VoIP Timing and Synchronization Best Practices

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Introduction

The explosive adoption of packet-based networks from circuit switched (i.e. PSTN) continues to change the networking landscape unabated. Long gone are the days when IP was considered a best-effort technology which was confined to the amateur technologist. Voice transmission, once considered an application never to embark upon the IP bandwagon because of its susceptibility to delays, now enjoys widespread adoption in the form of Voice over IP (VoIP), from the savvy home user to the cost-conscious business professional.

With VoIP technology, businesses now have a cost effective, feature-rich alternative to traditional business phone systems, a powerful business feature set, plus local and long distance calling for a fraction of the cost of both the low-feature multi-line phones and the feature-rich PBX.

In building a seamless VoIP network, careful engineering design and consideration must be taken to ensure the transmission of your voice traffic reaches its desired destination intact. Of paramount importance is highly accurate timing and synchronization which plays a hand in billing, troubleshooting, voice quality and traffic reporting.

- Billing – Call Detail Records (CDRs) are essential pieces of billing for voice calls; they provide the call origination/destination numbers, start and stop time, as well as duration for each hop on the network, and across multiple carriers' networks. Without accurate, traceable time, it is impossible to reconcile CDR and other billing information, which can have significant financial implications.
- Troubleshooting – Establishing cause vs. effect without highly accurate timing is troublesome. An event at one location may cause an outage elsewhere, but with inaccurate time, it may be impossible to determine which event was the cause, which can have implications in terms of Service Level Agreement (SLA) compliance, regulatory compliance, and forensic applications to conduct diagnosis and recovery.
- Voice quality – Perceived voice quality is highly susceptible to latency and jitter as well as bit loss. As VoIP is a real-time application, bits (i.e. packets) are not retransmitted and are delivered sequentially, however, are reliant upon accurate timestamps to ensure accurate order (see figure 1). In addition, measurement of latency—a true Quality of Service (QoS) metric—requires highly accurate, synchronized clocks at each end. In the absence of good QoS metrics, network operators are forced to over-provision their networks to increase the probability—*not guarantee*—of high quality voice.

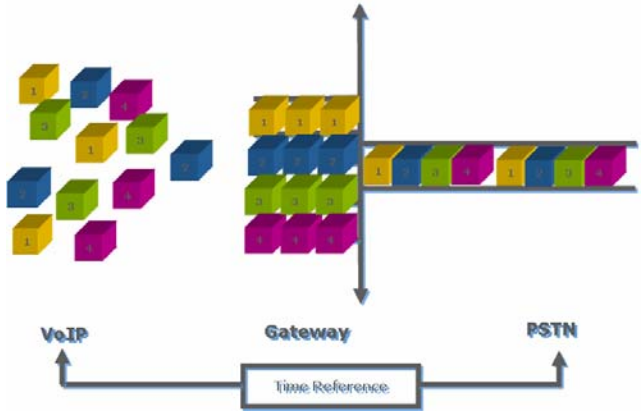

Figure 1. Precise time is required for reordering of VoIP packets for delivery to the PSTN.

- Traffic Reporting and Engineering – All carriers report on Busy Hour Call Attempts (BHCA), average load, and total minutes. Accurate timing is assumed, and must be ensured.

Traditional telephony timing and synchronization

In the circuit-switched network—the PSTN—we're all familiar with, frequency synchronization is required to ensure proper alignment of bits within a T1 frame (and higher speed circuits such as SONET). Loss of alignment can cause data errors, as well as dropped calls. In the traditional telephone network, timing and synchronization are distributed on the same TDM network as the data itself.

TDM networks are synchronous – that is all elements are synchronized with each other, thus time and frequency distribution are inherent in the structure of the network. In each node of the network, synchronization is distributed from a synchronization system to all of the network elements, and throughout the network, node to node with TDM frame alignment of PDH or SONET/SDH. In addition to transport and switching equipment, synchronization is also needed by service endpoints such as PBXs (Private Branch Exchanges) and IADs (Integrated Access Devices). These endpoints require a highly accurate timing source to ensure the alignment of the originating and terminating service endpoints for proper service operation. Typically each central office will have a Primary Reference Clock (PRC) synched with the GPS system to regenerate timing and ensure that the electronics maintain accurate synchronization.

The Challenge: Distribution of time over an IP infrastructure

IP, rather than being a synchronous system is asynchronous; not every bit or packet arrives at an end point precisely on time. In fact, they may not even arrive in the same order they were transmitted. Therefore, the challenge for operators of VoIP networks is how to provide accurate timing at all points in their networks. In the case of Cisco and many other equipment providers, there are several options for providing synchronized timing. The Network Time Protocol (NTP) and Windows Time Service (W32Time) are the two most common time distribution methods in use for IP telephony. However, Cisco recommends the use of a highly accurate NTP based solution for their product set[1] because it ensures a more accurate time across the network. W32Time can satisfy the loose timing requirements of the Kerberos authentication protocol (see http://www.windowsnetworking.com/articles_tutorials/Configuring-Windows-Time-Service.html) and provides that "clocks of all Windows 2000/XP/2003 machines in a forest will agree within 20 seconds of one another"[2], it does not meet the much more stringent requirements of a VoIP network.

To ensure accuracy of time anywhere in the IP cloud, the concept of a timing network must be introduced. NTP allows for distribution of time over IP, but does not address holdover when the IP network is lost, nor does it provide for the ultra-accurate timing required for the frequency recovery that is used to ensure bit boundaries are maintained on TDM networks. In addition, the traceability of the timing source must be guaranteed, simply pointing at a public NTP source is not sufficient to ensure the traceability required for many legal requirements. What is required is a system that ensures timing is traceable to a Stratum 0 (such as GPS) source, timing loops in the network are avoided, and that multiple NTP peers are used for backup timing in the case of loss of GPS signal. Today, only one such architecture exists.

The Solution

Even without malicious intent, businesses can be exposed to severe problems resulting from inaccurate clock and timing distribution. These problems include network outages resulting in loss of business, disruptions to workflow or erroneous recordkeeping.

Inaccurate clocks and timestamps adversely impact a businesses ability to detect and identify frauds as well as malfunctions. As a result, not only does it increase the time taken to detect such business impacting events, but once detected, the time taken to correlate the events to accurately identify the entity responsible for the original event is also increased.

Brilliant's Zurich, a zero footprint, industrial hardened, wirespeed hardware-based NTP server, and Cern the counterpoint Primary Reference Source/Primary Reference Clock (PRS/PRC) product lines are the only options to ensure highly available timing sources for today's networks.

Brilliant Telecom's line of timing and synchronization products can enable businesses to ensure ultra-accurate timing, carrier class robustness and *legally traceable Stratum* time for all types of networks, including Voice over IP requirements. Brilliant's NTP servers exceed the requirements for existing billing applications, and even the nascent IEEE 1588 Precise Timing Protocol's (PTP) more stringent requirement for HW based timestamping. Brilliant's solution is the only option to ensure continued survivability in the case of traffic based Denial of Service (DoS) attacks, loss of GPS connectivity, and SLA enforcement.

Best Practices

Best practices demand that organizations and businesses deploy a highly secure, highly reliable and highly accurate timing network. In order to make an educated decision, the following factors should be taken into careful consideration:

- List of regulatory and industrial compliances that demand timing accuracy
- Contractual obligations which are dependent on timing accuracy
- An executive team member responsible for ensuring the organization is maintaining secured, redundant, robust, accurate timing and clock systems
- Possible exposure to business liabilities in case of misconfigured timing in the system
- Schedule for periodic review of all the items identified in this checklist.
- Develop a time distribution architecture that identifies a primary NTP server that is in turn locked to a Stratum 0 clock source (i.e. GPS) and consider a NTP-based holdover methodology
- Establish the correct NTP polling interval – it is recommended to use the minimum allowable polling interval of 64 seconds for greatest accuracy
- Deploy appropriate QoS for both timing distribution and VoIP, as well as other real-time based services, such as IPTV

Brilliant Telecommunications' NTP servers provide an ideal solution for building highly accurate and reliable timing networks.

Brilliant's NTP server products not only eliminate the risks arising from public NTP usage but also provide other significant benefits. These benefits include a highly accurate NTP server that is referenced to GPS, a distributed clock through a private timing network, and an intuitive timing management interface that provides tools for diagnosis, monitoring, alarms,

etc. Brilliant provides the most cost-effective solution for maintaining highly accurate timing and synchronization of your IP and TDM networks.

Advantages of Brilliant's NTP server product line

Carrier-class time and frequency equipment

- World's most accurate NTP server (sub 50 ns vs. ms)
- Zero footprint in Colo or data center
- Bi-directional timing (packet to TDM; TDM to packet)
- Fully redundant and modular
- Meets tough industrial environmental specs
- Only NTP-based Stratum 2 holdover (50pbb)

Hardened network timing

- World's only fully hardened, outdoor, redundant NTP servers
- Ultra-high precision hardware timestamps and location based on GPS
- Most compact and highly integrated NTP server
- Scalable processing for GPS location-based services
- Enables triple-play QoS for real-time VoIP, streaming IPTV and data
- Spans the entire space from basestation to enterprise

References

1. Cisco IP Telephony Clock Synchronization: Best Practices
2. WindowsNetworking.com: http://www.windowsnetworking.com/articles_tutorials/Configuring-Windows-Time-Service.html

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