Signaling Considerations

For The Delivery of

Voice Services over Broadband Networks

Message-based Signaling is a critical factor for successfully implementing robust VoDSL Services

Prepared By
Jetstream Communications, Inc.

Executive Summary

The Importance of Signaling

Throughout the century-long evolution of modern telephony services, increasingly powerful signaling methods have provided a key part of the foundation for maintaining system-wide inter-device communications and robust call-control functions as well as providing the extensibility needed for provisioning new advanced services. As signaling methods have progressed from early voltage/current based schemes, through DTMF to today's digital technologies, overall telephony capabilities have also expanded to include additional features, such as touch tone activated services, caller ID, phone number portability, ISDN, and computer telephony integration (CTI). Similarly, the evolution toward intelligent, message-based, digital signaling has also allowed for more efficient call setup, improved quality, more effective system management and expanded scalability of telephony networks.

With each new level of signaling sophistication, the ability to efficiently emulate previous signaling schemes has always been a fundamental requirement in order to ensure seamless compatibility with the full range of previously deployed equipment. In addition, the public at large has become entrenched in a very high level of expectations from the POTS ("plain old telephony service") system, demanding nothing less than always-there, on-demand, flawless quality connections by dialing any number from any location. Therefore, every new step in the evolution of signaling also has been rigorously designed to withstand the most extreme conditions possible with regard to peak loads, equipment variability, marginal line conditions, emergency re-route demands, etc. In essence, every advance in signaling methodology served to reliably extend and expand the basic bedrock that underlies the entire worldwide telephone system.

The Voice-Over-DSL (VoDSL) Opportunity

Today, the widening availability, higher-bandwidths and low-latency performance capabilities of broadband network connections, such as DSL, have made the provision of voice-over-broadband an increasingly attractive service offering. For instance, for an Integrated Communications Provider (ICP) the ability to offer customers multiple voice lines over a single DSL connection greatly leverages the provider's competitive position by packing more service capacity across the "final mile of copper" that the ICP typically has to lease from incumbent carriers. By enabling 16 or more voice connections plus high speed Internet access over a single DSL connection, ICPs are now able to cost effectively address the needs of the huge market for small and mid-sized businesses.

Although VoDSL represents a major new and immediate revenue opportunity for ICPs, as this new market takes off their ultimate success will invariably hinge upon the robustness and adaptability of their initial engineering and deployment choices. The signaling methodology incorporated in these new VoDSL system implementations will play a strategic role in laying a solid foundation for achieving the required levels of system-wide compatibility, reliability and extensibility. Likewise, a wrong choice of signaling methodology can lead to unacceptable line failures at the customer end and ultimately to a lack of competitive viability for the service.

While it certainly is possible to try and short-cut the implementation of signaling methods within VoDSL systems by stepping backward to a previous level of signaling evolution, this can extract a huge cost in service failures, management costs, and an inability offer advanced and emerging services. As will be demonstrated in the balance of this white paper, modern message-based digital signaling techniques currently represent the highest point of the signaling evolution as well as offering the best combination of efficiency, robustness and extensibility for implementing carrier-class VoDSL systems.

Key Signaling Functions

While most people naturally think of telephony in terms of the voice content that forms the heart of their person-to-person conversations over the phone, in reality the telephone system could not even exist without the underlying signaling mechanisms that provide network-wide coherence, interoperability and non-voice communications.

Call Set-up and Supervision

In the set-up and establishment of any voice connection, signaling provides everything from the caller's initial dial tone, to the addressing functions involved in dialing, to the ringing of the recipient's telephone. In the process, the underlying signaling system also has to gracefully handle a variety of conditions and provide appropriate responses, such as busy signals, error-tones, distinctive ringing, call-waiting indicators, and/or caller-ID functions. Once the connection is established, the signaling system also continues to stay involved for the duration of the call, to provide critical billing and system management functions such as definitive answer supervision, call-waiting notification, and disconnection indicators.

Digital Set Control

In addition to supporting POTS functions, today's signaling schemes also must provide for control of feature-rich digital telephony equipment at the customer's premises. These requirements can include functions such as, turning line indicators on and off, providing alphanumeric display messages, setting special features, automatic-forwarding to voice mail, managing ISDN functionality, etc.

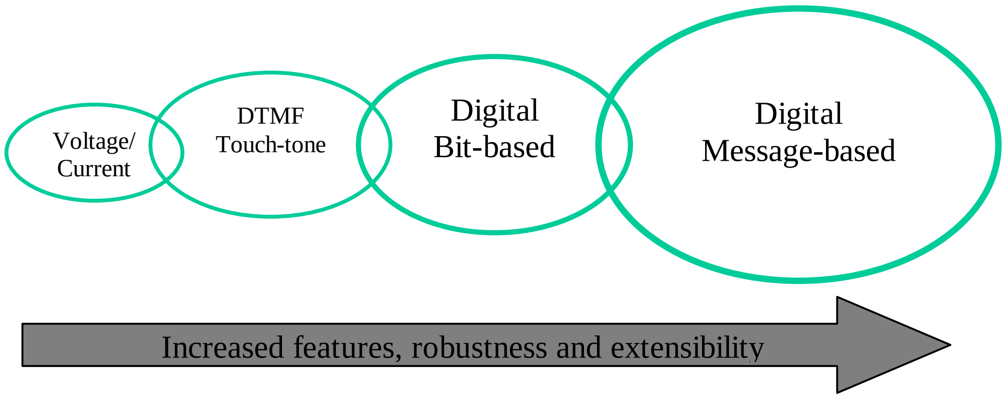
Node-to-node Communication

Going beyond individual telephones, the signaling system is also responsible for node-to-node communications, such as enabling switches (including PBXs) to talk to each other. These functions can include such things as, defining and assigning trunk paths, handling loop-back testing functions, providing routing instructions for number portability and dynamically adapting the overall network to the current state of each system, such as in-service or out-of-service status of line cards. Dealing with network anomalies is a critical signaling capability that is only appreciated when things go wrong. Routing calls around failures is an obvious requirement, but the network also is expected to deal gracefully with externally-induced events. A simple example would be a radio contest that results in a huge flood of simultaneous calls.

Network Management

At the network level, modern message-based signaling methodologies can provide the flexibility to dynamically manage high level network functions, such as provisioning new services, remotely updating software versions, and maintaining network security systems.

The Evolution of Signaling Methods



Voltage/current

The earliest signaling schemes consisted of relatively uncomplicated voltage/current methods that directly stimulated the phone to ring by applying a voltage to the phone line. On-hook and off-hook conditions were simply a function of the loop current on the line and pulse dialing was accomplished by repeatedly interrupting the line's loop current in grouped sequences that provided an analog representation of the numbers being dialed. Although these early voltage/current mechanisms are emulated by today's advanced digital signaling systems, for efficiency and simplicity the voltage itself is not carried across the entire connection but instead is generated as close as possible to the end-point.

In-Band

In the 1960s, touch-tone dialing was introduced using a set of distinct DTMF tones to represent individual numbers and special functions. Because the tones are audible and carried in the same frequency band as the voice traffic, DTMF is also referred to as an "in-band" signaling scheme. Of course one of the major outgrowths of in-band touch-tone signaling has been the adoption of the audible DTMF tones as a human access device to control remote functions, such as accessing voice mail and CTI systems. Although DTMF (and related schemes) are all but phased out as a trunk signaling methods, the tones continue to be universally supported in subsequent signaling methodologies both for backward compatibility reasons and because of their added intrinsic value as familiar, in-band, human-audible control mechanisms.

Bit-based Digital Signaling

As signaling technology evolved into the digital world, the initial implementations were relatively limited bit-based schemes, using either 2-bit (AB) or 4-bit (ABCD) codes to communicate signaling information. These early bit-based schemes brought the advantages of the digital domain's inherent robustness to telephony signaling. However, the limited number of available states (four with 2-bits and sixteen for 4-bits) placed significant constraints on the total number of functions that could be implemented. Legacy bit-based signaling uses a "robbed bit" scheme, which dedicates specific bit positions in the voice-band information to permit the continuous transmission of the ABCD bits. Because bit-based signaling is essentially a one-way communications mechanism, it lacks optimal robustness and provides only minimal capabilities for acknowledgements, retransmission and problem logging.

Message-based Digital Signaling

While bit-based signaling methods have been deployed mostly for handling trunk connections within North America, the rest of the world and higher functionality services such as Signaling System 7 (SS7) and ISDN have moved directly to the greater flexibility of message-based digital signaling. Digital messaging has proven to provide a much more robust and flexible communications mechanism for telephony signaling because it provides an extensible message set for robust implementation of an essentially infinite range of functionality.

Benefits of Modern Message-Based Signaling Systems

As the current state-of-the-art in telephony signaling, digital message-based systems have brought together an optimal balance of efficiency, scalability, and robustness, along with the extensibility needed for advanced services.

Improved Efficiency

Message-based information can be sent and acknowledged across a common channel for many different connections. This use of "common channel signaling" (CCS) allows for significantly more efficient use of system bandwidth as compared to the "channel associated signaling" (CAS) used in bit-based schemes where dedicated signaling bandwidth is required for every connection. In addition, CCS messages need not be associated with any specific connection, thus making it possible to efficiently implement system-enhancing mechanisms, such as automated status reporting, software updates, etc. during off-peak periods. The bottom line results from message-based signaling include faster call set-up, better utilization of network resources and much greater scalability.

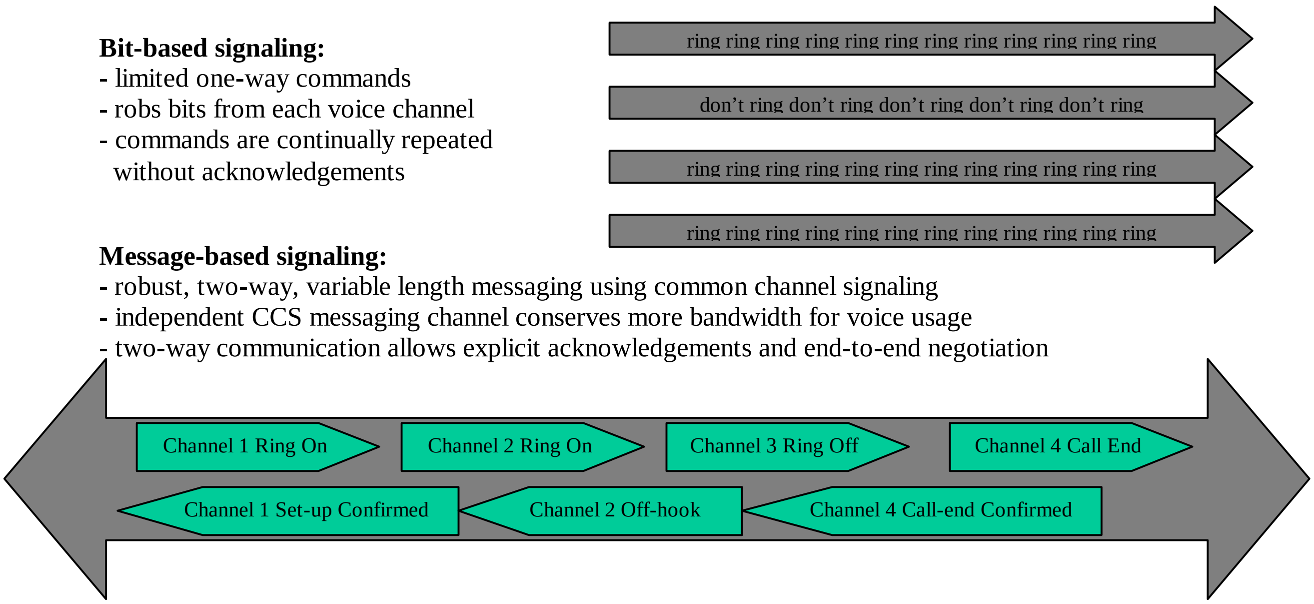
Robust Quality

The inherent two-way communications methods used in message-based signaling provide for assured transmission and automatic re-transmission of any message that is not received. This not only provides a higher level of quality for each individual connection, it also gives network management systems access to a rich stream of on-going statistical information, such as frequency of re-transmissions, which can be used for making proactive routing and configuration adjustments to anticipate and avoid catastrophic failures.

Advanced Services

Because any number of explicit messages can be created as required, a message-based system can be extended to specifically encompass any new circumstance, as compared to bit-based systems that often resort to using the same bit-code to mean different things in different situations. This inherent extensibility, along with two-way communication, has enabled message-based systems like SS7 to implement advanced revenue-enhancing services such as Caller-ID, one-number services, number portability, etc.

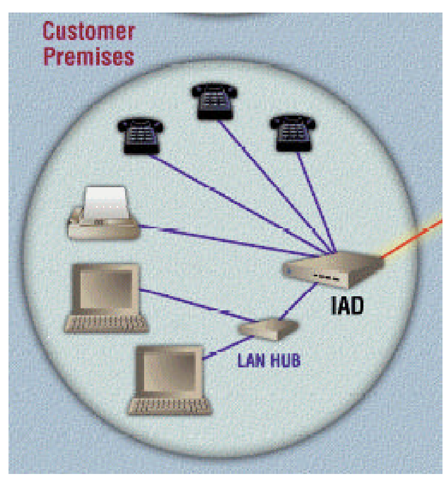
In addition, because both end-points of a message-based connection can participate in a two-way negotiation, the network design can be extended to include built-in mechanisms for automatically managing forward/backward compatibility issues between multiple system revision levels. In addition, the two-way negotiation capability gives a message-based system significantly greater flexibility for interfacing with a wider range of Customer Located Equipment (CLE). Standardization of messages insures interoperability, even among equipment from different manufacturers.



Implementing Signaling for Voice over Broadband

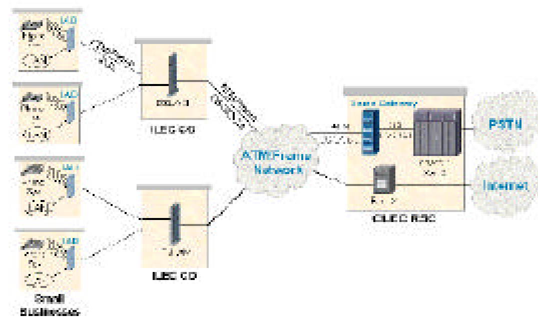
The deployment of a leading-edge voice-over-broadband service, such as VoDSL, significantly raises the level of network complexity that must be accommodated by the signaling system.

Instead of relatively simple telephones, the CLE in a VoDSL system must consist of more sophisticated Integrated Access Devices (IADs) to handle the local multiplexing of voice and data traffic as well as interfacing to individual voice handsets.



With the deployment of IADs to thousands, and ultimately millions, of individual customer locations, service providers can leverage the extensibility of message-based signaling to cost-effectively conduct remote maintenance and software upgrades of CLE, without incurring the expense of on site service calls.

In addition to supporting a higher number of CLE, the delivery of VoDSL services also entails coordination of more sophisticated intervening equipment throughout the network. Instead of just a copper wire loop between the customer's telephone and the central office switch, a VoDSL service consists of a sophisticated packet-switching network with many key elements, such as DSLAMs, carrier switches, and VoDSL gateways, which typically are geographically dispersed. This geographic flexibility is quite important to CLECs because it allows them to minimize the use of expensive leased floor space in an ILEC's central office, however it also places greater demands on the underlying signaling system. Message-based signaling provides the deterministic end-to-end, two-way communications needed for on-going dynamic network management, performance monitoring, fault isolation and load balancing.



Building on Leading-edge Messaging Methods

Message-based signaling standards such as Q.931 and transport protocols such as Q.921 offer a proven foundation for effective and extensible implementation of signaling in VoDSL environments. Q.931 is the native messaging mechanism already being used in V5, ISDN, VoIP and GR-303 call control systems. It defines a full range of two-way messages for controlling both advanced functions and providing backward compatibility with legacy systems. DTMF in-band touch-tone functions can simply be carried within the VoDSL system's voice traffic, while the generation of loop voltage current can be handled by the IAD at the customer end.

Message-based signaling also provides a simple mechanism for interfacing to existing AB or ABCD bit-coded PSTN trunk lines. Because any VoDSL implementation will need to extract the bit-codes from the PSTN's TDM bitstream and re-formulate them for propagation over the packet network, it is a straightforward operation to convert them to message-based equivalents during the same process. In this way, the VoDSL system avoids the challenge of juggling hybrid signaling methods, while gaining all of the robustness and end-to-end deterministic control that can only be achieved through message-based signaling.

Achieving User Expectations for Voice

Maintaining acceptable voice Quality of Service (QoS) for multiple connections over a shared DSL link requires a higher level of signaling support than has been traditionally required for simply establishing and supervising individual isochronous TDM connections. Because the available DSL bandwidth has to be dynamically allocated across all of the voice and data traffic on the link, the signaling system must include sufficient intelligence to stay abreast of bandwidth availability as well as the demands being placed upon the link by other connections.

For instance, if system conditions temporarily drive the DSL link's available bandwidth down below specifications, the signaling system needs to have the capability for dynamically adjusting the number of simultaneously allowable voice connections in order to maintain required QoS levels. If this is not done, and an additional voice call is admitted to the link when bandwidth is not available, the results are disastrous. Not only will the new call be compromised but calls already established will also be destroyed.

Similarly, the bi-directional acknowledgement capability inherent to digital messaging allows a network to robustly handle so-called "glare" issues in which calls initiated from both ends of the line attempt to seize the trunk simultaneously. While one-way bit-based signaling requires cumbersome system work-arounds to reduce the risk of collisions, the built-in two-way intelligence of digital message-based signaling can completely resolve such situations through auto-negotiation within the signaling channel.

In addition to avoiding such problems, the use of digital message-based signaling can also increase system flexibility by reliability enabling the provision of more individual lines than could actually simultaneously use the available bandwidth. For instance a user's system might support 24 different phone numbers although only 16 of them could use the DSL connection at any one time. The customer receives the benefit of increased flexibility while the provider enjoys the advantage of an expanded service offering. Limited bit-based signaling cannot support such flexibility for over-subscription because its channel-associated focus lacks the ability to manage overall bandwidth usage for multiple channels. On the other hand, message-based signaling gives the provider the option to provision additional lines without any risk of ever exceeding the DSL connection's actual capacity.

Laying a Strategic Foundation of Extensibility

In the long run the VoDSL signaling system also has to support sustained growth, in terms of both network-wide scalability as well as the capacity to add new services and functionality. As the state-of-the-art in signaling evolution, message-based methods are currently deployed in some form within the majority of existing PSTN telephony systems. The inherent flexibility of message-based signaling is already accelerating the deployment of advanced services, such as caller-ID, within the PSTN environment and therefore is constantly "raising the bar" for user expectations.

For providers of VoDSL services, the deployment of message-based signaling therefore represents a fundamentally strategic imperative – providing a solid foundation for delivering both today's required quality levels and for keeping up with tomorrow's escalating traffic and service demands.