VoIP Phoneset Power Via the Ethernet

An SEI White Paper

Quality of Service in Enterprise VoIP

Voice-Over-IP (VoIP) allows the convergence of voice and data traffic on the enterprise packet-based data network. Migration to VoIP telephony is accelerating: organizations upgrading or changing facilities are examining VoIP-based solutions. For those implementing VoIP, success depends on guaranteeing that "Quality of Service" (QoS) is equivalent to that provided by traditional telecom technology.

High QoS is a fundamental design goal for networks carrying voice transmission. This is because voice communication is both sensitive to transmission delays and an indispensable "lifeline" service. In contrast, data networks traditionally employ less stringent requirements with regard to segment congestion and availability. For these networks, three requirements must be fulfilled before voice traffic should be introduced:

1. Voice transmission must be prioritized when network congestion exists.
2. A high level of network availability must be maintained.
3. Phonesets and critical infrastructure must be isolated against adverse external events such as the loss of AC power with the resulting loss of phone service.

. Today, most QoS discussion revolves around the first requirement of packet prioritization: does the network infrastructure have the intelligence to recognize segment congestion and prioritize voice transmissions? Legacy data networks do not have this capability, nor is it readily available outside of single-vendor VoIP and network infrastructure solutions (e.g. Cisco AVVID). But over time packet prioritization will prove the least significant QoS issue for the large enterprise. In a fully switched, high-bandwidth Ethernet network, prioritization is largely a standards and software issue. Given appropriately defined standards and some degree of market momentum, packet prioritization will require neither significant development costs to the vendor nor added expense to the end-user.

Maintaining high network availability will be more of a problem. Where QoS is a fundamental design goal, as in telecom carrier networks, a very high level of availability is maintained. In large enterprises, this focus on voice network availability is seen in the durability of big-iron, legacy PBX's and Class 5 campus switches. In contrast, data network expenditures for high-end, fault-tolerant infrastructure and segment redundancy have been traditionally limited to single-points-of-failure for the entire network and mission-critical operating areas. In most of the network, limited sporadic downtime is usually accepted as a fact of modern computing. However, high expectations for dial tone availability suggest that this level of tolerance will not extend to the VoIP telephone system.

Hardening the data network for high availability will be an expensive undertaking. Hardware fault-tolerance comes at a significant cost premium, made all the more painful by the short obsolescence cycle for network infrastructure. Data network architects have preferred to take advantage of the distributed nature of packet-based networks to utilize inexpensive infrastructure with the expectation that it will be quickly replaced as new technology becomes available. This design philosophy implicitly legitimizes localized network downtime. Given budget and resource constraints, early adopters of VoIP will likely finesse this issue, discovering first-hand how users and management react to more frequent telecom outages.

The final requirement for high QoS is isolation against adverse external events. For telecom carriers, this encompasses a wide array of factors ranging from central office premises security to redundant long-distance cable runs to guard against accidental cable cuts or localized natural disasters. Most of these issues are not relevant to an organization implementing VoIP. However, one consideration of equal importance to both the telecom carrier and the enterprise is protection against the loss of AC power.

Protecting Against the Loss of AC Power

Implementing VoIP with a high QoS guarantee requires that the network is protected against the loss of AC power. Within the public telephone system, central offices are designed to utilize internal DC power with long-term battery backup. In traditional enterprise telephony, switches and premises equipment are also DC-based and utilize long-term battery backup. Because desktop phonesets are DC-powered via the dedicated telephone network, loss of AC power, even for an extended period, will not impact telephone service. While mission-critical environments employ sufficient battery capacity to maintain telephone service for eight hours or more, two hours is the traditional business minimum. Two hours of battery backup for the telephone system allows management one hour to wait for the restoration of power, and, failing that, a second hour to implement contingency plans.

In contrast, the enterprise data network is rarely protected against the extended loss of AC power. Battery backup is provided only to allow the graceful shutdown of core applications, and few data networks will continue to function after a power outage exceeding 15 minutes. This backup period must be significantly extended before implementing VoIP in order to avoid the complete and unexpected loss of telephone service at a time when this service will be required the most.

There is a trend in new facilities to implement diesel generators to supply backup AC power. However, because power needs for an entire building are considerable, whole-building UPS systems usually protect against only short-term power outages. Regarded more as a convenience than a lifeline service, maintenance and testing schedules are usually haphazard, and, when needed, these systems may fail to come online. Managed by the organization's Facilities department, or, less desirably, by a third-party landlord, it will be impossible for the IT department to impose operational specifications. As a result, whole-building UPS systems are unacceptable single-points-of-failure for telephone system power backup.

Protecting an enterprise VoIP implementation against the loss of AC power requires that key network components be identified and connected to long-duration uninterruptible power supplies (UPS). This can be surprisingly expensive: because these systems utilize sealed lead-acid batteries whose cost is relatively fixed over volume, UPS pricing does not reflect the economies of scale typical in network hardware. Distributed UPS systems also add management overhead: even high quality batteries have a mean life span of only five years, and, depending on environmental conditions, normal failure can occur in three years or less. Organizations should select UPS systems that offer economical battery replacement, and implement procedures to regularly monitor these systems for degraded performance.

Because only a limited quantity of infrastructure will require UPS protection, neither the cost nor the management overhead should prove too burdensome. Extending this distributed UPS paradigm to the desktop phoneset, however, would be entirely inappropriate. Traditional business phonesets consume an average 5 Watts of 48 Volt DC power, supplied directly from either the central office (Analog Centrex), the PBX, or a dedicated inline power source (Digital Centrex/ISDN), and equipped with battery backup to provide from 2 to 8 hours of protection against AC power failure. Early VoIP phoneset developers largely ignored centralized power and backup, treating phones analogously to the PC, with power drawn from an AC outlet, and, if desired, battery backup provided by a local UPS. However, while desktop UPS systems can be found cheaply enough to make them comparable in initial cost to centralized power systems, over time the highly scalable nature of centralized power results in dramatically reduced per port powering costs. Cost-of-ownership for centralized power is also far lower: economical battery replacement coupled with high component quality result in considerably longer service life for centralized systems.

But it is the logistics of independent battery backup for every phoneset that make this scheme completely unworkable. While an inexpensive desktop UPS can provide 2 hours of backup if entirely dedicated to a VoIP phoneset, this drops to five minutes or less if other devices, such as a PC, are inappropriately connected by a technician or user. Commodity UPS's have notoriously short and unpredictable life spans; because these systems cannot be centrally managed, a significant percentage will fail during a power outage. In fact, there is no way to insure that the UPS is even in use: only after a power failure would it be possible to identify those phones incorrectly powered directly by an AC outlet. Clearly the traditional telecom approach of centralized phoneset powering remains valid for VoIP; however, while traditional phonesets are powered via a dedicated telecom network, centralized power and battery backup for VoIP must be provided by the Ethernet.

Power over Ethernet

Because Ethernet 10Base-T and 100Base-TX utilize only two of the four wire pairs available in Cat5 and Cat3 UTP wiring, a simple solution to powering VoIP phonesets is to utilize the spare wire pairs to provide DC current. Power can be injected either at the data switch or by a dedicated "inline" power device located between the switch and the VoIP phoneset (also known as "midspan" powering). In a very small number of networks, cost saving measures in the early days of Cat3 may have resulted in spare pair wiring irregularities; however, this is a minor concern as most enterprises will deploy VoIP over Cat5 or better cabling.

IEEE 802.3af

Power over Ethernet is defined by the IEEE 802.3af specification. In 802.3af, a "resistive signature" algorithm is employed to guarantee that only power-using devices are powered: the power source sends out a specific "discovery" voltage (or current) on the wiring pairs used to carry the power, measuring for a current (or voltage) which implies a certain resistance at the device end. This discovery power is small enough to be safe for non-power-using devices. Having found an appropriate resistance, a slightly higher voltage is applied, again measuring for a current that confirms a certain resistance at the device. Having passed both tests, the power source applies full voltage; if the current falls outside of a specified min/max range (e.g. the device is disconnected or a short has occurred), power is removed and the discovery process reinitiated. Minimal additional circuitry is required by this algorithm, which has tested successfully against a wide range of non-power-using legacy devices.

802.3af also states what kind of power is to be provided via the Ethernet and how it is applied to the UTP wiring.

This specification is in line with traditional telecom needs: 350mA of nominal 48Vdc current, enough to guarantee a little under 13 Watts of power to the device (at a maximum distance of 100 meters).

Traditional telecom powering assumes a knowledgeable telecom manager making reasonable assumptions with regard to power consumption. The power source is sized according to these calculations and if too little power is provided, sporadic problems will occur throughout the system when the Nth phoneset is taken off-hook and voltage drops below device tolerance levels. 802.3af, which is intended as a generic solution to low-level Ethernet power, cannot assume such a knowledgeable user. As a result, early drafts of the standard apportioned a full 13 Watts, needed or not, to every port on which a power-using device was detected. However, power solutions with unnecessarily large power supplies are larger and more expensive than necessary, especially when expensive UPS systems are sized to these specifications.

This issue was addressed in the formulation of 803.3af by adding provision for a four-tiered power consumption classification scheme. The power-using device, by varying its resistive discovery signature, signals to the source a lower power requirement, allowing less power to be apportioned to its port. Support for classification is, however, optional both for the power source and the power-using device. Because classification is only marginally more expensive for hardware vendors to implement, it would be extremely unfortunate if this feature was not widely implemented. If classification is ignored by the industry, power consumption will be effectively removed as a VoIP phoneset design criterion. When developers expect a full 13 Watts of power, it is likely that engineering cost-cutting and feature bloat will quickly combine to utilize all 13 Watts, with drastic cumulative implications for power systems cost and energy usage.

Organizations evaluating VoIP should require that phonesets be compliant with the 802.3af standard. Doing so will not unduly burden the phoneset developer, and preserves the organization’s investment in hardware.

The Ethernet Power Source

Power can be injected onto the Ethernet using either the data switch or a dedicated inline (midspan) power source. Bundling power injection into the data switch has the advantage of not requiring a separate power device with additional patch cabling. Once the necessary silicon is available, switches may incorporate 802.3af detection and power injection at only a small increase to manufacturing expense, perhaps low enough to induce vendors to provide Ethernet power as a basic feature in higher-quality data switches, but it will take a few years. If market momentum for VoIP does not develop, it may take considerably longer.

An additional complication is the QoS requirement to prioritize time-sensitive VoIP packets during periods of network congestion. Industry standards for accomplishing this remain in preliminary form, and until a widely accepted standard is promulgated, true “VoIP-ready” data switches will be confined to proprietary solutions. Under this scenario, Ethernet power and voice packet prioritization become a means for achieving higher profit margins or other strategic marketing goals.

An example of these real-world economics in action can be found in Cisco’s AVVID VoIP application. AVVID, has significant proprietary elements: the customer purchases Cisco VoIP phonesets and a Cisco box with the intelligence that performs the telecom switching function. The higher cost phonesets are offset by the lower cost switching capability to make the Cisco solution comparable in initial cost to a traditional PBX. As the design process proceeds, however, an organization desiring high QoS will find strong incentives to move to an all-Cisco network architecture. For example, Cisco data switches both address VoIP packet prioritization and centrally power phonesets. While some of this capability can be purchased from Cisco in separate boxes, the pricing makes new switch purchases more palatable. This will not be an issue for an all-Cisco shop with depreciated architecture, but multi-vendor environments will be faced with some difficult decisions.

Inline power is a vendor-independent alternative for organizations not ready to replace existing switch infrastructure with a proprietary solution. In this paradigm, a dedicated power device is added to the floor data closet between the data switch and the patch panel. Easy to configure and expand, and well-suited for evaluation groups and gradual VoIP migration strategies, inline power does have some minor disadvantages: unless all ports are powered it is necessary to identify those with power-using devices, and extra space on the equipment rack is required.

The more significant concern for inline power lies in the future. As noted earlier, 802.3af restricts inline powering to the spare UTP wiring pair. This precludes powering 1000base-T and future higher speed variants which employ all four wiring pairs for signaling. Although 1Gbs Ethernet is employed exclusively as a network backbone protocol today and therefore irrelevant to phoneset powering (in fact, 802.3af does not formally support 1000base-T), if this restriction is not lifted in future revisions of the standard, inline power may eventually be relegated to a niche solution.

Summary and Recommendations

Enterprise migration to VoIP is happening more slowly than anticipated, but it remains the next-generation platform for business telephony. Organizations considering VoIP need to guarantee that Quality of Service (QoS) is equivalent to that provided today by traditional telecom solutions. One aspect of QoS that cannot be overlooked is the need to protect the telephone system against the loss of AC power. As with traditional telephony, accomplishing this requires that the phonesets be centrally powered. Because VoIP phonesets are connected to the enterprise data network, central powering must be accomplished via the Ethernet and the IEEE has now formulated a standard for Ethernet power; 802.3af.

In the long-run, economy and convenience may result in power being injected onto the Ethernet by the data switch. Today, however, implementing switch-based centralized power requires an expensive commitment to a single-vendor network architecture. An alternative is to use vendor-independent, 802.3af-based dedicated inline power devices. These devices are located in the data closet between the switch and the patch panel; easy to configure and expand, they are well-suited to evaluation groups and gradual migration strategies.

SEI, a world leader in centralized telecom powering for over 20 years, has developed the Juice Box, a power hub solution that meets the inline power needs of organizations implementing VoIP. With ports for 24 phonesets with full SNMP capability, the Juice Box features telecom-quality architecture and is fully compliant with the 802.3af standard. The Juice Box will work with most VoIP phonesets, including Cisco AVVID, and allows the enterprise to easily migrate from traditional telecom solutions to IP-based technology without compromising its power system investment.