TECHNICAL REPORT SHOWCASING COMMONLY ENCOUNTERED SCENARIOS ON LEGACY DIAL-UP

Despite the perceived obsolescence of dial-up modems, these are still pervasive in legacy infrastructures. Not only that, but they are still causing headaches to developers, system integrators and operators worldwide. In this report, we highlight a number of scenarios known to be fraught with problems; problems that are difficult to solve without appropriate diagnostic tools. These scenarios include migration from PSTN to VoIP networks, migrating new equipment to an existing network, protocol reverse engineering on legacy systems, call success rate issues, and finally, soft-modem development and integration. 3am LineScope, a diagnostic product for V.22 and V.22*bis* modems, can provide insight into these scenarios.

MIGRATION FROM PSTN TO VOIP NETWORKS

Pass-though infrastructures

With trade-offs designed for voice traffic, VoIP networks present unique challenges when migrating traditional dial-up modems from traditional PSTN lines. In most scenarios, a pass-though infrastructure is all that is available. Impairments associated with VoIP lines include distortion from lossy voice codecs and silence gaps from dropped packets. For modems to work at all, a lossless codec such as G.711 should be used. Silence gaps will result in a catastrophic loss of synchronization and retrains, as will any missing/extra samples. Apart from dropped calls, retrains will have a severe impact on protocol latencies and throughput.

The use of traffic engineering on carrier infrastructure to prioritize VoIP traffic is taken as a given. To reduce the effect of packet loss, jitter buffers can be increased in size without too much ill effect. Modems are less sensitive to delay than humans are to interactive voice, and a little extra jitter buffering goes a long way to reduce dropped packets. Other than that, error correction and data compression protocols can be enabled to increase resilience. A commonly encountered issue is reduced throughput due to poor performance of legacy application protocols when piggybacked over other protocols (such as LAPM V.42bis or V.44). Using large frame sizes might help, as would enabling selective reject (SREJ) capability, if available. The latter, however, is rarely found as an option on low-end modems.

Modem-relay infrastructures

In scenarios involving high-end gateways, such as Fibre to the Building and other FTTx, one is more likely to encounter modem-relay infrastructures. Such gateways use demodulation and re-modulation techniques to transport the voice band modem traffic over the packet network, solving most of the problems associated with pass-though infrastructures. Modem-relay, also known as Modem over IP (MoIP), is standardised in ITU-T V.150.1. The basic idea is similar to the ITU-T T.38 standard adopted for fax modems way back in 1998 to solve the same problem. Refer to [kc03] for details.

Problems typically encountered when migrating to such infrastructures can be divided into two categories. The first relates to the increased data latencies and the possible effects on non-robustly implemented host protocols. Such shortcomings will most probably need tweaking of the deployed applications.

The second category relates to quirky modem implementations. Known issues include FastConnect handshakes on payment terminals and mid-stream speed changes on alarm panels. Here, intervention at the gateway may be needed, in the form of an advanced configuration or an outright firmware upgrade.

On a final note, we do not exclude the possibility of seeing modem-relay appear on low-end gateways typically found in small businesses. To date this is not the case, but we expect this to change as gateway firmware code-bases mature and on-board processing power continues to rise.

VoIP & clock mismatch issues

Ordinarily, the system sampling rate is derived from the PSTN T1/E1 PRI interface. Being a stratum-2 clock (~0.02ppm), its accuracy does not pose any sampling rate matching issues for V.22 ad V.22*bis*.

However, some on-premises equipment may use line-cards with less accurate stratum-4 clocks (~30ppm)[1]. A worst-case clock mismatch can result in a periodic adding or dropping of a single sample every few seconds to match the PRI rate, giving rise to tell-tale periodic phase jumps, and consequently, periodic bit errors on PSK modes, while having no impact on FSK modes and voice.

Affected end-users may report longer-than-usual transaction times or outright failures due to frame retransmissions. To mitigate this, check whether the line-card supports the option of deriving the clock from the PSTN T1/E1 interface, and enable it.

Impact on handshake and protocol timings

Clearly, VoIP and MoIP will each have some impact on handshake and protocol timings; in general, slightly extending them. On robust implementations, this will be inconsequential. Refer to the next section for information on potential issues.

[1] High-density VoIP gateways will often contain a more accurate stratum-3 clock (~5ppm), which is a better compromise. Still, enabling the option to lock onto the PSTN T1/E1 PRI clock provides a further improvement.

MIGRATING NEW EQUIPMENT TO AN EXISTING NETWORK

Where a different modem or transaction gateway (NAC) is being introduced, handshake and connection issues are likely, as NACs often use proprietary handshakes to shorten overall transaction times and to provide auto-detect capabilities.

Specifically, NACs speed up transaction times with features such as FastConnect, which reduces or eliminates steps such as alerting, audible ring, billing delay, answer tone, and call termination. They also support multiple transaction protocols such as VISA I/II and Synchronous Data Link Control (SDLC). In doing so, they may send bursts of scrambled flags instead of scrambled marks during the handshake, which can confuse a new modem. As with FastConnect, SDLC increases throughput, thereby reducing congestion. Conversely, if modems revert to long-drawn-out standard handshakes, expect increased congestion in peak periods.

Legacy terminals can contain modem implementations based on controllerless datapumps. This means that modem operation, and in particular, the rather critical handshake phase, is completely under the host CPU's control or lack thereof. With controllerless datapumps, firmware implementation quirks are rife and a fully ITU-T compliant implementation is unlikely. Sometimes you just need to look into a working legacy terminal to help you understand why a newer terminal with a standard modem is behaving differently when it dials a tweaked NAC.

Present-day modems chipsets may also have issues with FastConnect and SDLC. The first hurdle is getting them to connect to the specific NAC, reliably and rapidly. A second hurdle is getting them to work with larger frames, which of course necessitates functional flow-control features in the modem, and appropriate handling in the terminal's firmware.

For newly developed applications, application protocol issues are likely. Specifications can contain obscure errors, and a peek into a functioning system will help you understand the problem. And sometimes, hosts have their own quirks, for example in their ISO 8583 implementation.

PROTOCOL REVERSE-ENGINEERING ON LEGACY SYSTEMS

Sometimes, it just happens that old terminals need replacing, but details about the application are unavailable due to incomplete or lost specifications. Even the most mundane information, such as exchanges on an X.25 PAD, can stop you from working. A non-intrusive data-tracing tool will greatly facilitate such a task.

CALL SUCCESS RATE ISSUES

Sporadic call failures can be difficult to deal with and solve because they are unpredictable and hence not easily reproduced. One approach is to capture a large number of exchanges, such as over one day, as necessary, possibly in an unattended manner. With the right tools, the recordings can be analyzed in real-time, synchronized with audio, or else analyzed off-line at rapid speeds, and possibly exported as text files. Problematic calls can then be isolated and analyzed in detail.

SOFT-MODEM DEVELOPMENT AND INTEGRATION

Despite the attractiveness of low unit cost, development and integration of soft-modems into a system is not trivial. The code itself is complex to develop, and it normally makes sense to just license a certified version from a reputable third party. Integrating the soft-modem code into your target is fraught with pitfalls due to hard real-time constraints. The target hardware environment can also cause its own problems; examples include excessive clock jitter, power rail noise and poor analogue-front-end (AFE) performance. For more information on integrating soft-modems, see [th99].

Here, you will need a physical layer analyser with powerful diagnostic instrumentation, such as live constellation displays and plotting of key control loop variables, which will aid in the detection of internal impairments.

Acronyms

AFE	*Analogue front end*
bps	*bits per second*
DCE	*Data circuit-terminating equipment*
DTE	*Data terminal equipment*
HDLC	*High-level data link control*
ITU	*International telecommunications union*
ITU-T	*ITU telecommunication standardization sector*
LAPM	*Link access procedure for modems*
MoIP	*Modem over internet protocol*
NAC	*Network access controller*
PAD	*Packet assembler / disassembler*
PRI	*Primary rate interface*
PSTN	*Public switched telephone network*
SDLC	*Synchronous data link control*
SREJ	*Selective reject*
VoIP	*Voice over internet protocol*

Recommendations / standards

G.711	*Pulse code modulation (PCM) of voice frequencies*
ISO 8583	*Financial transaction card originated interchange messaging*
T.38	*Procedures for real-time Group 3 facsimile communication over IP networks*
V.150.1	*MoIP networks: Procedures for the end-to-end connection of V-series DCEs*
V.22	*1200 bps duplex modem standardized for use in the PSTN*
V.22bis	*2400 bps duplex modem using the frequency division technique*
V.42bis	*Data compression procedures for DCE using error correction procedures*
V.44	*Data compression procedures*
X.25	*Interface between DTE and DCE for terminals operating in the packet mode and connected to public data networks by dedicated circuit*

References

[kc03] *"MoIP: Making PSTN Modems Work on IP Networks"*
Chu K, Metzger M; Mindspeed Technologies, 2003

[th99] *"Integrating a soft modem"*
Herbert, TF; EE Times-India, Mar-1999