WHITE PAPER>>>

MESSAGEmanager
Solutions

MESSAGEmanager IP FAX

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Overview

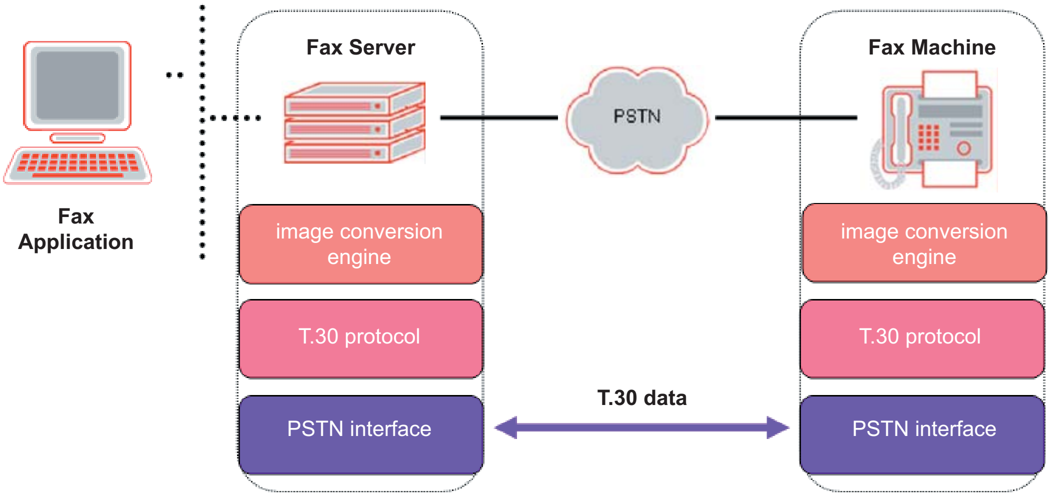
Despite the popularity of email and the Internet, fax continues to be an important technology for business communications.

It is estimated that there are 112 million fax machines in use in the world today with more than 6 million new units sold each year.

As VoIP becomes more prevalent as a replacement for traditional PSTN connections, the issue of how to handle fax traffic becomes more and more of an issue. If you are thinking that you can just plug your fax machine into your IP telephony system, you will be disappointed. Fax imposes special demands on VoIP networks because the standards used for fax transmission are designed to exploit features of switched circuits that do not fit within the parameters of most VoIP equipment.

A fax terminal works by scanning the source image and converting it into a stream of pixels that are transmitted to the remote terminal using the ITU T.30 data protocol. This protocol defines how the pixel data is compressed and how to attach additional meta-data to the transmission like the source terminal number, resolution, number of pages etc. T.30 is an interactive protocol that is composed of commands and responses that allow the terminals to negotiate capabilities at run-time.

The Basics of T.30 G3 Fax Protocol



T.30 is transmitted over a switched circuit voice line by converting the bitstream into modulated tones. This is the familar warbling that you hear when you accidentally pick up on a fax call. But these tones are merely the modulation technique used to transmit the T.30 data over a fixed bandwith communications channel. The actual payload is the underlying T.30 fax commands transmitted at baud rates between 300 and 33600 baud - the tones themselves are not really important. In this regard, a fax machine is exactly the same as a data modem, except that T.30 defines the higher protocol layers rather than just providing a raw bit stream like a data modem.

T.30 tone modulation is designed to work over a circuit switched voice connection, which these days is usually a 64 kbps voice channel sampled 8000 times a second. This approximates the previous generation analog phone technology that used a copper wire pair with an approximate bandwidth of 3100 hz. These circuit switched connections have low (and constant) latency, no jitter, but may experience loss or dropouts. T.30 modulation is designed for this environment - it exploits the full bandwidth of the circuit switched connection (well, as far as the modulation technology of the era allowed) and the T.30 protocol implements error detection and error correction, to solve the drop-out and signal noise problems.

Given all of this, it might seem that T.30 could be used over a G.711 VoIP connection, because these are intended to emulate analog copper wire circuit connections just like a BRI. After all, fax is just audio tones and G.711 is (by definition) the same audio modulation used on PSTN for BRI or PRI lines. But as many people will tell you, fax over G.711 only works reliably over a LAN network, and becomes very unreliable if used over the public Internet because it is very susceptible to jitter due to the heavy load on the underlying network. Voice calls tend to break up unless every hop in the underlying network can easily handle the raw 64 kbps data rate, which is actually closer to 80 kbps if a frame size of 30 msec is used.

The circuit switched networks for which T.30 was designed don’t have jitter, and the modulation techniques and protocols specified by T.30 contain no provision for dealing with it. T.30 simply can’t deal with the variable jitter of a VoIP connection, although it tries (and fails) valiantly.

Benefits of IP FAX

Convergence

- One network for voice, fax and data.
- Eliminate redundant administration costs.
- More efficient bandwidth use (packet switched vs. circuit switched).
- Seamless maintenance – fax server doesn't touch PSTN.
- Savings grow with VoIP roll out!

Centralised Administration

- Eliminate fax server in every location.
- One fax server can support multiple offices.
- Gateways connect remote offices to PSTN.
- Proxy servers route between gateways.
- WAN / VPN provides back haul.

Consolidation

- Reduces idle fax resources.
- Less personnel, fewer servers, less rack space, etc.
- Least cost routing.
- Lower cost of IDD and STD Calls by shifting traffic to IP.

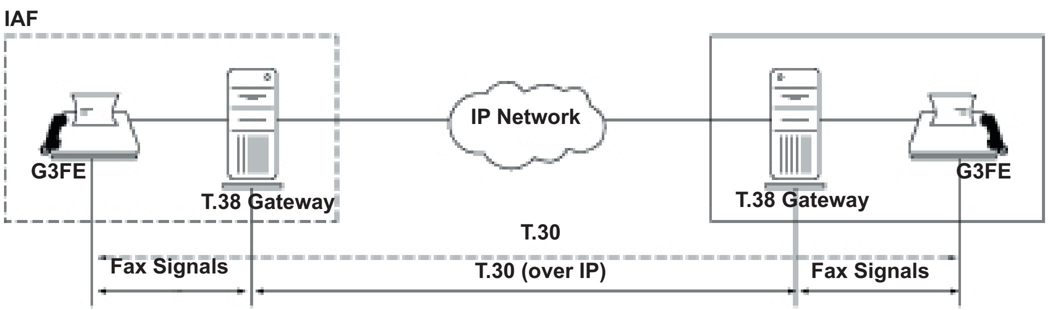
The ITU T.38 IP FAX Standard

The T.38 standard for real-time IP FAX was ratified on June 18 1998, by Study Group 8 of the International Telecommunications Union (ITU). The ITU recommendation entitled "T.38: Procedures for Real-Time Group 3 Facsimile Communication Over IP Networks" defines the procedures to be applied to allow Group 3 facsimile transmission between terminals, where a portion of the transmission path between terminals includes, besides the PSTN or ISDN, an IP network such as the Internet.

T.38 should not be confused with the similar-sounding T.37 which uses a totally different approach. Whereas T.38 is intended for realtime fax transmision using an encapsulated T.30 data stream, T.37 is intended for "store and forward" applications. It requires the fax data to be converted into TIFF format and then encoded using base64 into a text message and then transmitted using SMTP.

Figure 1 shows the architectural framework of the T.38 recommendation. A traditional Group 3 facsimile terminal is connected to a gateway, emitting a facsimile through an IP network to a receiving gateway. The receiving gateway makes a PSTN call to the receiving Group 3 facsimile equipment on the other side of the network. Once the PSTN calls are established on both ends, the two Group 3 terminals are virtually linked. The terminals establish the T.30 session and negotiate capabilities for fax functions like positive page confirmation and minimal call elongation. Another scenario, defined in the T.38 recommendation, is a connection on one or both ends of the transmission to a fax-enabled device like a PC, which is directly connected to an IP network

Figure 1. The T.38 system comprises Group 3 fax equipment (G3FE) devices, Internet-aware facsimile (IAF) devices and T.38 gateways.



When fax is transmitted over IP networks the data is assembled by a packet assembler/disassembler (PAD) into individual packets of data, involving a process of segmentation or subdivision of larger sets of data as specified by the native protocol of the sending device. Each packet has a unique identifier that makes it independent and has its own destination address. Because the packet is unique and independent, it can traverse the network in a stream of packets and use different routes. This fact has some implications for fax transmissions that use data packets rather than using an analog signal over a circuit-switched network.

Individual packets that are part of the same data transmission may follow different physical paths of varying lengths. They can also experience varying levels of propagation delay (latency) and delay that is caused by being held in packet buffers awaiting the availability of a subsequent circuit. The packets can also arrive in an order different from the order in which they entered the network. The destination node of the network uses the identifiers and addresses in the packet sequencing information to reassemble the packets into the correct sequence.

In the T.38 architecture, fax signals are demodulated at the voice/ fax gateway and sent over the IP network as IP fax packets using either TCP or UDP, depending on the service environment. Figures 2 and 3 show the packet structure for both transport mechanisms. TCP provides 100% error-free transmission, but the downside is reduced real-time performance. Routers discard TCP packets first when congestion occurs. UDP has good real-time performance, since routers do not discard datagrams as readily as TCP packets.

However, the downside of UDP is a reduced quality of service. It is possible for datagrams to get lost, arrive out of order, or to be duplicated. At the other end of the IP network, the remote gateway decodes IP fax packets and regenerates fax signals. Modulation methods that can be used with the T.38 format are V.21 Channel 2, V.27ter 2400, V.27ter 4800, V.29 7200, V.29 9600, V.17 7200, V.17 9600, V.17 12000, V.17 14400 and V.34 33600.

Figure 2. High-level IFC/TCP/IP packet structure.

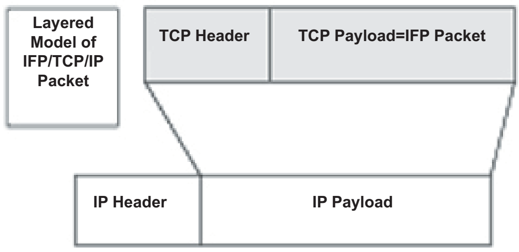
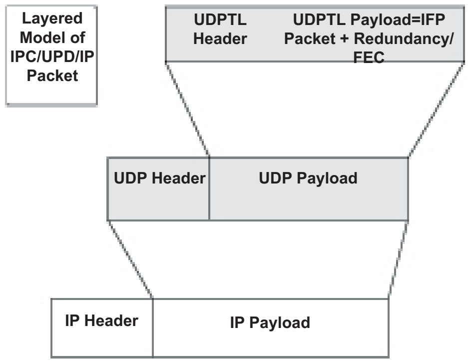


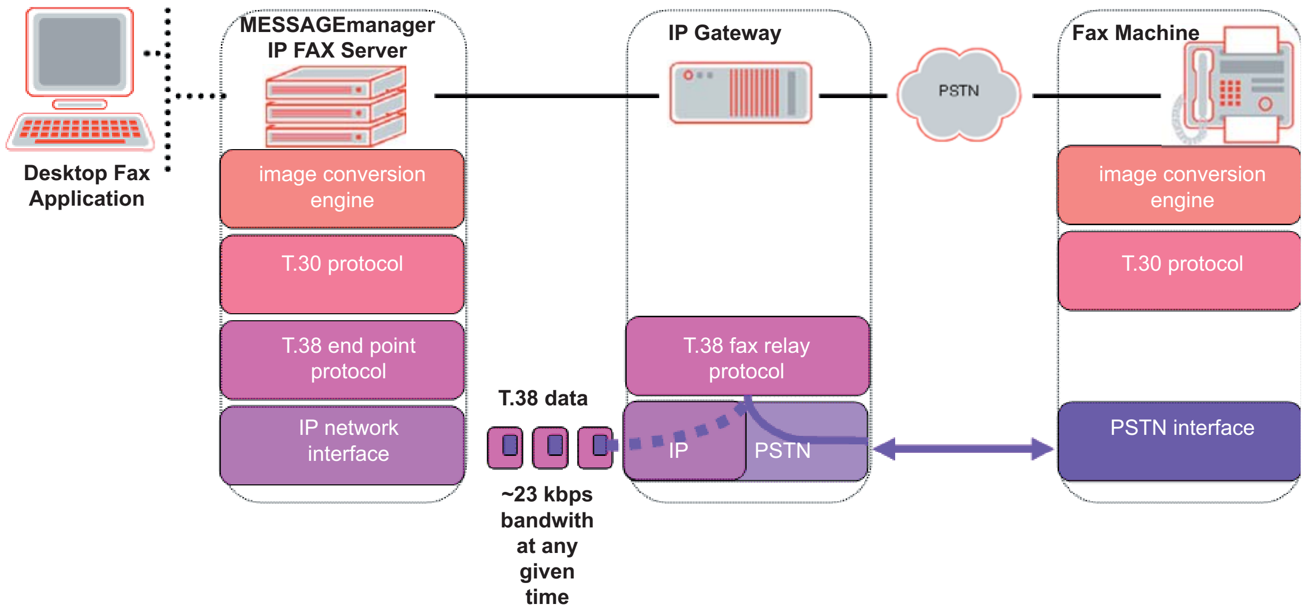
Figure 3. High-level UDPTL/IP packet structure.



The Basics of IP FAX

IP FAX requires a gateway to access the PSTN. The gateway can either be used for data, voice and fax or just fax or just voice. Typically gateways are standalone appliances although they can also be integrated into an IP-PBX. Gateways provide a PSTN connection that communicates with T.30 fax machines over the PSTN and an IP interface that provides bi-directional conversion between T.30 signals/data and equivalent T.38 packets.

T.38 IP FAX Components



The IP FAX Server is connected to the IP network and transmits the T.30 protocol and fax image data using T.38 packets over the IP network to the receiving gateway. The receiving T.38 gateway, in turn, translates the T.38 packets into T.30 protocol signals which are transferred to the receiving fax machine using modem modulation. The receiving fax machine has a T.30 protocol engine that communicates with the T.30 protocol engine in the fax server through the gateway.

The IP Gateway requires a protocol engine which understands much of the T.30 fax protocol. It must track the sequence of events in various ways to provide reliable timing tolerant communication between a traditional PSTN fax terminal and another T.38 entity somewhere on the Internet (which might be another gateway). Data buffering and protocol spoofing are used to maximise the network delay and jitter tolerance of the gateways. Error correction and mitigation mechanisms are used to minimise the effects of packet loss. Spoofing in T.38 gateways takes several forms, modifying the T.30 commands and responses to prevent network delays causing communication to timeout and fail.
For example:

- Non-ECM image lines are padded when image data arrives late.
- Message retransmission may be forced to avoid fatal timeouts.

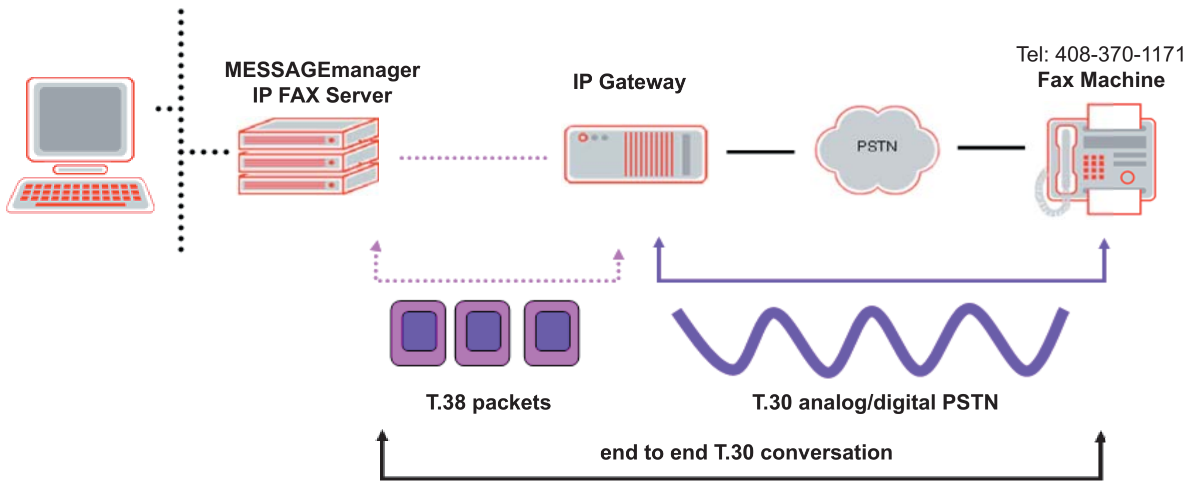
These tricks render the use of T.38 largely transparent to the PSTN fax terminal. Although they may slow the fax transmission a little, they increase reliability.

SIP and H.323 call control is used for establishing and managing voice and fax calls over the IP network.

The image conversion engine and the T.30 protocol in the endpoints, the originating and receiving devices, are the same for PSTN and IP FAX. Both transport the same T.30 control and image data. The physical interface to the IP network is standard Ethernet.

The fax server uses the T.30 protocol to negotiate the connection and performs the image conversion. The gateway simply passes the fax between a PSTN and IP connection. In endpoint facsimile devices, such as a fax server, the T.38 protocol provides the equivalent to the modem in traditional faxing. In a gateway, the T.38 protocol is used to translate or unwrap or wrap T.30 protocol and image data from the modems in the gateway to and from the IP endpoint connection with T.38 data.

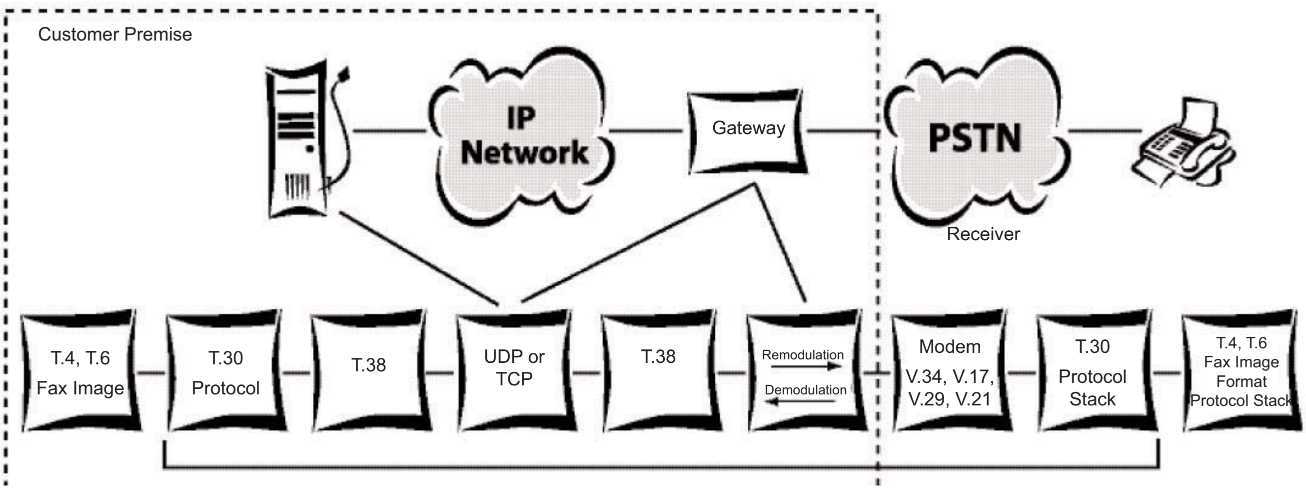
How does the fax go from IP to PSTN?



In the above example of MESSAGEmanager IP FAX Server sending a fax to a legacy fax machine connected to the PSTN with phone number 408-370-1171, the IP FAX Server has an ethernet cable that connects it to the local area network (LAN).

The IP Gateway provides the interconnection from the IP network to the PSTN network, has one or more Ethernet ports to connect it to the LAN and will also have an analog or ISDN telephony interface to the PSTN. The IP FAX Server makes a SIP call to the IP Gateway, which then places an outbound call over the ISDN line to the remote fax device at 408-370-1171. The fax communication between the IP FAX Server and the remote fax machine will be T.30 from end-to-end; on the IP network side, the T.30 protocol is in T.38 packets; on the PSTN side, the T.30 protocol is analog or digital signals. The IP Gateway converts the T.38 packets on the IP network side to analog or digital signals, which are then passed across the PSTN to the remote fax device. This process works in reverse when receiving a fax from a traditional fax device.

The diagram below shows how the protocols work together during the call:



Call Routing

Within a SIP network an "infrastructure" proxy server can be used to control call routing to multiple servers and gateways. The proxy server also performs functions such as registration, authentication, authorization, network access control and network security.

In a H.323 network, calls to gateways and servers are routed via a Gatekeeper. The Gatekeeper is the logical "switch" of the H.323 network, providing several basic services to all endpoints in its zone. Services include address translation (alias name/number-to-network address), endpoint admission control (based on bandwidth availability, concurrent call limitations or registration privileges), bandwidth management, and zone management (the routing of calls originating or terminating in the gatekeeper zone, including multiple path reroute). Gateways coordinate calls by communicating with Gatekeepers using the Registration, Admission, and Status (RAS) protocol.

MESSAGEmanager T.38 IP FAX Software

T.30 remains at the heart of fax connection and session management for both real-time over the PSTN and over IP. Even calls between two T.38 endpoint devices require a good T.30 implementation.

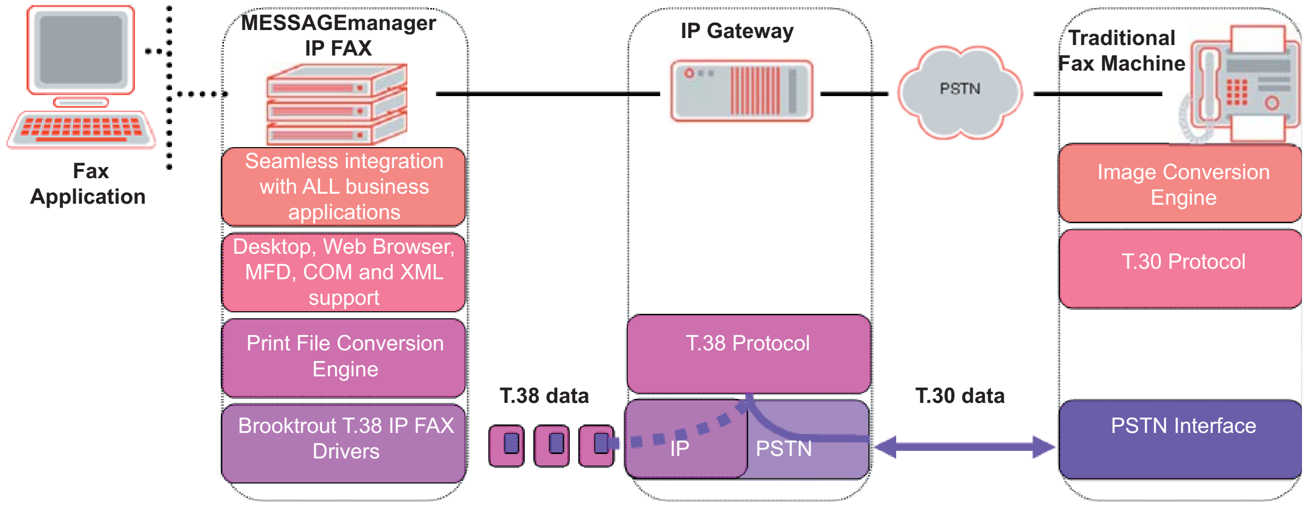
A critical issue often not widely recognized with PSTN-based faxing is that many of the fax machines currently in use around the world do not closely adhere to the T.30 specification, particularly during negotiations and training. This can lead to dropped calls and missed faxes.

A robust and forgiving T.30 protocol engine is required to compensate for errors that may occur during the negotiation and training phase of T.30. The more forgiving the T.30 protocol engine, the greater the ability to connect to a much higher percentage of fax machines that do not handle network or protocol problems very well.

MESSAGEmanager supports Brooktrout T.38 IP FAX Media Processing Resources from US based Cantata. Brooktrout T.38 IP FAX provides the same high levels of performance, reliability and scalability of Brooktrout intelligent fax boards. Cantata has a long history in both real-time PSTN and packet-based fax and was the primary editor and contributing author of the T.38 real-time fax over IP protocol specification.

Cantata is the intelligent fax technology market leader with over 73% market share.

MESSAGEmanager and Brooktrout T.38 IP FAX



Brooktrout™ by Cantata Technology
PREFERRED BROOKTROUT SR140 SOLUTIONS PROVIDER

With no boards to install or maintain, MESSAGEmanager IP FAX reduces complexity, simplifies deployment, lowers maintenance costs and provides the industry leading T.30 protocol, Error Correction Mode, MMR fax compression plus real-time IP FAX.

MESSAGEmanager host-based intelligent fax takes advantage of the latest advances in computational processing power. Host-based processing allows media processing and call control functions — traditionally performed by specialised digital signal processors (DSP) on boards—to be performed on general purpose host CPU's that run on industry standard servers. CPU Utilization is 3% with 30 channels on a Pentium 4, 3.0 GHz, 7% with 60 channels and 13% with 120 channels.

MESSAGEmanager supports both SIP and H.323 call control and is available in 2, 4, 8 or 12, 24, 30, 48 and 60 channels. As requirements grow additional channels can be easily added via a software license upgrade.

Security

Brooktrout T.38 IP FAX introduces no additional threat to security from network attack. The IP FAX Server sits behind the corporate firewall.

If malicious packets get through or a virus is spawned internally, Brooktrout IP FAX examines data at four levels.

- Invalid T.38 packets are dropped.
- Invalid T.30 messages are dropped.
- Invalid T.4/T.6 image data is dropped.
- Invalid T.30 messages or T.4/T.6 image data for a specific point in the call are dropped.

Network Delay / Latency/Jitter

Acceptable VoIP latency ranges from 250-300 milliseconds or less for each packet. A network properly configured for VoIP will support IP FAX.

- Loss of consecutive packets can cause the fax process to fail -T.30 will fail if 3 consecutive signals are missing - overcome by Brooktrout T.38 sending redundant packets.
- Jitter - Variable timing between packets is overcome by Brooktrout adding time stamps to the T.38 packets ensuring signals are 'played' at the right instance by the gateway.

Gateway Interoperability

A "supported" T.38 Gateway is one for which the software has been designed and tested.

It is certainly possible that T.38 IP FAX will operate properly with other T.38 Gateways, but we have not necessarily designed or tested to gateways not in the list below, and we do not support interoperability with gateways that we have not tested.

Cisco - tested and supported

- 1700 series
- 2600 series
- 2800 series
- 3700 series
- 3800 series
- AS5400

Cantata's Brooktrout intelligent fax-over-IP platforms enable MESSAGEmanager Solutions to deliver proven solutions for Cisco IP Communications.

Cisco Compatible

Known Limitations

When communicating with combined fax/phone devices Cisco gateways do not transmit CNG tone on PSTN to announce to the remote end the communication is a fax call. The combined fax/answering machine requires the CNG tone to switch to fax mode. We are working on adding a CNG tone to the T.38 driver to deliver CNG to the remote endpoint which is anticipated to be available in March 2007.

Ricoh - tested and supported

- Ricoh RIFAX SL3400 H.323
- Ricoh RIFAX ML4600 H.323

Avaya - anticipated completion by October 2006

- G350 Media Gateway
- G650 Media Gateway
- G700 Media Gateway

Alcatel - anticipated completion by October 2006

- PCX Entreprise

Founded in 1982, MESSAGEmanager Solutions has developed a reputation for innovation in technology aligned with real world business strategies. MESSAGEmanager Solutions is the developer of MESSAGEmanager, a modular messaging and communications platform that integrates Voice Messaging, FAX, SMS, Telex, Speech Enabled IVR and Presence into Telephone Systems and Desktop and Back Office applications.

MESSAGEmanager Solutions is a Microsoft Gold Certified Partner, IBM Business Partner, SAP Certified Solution Partner, HP Development Partner, Intel, Cantata Technology, Cisco, Nuance, Alcatel, Avaya, DocsCorp and AudioCodes Partner.

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