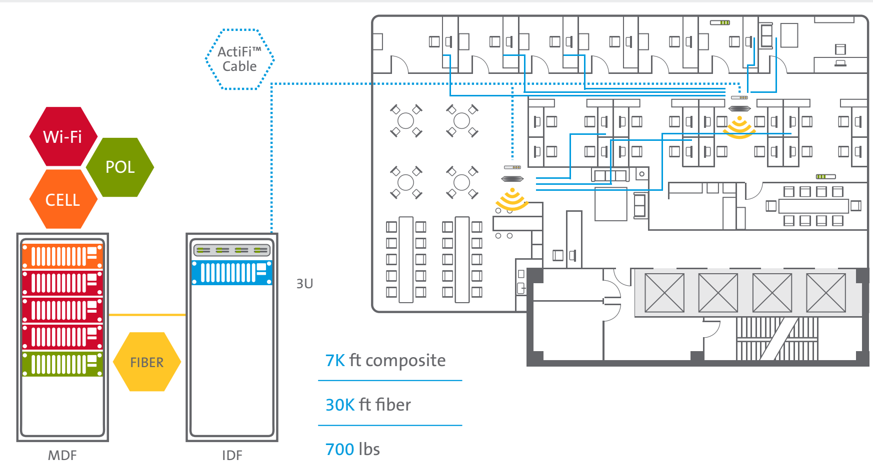
Converging all of the services onto a single SDN platform allows for efficient, real-time prioritization of the network's overall bandwidth, and the successful operation of each service.

Dynamic Control of Bandwidth Allocation Throughout Network

Tomorrow's network will be a fiber-deep (to the edge), software-defined network.

- **Fiber deep** means maximum bandwidth and speed right out to the edge (user) of the network.
- **Software-defined networking (SDN)** allows the maximum, efficient use of the fiber's bandwidth and speed as service priorities shift.
- **Converged** allows for effective control and prioritization.

A flexible, high-speed, low-latency, high QoS, efficient, and reliable network infrastructure.



Full-Fiber Infrastructure

This converged, software-defined network approach provides the following benefits:

- Fully fiber-fed, extending fiber into the horizontal for unlimited bandwidth
- Converges multiple infrastructures and applications on a single platform:
    - LAN
    - WLAN
    - Point-to-point active Ethernet and/or point-to-multipoint PON capability
    - Security cameras
    - Building controls
    - Fire protection and access control
    - AV
    - Digital signage
    - Cellular DAS
    - Saves space
- Directs the bandwidth where it is needed and when it is needed by a central control plane
- Requires little to no equipment in the IDF (smaller footprint required)
- Up to a 60 percent savings in cabling costs (1 fiber = multiple copper runs)
- Up to a 30 percent annual operational savings:
    - With fiber running to the edge, distance problems are minimized and so are the majority of the IDFs.
    - Fewer devices requiring power means less power consumption (lower operating costs)
    - Little to no air conditioning required because of eliminated/reduced IDF space requirements (lower operating costs)

These networks can be the traditional point-to-point or point-to-multipoint (passive optical networking) in design, or a hybrid of both. In these approaches, we are still taking fiber (bandwidth) right out to the edge.

Tomorrow's Networking Tool Chest

The basic tool set for this new infrastructure is represented in the diagram on page 6. Components include:

TOR SDN Switch – A 48-port combination connection/data plane/switching point fed by all of the network services and host to the many virtualized apps on the network such as a router, Wi-Fi controller, firewalls, etc. all of which is controlled by the SDN control plane. The 48 ports are swappable, mini-SFPs (small-form-pluggable) which can be changed out as needed to single-mode or multimode fiber, Ethernet, etc. Services coming into the TOR switch receive port assignment(s) and bandwidth allocation from the control plane, which is setting up the appropriate flows. This is located in the MDF.

TOR SDN Switch

AGR SDN Switch – Shares the same form factor as the TOR switch (48 port, swappable mini-SFPs) but with services being fed via a fiber jumper from the TOR switch. This is the aggregation switch and is used primarily for distributing point-to-point (P2P) services across the network. Choosing P2P distribution over PON distribution will be a function of service compatibility as well as overall infrastructure cost. Like with the TOR, services coming into the AGR switch receive their port assignment(s) and bandwidth allocation from the control plane which is setting up the appropriate flows. This is located in the IDF.

AGR SDN Switch

PON OLT – The passive optical network (PON) optical line terminal (OLT) is the beginning of a PON. Services are being fed via a fiber jumper from the TOR switch and then distributed throughout the PON. This is located in the MDF.

PON OLT

PSU6-1U 57 VDC Power Supply – The traditional power supply used to provide multiple 100 W/57 V DC circuits out to the devices. This infrastructure meets the required low voltage definition and is considered intrinsically safe should the distribution wiring be cut or shorted out. Wire size can be affected dramatically based upon the end device requirements and the distance between the power supply and the device. This is located in the IDF.

High-Density Power Transport – Power solutions that deliver high levels of power over just a few small-gauge copper wires. Innovative technology achieves high-power density per pair while meeting safety requirements such that a traditional low-voltage technician can install. Conduit is generally not required. A power sending unit is located in the MDF or IDF; a conversion device in the IDF or zone then provides power appropriate for edge device(s). These solutions deliver more power with less copper content while extending reach and allowing flexibility to optimally place a range of fiber-fed devices.

PSU6-1U 57 VDC Power Supply

PON Splitter – A passive optical network splitter, fed via a single fiber from the OLT, which splits the data signal from four to up to 32 fiber ports. This is located in the IDF.

ONT – An optical network terminal is fed via fiber from the AGR switch or from the PON network and converts the services on the fiber to up to four Ethernet ports. This is located at the network edge.

Patch Panel – Provides patching for both fiber and copper power. Located in the MDF and IDF.

Fiber – Connection between the MDF and IDF. Connection from the closet to ONT in the case of local power.

Composite Fiber (with copper) – Connection from the IDF to ONT.

Ethernet (copper) – Final connection to end device.

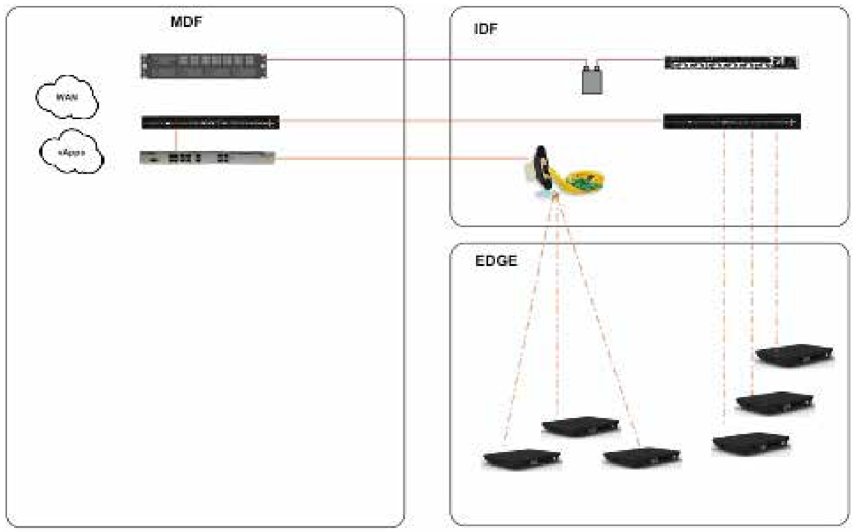
PON Splitter

ONT

Patch Panel

Network Infrastructure Example

Because fiber has no length limitation in a building environment, the use of IDF closet space is virtually eliminated. In a campus environment, distribution from the MDF to a single closet in each remote building is adequate.



Simplified Network Infrastructure

The Obvious Conclusion

Less expensive, high bandwidth, low latency, and spectrum efficient ... A fiber-deep, software-defined network infrastructure is the hands-down winner when it comes to supporting tomorrow's millions of new devices connecting to the network. Plus, with the connection point out at the edge next to the user, adding or changing devices will be less invasive, faster, and less expensive.

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