BACKING UP FIBER-TO-THE-?

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ABSTRACT

Traditional phone companies have seen their telephone market share significantly eroded in the past few years mainly due to competition from wireless, cable TV companies, etc. To keep existing customers and regain market share, these companies believe they have to offer the “bundle”; i.e., wireless, wireline, broadband data, and video. The existing long copper loops in the ground are not going to provide the necessary broadband pipe to do the “triple play”. So, similarly to what the cable TV companies have done, fiber must be extended deeper into the network. The amount of power carried by fiber is so miniscule that the optical-to-electrical conversion electronics must be powered by some other means. Although lifeline telephone service is required to have 3-8 hours of battery (or similar alternatives) backup by various regulations in the U.S., those same regulations do not exist for high speed data and video service. As new fiber-based architectures are deployed, these phone companies must decide which services to back up, how much backup to provide, and how to maintain that backup power.

There are three primary fiber-based architectures that have been or are being deployed. Fiber-to-the-curb (FTTC) was used on several projects in the past, and brings fiber to within about 1,000 feet of the end user. The drop to the premise was either twisted pair copper, or coaxial cable. Bandwidths of at least 50 Mbps are possible over this architecture. This architecture has generally fallen out of favor going forward because the same bandwidths can now be achieved with longer copper drops. Fiber-to-the-node/neighborhood (FTTN) brings fiber to the local cross-connect box. Most customers are within a mile of this box. The last mile remains twisted pair copper. Bandwidths of 12-50 Mbps are possible, depending on the transport technology used. This is the most popular technology to rebuild existing areas (“brownfield”) since existing yards generally don’t have to be dug up. Fiber-to-the-home/business/premise (FTTH/B/P) brings fiber all the way from the Central Office (CO) to the customer’s premise, and offers bandwidths exceeding 100 Mbps. This is the primary architecture of new developments (“greenfield”), especially larger ones.

FTTC architectures commonly used line-powering (spare twisted copper pairs running in the same trench as the fiber) at higher than normal DC voltages. This paper will discuss the advantages and disadvantages of line-powering, the placement of the centralized power supply, and what services are backed up.

FTTN architectures usually have a local power feed from the commercial AC utility company. Some FTTN architectures derive both plain old telephone service (POTS) and broadband from the same fiber feed. Others simply derive the broadband services and bridge them onto the same long copper loop that carries the POTS. In the latter case, the POTS is getting its backup through the existing feeder loop. The paper will discuss whether to provide no backup, a few minutes of backup, or the traditional 8 hours of backup to the video and data services, and the technologies used to provide backup power.

For FTTP architectures, power is obtained from the premise owner. Because POTS is derived from the fiber feed, at least the POTS must be backed up by batteries. How to obtain the power from the customer, what services to back up, and who is responsible for the maintenance of the battery will be covered in the paper.

TRADITIONAL TELEPHONY BACKUP

Since the early 1900s to about the mid-1970s, all landline telephony was provided on direct metallic conductors (typically copper twisted pair) out of the Central Office (see Figure 1 below), regardless of the distance of the customer from the Central Office (CO). The majority of the telephony equipment in the CO is powered by commercial AC-fed -48 VDC N+1 redundant rectifiers, backed up by 3-4 hours of batteries (typically multiple strings of flooded batteries). This same nominal -48 VDC appears across the tip and ring pair at the customer's premises. During a commercial power outage, most COs have a standby engine-alternator that will take over the AC load (thus feeding the rectifiers) for outages lasting longer than a minute. For some smaller COs, there is not a permanent on-site engine-alternator. In these cases there is at least 8 hours of battery backup (both the 3-4 and 8 hour minimums are set by federal and state rules in the U.S.), and there is a genset plug on the outside of the building to which a portable generator can be connected.

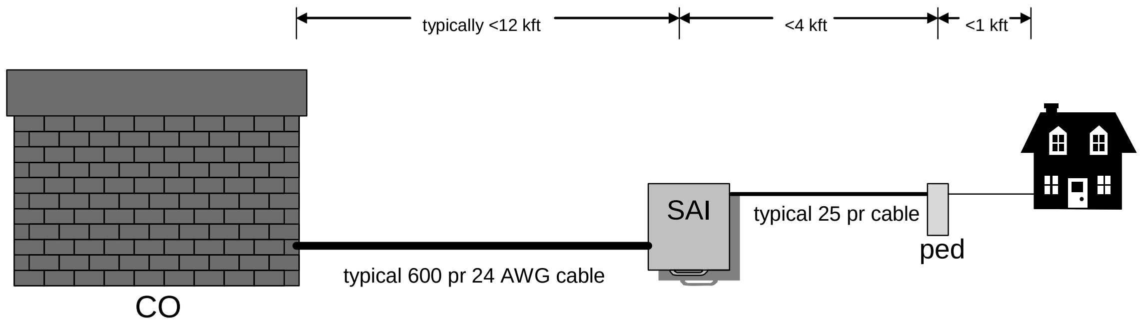

Figure 1. Direct Copper Telephony Feed From the CO

In the late 1970s, deployment of digital loop carrier (DLC) began. This allowed a few high-speed copper pairs (later fiber) to be run from the CO to the DLC location (typically within 12,000 feet of the customer), where all the subtending customers could be multiplexed back onto the high-speed link(s). This greatly reduced the cost of deploying telephony to customers living more than 18,000 cable feet from a CO by saving the cost of all the copper pairs for at least 12,000 feet (see Figure 2). However, the multiplexer placed in the DLC cabinet requires power. Power is derived locally from the utility. This feeds a much smaller (smaller than the CO) N+1 -48 VDC rectifier bank, which is also backed up by 8 or more hours of battery backup (typically multiple VRLA strings). The site (usually a cabinet, but could be a hut or a controlled environmental vault) will also have a manual transfer switch and a portable genset plug.

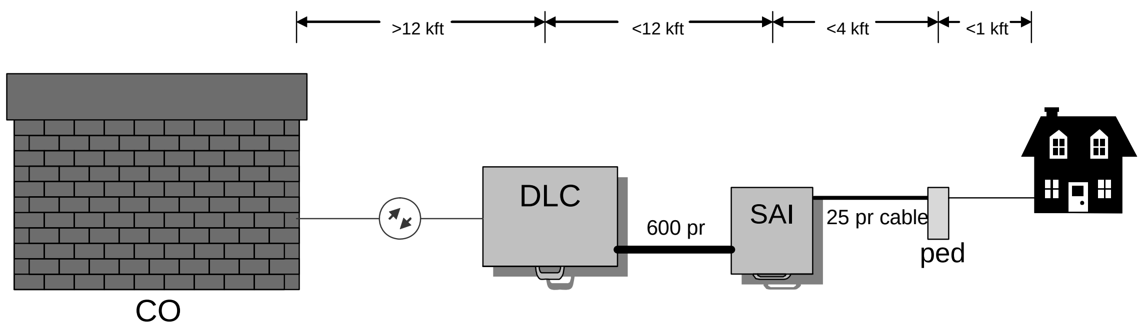

Figure 2. Telephony Feed From a DLC Cabinet

BACKUP FOR FTTC ARCHITECTURES

In the early ‘90s, field trials and small scale deployments of fiber-to-the-curb (FTTC) architectures began. This ran fiber from the CO to individual ONUs (Optical Network Units) typically located within 1,000 feet of the served customers. The primary purpose of these deployments was to provide POTS (plain old telephone service), but prepare the network in those areas to provide video and/or high-speed data in the future. For various reasons, FTTC was never widely deployed except in some areas of BellSouth.

One way to backup the FTTC was to provide power locally at each ONU. This involved obtaining a commercial power drop from the utility, and providing rectifiers and backup batteries. Not only is the first cost of this type of backup power deployment high, but the expense and man-hours required to maintain all those batteries is daunting. So, many FTTC deployments used centralized power supplies. From the centralized power plant hub site, power was distributed on coax (60 or 90 VAC) or twisted pair (typically -130 or ±130 VDC) to the individual ONUs (see Figure 3). An RPS (Remote Power Supply) might serve 20-70 ONUs typically. The RPS typically has 8 or more hours of battery backup and is equipped with a portable genset plug.

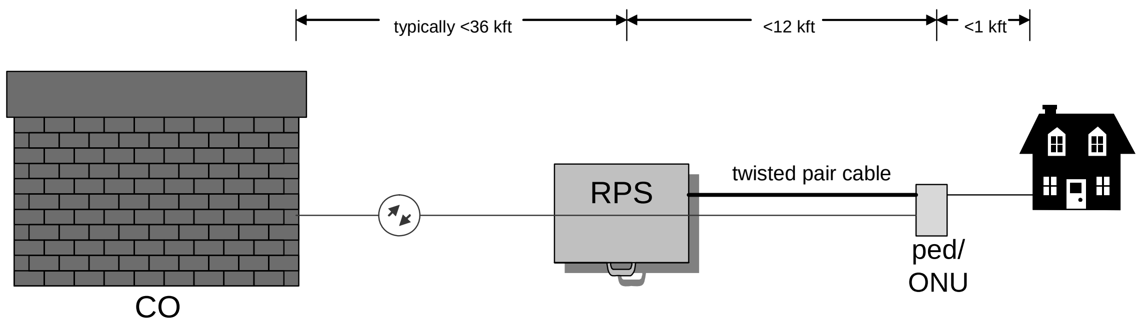

Figure 3. FTTC powered from an RPS

DSL CHANGES THE BACKUP EQUATION

With the advent of the World-Wide Web in the mid-90s, consumer demand for bandwidth picked up. Traditional telephone companies looked at many different architectures to provide this service. For customers within 3 miles of a CO served on a direct copper pair, bandwidths up to 1.5 Mbps could be achieved by the placement of a DSLAM (Digital Subscriber Line Access Multiplexer) in the CO. These DSLAMs are fed with the common -48 VDC power plant of the CO, and get the benefits of its backup power.

For the more than 50% of telephone customers who were beyond this 3-mile distance, the DSLAM needed to get closer to them. Originally, a lot of deployments were to be able to guarantee about 6 Mbps of bandwidth by placing the DSLAM within 12,000 feet of the furthest customer (Customer Serving Area, or CSA). In some cases, depending on the type of DLC already deployed, this was as simple as adding combination POTS/DSL cards to the cabinet. However, the battery reserve of the cabinets was originally designed only to provide backup to the POTS loads. So, because regulatory bodies do not require data services to be “lifeline” like POTS, many of these types of deployments have power sensing circuitry that turn down the DSL portion of the line after a few minutes or few hours of a power outage (most power outages are of very short duration — and for long-duration outages, it is likely that the nearby neighborhoods are also out of power; thus the customers’ computers aren’t working either). For some deployments, though, there was not already a DLC there, or the existing DLC could not support combo cards. In those cases, a separate DSLAM must be added. The DSLAM could be fed with fiber, or with high-speed copper T1 or HDSL lines.

BACKING UP FIBER-TO-THE-NODE

As telephone companies began to explore offering video as well as high speed data, it was realized that 6 Mbps of bandwidth was not enough (especially for the future of HDTV). To increase the bandwidth, the copper drop needed to be shortened. If fiber were extended to the cross box (the DA or Distribution area), this would get within a mile of most customers; and, depending on the “flavor” of DSL used, bandwidths can be as high as 50 Mbps. The Fiber-to-the Node/Neighborhood (FTTN) architecture was born (see Figure 4 — in the drawing, the DLC is shown in dashed lines because it may or may not be in the loop, depending on the customer’s ultimate distance from the CO).

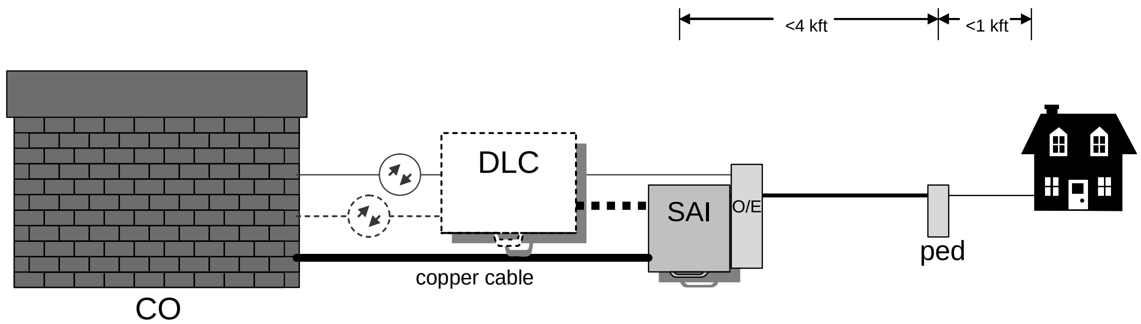

Figure 4. FTTN Architecture

Most DAs in metropolitan areas have between 300-500 homes. The amount of power required to provide POTS, video, and data to that many customers requires a utility feed at the cross box (Serving Area Interface or SAI). Because the copper lifeline POTs pair already exists and is backpowered from the CO or DLC (the DSL is passively bridged onto the existing POTS pair), the question comes up of whether to back up the newly derived DSL and how much backup to provide?

Because all customers are within a mile, it is highly likely that a power outage that affects the DSLAM is also going to affect the nearby customers (although not always). If the provider decides not to provide backup now or ever, the best choice is probably direct-AC-powered equipment. This avoids the expense and potential point of failure known as rectifiers.

The decision to have no backup at all must be carefully weighed and tested against the DSLAM equipment being used. Some DSLAMs reboot quickly when power returns, while others can take more than 10 minutes. If only high-speed data is being provided, very few customers have UPS. So, a 1-3 second outage that is typically seen with an automatic recloser on power lines is going to take down the DSLAM and the customer’s computer. When this happens, not only does the DSLAM have to reboot, but the user’s computer also has to reboot and the DSL modem has to retrain. That is not a quick process. So, a DSLAM that takes a minute to reboot is not that big of a deal, since the user computers are rebooting at the same time. Video may be a different story for that same 1-second outage. The user’s TV and set-top box will come back on within seconds. A DSLAM that takes 10 minutes to reboot after a 1-second power outage is going to prompt a lot of angry viewers.

If the provider chooses to provide backup (now or later), -48 VDC powered equipment is the usual choice. The DSLAM is equipped with rectifiers and batteries. However, 8 hours of backup is not required, and some providers choose to provide much less than that (since most power outages are short). Due to the notorious unreliability of VRLA batteries in harsh outdoor environments, other backup technologies are being tried. Super™/Ultra™ Capacitors can economically provide maintenance free backup for less than 1 minute. High-rate Li-ion and NiMH batteries may also do the trick in high heat areas where a few minutes to a few hours of backup is desired. Although their first cost is higher than VRLAs, they will last longer in these high temperature environments, making their life-cycle cost competitive. With a large proliferation of batteries at every DA, the operator cannot afford (in man-hours) to be replacing batteries at every site every 2-3 years.

One other powering option exists for smaller DAs. For DAs of less than 100 customers, the DSLAM can come in a small sealed pedestal. Because of the fewer numbers of lines this DSLAM serves, its power needs are much less. If extra copper pairs are already in the ground (or hung on the poles), and the distance from a CO (or DLC in rare cases) is not excessive, the DSLAM can be line-powered with the common ±130 VDC that has been used for decades to power T1 repeaters.

BACKING UP FIBER-TO-THE-HOME

Even 12-50 Mbps provided by FTTN architectures may not be enough bandwidth for the future according to some visionaries. So, the idea of a huge broadband pipe to each home (that can provide 100 Mbps+) has been gaining steam since the early ‘90s. Widespread deployments of fiber-to-the-home/business/premise (FTTH) have been going on for a couple of years now (see Figure 5). Fiber and fiber conversion equipment is slightly more expensive than copper. However, for brand new home or apartment complex construction, the costs of FTTH (with passive optical splitters) vs. a traditional DLC architecture are pretty close when the added revenue from the broadband services is figured in. Most FTTH deployments are this “greenfield” type of build. Although there are some “brownfield” (retrofit of existing homes) deployments of FTTH, the cost is higher to dig new trenches (in greenfield there’s an open electric trench already). Also, the customer satisfaction meter heads toward the red “irked” zone when yards are dug up.

Since fiber cannot carry more than a few milliWatts of power, the power source for the Optical Network Terminal (ONT) must be at the customer end. The 120 VAC power source for ONT power units in the garage or house is typically a simple duplex outlet. However, if the ONT power unit is outside, a duplex outlet is not always available, nor may it be desirous because it is likely to be a GFCI (prone to nuisance tripping). Meter collars are available that derive power directly from the meter socket (since the ONT typically goes very near the electric service entrance).

Also, in this architecture, there is no backed up copper pair providing the lifeline telephony service, so 8 hours of backup must be provided for at least the POTS portion of the derived services. The power demands of the ONT are very small, so the battery needed for backup is very small. In the lead-acid battery market, the smaller the battery, the shorter the design life, typically; so commercially available ONT power units today normally have a small VRLA battery with a 5-year design life (which might give 3 years of service if in a good environment).

Multiple things can be done to improve the reliability of the backup at the customer’s premises. Number one, especially for hotter climates, is to put the ONT power unit (with its battery) in a good temperature environment. The worst environment is outdoors on the side of the house; better is in the garage; and the best environment is inside the house. The problem with putting it inside the house or garage is that if the service provider is required to service the unit, they must coordinate a time with the homeowner when they will be home. This drives up costs from missed commitments (on both sides). However, if battery maintenance is made the responsibility of the user, some of this concern goes away. There are also boxes that go through the wall, providing ONT access on the outside, and power unit access on the inside. The power unit can also be accessed from the outside by the technician with a special key through an insulated compartment “wall”.

The service provider (and the user if the user does replacements) can specify longer-life (8-year design life) VRLA batteries. These cost a little more, but are probably worth the extra expense. Other battery technologies (such as NiMH, etc.) should be looked at for these ONT power units to see if they can give longer battery life at a reasonable cost.

The ONT power unit and ONT can (and should) be procured with the ability to monitor the battery. Units exist that can give alarms when the battery reaches 80% capacity, 60% capacity, etc. If battery maintenance is the responsibility of the user, the ONT can give them a call (or voice message) regarding the need to replace the battery, with instructions on how to order a new one.

IS BATTERY BACKUP REALLY NECESSARY FOR FTTH?

There are many consumers who are angry that service providers have turned over the primary responsibility for battery maintenance in FTTH architectures to them. This is a return to the original days of telephony (1880s to the early 1900s) when every phone had its own battery on a shelf at the bottom, and every customer provided their own ringing with a hand crank. The reason service providers have gone this route is purely economic. They simply cannot afford to offer FTTH service at a reasonably competitive price if they have to absorb the cost of battery maintenance at every home. The average truck roll costs about $150 (the battery that is being replaced costs only about $20). When the batteries are centralized in a CSA DLC cabinet serving 1300 customers, a $150 truck roll spread over that number of customers is easy to absorb (only about 11 cents per customer). However, a $150 truck roll spread over a single customer still equals $150. Some service providers are willing to replace the batteries for their customers, but they will bill the customers for not only the battery but the service call.

Perhaps the better question is why are we backing up the POTS anyways? Until 20 years ago, almost all landline phones had a handset with a cord. When the power went out, that nominal -48 VDC traveled from the CO (or DLC site) over the copper twisted pair, and enabled the customer to continue talking. However, now more than 90% of consumers don’t even own a corded landline phone. So, not only do they not know that their old corded phones worked during a power outage, but their cordless phones won’t work during a power outage now. Most consumers also have cellular/PCS phones that they will use if their landline phone is not working. In short, the only reason the phone companies provide battery backup for the POTS on FTTH service is because the federal and state regulators say they have to. Perhaps in the years to come, combined pressure from the service providers and the end users will convince regulators that lifeline telephony is an anachronism whose time has passed?

SUMMARY

There are a proliferation of fiber-based architectures out there to provide telephony, high-speed data, and video. There is a wide variety of powering schemes for these architectures. As we move into the future, the old paradigm of 8 hours of battery backup may change.