Fax and Fax over IP Analysis

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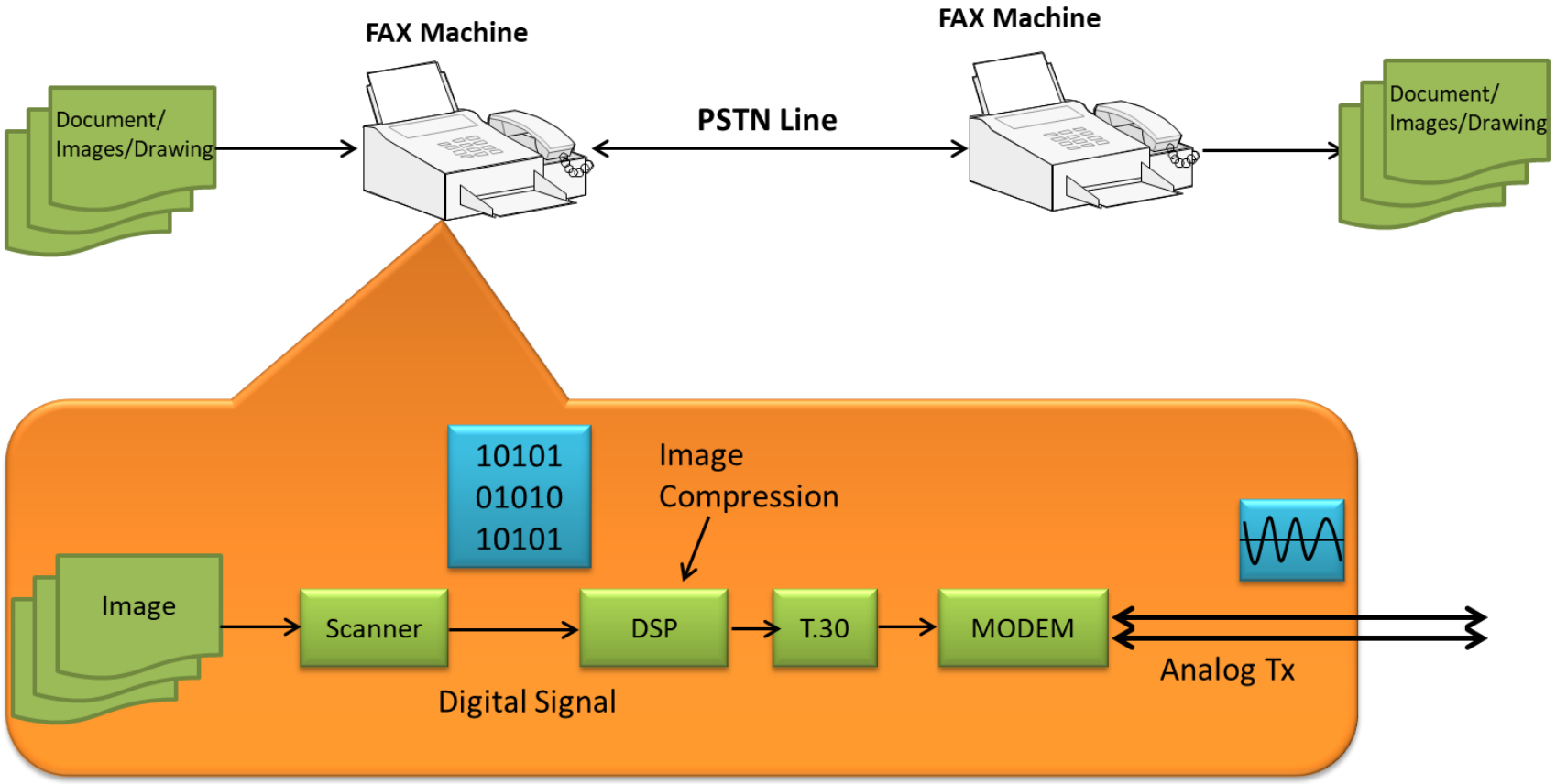
Fax Transmission Overview



- The protocol for sending or receiving a fax image and exchanging associated messages is defined in the International Telecommunications Union (ITU) Recommendation T.30

Basic Standards

- Group 1 standard for transmission for a single-page letter about six minutes to send over public phone lines
- Group 2 standard - reduced the time to send a page to three minutes, but still could not provide transmission at a dense enough resolution for the clear reproduction of small print
- Group 3 standard - improved fax scanning resolution and introduced digital transmission techniques to enable transmission rates of 14400 bits per second (bps). Group 3 fax machines are the most common today by far
- Group 4 is a standard for digital phone lines such as ISDN, and it operates at 64 kbps

Overview of Standards

Standard	Description
V.8	Procedures for starting sessions of data transmission over the public switched telephone network Part of the capabilities exchange during the modem and fax answering procedures
V.14	Transmission of start-stop characters over synchronous bearer channels
V.17	High speed data transmission, used for high transfer rates of High Speed (HS) fax page data (9600 to 14400 bps)
V.21	Low Speed (LS) data transmission, used for the fax control information (300 baud)
V.22bis	Medium speed data transmission, used for low transfer rates of High Speed (HS) fax page data (1200 to 2400 bps)
V.23	600/1200-baud modem standardized for use in the general switched telephone network
V.29	High speed data transmission, used for medium transfer rates of High Speed (HS) fax page data (4800 to 9600 bps)
V.32	A family of 2-wire, duplex modems operating at data signaling rates of up to 9600 bit/s for use on the general switched telephone network and on leased telephone-type circuits
V.32bis	A duplex modem operating at data signaling rates of up to 14 400 bit/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone-type circuits
V.33	High speed data transmission, fax page data (1200 to 1440bps). Used for synchronous data transmission
V.34	High speed data transmission, fax page data (1200 to 2880 bps). Used for Sync/Async data transmission

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Overview of Standards

Standard	Description
V.42	Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion
V.42bis	Data compression procedures for data circuit-terminating equipment (DCE) using error correction procedures
V.44	Data compression procedures
V.90	Adopted in 1998, V.90 improves upon V.34 by using pulse-code modulation (PCM) for the downstream link, achieving speeds of up to 56,000 bps when connected to a digital modem, sending G.711 signals with a symbol rate of 8000 baud
V.92	Adopted in 1999, V.92 improves upon V.90 by adding 'Quick Connect', 'Modem on Hold', 'V.PCM upstream' and 'V.44 compression' features

Overview of Standards

Standard	Description
T.4	Defines the encoding of printed information (content) into a digital stream ready for modulation (defines algorithms used for one-dimensional and two-dimensional data compression)
T.6	Defines algorithms used for error correction mode (ECM)
T.30	Defines the handshaking protocol and capabilities exchange that takes place during fax transmission
T.30Annex A	Defines Error Correction Mode (ECM) facilities
T.38	IP-Fax protocol for real time transmission of FoIP networks

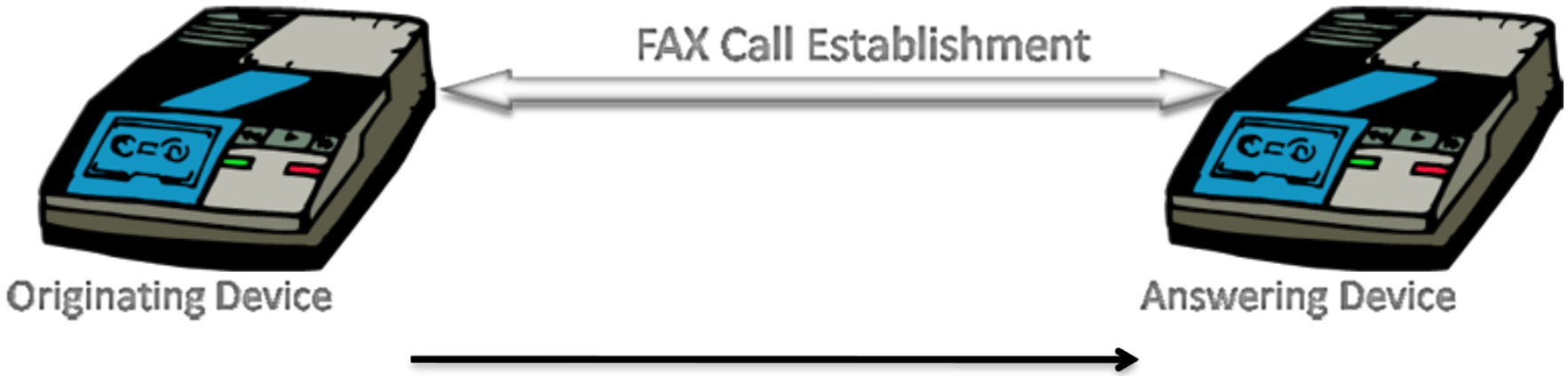
Fax Traffic Modulation

- Fax traffic consists of digital data modulated onto high-frequency carrier tones.
- There are various ways to modulate this information, such as
  - Amplitude Modulation (AM)
  - Frequency Modulation (FM) or Frequency Shift Keying (FSK)
  - Phase Modulation (PM) or Phase Shift Keying (PSK)

Fax Transmission Through PSTN

Phase	Description
Phase A - Establishing a Voice Call	The calling party picks up a handset or prepares a fax and then dials a destination phone or fax machine.
Phase B - Identifying Facilities and Capabilities	Facilities and capabilities are identified and negotiated between the calling and called parties.
Phase C - Transmitting Content	The message or page is sent.
Phase D - Signaling End of Transmission and Confirmation	The end of transmission and confirmation are signaled between the calling and called parties.
Phase E - Releasing the Call	The call is released when a phone or fax machine hangs up.

Phase A-Establishing a Voice Call (Pre-Image Handshake Sequence)



Send 1100 Hz CNG tone sent

The Calling Unit Announcing tone identifies the calling device as a fax machine.

(The Calling tone is a repeating 1100-Hz tone that is on for 0.5 seconds and then off for 3 seconds)

Send 2200 Hz CED tone sent

Called Station Identifier (CED) tone identifies the called device as a fax machine

(CED is a 2100-Hz tone that is on for 2.6 to 4 seconds)

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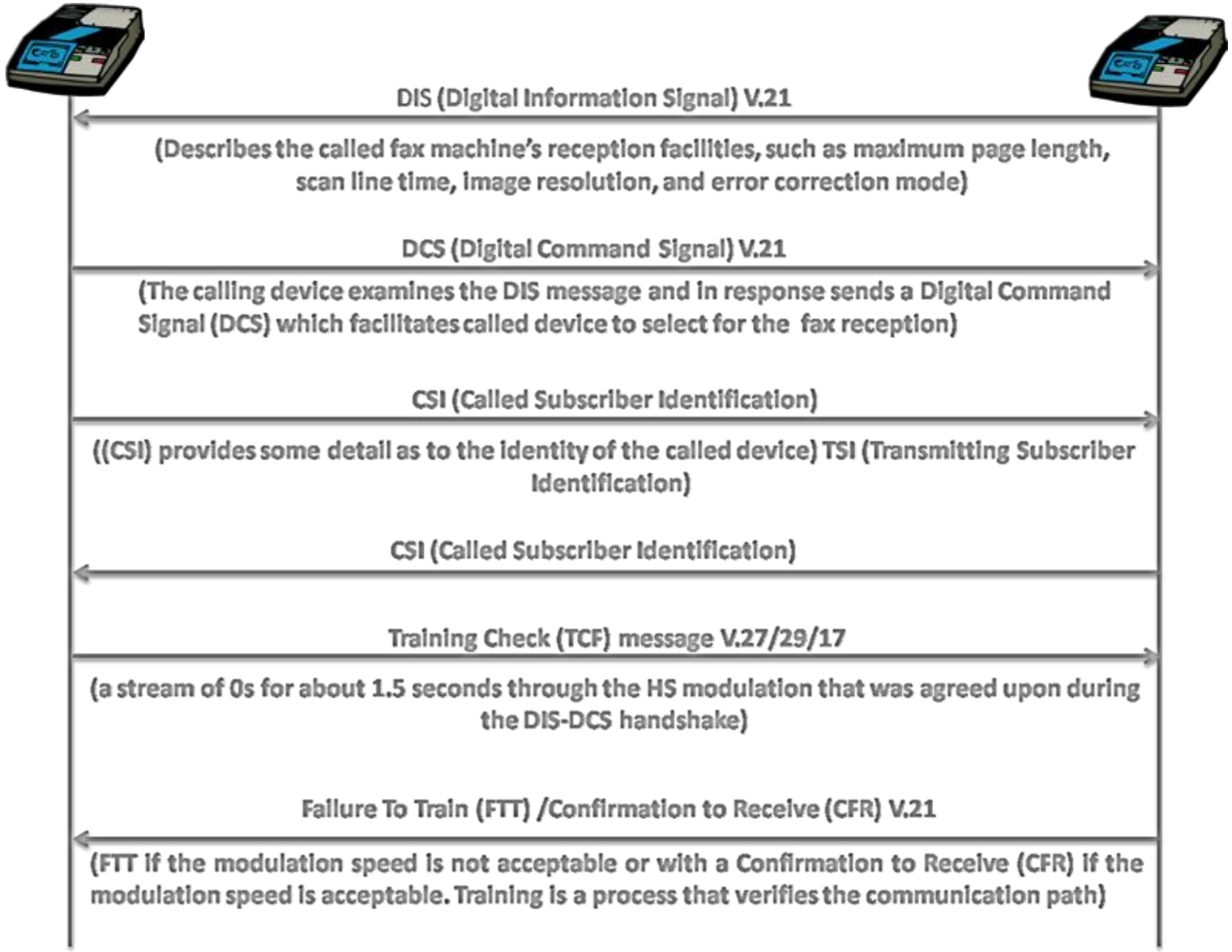
Phase B-Identifying Facilities and Capabilities (DIS and DCS handshakes)



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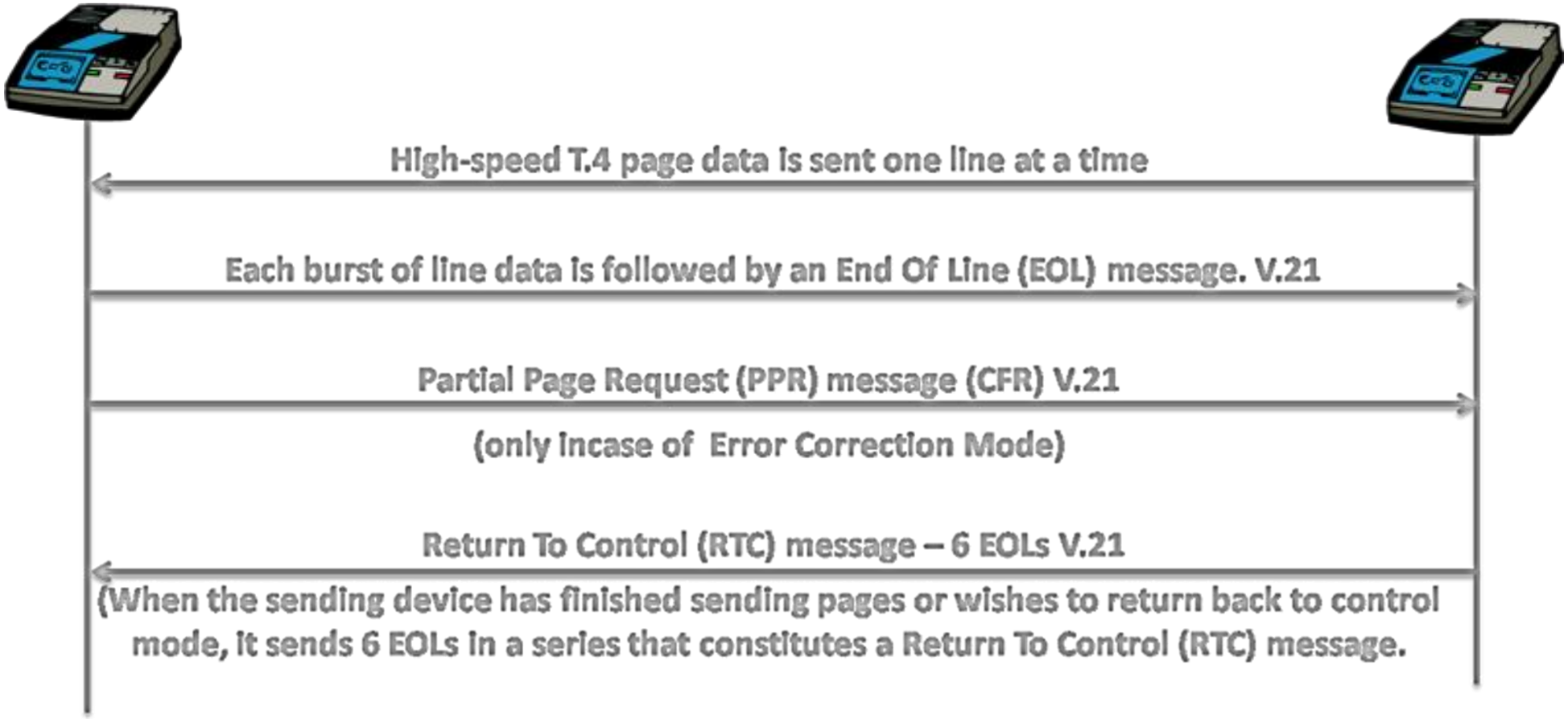
Phase C-Transmitting Content



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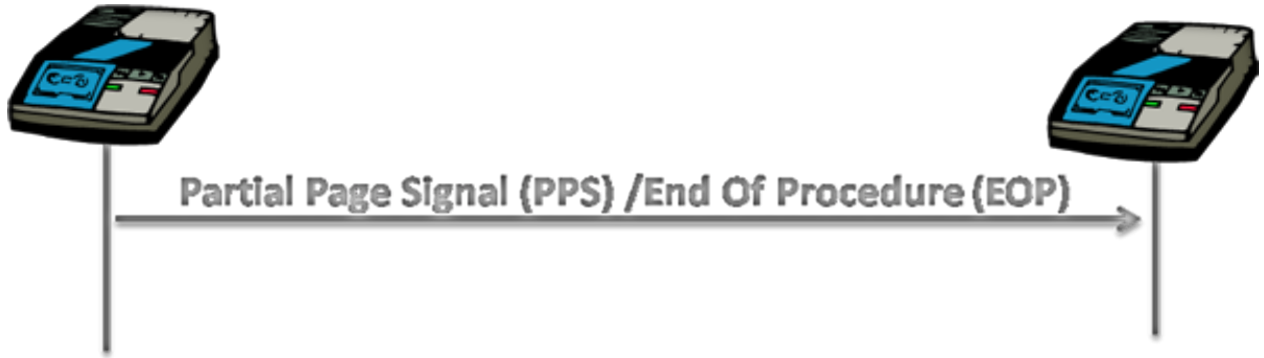
Phase D-Signaling End of Transmission and Confirmation

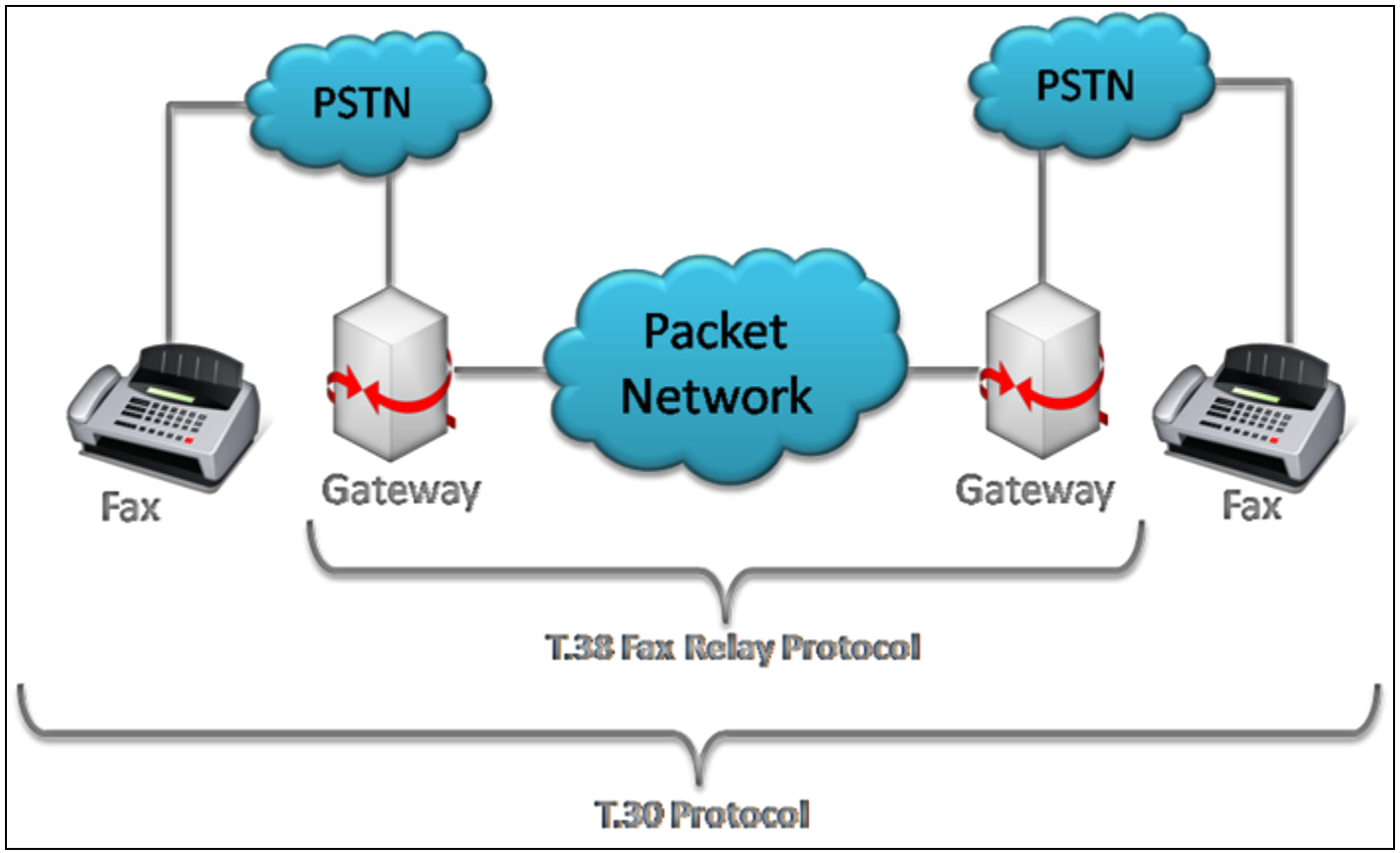


- (PPS)—Devices that send faxes with ECM can send a PPS, which must be acknowledged by a Message Confirmation (MCF) signal from the receiving device
- (EOP)—This signal indicates that transmission of pages is complete and that there are no more pages to send. The EOP must be acknowledged with an MCF from the receiving device, after which the devices can move to phase E

Phase E-Releasing the Call

- Following the fax transmission and the post message transactions, either the calling device or the called device can send a Disconnect (DCN) message, at which point the devices tear down the call, and the telephony call control layer releases the circuit
- DCN messages do not require a response from the opposite device

Fax over IP

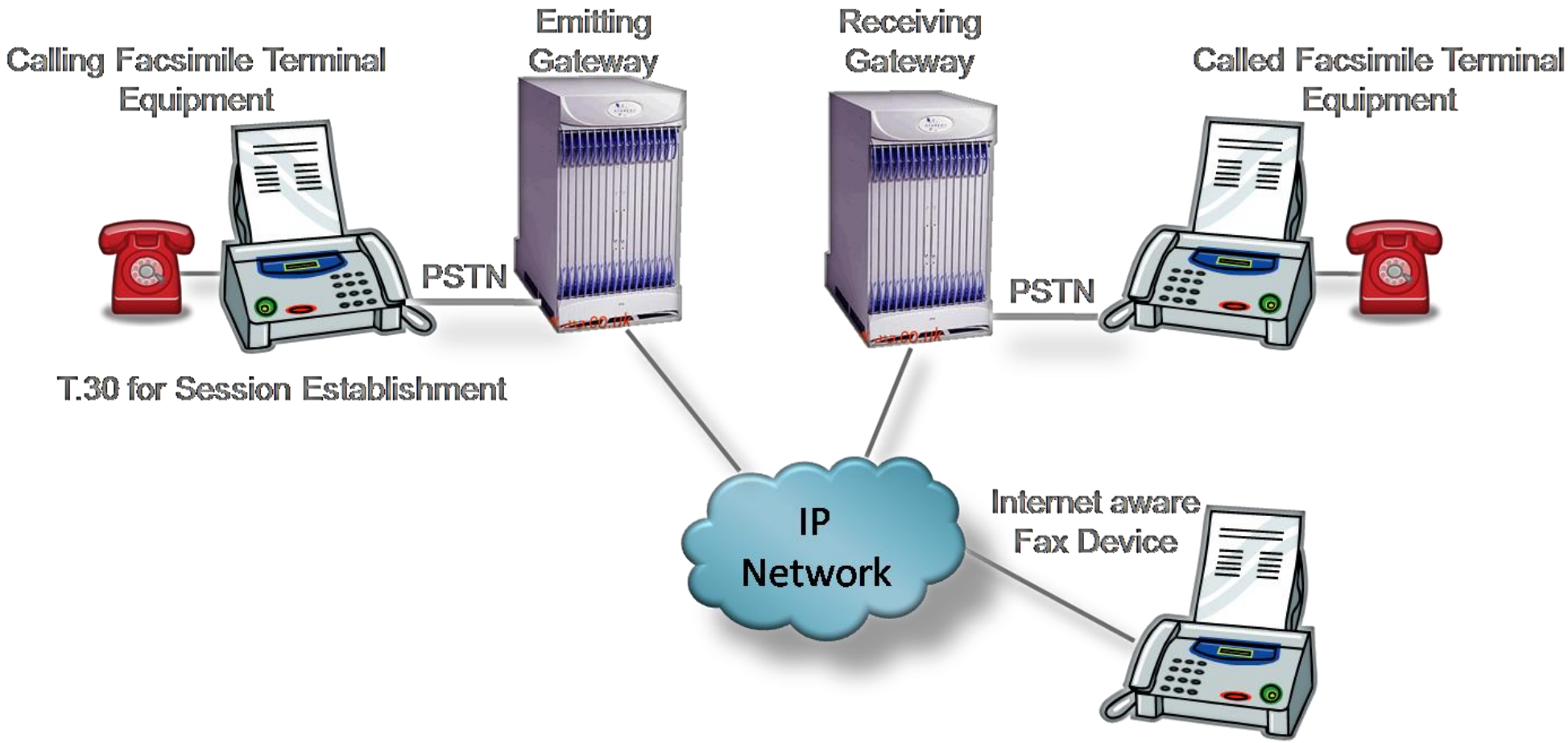


- T.38 is the real-time FAX over IP protocol
- It is an ITU recommendation for allowing transmission of fax over IP networks in real time

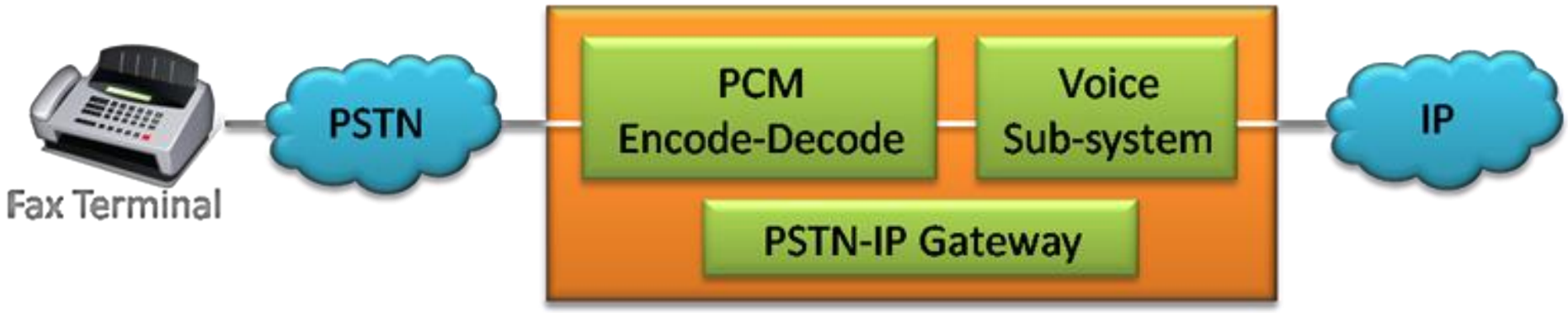
Why do we need T.38 ?

- It is common for each packet to contain a copy of the main data in the previous packet. This forward error correction scheme makes T.38 far more tolerate of dropped packets
- Loosing a packet in a T.38 stream does not cause the modems to loose sync. This means two successive lost packets should only corrupt a section of an image. If the optional FAX error correction (ECM) mode is used, there is a good chance that with a retry or two, a perfect image will be transferred. Not ideal, but functional
- T.38 gateway can start sending a page as soon as it gets some data, without performing any jitter buffering

Real-time Transmission of Fax-over-IP (FoIP) Networks

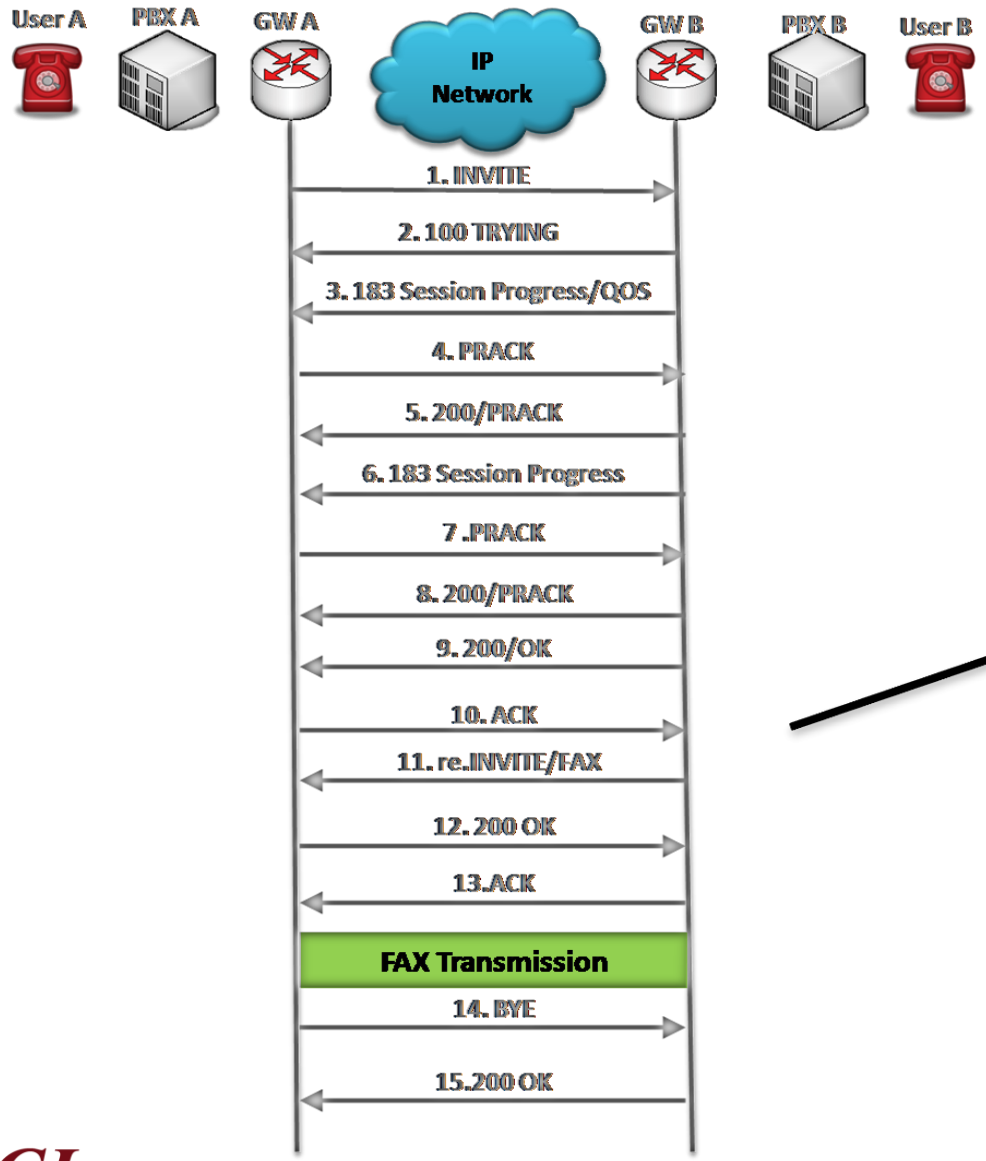


T.38 Subsystem



- A T.38 gateway is comprised of two primary elements: the fax modems and the T.38 subsystem
- The fax modems modulate and demodulate the PCM samples of the analog data, turning the sampled-data representation of the fax terminal's analog signal to its binary translation, and vice versa
- The PSTN network samples the analog signal of a voice or modem signal (it doesn't know the difference) 8,000 times per second (SPS), and encodes them as 8-bit data bytes

SIP T.38 Call with QoS Enabled Output




```
INVITE sip:1000@172.18.193.196:5060;user=phone SIP/2.0
Via: SIP/2.0/UDP 172.18.193.135:5060
From: <sip:2000@172.18.193.187;user=phone>;tag=14B968AC-2668
To: "1000"<sip:1000@172.18.193.196>;tag=14B99A90-269E
Date: Mon, 14 May 2001 17:43:11 GMT
Call-ID: F8C02D00-47BE11D5-805FE64C-BD156232@172.18.193.196
Supported: 100relCisco-Guid: 4143344000-1203638741-2153637452-
3172295218
User-Agent: Cisco-SIPGateway/IOS-12.x
CSeq: 101 INVITE
Max-Forwards: 6
Timestamp: 989858591
Contact: <sip:2000@172.18.193.135:5060;user=phone>
Expires: 180
Content-Type: application/sdp
Content-Length: 403
v=0
o=CiscoSystemsSIP-GW-UserAgent 5201 1829 IN IP4 172.18.193.135
s=SIP Call
c=IN IP4 172.18.193.135t=0 0
m=image 18036 udptl t38
a=T38FaxVersion:0
a=T38MaxBitRate:14400
a=T38FaxFillBitRemoval:0
a=T38FaxTranscodingMMR:0
a=T38FaxTranscodingJBIG:0
a=T38FaxRateManagement:transferredTCF
a=T38FaxMaxBuffer:200
a=T38FaxMaxDatagram:72
a=T38FaxUdpEC:t38UDPRedundancy
a=qos:optional sendrecv
```

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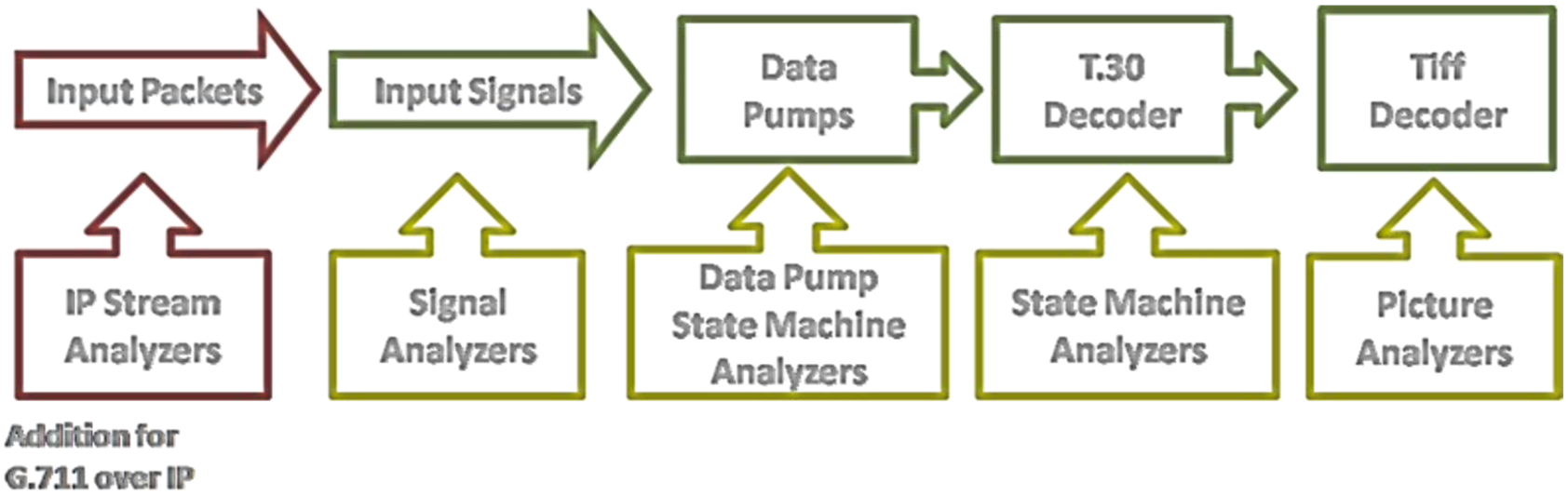
GLInsight™ Fax Coding and Analysis Information

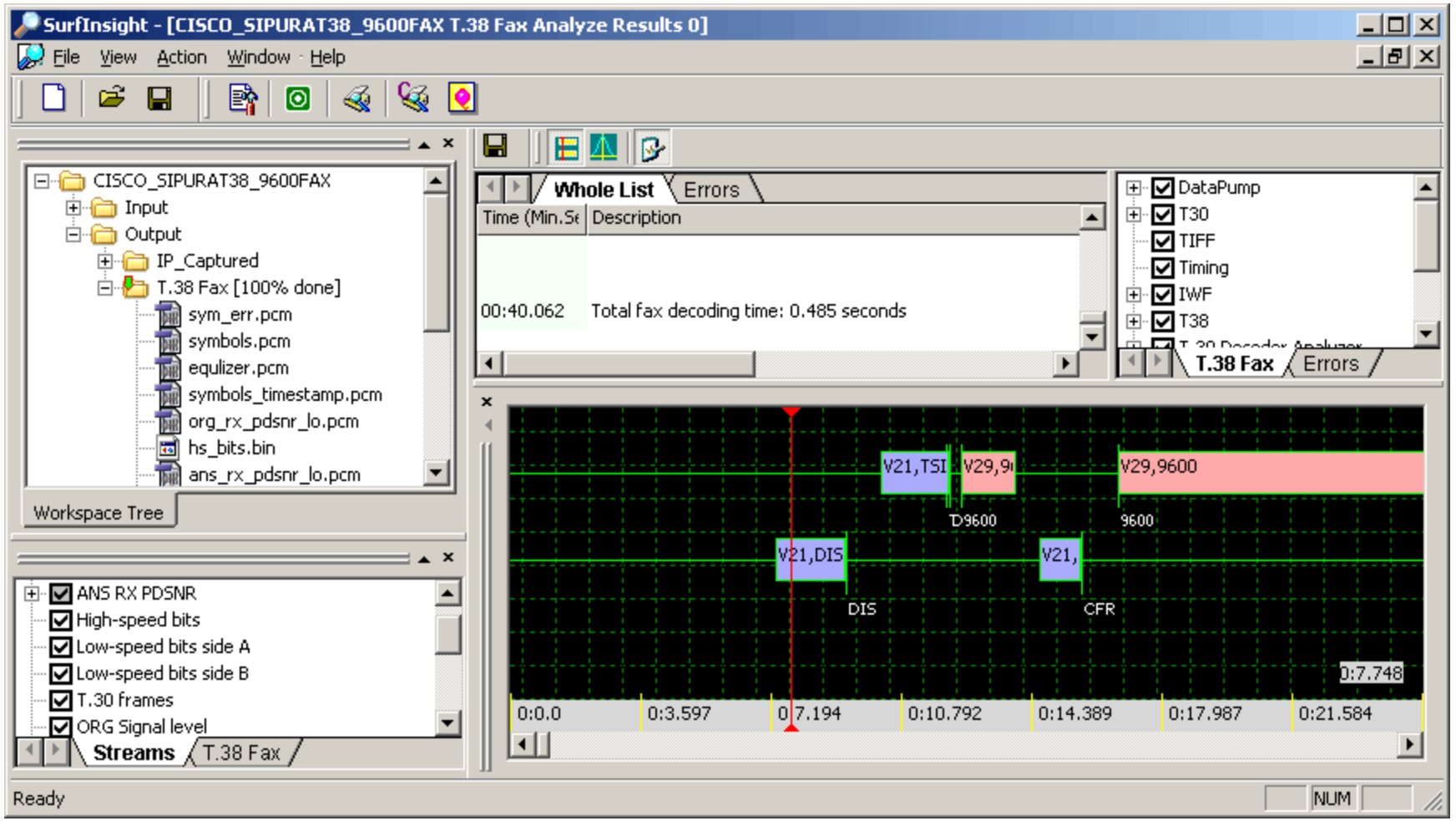


Supported Protocols

- GLInsight™ supports the following protocols:

  - Startup Protocols - V.8, V.8bis, and V.8 short
  - Fax Protocols - T4/T6, T.30 ,T.38
  - Modulations - V.92, V.90, V.34, V.32bis/V.32, V22bis/V.22, V.21, V.23, and Bell 103/ Bell 212
  - Error Correction and Data Compression Protocols - V.42, V.42bis, V.44, MNP2-4, MNP5, and V.14

GLInsight™ Fax Analysis



GLInsight™ Decoded Files

a_ls_bits.bin b_ls_bits.bin	**The a_ls_bits file contain all the lowspeed bits decoded in the fax call. (It is similar to the hs_bits file which contains the High Speed bits)**
ans_rx_pdsnr_lo.pcm org_rx_pdsnr_lo.pcm	Post Detection Signal to Noise Ratio) files should be opened as 8000samples/sec, mono, 16 bit linear. Lo is low resolution (133.3 measurements per second) and Shows the value in dB (/100) of the Signal-to-Noise ratio of the answer side training data signal respectively
ans_level.pcm org_level.pcm	The ans_level and org_level files are similar to the PDSNR files. Each provides the value of the signal power of the direction denoted by the name of the file Divide the value by a 100 to get the signal power in the recording
jitter.bin	The Jitter.bin file is relevant in T.38 files and contains the network jitter of the recorded analyzed packets
equalizer.pcm	The equalizer file describes the equalizer values used when entering the data in the hs portion. They serve as to distinguish between the highspeed sections
t30_bytes.bin	Contains T.30 signal bits
hs_bits.bin	High speed (page transmitting side) bits decoded in the fax call
symbols.pcm	Demodulated 2-dimensional symbols
sym_err.pcm	Estimated demodulated 2-dimensional symbol errors (noise)

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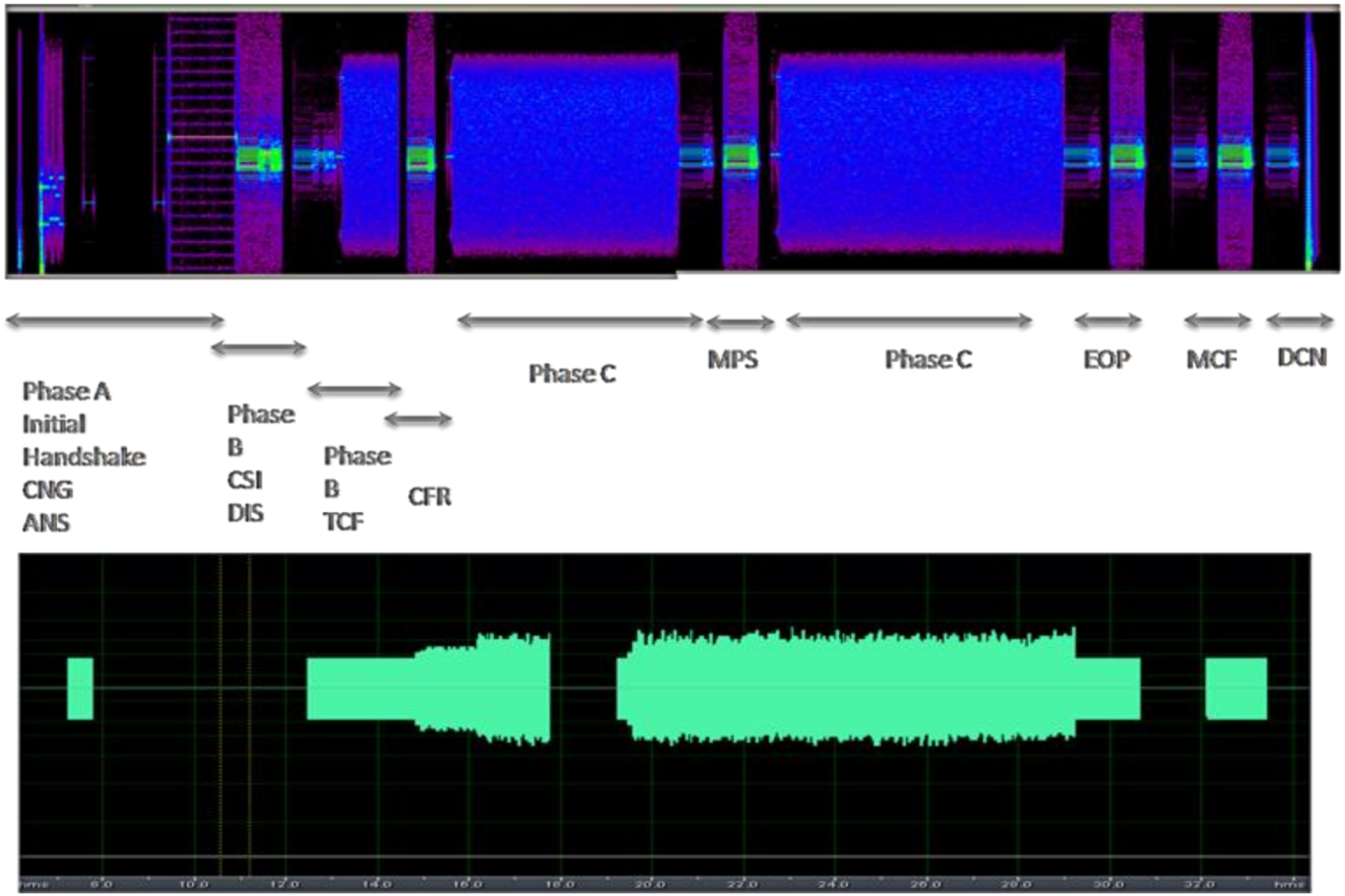
Standards applicable in GLInsight™

Description	Standard
General	V.1 – V.9
Interfaces and modems	V.10– V.34
Wideband modems	V.35–V.39
Error Control	V.40 –V.49
Transmission quality and maintenance	V.50 – V.59
Simultaneous transmission of data and other signals	V.60– V.99
Internetworking with other networks	V.100 – V.199
Interface layering specifications for data communications	V.200 – V.249
Control procedures	V.250 – V.299
Modems on Digital circuits	V.300 – V.399

Spectrogram view of ECM_v17_14400_ans.pcm



Thank you !