Information on Sage's Fax Emulator

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1 Introduction

Sage's Fax Emulator (SFE) is a test feature that allows a user to place a call to a real fax machine from Sage's test equipment (92x, 93x and 94x). After establishing the call, SFE will communicate with the actual fax machine through the protocol procedures specified in ITU T.30 [3]. After verifying the protocols, SFE will then transmit a prescribed fax pattern to the receiving fax machine. If all goes well, SFE will end with the message "Fax Transmittal Successful", and the receiving fax machine will print a test pattern that reads "SAGE FACS TEST 2002". If the fax call is not successful, either caused by problems on the communication link under test, or by protocol incompatibilities, SFE will display diagnostic messages that indicate the exact cause of the failure.

The primary use of such a fax call emulator is to ensure the "safe" delivery of a fax call through the increasingly-popular VoP networks. As various forms of VoP (VoDSL, VoCable and VoIP etc) technologies get deployed, the gateway manufacturers and service providers not only have to focus on voice quality control, but also have to pay attention to fax and modem calls. Unlike a voice call, which is sensitive to long delay, but less sensitive to occasional packet losses and jitters, and can tolerate high level of vocoder compression, a fax and modem call, however, cannot tolerate slightest amount of jitters, packet losses and non-waveform-type of voice compression. A "smart" gateway, therefore, needs to detect a fax or modem call, and then handle the call differently from a voice call. A simple approach is to disable all voice processing units (low-bit-rate voice compression, comfort noise generation, dynamic jitter buffer resizing, and any voice enhancement features etc), build a large static jitter buffer (long delay but no packet losses and no jitters), and to use the simple PCM or at least ADPCM coding. A better, although more complicated approach, is to use the Internet-Fax-Protocol as specified in ITU T.38 [1]. In this approach, the emitting gateway (where the transmitting G3 fax machine or SFE is connected) shall demodulate all fax control and data messages, and send those demodulated data through the IP network using IFP over UDP or TCP. Of course, the total network delay must be short enough to allow actual real-time fax communications. Regardless of the approaches, Sage's Fax Emulator allows a user to conveniently verify a gateway and network's fax call handling capabilities at the R&D, production and installation stages.

Of course, SFE can also be used to test the basic fax call protocol conformity of various fax-capable devices.

For other applications where a repeatable fax-call signal traffic is required, SFE is also an excellent solution.

2 Test specifications

SFE only tests the communication aspect of a fax call. Other aspects related to the fax scanners and printers are not tested.

2.1 Fax type

SFE emulates a *Group 3* facsimile terminal as specified ITU T.4 [2]. The communication procedures follow those specified in ITU T.30 [3].

2.2 Modem type

ITU T.4 [2] mandates the use and support of V.27*ter* modem [4] at 4800 bps for all G3 fax machines. SFE uses this mandatory modem type and its associated training sequences to transmit the test pattern. This guarantees that SFE can communicate with all G3 fax machines in the field. Other optional modem types such as V.29 [5], V.17 [6] and V.34 [7] etc are not supported by SFE at this moment of writing.

2.3 Message coding and resolution

SFE uses the standard one-dimensional coding scheme specified in T.4 [2] when generating the test pattern. A standard vertical resolution of 3.85 lines/mm and a horizontal resolution of 1728 picture elements per 215 mm are used.

The test pattern data are transmitted without using the optional error correction mode. First of all, this is to ensure the compatibility with all fax machines in the field that may or may not have such error correction mode. Secondly, the purpose of SFE is to expose all potential communication errors, instead of masking them. Even without the optional error correction mode, any transmission errors (fax data bit errors) will still be detected by the receiving fax machine as the bit errors will cause invalid codes or invalid scan line length. Upon detecting the errors, the receiving fax machine will notify the SFE using the MCF packet (explained later), indicating that the fax data has not been satisfactorily received due to communication errors. SFE will then display messages like "Fax transmittal unsuccessful". The receiving fax machine meanwhile may print out an erroneous test pattern.

2.4 Test pattern

If the fax call succeeds, a test pattern shown in Figure 2.4 will be printed at the receiving fax machine. The printed pattern should have sharp edges and corners. Any signs of broken lines or fuzzy edges indicate potential transmission errors. Notice that the pattern is generated through software arithmetics. It is not created from an actual scanner, therefore, the pattern when printed out should have very sharp edges and be "crystal clear". The fuzzy-looking image from most fax machines are caused by the "lousy" scanners at the transmitting end. By avoiding the scanner, SFE is able to generate crisp sharp image for testing the communication link only.

Figure 1: Fax test pattern generated by SFE.

2.5 Test call duration

The test pattern message itself takes about 33 seconds to transmit. Other protocol negotiations and training portions require additional 10 seconds. So the total test call duration is around 43 seconds.

3 Fax call signal sequences

Some knowledge of the fax call signal sequences is required in order to understand the error messages displayed by SFE. Figure 3 shows the signal sequences where a calling fax machine (like SFE) is transmitting.

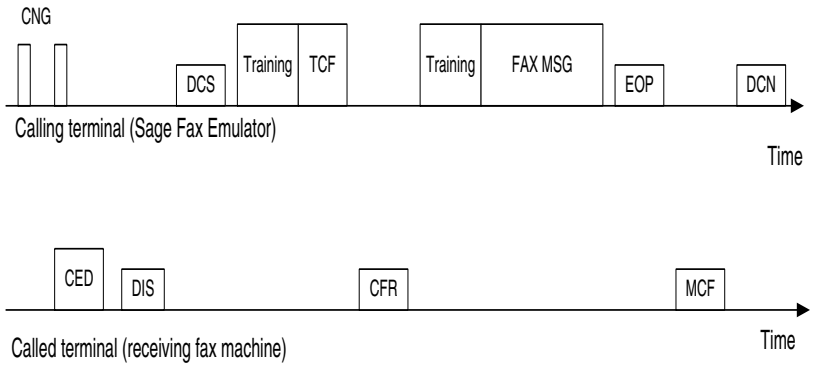

Figure 2: Fax call signal sequences.

Detailed descriptions of the signal sequences as as follows:

1. Tonal signals. These include two straight tone signals, CNG and CED.

   CNG: , CNG (Calling tone) is transmitted by the calling fax terminal (such as SFE) to indicate that this calling device is a fax device, and ready to transmit on receipt of the

DIS explained below) from the receiving fax terminal. It is a 1100 Hz tone with 0.5s on and 3s off.

CED: , CED (Called terminal identification) is an answer tone used by the called device to indicate that it is a fax machine. This is a continuous 2100 Hz tone. Valid tone duration is between 2.6s and 4.0s.

2. Control messages. The fax control messages include the DIS, DCS, CFR, EOP, MCF and DCN signals. All these binary messages are encoded with an HDLC frame structure, and then modulated using the V.21 [8] FSK scheme (1750 Hz center frequency with 100 Hz frequency deviation). The HDLC frame structure implies that the binary message payload is preceded by control field, address field and flags (0x7e), and followed by CRC checking and flags. The HDLC transparency check (transmitter inserts extra zero bit following 5 consecutive ones and receiver shall remove the extra zero bit after 5 consecutive ones) is also applied to the data payload and CRC bits.

   DIS: This DIS (digital identification signal) is used by the called fax machine to indicate its capabilities on scanning and printing resolutions and modem capabilities etc.

   DCS: This DCS (digital command signal) is the calling terminal's response to the DIS. It informs the called terminal what type of modem and what type of coding and resolution will used. In Sage's Fax Emulator, this DCS packet will inform the receiving fax machine that it will use the V.27*ter* modem at 4800 bps with standard 1-D coding scheme with vertical resolution of 3.85 lines/mm and horizontal resolution of 1728 picture elements per line.

   CFR: This CFR (confirmation to receive) is transmitted by the called terminal to indicate whether or not the entire pre-message signals (DCS and training signals) have been successfully received.

   EOP: This EOP (end of procedure) is sent by calling terminal to indicate that the transmission of the current page has completed and no more pages are forthcoming.

   MCF: This MCF (message confirmation) is transmitted by the called terminal to indicate whether or not the complete fax message has been successfully received.

   DCN: This DCN (disconnect) is sent by the calling terminal to inform the called terminal that it may disconnect.

3. Fax data messages. These include the training sequence, TCF and actual fax message sequences. All these sequences are modulated through the modem type specified in the DCS command. The mandatory modem type is V.27*ter* at 4800 bps, which is the modem type used by SFE. Other optional modem types are V.17, V.29 and V.34.

   Training sequence is specific to each modem type. Basically it contains various segments of known signal to help the receiver equalize out the static and linear communication channel distortions.

   TCF: This is the training check sequence that is formed by feeding continuous zero bits into the modem scrambler and modulating the output bits for 1.5s.

   Fax message: the black-and-whiter line-by-line image from the "scanner" is encoded into a sequence of "raw" bits according to the 1-D encoding scheme specified in T.4 [2]. Each line of bits are preceded with EOL (end-of-line) pattern and followed by fill bits to guarantee minimum transmission time per line, and then modulated according to the

modem type. In SFE, the differential 8PSK modulation scheme in V.27*ter*is used with 50% square-root-raised-cosine pulse shaping filter.

4 SFE test messages

When the fax call succeeds, a user should see "Fax transmittal successful" being displayed. If not successful, one will notice one of the following error messages. You may need to read the signal sequence descriptions on previous section to fully understand the nature of the error messages.

CED tone too long or to short indicates that the duration of the answering tone falls outside the valid range of 2.6s to 4.0s. The answering device may be an invalid fax machine or the communication link has squelched out a portion of the CED tone.

CED or DIS detection time out indicates that SFE has not detected a valid CED tone or DIS packet from the answering device within 15 seconds after call establishment. The called terminal may not be a valid fax machine or the communication link has distorted the CED and DIS signals.

DIS info error indicates that the received DIS packet contains errors that violated the HDLC frame structure. The errors could be due to CRC error or invalid control and address fields. The DIS signal may have been degraded by the communication link.

Non-V27 modem type indicates that the answering fax machine does not support the mandatory V.27*ter* type of modem.

CFR info error indicates that the received CFR packet contains errors that violated the HDLC frame structure. The errors could be due to CRC error or invalid control and address fields. The CFR signal may have been degraded by the communication link.

CFR request re-train indicates that the answering fax machine is not happy with the pre-message training or DCS signals due to communication link problems. It requests the SFE to resend the DCS and training sequences.

CFR detection time out indicates that the SFE has not detected the CFR packet after the completion of the training and TCF sequences within 10 seconds.

MCF info error indicates that the received MCF packet contains errors that violated the HDLC frame structure. The errors could be due to CRC error or invalid control and address fields. The MCF signal may have been degraded by the communication link.

MCF detection time out indicates that the SFE has not received the MCF packet within 10 seconds after sending the EOP packet.

Fax transmittal unsuccessful indicates that the fax message has not been satisfactorily received by the answering fax machine due to errors in the communication link under test. This error information is encoded in the MCF packet.

References

[1] "Procedures for real-time Group 3 facsimile communication over IP networks," *ITU-T Recommendation T.38*, June 1998.

[2] "Standardization of Group 3 facsimile terminals for document transmission," *ITU-T Recommendation T.4*, April, 1999.

[3] "Procedures for document facsimile transmission in the general switched telephone network," *ITU-T Recommendation T.30*, April, 1999.

[4] "4800/2400 bits per second modem standardized for use in the general switched telephone network," *ITU-T Recommendation V2.7 ter*, 1993.

[5] "9600 bits per second modem standardized for use on point-to-point 4-wire leased telephone-type circuits," *ITU-T Recommendation V.29*, 1993.

[6] "A 2-wire modem for facsimile applications with rates up to 14400 bit/s," *ITU-T Recommendation V.17*, 1991.

[7] "A modem operating at data signalling rates of up to 33600 bits/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone-type circuits," *ITU-T Recommendation V. 34*, 1998.

[8] "300 bits per second duplex modem standardized for use in the general switched telephone network," *ITU-T Recommendation V.21*, 1993.