V.150 Modem over IP
White Paper

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Abstract

Modem traffic over a hybrid of switched and packet type networks has become a feature needed in nowadays' Gateway systems. Since August 2000, intensive standardization work has been devoted to the development of the Modem over IP (MoIP) standard. This effort culminated in the recent publication of the V.150.0 and V.150.1 ITU standards. Other protocols, such as H.323 call setup have been adjusted to enable MoIP calls over hybrid PSTN-IP networks. In this paper, the V.150 MoIP protocol is introduced. The related network configuration is described. In addition, various aspects of the MoIP protocol, such as preferred physical layer, session flow and transport protocol requirements are discussed in depth.

Introduction

IP networks, such as the Internet, have broadened greatly. These networks are cheaper to install and maintain than the legacy PSTN/ISDN. This fact encourages the replacement of a portion of the PSTN/ISDN systems by private and/or public IP networks. This application is often referred to as *Trunking Gateway*. In addition, many enterprises are upgrading their telephone networks with IP-PBX. When a portion of the PSTN/ISDN network is replaced, provisions must be made to support legacy end-to-end services such as Voice, Fax and Data. Voice and Fax services are supported by VoIP and FoIP protocols (ITU-T T.38) respectively, implemented on Gateways that are located at the cross-section between the IP and ISDN/PSTN networks. Data traffic of V-series Voice-Band Modems over IP networks, referred to as MoIP, is usually implemented, after proper discrimination, by establishing a transparent VoIP G.711 channel over the IP network between the two Gateways. In addition, the echo-canceller and VAD/CNG mechanisms are disabled. For such a solution to succeed, a very high Quality of Service (QoS) is needed over the IP network. This is because any change in packet delay, packet loss or jitter behavior will initiate a retrain procedure in the Voice band Modem. In regular Voice-enabled IP networks, were QoS conditions of 1% of packet loss is common, the modem throughput is expected to be very low (if any) when advanced Modem protocols (V.34, V.90 or V.92) are involved.

Due to the failure of the naïve solution of conveying high-speed Modem traffic over high QoS IP networks, the ITU and TIA have initiated a standardization effort to provide an adequate solution for Modem transport over packet network (MoIP). The Standard has been ratified on January 2003. It includes options for Modem termination, a reliable transport protocol, and methods for call set up.

References

[1] ITU-T G.114

[2] ITU-T H.323 Annex P (Draft) "Real time Modem relay over H.323 system"

[3] ITU-T T.38

Network Model

In a conventional setting, a client Voice Band Modem (VBM) is connected to the PSTN via a twisted-pair cable, while a server Modem is connected to the PSTN via a digital trunk, such as an ISDN PRI. In this setting, a Modem call is categorized into one of the following call types:

- Client Modem versus server Modem
- Client Modem versus client Modem
- Server Modem versus server Modem

The first type might support up to V.92-standard connection speeds, while the second type supports only up to V.34-standard connection speeds, and the third type supports up to V.91-standard connection speeds. In a conventional setting, after the call establishment, a PCM-switched channel is provided between the caller modem and the answering modem. Though a portion of this path can be replaced with an analog twisted pair, it is still treated as a conventional PSTN system.

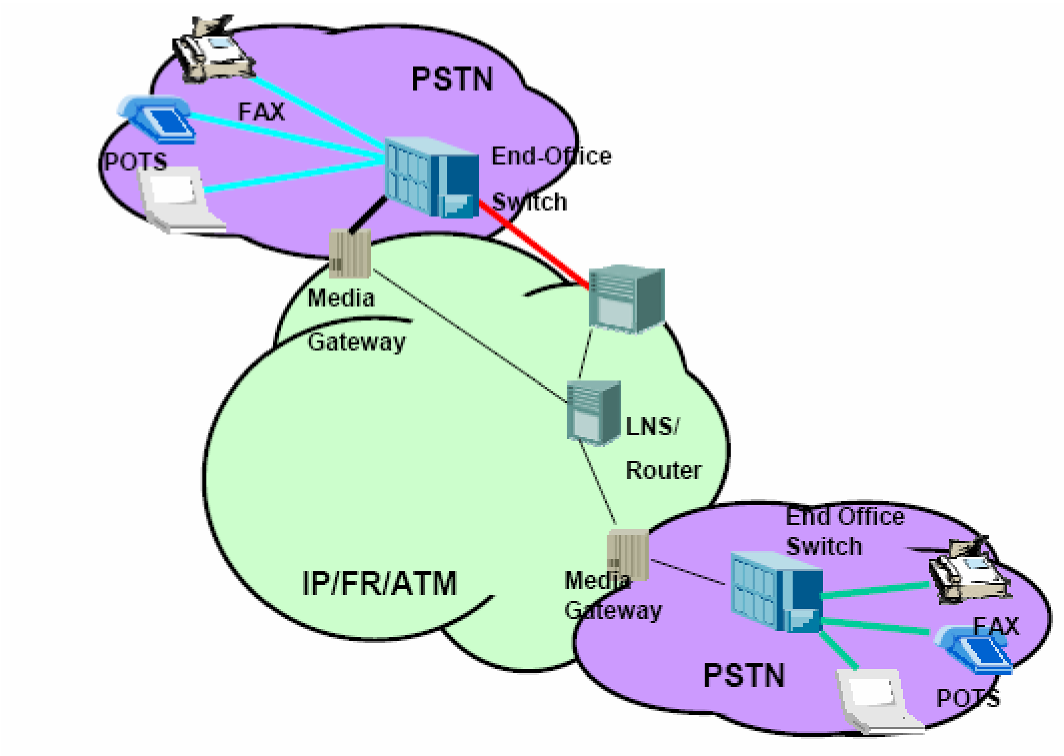

Figure 1: Trunking Gateway Configuration

In a hybrid setting (see Figure 1), in which a portion of the PSTN/ISDN is replaced by an IP network leg, Gateways are placed in the cross-section between the PSTN and the IP network. In addition, Media Gateway Controllers (MGCs) are placed in the IP network to handle operations, as call-establishment, call-control and call-termination, using IP control protocols such as MEdia GAteway COntrol (MEGACO H.248). To support near toll-quality voice service, the IP transmission path should have reasonably low delay (latency of less than 150msec, see Reference [1]), low packet loss (in the range of 1-5%) and low packet jitter parameters (less than ±100msec). Over this hybrid IP/PSTN setting, in addition to regular Voice and Fax calls, all the above Voice-band Modem call types may also be conducted.

Beside these scenarios, other settings exist in which Voice calls (and Modem calls) are to be supported over a hybrid of switched and packet networks. Among them are residential Gateway devices such as Cable Set-top boxes and Integrated Access Devices (IADs) using ADSL lines.

Standardization Work

The MoIP-related standardization work, initiated in August 2000 by Surf Communication Solutions, has been spread over several standardization bodies. Each deals with another aspect of the standard.

- ITU SG16 Q11 and TIA TR 30.1—deal with the actual MoIP session. This includes the physical layer (modulation, Link Access Procedure for Modems [LAPM] and DC layers), V.150 protocol messages and other system-level issues. This development effort resulted in the V.150.1 and V.150.0 standards
- ITU SG16 Q2—deals with the inter-working of V.150 and the IP signaling protocol, starting with H.323 (Annex P), Reference [2].
- IETF (Internet Engineering Task Force)—deals with development of the reliable transport layer to be used by V.150.

V.150

The V.150 includes options for partial termination of the Modem and a "light" reliable transport protocol to carry the data across the IP network. The selected MoIP types will not require any improvement in the QoS of existing Voice-enabled IP networks. An additional guideline followed in the development of the standard is that the emerging standard should have minimal effect on existing call establishment and Gateway control protocols. It is also agreed that the quality of Modem connection achieved through the Gateways should be as good as the connection that would have been achieved through the PSTN. Figure 2 illustrates the MoIP Gateway reference model.

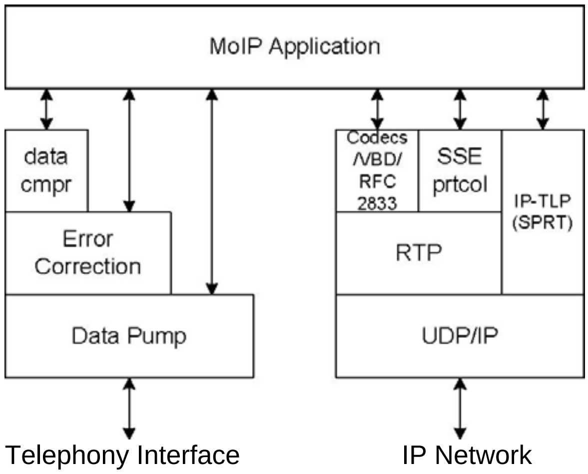

Figure 2: MoIP Gateway Reference Model

The relevant MoIP-type layer models are illustrated in Figure 2.

The V.150 standards provide selectable options for some of the layers of the MoIP Gateway.

First, the standard specifies two types of compatible Gateways—Universal Modem Relay Gateways and V.8 Gateways. A Universal Modem Gateway (U-MR) will perform full termination of a specific set of V-series modulations, namely V.92, V.90, V.34, V.32bis, V.32, V.22bis, V.23 and V.21. A V.8 Gateway provides termination for modulations negotiated through V.8. It may pass other modulations using the VBD mode.

The standard dictates that termination of the error correction layer will be performed by the Gateways. The standard also provides solutions for situations in which one of the Gateways is connected without error correction.

The standard provides several options for implementation of the data compression:

- **MR1—**in this mode, the data compression is performed by the end-modems. The data compression parameters are negotiated between each Gateway and its end-modem where either a default set of parameters is used or the negotiation in one side is delayed until the other side is ready.
- **MR2—**in this mode, full termination of the data compression is performed in the Gateway.
- **MR3—**in this mode, each Gateway terminates one direction of the compression—the direction from the modem to the Gateway. This means that Gateway 1 will decompress data coming from Modem 1 and compress it again using the parameters of Modem 2.
- **MR4—**in this mode, one Gateway performs all data compression and decompression and the other passes that data through it.

The Gateways exchange their data compression capabilities and preferences during the call setup phase.

In addition, the standard deals with call discrimination issues and call-setup parameters. For example:

- Supported Data Pump list for Universal and V.8 Gateways
- Information to be exchanged between the Gateways during the call setup procedure.

- Information to be exchanged between the Gateways when the Modem connection have been set up such as connection rates, compression parameters, and events such as retrains and rate renegotiations.

Some of these features can be appreciated by Telcos for monitoring integrity and easy customer support considerations.

- The standard also defines requirements and specifies the SPRT, an IP/TLP (IP Transport Layer Protocol) to be used to reliably carry the Modem traffic over the IP network.

Reliable Transport Protocol

Any Modem relay configuration must operate with a reliable transport over the IP network. The ITU SG11/16 has developed the SPRT—Simple Packet Relay Protocol for a light reliable transport over the IP network. The SPRT runs over UDP/IP. It provides four transport channels, two reliable channels for data and control, where control has higher priority, and two unreliable channels for acknowledgements and data that do not require reliable delivery. Packets in the reliable channels not acknowledged within 500ms of their transmission are retransmitted.

Inter-Working IP Signaling Protocols

The V.150 inter-works with H.323 annex P, H.245, and SIP/SDP IP signaling protocols. The inter-working function includes MoIP capabilities exchange, call-establishment negotiation of MoIP session parameters and call clear-down.

MoIP Session Overview

This section elaborates on the MoIP Gateway session states and on the phases of a MoIP session.

MoIP Gateway States

A MoIP Gateway session may be in one of three states

- Audio—this is the normal VoIP state, in this state the Gateway monitors the call to detect Modem tones and intercepts, and signals the other Gateway, using RFC2833 signals, that they have been received. The other Gateway shall reproduce these signals in its telephony interface.
- VBD—Voice Band Data. In this mode, the call signal is passed transparently between the Gateways using a voice codec that has minimal distortion with VAD/CNG and DC removal filters disabled. This state is fit for slow Modems and for early phases of the Modem training. Higher rate modems, such as V.34 and higher, will not function in this mode under normal network conditions, as previously described.
- Modem Relay—in this mode, the Modem signals are terminated in each Gateway. In the data phase, data is relayed between the Gateways using the SPRT protocol.

In addition to these states, the MoIP Gateway may also transition to the Fax over IP (FoIP) state.

Transition between states are agreed between the Gateways using state signaling events (SSEs). The standard details the rules governing the Gateways' state changes.

The initial state of the Gateway is usually the Audio state. It may be in VBD or Modem Relay state if during call setup it is clear that the call is a Modem call.

Phase 0: Call Setup

This phase is beyond the scope of the V.150 and it should be handled by the IP signaling protocol. The V.150 standard defines however the information that should be transmitted at this phase. It includes V.150 flavor capabilities (Universal vs.V.8), Data Compression capabilities and preferences, FoIP capabilities, modulations supported and other parameters.

Phase 1: Initial Call Discrimination

In this phase, both Gateways are in the Audio state. In this state, they monitor the incoming signals for "advanced Modem-like" and/or Fax signals. The standard requires that these signals be detected within 50ms, to prevent leakage of these signals to the other PSTN leg. The Gateway of the answering modem shall inform the Gateway of the calling modem of the reception of these signals. It must recognize the type of the signal within 350ms. When it recognizes the type of the signal, it signals the other Gateway, using RFC2833 signaling, on the type of signal received. The calling Modem Gateway shall reproduce the same type of signal at its telephony side.

Legacy Modems, such as Bell 103, V.21, V.23 and TDD (V.18) may be transmitted, once identified, in the VBD state.

Phase 2: Secondary Call Discrimination

In this phase, the MoIP session is either in the Audio state or in the VBD state. In this phase, the Gateways negotiate with the end-modem as part of the MoIP session. The negotiation may involve V.8 or V.32bis Annex A Auto-mode (PN4930) protocols. In this state, one of the modems exchanges can be delayed to enable staggered compression parameters negotiation. During this phase, the MoIP session will determine whether to transition to the Modem Relay State or remain in the VBD state. Alternatively, MoIP channel may switch to FoIP channel (T.38) if G3 Fax or V.34HD Fax are negotiated during Modem start-up. This phase ends when the state of the session is determined as Modem Relay, VBD or FoIP.

Phase 3: Modem Training

In this phase, the MoIP session is in the Modem Relay state. During this phase, the modem pairs M1/G1 and M2/G2 train.

This phase ends (possibly in an asynchronous manner) when data can be exchanged between the M1/G1 or M2/G2 Modem pairs and the link layer (V.42, MNP2-4) has been established.

Phase 4: DC Layer Parameters Exchange

Depending on the call-setup and the MoIP selected type, the DC parameters are negotiated between M1/G1 and M2/G2.

Phase 5: Data Relay

This is the useful operational mode of the MoIP. This phase can be interrupted by retrain or rate renegotiation events over one of the two PSTN lags, or a clear-down event.

Phase 7: Clear-Down

This phase occurs on one of the following events:

- Loss of carrier between the Modem pairs M/G1 or M2/G2
- Modem session termination by user request of either M1 or M2 Part of the clear-down procedure is beyond the MoIP channel scope and is to be negotiated between the Gateways. Nevertheless, the MoIP channel notifies its controller when it detects lost-carrier event or user request for clear-down coming from its local Modem. In addition, the MoIP channel should initiate a clear-down procedure towards its local Modem upon a request from its controller.

Coexistence of XoIP Protocols

The emerging V.150 standard is joining the existing FoIP (T.38) and VoIP family of standards. The existing VoIP and FoIP standards were developed independently of each other, and they have little in common. For example, each uses different transport protocol (VoIP—RTP/UDP, FoIP—UDP/TL). The V.150 standard uses the RTP for state signaling but uses SPRT to transfer the data.

Implementation Comment

MR1 has superiority over the other types of MRs in that it consumes the least system resources. MR1 is the only type that does not terminate the data compression protocols in the Gateway and, thus, uses approximately 25% lower MIPS resources and approximately 50KB less memory per channel than other MRs.

The only drawback of MR1 is that the compression might be forced to be V.42bis and not V.44. Because most traffic is already compressed in the PPP layer, this has a negligible effect.

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