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**Procedures for real-time Group 3 facsimile
communication over IP networks**

ITU-T Recommendation T.38

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION T.38

PROCEDURES FOR REAL-TIME GROUP 3 FACSIMILE COMMUNICATION OVER IP NETWORKS

Summary

This Recommendation describes the technical features necessary to transfer facsimile documents in real-time between two standard Group 3 facsimile terminals over the Internet or other networks using IP protocols. This Recommendation allows the use of either TCP or UDP depending on the service environment.

Source

ITU-T Recommendation T.38 was prepared by ITU-T Study Group 8 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 18th of June 1998.

FOREWORD

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PROCEDURES FOR REAL-TIME GROUP 3 FACSIMILE COMMUNICATION OVER IP NETWORKS

(Geneva, 1998)

1 Scope

This Recommendation defines the procedures to be applied to allow Group 3 facsimile transmission between terminals where in addition to the PSTN or ISDN a portion of the transmission path used between terminals includes an IP network, e.g. the Internet.

2 Normative references

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

- ITU-T Recommendation F.185 (1998), *Internet facsimile: Guidelines for the support of the communication of facsimile documents*.
- ITU-T Recommendation H.323 (1998), *Packet-based multimedia communications systems*.
- ITU-T Recommendation T.4 (1996), *Standardization of Group 3 facsimile terminals for document transmission*.
- CCITT Recommendation T.6 (1988), *Facsimile coding schemes and coding control functions for Group 4 facsimile apparatus*.
- ITU-T Recommendation T.30 (1996), *Procedures for document facsimile transmission in the general switched telephone network*.
- ITU-T Recommendation X.680 (1997), *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*.
- ITU-T Recommendation X.691 (1997), *Information technology – ASN.1 encoding rules – Specification of Packet Encoding Rules (PER)*.
- RFC 768, *User Datagram Protocol*.
- RFC 791, *Internet Protocol*.
- RFC 793, *Transmission Control Protocol*.

3 Definitions

Unless otherwise noted, the definitions in Recommendation F.185 shall apply. This Recommendation defines the following terms:

3.1 emitting gateway: The IFP peer which initiates IFT service for a calling G3FE. It initiates a TCP or UDP connection to a receiving gateway to begin an IFT session.

3.2 receiving gateway: The IFP peer which accepts a TCP or UDP connection from an emitting gateway, providing IFT service to a called G3FE.

3.3 G3 facsimile equipment (G3FE): In this Recommendation, G3FE refers to any entity which presents a communications interface conforming to Recommendation T.30, T.4, and, optionally, T.6. A G3FE may be a traditional G3 facsimile machine, an application with a T.30 protocol engine, or any of the other possibilities mentioned in the network model for IP Facsimile.

4 Abbreviations

This Recommendation uses the following abbreviations:

ECM	Error Correction Mode
IAF	Internet Aware Fax device
IFP	Internet Facsimile Protocol
IFT	Internet Facsimile Transfer
IP	Internet Protocol
LSB	Least Significant Bit
MSB	Most Significant Bit
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UDPTL	Facsimile UDP Transport Layer protocol
SUB	Sub-address

5 Introduction

The availability of IP networks such as the Internet for international communication provides the potential for utilizing this transmission medium in the transfer of Group 3 facsimile messages between terminals. Since the characteristics of IP networks differ from those provided by the PSTN or ISDN, some additional provisions need to be standardized to maintain successful facsimile operation.

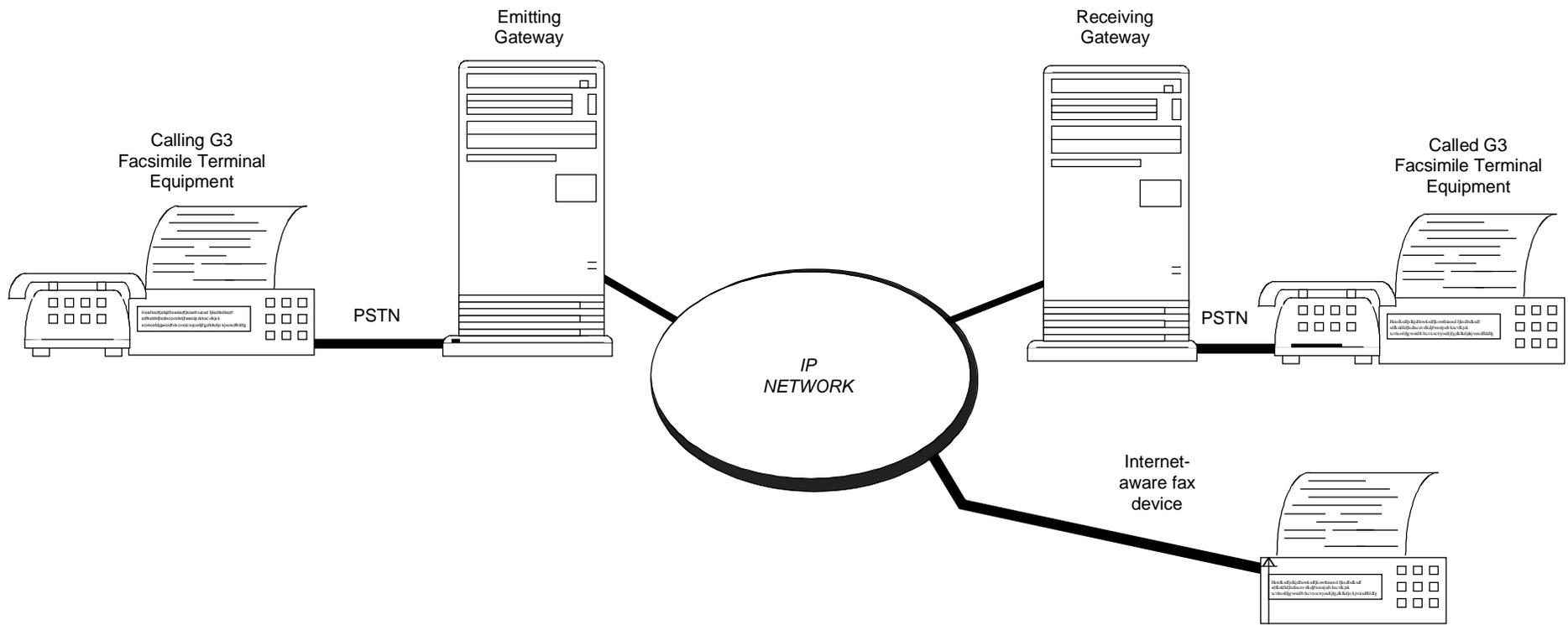
The protocol defined in this Recommendation specifies the messages and data exchanged between facsimile gateways and/or IAFs connected via an IP network. The reference model for this Recommendation is shown in Figure 1.

This model shows a traditional Group 3 facsimile terminal connected to a gateway emitting a facsimile through an IP network to a receiving gateway which makes a PSTN call to the called Group 3 facsimile equipment. Once the PSTN calls are established on both ends, the two Group 3 terminals are virtually linked. All standard T.30 session establishment and capabilities negotiation is carried out between the terminals. TCF is either generated locally or it is transferred between the terminals, depending on the mode of operation to synchronize modulation rates between the gateways and G3FEs.

An alternate scenario would be a connection to a facsimile-enabled device (for example, a PC) which is directly connected to an IP network. In this case, there is a virtual receiving gateway as part of the device's facsimile-enabling software and/or hardware. In other environments, the roles could be reversed, or there might be two facsimile-enabled network devices. The protocol defined by this Recommendation operates directly between the emitting and receiving gateways. Communication between the gateways and facsimile terminals and/or other devices is outside the scope of this Recommendation.

The protocol defined in this Recommendation was chosen on the basis of efficiency and economy. For optimum performance, the IP transmission paths should have reasonably low delays to meet the F.185 requirements. Good image quality is provided by error control in the network in addition to the means provided by the Recommendation T.30 protocol.

Reliable data transport is provided in two ways: by using TCP over IP networks, or by using UDP over IP networks with optional means for error control. H.323 systems may utilize either method as described in Annex D/H.323. The H.323 environment is being used to support voice transmission over IP as an alternative to the PSTN. Since facsimile generally uses the same facilities as voice communications, it may be desirable to utilize the H.323 environment when implementing facsimile over IP.



T0827880-98/d01

Figure 1/T.38 – Model for facsimile transmission over IP networks

Under some circumstances it may be necessary to make some adjustments to the procedures between the gateway and the Group 3 terminal. Any such adjustments should not go beyond those available in the T.30 protocol. These adjustments are implementation-dependent.

The protocol defined in this Recommendation focuses on the interval where a network connection has been established between two peers (gateway or IAF) implementing the Real-Time Facsimile document transfer over Internet Protocol.

Management issues, such as directory services (converting PSTN numbers to IP addresses when required), network hunting, user authentication and CDR (Call Detail Record) collection and network management (SNMP or others) are important but are not addressed in this Recommendation. Standardization of these issues will allow the implementation of a network based on third party management devices, including sharing such devices with other Internet gateways such as Internet telephony and video, remote access and e-mail.

In addition, user interface aspects, such as the way that the facsimile operator selects the PSTN number of the destination or identifies himself to the system (for security purposes) are also not in the scope of this Recommendation. However, it is reasonable to assume that the facsimile operator uses the Group 3 terminal equipment keypad (using DTMF signals) or the IAF keyboard to provide the gateway with the required information.

Some of these issues mentioned here are being addressed in other ITU-T Recommendations. Specifically, Recommendations H.323/H.225 and the Gatekeeper Recommendations address some of the above-mentioned dependencies.

It is intended that all procedures in this Recommendation conform to the requirements of Recommendation F.185.

The main body of this Recommendation describes the protocol and communication procedures between the emitting gateway and the receiving gateway. Communication between the gateways and the calling and called G3FEs as well as call control procedures are described in Annex B.

6 Communication between gateways

6.1 Internet protocol – TCP or UDP

The public Internet service provides two principal modes of data transmission:

- TCP (Transmission Control Protocol) – A session-based, confirmed delivery service;
- UDP (User Datagram Protocol) – Datagram service, non-confirmed delivery.

This Recommendation allows the use of either TCP or UDP depending on the service environment. It defines a layered protocol such that the T.38 messages exchanged for TCP and UDP implementations are identical.

6.2 Gateway facsimile data transfer functions

The emitting gateway shall demodulate the T.30 transmission received from the calling terminal. The T.30 facsimile control and image data shall be transferred in an octet stream structure using the IFP packets, over a transport protocol (TCP or UDP). The following signals are not transferred between gateways but are generated or handled locally between the gateway and the G3FE: CNG, CED, and in one mode, TCF. The gateways may indicate the detection of the tonal signals CNG and CED so that the other gateway can generate them.

The receiving gateway shall decode the transferred information and establish communication with the called facsimile terminal using normal T.30 procedures. The receiving gateway shall forward all relevant responses from the called terminal to the emitting gateway.

The facsimile data transfer structure is described in 7.1.3. The flow between gateways is described in clause 8.

6.2.1 Treatment of non-standard facilities requests

The emitting gateway may optionally ignore NSF, NCS and NSS, take appropriate action or pass the information to the receiving gateway. The receiving gateway may optionally ignore NSF, NCS and NSS or take appropriate action including passing the information to the receiving G3FE. Information in other frames related directly to these frames may be altered by the gateway.

7 IFT protocol definition and procedures

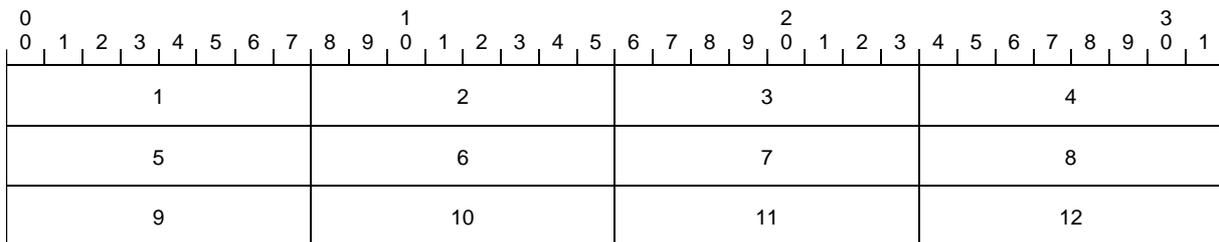
7.1 General

This clause contains the textual description of the IFT protocol. The IFT protocol is specified by the ASN.1 description in Annex A. In the case of a conflict between the ASN.1 and the text, the ASN.1 governs. The ASN.1 encoding in Annex A should employ the BASIC-ALIGNED version of Packed Encoding Rules (PER) according to Recommendation X.691.

7.1.1 Bit and octet transmission order

Transmission order is as defined in Internet RFC 791 "Internet Protocol", quoted herein as reference:

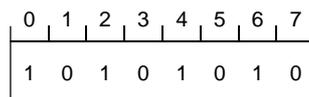
- The order of transmission of the header and data described in this document is resolved to the octet level. Whenever a diagram shows a group of octets, the order of transmission of those octets is the normal order in which they are read in English. For example, in the following diagram the octets are transmitted in the order they are numbered.



T0828400-98/d02

Figure 2/T.38 – Transmission order of octets (based on RFC 791, Figure 10)

- Whenever an octet represents a numeric quantity the left most bit in the diagram is the high order or most significant bit. This is, the bit labelled 0 is the most significant bit. For example, the following diagram represents the value 170 (decimal).



T0828410-98/d03

Figure 3/T.38 – Significance of bit (based on RFC 791, Figure 11)

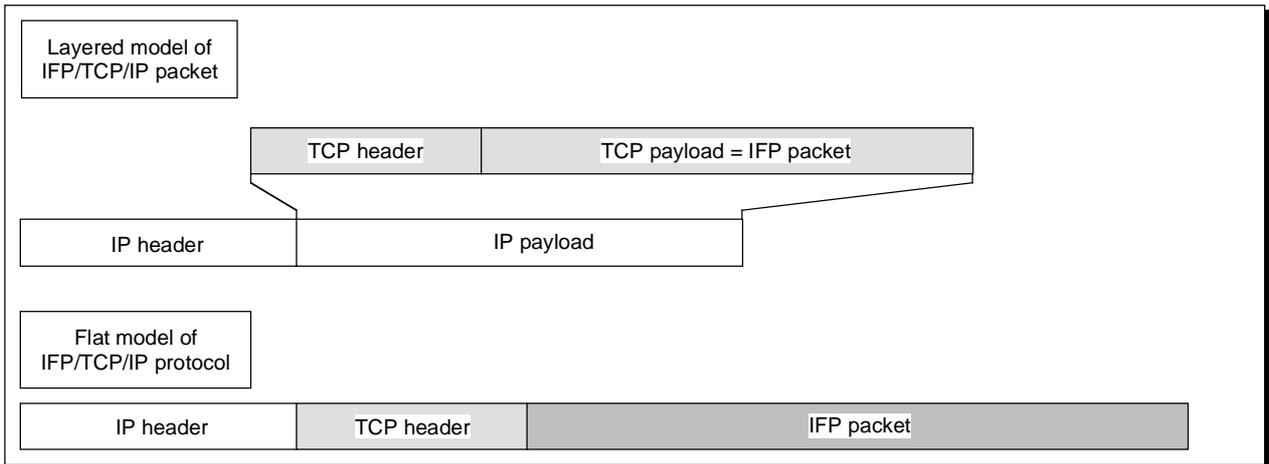
- Similarly, whenever a multi-octet field represents a numeric quantity the left most bit of the whole field is the most significant bit. When a multi-octet quantity is transmitted the most significant octet is transmitted first.

7.1.2 Mapping of the T.30 bit stream

The T.30 bit stream is mapped so that *bit* order is maintained between the PSTN and IP networks. This means that the first bit transmitted is stored in the MSB of the first octet, where the MSB is defined as in 7.1.1.

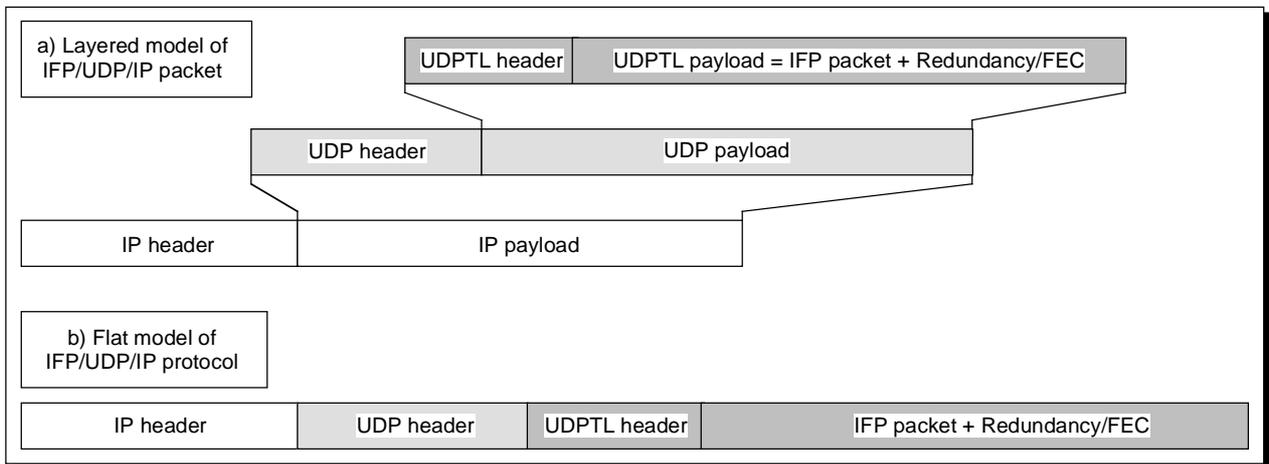
7.1.3 IFP Packet Layers for TCP/IP and UDP/IP

The IFP packets described in 7.2 are combined with the appropriate headers for TCP/IP and UDP/IP as shown in Figures 4 and 5. In Figure 4, the UDPTL header represents the additional header information required for error control over UDP.



T0827890-98/d04

Figure 4/T.38 – High-level IFP/TCP packet structure



T0827900-98/d05

Figure 5/T.38 – High-level UDPTL/IP packet structure

7.2 IFP packet format

In the following discussion, a message is the protocol or data information transferred in one direction from a G3FE to or from a gateway during a single period. It may include, for example, one or more HDLC frames, or a "page" of Phase C data. Messages may be sent across the IP network in multiple packets. The packets may, for example, contain partial or full, singular or multiple HDLC frames. Support for multiple packets is provided in this protocol. The DATA element uses Fields to support partial and full HDLC frames.

IFP operates (listens) over TCP/IP or UDP/IP using a port determined during call setup. All communication between IFP Peers is done using packets, identified as IFPPackets.

Table 1 summarizes the IFPPackets (for full explanation, refer to the following subclauses).

Table 1/T.38 – IFP packet elements

Field	Description
TYPE	Type of message
DATA	Dependent on TYPE

7.2.1 T.38 packet

The T.38 packet element provides an alert for the start of a message. It is used by the IFP peer to verify message alignment. It is identified by an ASN.1 Application tag. When data is read by the peer from its TCP/IP or UDP/IP stack, and the expected tag is not present, the session should be immediately aborted by the receiver.

7.2.2 TYPE

The TYPE element describes the function of, and optionally, the data of the packet. The legitimate TYPEs are given in Table 2. Each TYPE is separately explained in the following subclauses. The table also indicates whether the TYPEs are Mandatory or Optional for implementations using TCP and UDP.

If the TYPE element is not recognized, it and the related data element shall be ignored.

Table 2/T.38 – IFP packet TYPE field

Type	DATA Type	Mandatory/ Optional (TCP)	Mandatory/ Optional (UDP)	Description
T30_INDICATOR	Regular	O	M	Carries indication about the presence of a facsimile signal (CED/CNG), preamble flags or modulation indications
T30_DATA	Field	M	M	T.30 HDLC Control and Phase C data (e.g. T.4/ T.6 image segment.)

7.2.3 DATA-Field

The DATA-Field element contains the T.30 HDLC control data and the Phase C image (or BFT) data. The structure of the DATA-Field is defined in 7.4. The structure carries the modulation data as well as indicators for the end of an HDLC frame, the status of the Frame Check Sequence (FCS) for an HDLC frame, and whether the data represents the end of a message.

7.3 TYPE definitions

The following subclauses describe the message TYPEs.

7.3.1 T30_INDICATOR

The T30_INDICATOR TYPE is used by the gateways to indicate the detection of signals such as CED, HDLC preamble flags, and modem modulation training. It is sent by the receiving gateway to the emitting gateway, and by the emitting gateway to the receiving gateway. The use of this message is optional for TCP implementations and mandatory for UDP implementations. A peer may send this message in order to notify its peer about upcoming messages. The T30_INDICATOR TYPE has one of the following values.

Table 3/T.38 – Listing of T30_INDICATOR values

Signal/Indication
No signal
CNG (1100 Hz)
CED (2100 Hz)
V.21 Preamble Flags
V.27 2400 modulation training
V.27 4800 modulation training
V.29 7200 modulation training
V.29 9600 modulation training
V.17 7200 modulation short training
V.17 7200 modulation long training
V.17 9600 modulation short training
V.17 9600 modulation long training
V.17 12 000 modulation short training
V.17 12 000 modulation long training
V.17 14 400 modulation short training
V.17 14 400 modulation long training

NOTE – It is the responsibility of the gateway receiving the indicator to properly generate the appropriate analogue signal, including, for example, the ON-OFF cadence, and to terminate it appropriately.

7.3.2 T30_DATA TYPE

The T30_DATA TYPE is used to indicate that the packet contains data in the DATA element and what modulation was used to carry the data. The T30_DATA TYPE is used to indicate both HDLC control data as well as any Phase C data (T.4/T.6 or other). It has the following values:

Table 4/T.38 – Listing of T30_DATA values

Modulation
V.21 Channel 2
V.27 <i>ter</i> 2400
V.27 <i>ter</i> 4800
V.29 7200
V.29 9600
V.17 7200
V.17 9600
V.17 12 000
V.17 14 400

7.4 The IFP DATA element

The DATA Element of the IFP packets contains the data from the PSTN connections and some indication of the data format. The DATA element is a structure containing one or more Fields. Each Field has two parts: the first part indicates the Field-Type, the second part contains the Field-Data. The meanings for the Field-Type are shown in Table 5.

Table 5/T.38 – Field-Type and Field-Data Description

Field-Type	Field-Type Description
HDLC data	Data transmitted over the PSTN connection as HDLC. This includes the T.30 control messages as well as Phase C data sent using ECM.
	The Field-Data which follows contains some, or all, of a single HDLC data frame starting with the address frame of the HDLC frame, up to up to but not including FCS. Bit stuffing is removed from all data. The end of a frame is indicated by the FCS Indicator field. The gateway is responsible for bit stuffing, FCS generation, and separating frames with one or more flags (0x7E) when sending the HDLC data to a G3FE. The FCS-xx-Sig-End Fields indicate the end of the final frame.
HDLC-Sig-End	Indicates that the HDLC power level has dropped below the turnoff threshold. There is no Field-Data with this Field-Type.
HDLC-FCS-OK	Indicates the end of an HDLC frame and that the proper FCS was received. It also indicates that this frame is not the final frame. There is no Field-Data with this Field-Type.
HDLC-FCS-Bad	Indicates the end of an HDLC frame and that the proper FCS was not received. It also indicates that this frame is not the final frame. There is no Field-Data with this Field-Type.
HDLC-FCS-OK-Sig-End	Indicates the end of an HDLC frame and that the proper FCS was received. It also indicates that this frame is the final frame. There is no Field-Data with this Field-Type.
HDLC-FCS-BAD-Sig-End	Indicates the end of an HDLC frame and that the proper FCS was not received. It also indicates that this frame is the final frame. There is no Field-Data with this Field-Type.
T.4-Non-ECM	T.4 Phase C data that is not sent using ECM or TCF data in the case of Method 2 of Rate Adaptation. It also indicates that this is not the end of the Phase C data.
	The Field-Data which follows is the demodulated Phase C data, including fill bits and RTC.
T.4-Non-ECM-Sig-End	T.4 phase C data that is not sent using ECM or TCF data in the case of Method 2 of Rate Adaptation. It also indicates that this is the end of the Phase C data.
	The Field-Data which follows is the demodulated Phase C data, including fill bits and RTC.

Multiple fields can appear in a single IFP DATA Element. The example below shows two HDLC frames arranged in a single DATA Element.

Field-Type	HDLC-Data	FCS-OK	HDLC-Data	FCS-OK-Sig-End
Field part description	First HDLC frame. The HDLC octets with zero stuffing and FCS removed in the Field-Data.	Indicates end of HDLC frame and more data to follow	Second HDLC frame	Indicates end of HDLC frame and end of HDLC data

NOTE – When the field-type DATA element is received, the receiver should analyze it by examining each field separately. If the receiver does not recognize a certain FIELD-TYPE of the field it is examining, the entire field shall be skipped, and the receiver shall continue with the next field.

The IFP peer may elect to send the message data in several packets. Although relatively large packets may be sent, smaller data packets are recommended. It is entirely up to the emitting gateway to decide on the size of packets being sent. The xx-Sig-End Field-Types indicate the end of the message data. Note that for each packet sent, the whole header is repeated.

A message with zero length data field may be sent to indicate, as early as possible, that T30_DATA messages are coming. Alternately, the appropriate T30_INDICATOR signal for High Speed could be sent. Implementations shall support both methods.

Partial HDLC frames are also supported. The next example shows how two HDLC frames would be transmitted using three consecutive IFP packets. (Data transport headers are not shown.)

TYPE Element	DATA Element								
--------------	--------------	--	--	--	--	--	--	--	--

V.21 Data	Field-Type: HDLC Data	HDLC Address (0xff)	HDLC Control	HDLC Octet 1	HDLC Octet 2	HDLC Octet 3	HDLC Octet 4	HDLC Octet 5	HDLC Octet 6
-----------	-----------------------	---------------------	--------------	--------------	--------------	--------------	--------------	--------------	--------------

V.21 Data	Field-Type: HDLC Data	HDLC Octet 7	HDLC Octet 8	HDLC Octet 9	Field-Type FCS-OK
-----------	-----------------------	--------------	--------------	--------------	-------------------

V.21 Data	Field-Type: HDLC Data	HDLC Address (0xff)	HDLC Control	HDLC Octet 1	Field-Type FCS-OK-Sig-End
-----------	-----------------------	---------------------	--------------	--------------	---------------------------

8 IFP message flow

The gateways follow the T.30 message flow and use the packet format in clause 7 to transmit these messages. This means, for example, that error correction in ECM mode is done between the sending G3FE and the receiving G3FE. The PPS, PPR, etc. signals are sent between the end G3FE devices. In another example, negotiation of security keys, etc. as proscribed in Annex H/T.30 is done between the end G3FE devices. Examples of typical message flows are shown in Appendix I.

There are two methods of handling the TCF signal for determining the high speed data rate. Either of these methods insures that both PSTN facsimile sessions be conducted at the same speed.

8.1 Data rate management method 1

Method 1 of data rate management requires that the TCF training signal be generated locally by the receiving gateway. Data rate management is performed by the emitting gateway based on training results from both PSTN connections.

When a CFR (Confirmation to receive) or an FTT (failure to train) is received from a G3FE at the receiving gateway, a T.30 HDLC packet (indicating CFR or FTT respectively) should be forwarded to the emitting gateway.

According to the result of a TCF received from a G3FE and the T.30 HDLC packet (CFR or FTT) forwarded from a receiving gateway, an emitting gateway transmits FTT or CFR according to Table 6.

Method 1 is used for TCP implementations and is optional for UDP implementations.

Table 6/T.38 – Decision table of signalling rate of an emitting gateway

T.30 signal message forwarded from receiving gateway	TCF signal received from a G3FE at emitting gateway	Signal to be transmitted to G3FE (emitter)
CFR	Success	CFR
FTT	Success	FTT
CFR	Failure	FTT
FTT	Failure	FTT

8.2 Data rate management method 2

Data rate management method 2 requires that the TCF be transferred from the sending G3FE to the receiving G3FE rather than having the receiving gateway generate it locally. Speed selection is done by the G3FEs in the same way as they would on a regular PSTN connection.

Data rate management method 2 is mandatory for use with UDP and is not recommended for use with TCP.

9 IFT over UDP transport: IFT/UDP

9.1 Overview of UDPTL protocol

In the following discussion, a packet is regarded as a block of information which has the overall structure of that presented in 7.1.3.

The layered model in Figure 5 a) may be visualised more simply [Figure 5 b)] in a flat space which allows packets to be regarded as a composite of headers plus the IFP payload. It is the IFP payload which is used to convey facsimile related information between gateways; all other information should be regarded as overhead necessary for the safe transportation and interpretation of IFP messages as described in clause 7. This clause describes the UDPTL payload. Descriptions of the IP and UDP headers and payloads are found in IETF RFCs 791 and 768 respectively.

UDPTL packets comprise a Sequence Number and a variable length, octet aligned, payload.

UDPTL packets are based upon the principle of framing. Each packet may contain one or more IFP packets in its payload section. The first packet in any payload is always formatted in accordance with the specifications of clause 7 and must correspond to the sequence number supplied in the header (for instance, the first field in a payload with sequence number 15 must have been generated 5 payloads later than the first field in the payload with sequence number 10). The IFP packet in a UDPTL payload is referred to as the "primary". Additional fields may be included in a payload after the primary. These fields are referred to as "secondaries" and may or may not be formatted as per clause 7 specifications depending on their form.

9.2 UDPTL header section format

The UDPTL Sequence Number is used to identify the sequencing in a payload.

9.2.1 UDPTL sequence number element

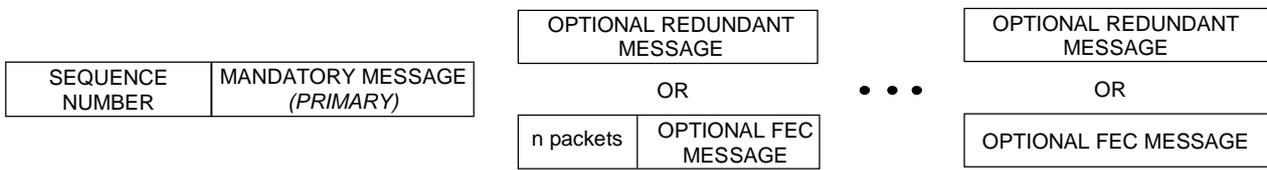
Each packet, and therefore primary field, has its own corresponding unique sequence number which specifies an ordering at the receiving gateway should packets arrive out of sequence. To enable gateways to be synchronized upon receipt of any packet, the first primary field transmitted shall have sequence number zero. Successive primaries shall have linearly increasing (integer adjacent) sequence numbers.

9.3 UDPTL payload section format

During H.323 capabilities exchange, a gateway shall indicate its support of the available error protection schemes, parity FEC, or redundancy. Based on these capabilities, a choice may be made on which scheme is used for error protection. If a capability is indicated to receive both parity error correction frames and redundant frames, then either scheme may be used. If, however, a gateway indicates a capability to receive only redundant error protection frames, then the transmitting gateway may not send parity FEC frames. The support of parity FEC is optional; a gateway providing parity FEC receive services should, however, also be capable of receiving redundant messages.

The IFP payload section comprises one or more fields. The basic format of an UDPTL payload is as shown in Figure 6.

Figure 6 specifies the order in which different messages are to be assembled into the UDPTL payload. It is invalid to transmit both redundant and FEC fields within the same packet.



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Figure 6/T.38 – Basic format of UDPTL Payload Section (UDP header not shown)

9.3.1 UDPTL FEC message format

An FEC contains a parity encoded representation of a number of primaries. The number of primary IPF packets represented by an FEC field is given by the fec-n-packets element of the UDPTLPacket.

9.4 IFP/UDP facsimile data transfer functions

9.4.1 Use of redundancy messages

Each primary contains an IFP Packet. As packets, and therefore primaries, are assigned unique and linearly increasing sequence numbers, receiving gateways can detect packet loss and re-sequencing requirements. By imposing a simple structure it is possible to provide error recovery by means of transmitting redundant information in the form of prior primary packets within each payload. The strategy used is to assemble an additional n prior packets after the primary with monotonically decreasing sequence numbers. Thus, should each payload contain a primary and two or more secondary fields, a loss of two consecutive UDPTL packets will be protected against. In order to provide a redundancy service in the UDPTL, it is necessary to maintain a buffer of "old" primaries for assembly into new packets. An illustration of such a buffer is provided in Figure 7 to demonstrate the principles of redundancy transfer by example.

Note that the UDPTL scheme is capable only of transmitting a block of redundant IFP packets whose sequence numbers are contiguous. Thus, if the current IFP packet has sequence number C and it is desired to redundantly transmit the IFP packet from UDPTL packet sequence number $C-2$, then the UDPTL packet must contain all the IFP packets from C , $C-1$, $C-2$ in the order given.

Gateways need not be capable of transmitting redundant packets. Receiving gateways may ignore them.

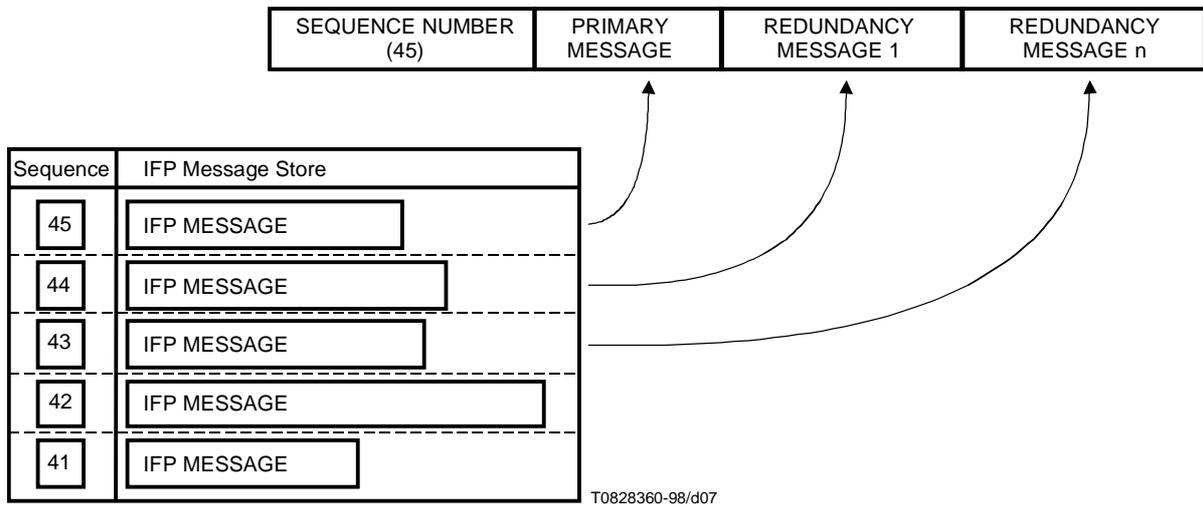


Figure 7/T.38 – Including prior (secondary) IFP packets (fields) into an UDPTL packet

Annex A

ASN.1 notation

A.1 ASN.1 notation

T38 DEFINITIONS AUTOMATIC TAGS ::= BEGIN

```
IFPPacket ::= SEQUENCE
{
    type-of-msg      Type-of-msg,
    data-field       Data-Field OPTIONAL
}
```

```
Type-of-msg ::= CHOICE
{
    t30-indicator ENUMERATED
    {
        no-signal,
        cng,
        ced,
        v21-preamble,
        v27-2400-training,
        v27-4800-training,
        v29-7200-training,
        v29-9600-training,
        v17-7200-short-training,
        v17-7200-long-training,
        v17-9600-short-training,
        v17-9600-long-training,
        v17-12000-short-training,
        v17-12000-long-training,
        v17-14400-short-training,
        v17-14400-long-training,
        ...
    }
}
```

```

data ENUMERATED
{
    v21,
    v27-2400,
    v27-4800,
    v29-7200,
    v29-9600,
    v17-7200,
    v17-9600,
    v17-12000,
    v17-14400,
    ...
}
}

Data-Field ::= SEQUENCE OF SEQUENCE
{
    field-type ENUMERATED
    {
        hdlc-data,
        hdlc-sig-end,
        hdlc-fcs-OK,
        hdlc-fcs-BAD,
        hdlc-fcs-OK-sig-end,
        hdlc-fcs-BAD-sig-end,
        t4-non-ecm-data,
        t4-non-ecm-sig-end
    },
    field-data OCTET STRING (SIZE(1..65535)) OPTIONAL
}

UDPTLPacket ::= SEQUENCE
{
    seq-number          INTEGER (0..65535),
    primary-ifp-packet TYPE-IDENTIFIER.&Type(IFPPacket),
    error-recovery CHOICE
    {
        secondary-ifp-packets SEQUENCE OF TYPE-IDENTIFIER.&Type(IFPPacket),
        fec-info              SEQUENCE
        {
            fec-npackets    INTEGER,
            fec-data        SEQUENCE OF OCTET STRING
        }
    }
}
END

```

Annex B

Call establishment procedures

B.1 Communication between facsimile terminal and gateway

Communication between a sending Group 3 facsimile terminal and the incoming gateway is generally effected using dialup procedures over the PSTN. Basic and optional T.30 procedures are supported. The support for V.34 is for further study.

The gateway may receive the facsimile transmission from the calling terminal as a modem signal on the PSTN if the gateway supports a direct-dial-in procedure. Where the gateway is located within the network it may receive the transmission in the form of a PCM encoded digital channel.

B.2 Transfer of addressing information

B.2.1 From calling terminal to gateway

The conveyance of the Recommendation E.164 address of the called terminal from the calling terminal to the emitting gateway may be by manual procedures using prompts; by means of double dialing; or by any other suitable means.

B.2.2 Communication between gateways

For further study.

Annex C

The optional forward error correction scheme for UDP

C.1 Overview of the optional forward error correction mechanism

The parity FEC scheme is symmetrical in that it is identical in both encode and decode modes, and may be computed for an arbitrary number of arbitrarily sized IFP messages. A transmitting gateway generates FEC messages by passing in a number of primaries; these FEC messages may then be assembled into a packet in accordance with Figure 5.

Receiving gateways which detect the loss of a primary that is covered by an FEC message may be able to reconstruct it by passing in the remaining (received) primaries and the FEC message itself to the parity encode/decode algorithm. Certain conditions apply in order for a lost primary to be recovered using the parity encoder/decoder; these shall be discussed in the following passages.

C.1.1 Parity encode/decode scheme operation and characteristics

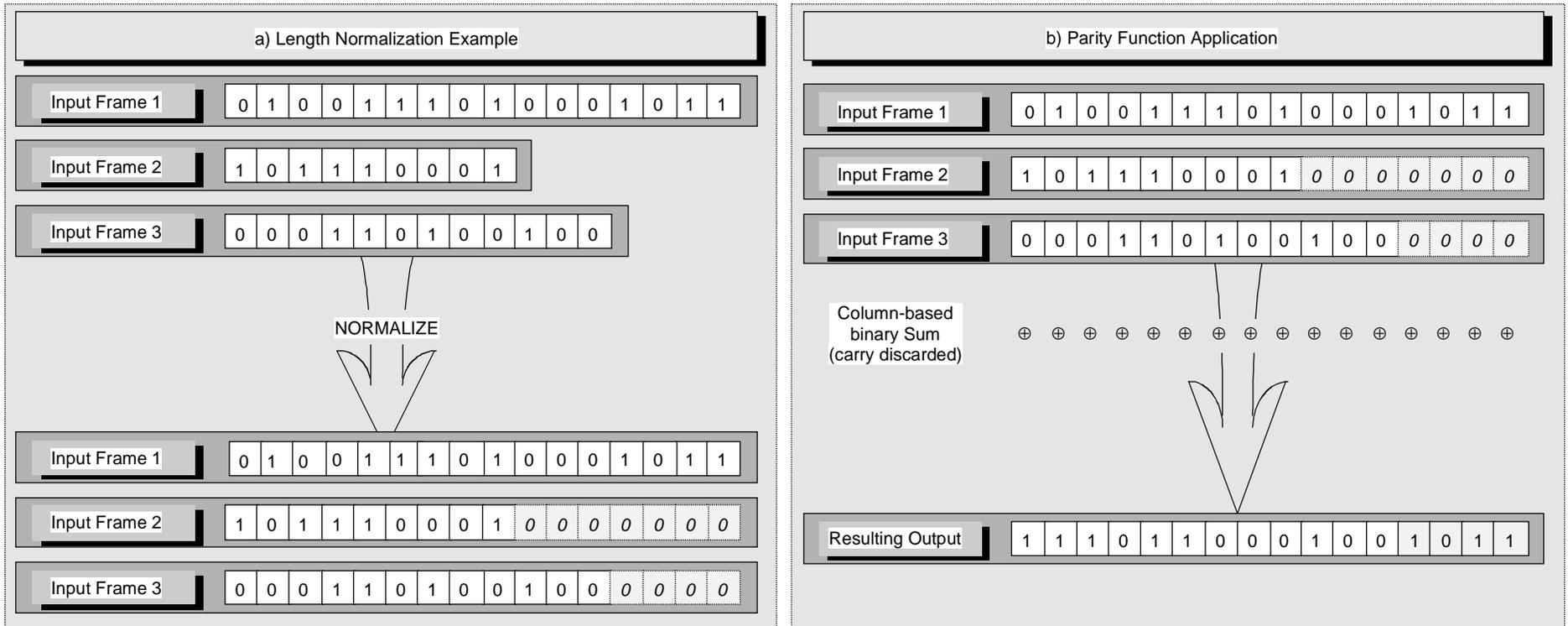
In essence, the parity scheme accepts a number of arbitrarily sized IFP messages. It aligns them vertically and zero pads the shorter length messages to produce a 2D matrix as shown in Figure C.1 a). A one-bit piece-wise sum is then performed on a column by column basis (equivalent to exclusive OR logic function) across the width of the matrix, each summation resulting in a binary digit. This process is illustrated in Figure C.1 b). The output from the parity scheme is the row of resulting binary data.

The basic error recovery scheme works by assuming that 1 loss in n packets may occur. If in the $(n + 1)^{\text{th}}$ packet we place an FEC message generated from the primaries of the n preceding packets, then provided no more than one of the first n packets is lost, we can reconstruct any missing IFP message. The generation and reconstruction of primaries using the parity scheme outlined above is described in the following subclauses.

C.1.2 Generating and transmitting FEC messages

By utilizing a buffer similar to that shown in Figure 7, it is possible to pass multiple prior primaries into the parity FEC algorithm for processing. The FEC scheme returns with a frame of encoded data which may then be assembled into a packet after the current primary. This technique is illustrated in Figure C.2.

The transmitting gateway must decide in advance the number of prior IFP messages it shall use to generate the FEC information: this number, n , is inserted into the message control field of the CONTROL Element in the UDPTL header. The FEC bit in the message content field must also be set and the most recently generated primary placed immediately after the completed UDPTL header. The n prior primaries are then sent to the parity encoding scheme which results in a single message of FEC data of length l octets where l is the largest message length value encountered in the list of primaries plus 2 octets. Finally, the newly generated FEC message is assembled as in Figure C.2 and inserted into the packet after the primary.



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Figure C.1/T.38 – Illustration of a) Length Normalization and, b) Parity Function Operation

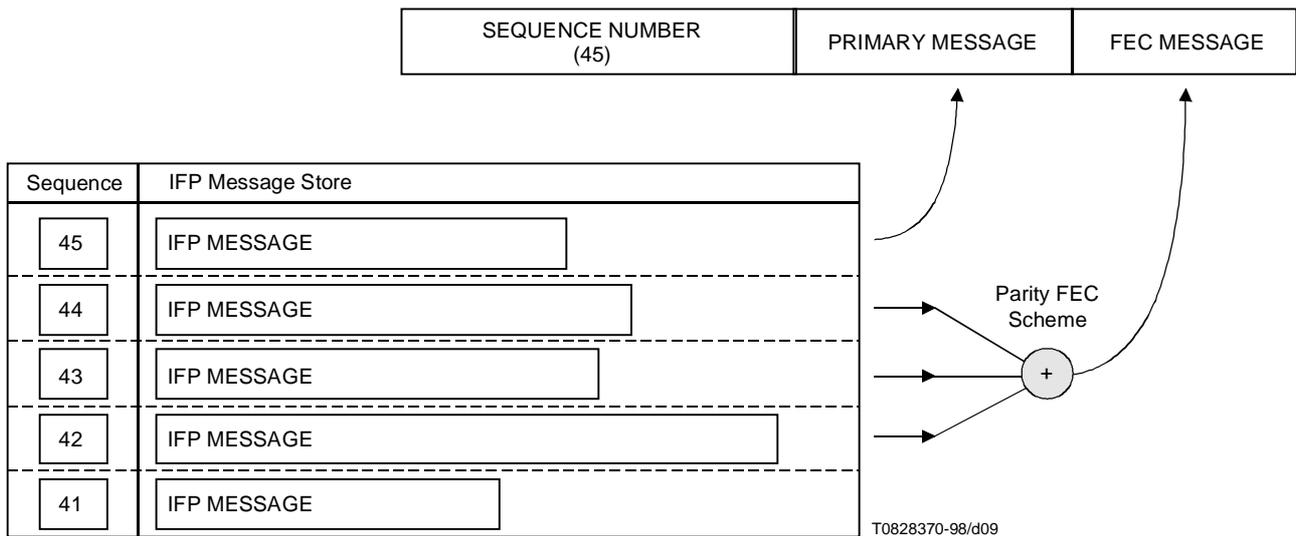


Figure C.2/T.38 – Generation and packetization of a single parity FEC frame

Multiple FEC messages may be sent in a single packet, each having been generated from n prior primary messages where n is the numerical value contained in the message control field of the CONTROL Element in the UDPTL header. Unlike the instance where only one FEC message is present, when multiple FEC messages are transmitted in a single packet, the contributing primaries for each FEC message are not consecutive, but are interleaved. This is illustrated in Figure C.3 which demonstrates protection against a burst of three consecutive packet losses.

C.1.3 Receiving FEC messages and primary reconstruction

A gateway in receipt of FEC messages in a packet must firstly determine from the UDPTL header:

- the number of FEC messages present in the packet. This is simply the value in the NumMsg Element -1;
- the sequence numbers of the primaries contained in each FEC message;
- the sequence numbers of any packets which have been "lost" over the network.

In order to determine the sequence numbers of the primaries encoded in a given FEC message, the receiving gateway must firstly extract the number of primaries covered by that frame. This figure is extracted from the message control field of the CONTROL Element in the UDPTL header. For a packet containing a single FEC message, the sequence numbers covered by that message are simply those from $[Seq - 1]$ to $[Seq - (n + 1)]$ where n is the value in the message control field and Seq is the value in the SEQUENCE NUMBER Element. For a packet containing m FEC messages with sequence number Seq and a message control field setting of n , the sequence number ranges for FEC message I (for $1 \leq I \leq m$) are trivially extracted from the following equations:

$$\text{StartSeq} = Seq - I$$

$$\text{EndSeq} = Seq - I - (m - 1)n$$

Intermediate sequence numbers between these ranges are linearly spaced with gap m . Once the sequence numbers of the primaries encoded in an FEC message have been determined, the receiving gateway may check to determine whether any of the primaries listed has failed to arrive. If one, and only one, of these primaries has failed to arrive, then the FEC message and the remaining (delivered) primaries may be sent to the parity algorithm to recover the missing sequence.

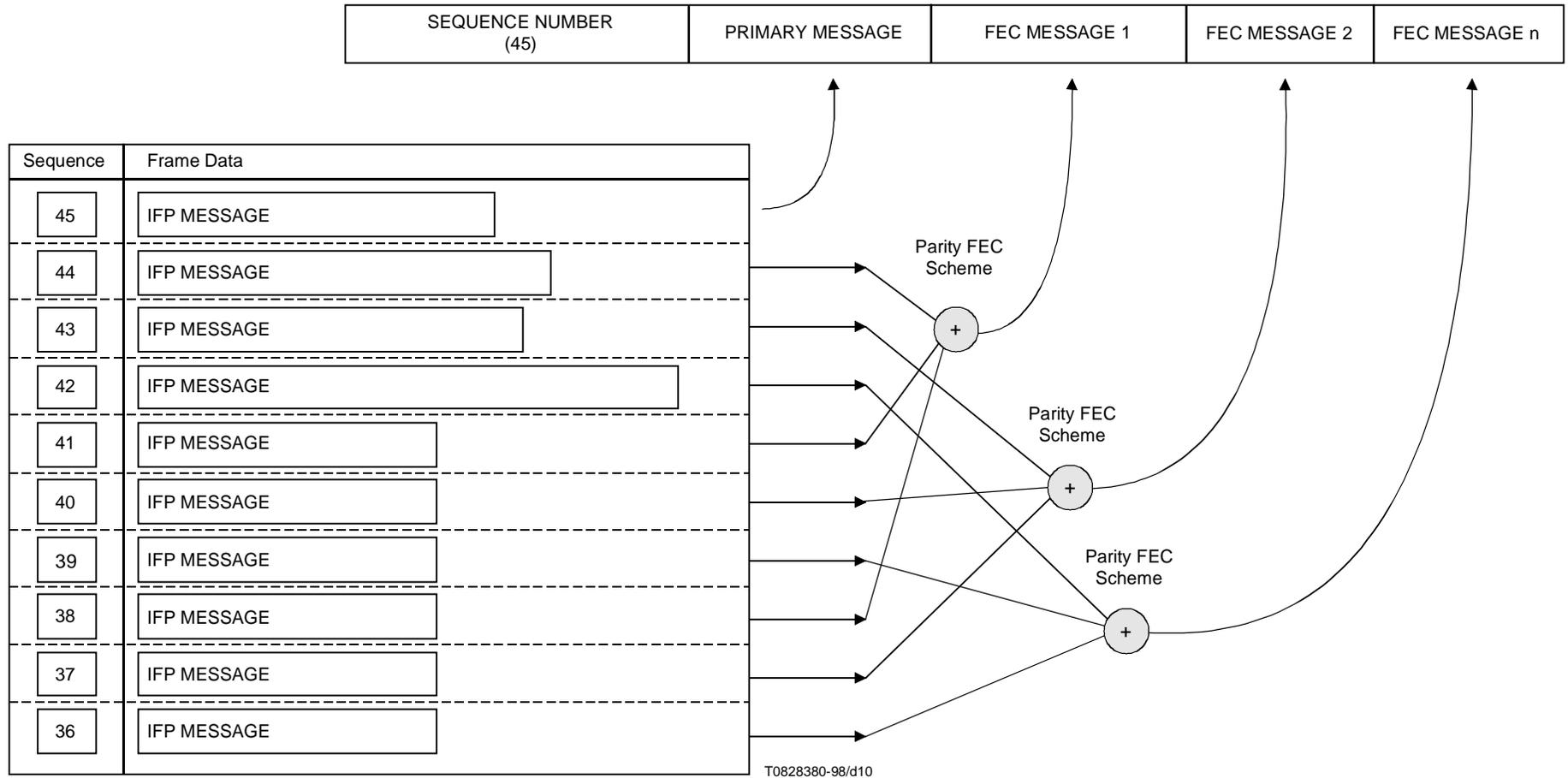


Figure C.3/T.38 – Generating multiple FEC messages to protects against burst errors

Appendix I

Session examples

I.1 Session examples

This subclause contains a number of examples to show how the sending and receiving G3FEs communicate with the gateways and what packets the gateways exchange. All examples show an TCP implementation using Method 1 Rate Adaptation.

Time proceeds downward. Information flows on the solid lines in the direction of the arrows. The box superimposed on each line indicates what information is being transmitted. All information between the G3FE and a gateway is T.30/T.4/T.6-conforming information. Information transmitted between the gateways is in the form of packets as described in this Recommendation. The contents of the labelling box on a packet transmission indicates the packet type, followed by any additional information which is carried in the packet's payload.

Dashed lines are used to clarify the point in time at which a piece of information begins transmission (for example, T30_INDICATOR: Flags packets are sent when flags are noticed, not necessarily when the flags begin or end transmission). Dashed lines do not indicate any type of information flow.

Packet labels indicate the type of packet as well as any field information, for field-type packets. For example, a label such as "V.21:HDLC:TSI/FCS" indicates a V.21 HDLC (T.30 Control) packet with a field containing TSI information and a field indicating FCS. Due to space constraints, the FCS is generalized to include FCS and FCS-Sig-End.

I.1.1 Two traditional facsimile devices communicating using ECM

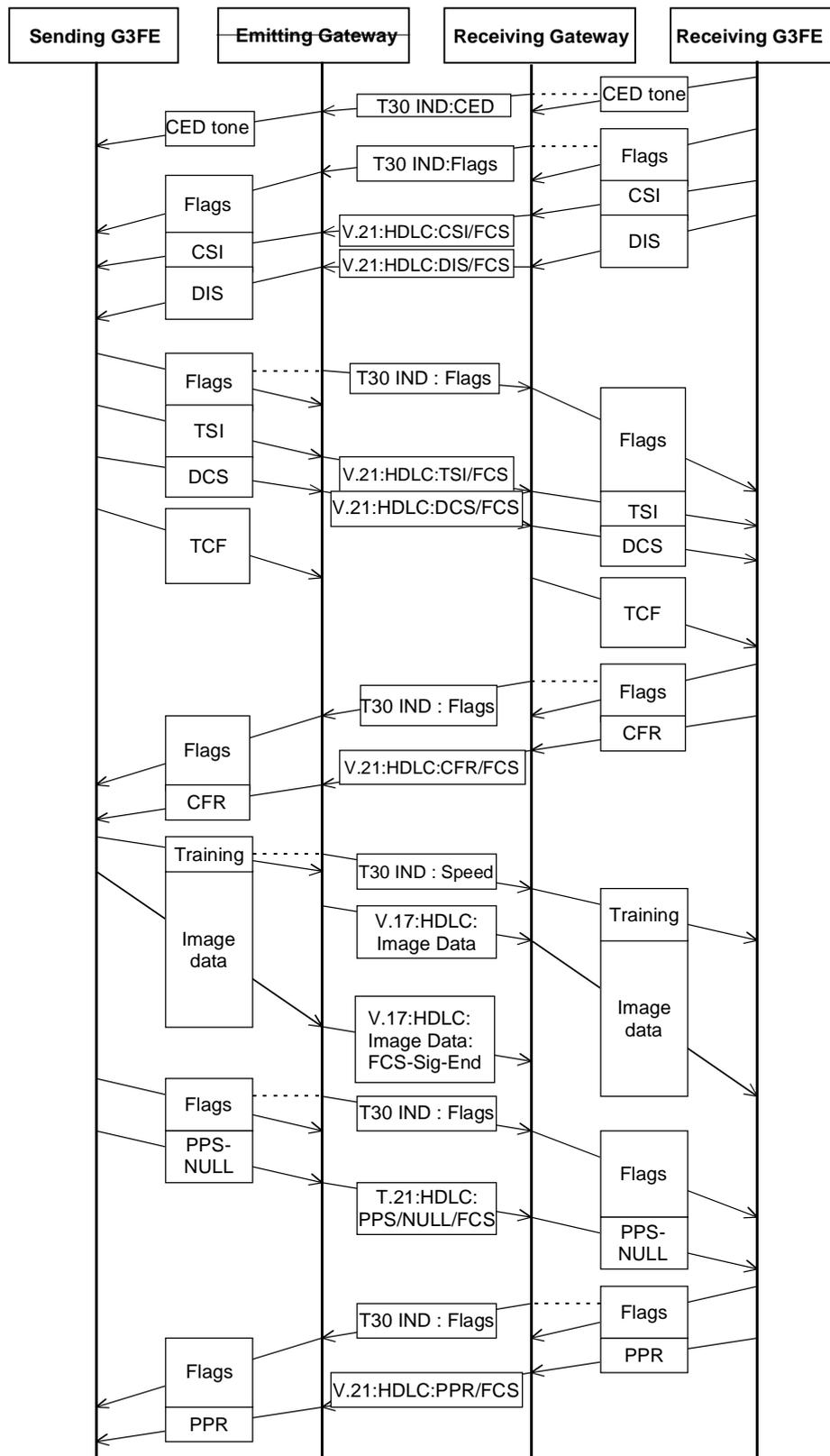
Figure I.1 shows two traditional Group 3 facsimile devices which use the PSTN for communicating with facsimile gateways. ECM is used for image transfer. The example begins after the transport connection/session has been established and the Receiving G3FE has answered a call from the Receiving Gateway and is about to generate CED.

I.1.2 Traditional facsimile device and Internet-aware facsimile device

Figure I.2 shows a traditional Group 3 facsimile device sending to an Internet-aware facsimile device without using ECM. The example begins after the transport connection/session has been established and the Receiving is about to generate CED.

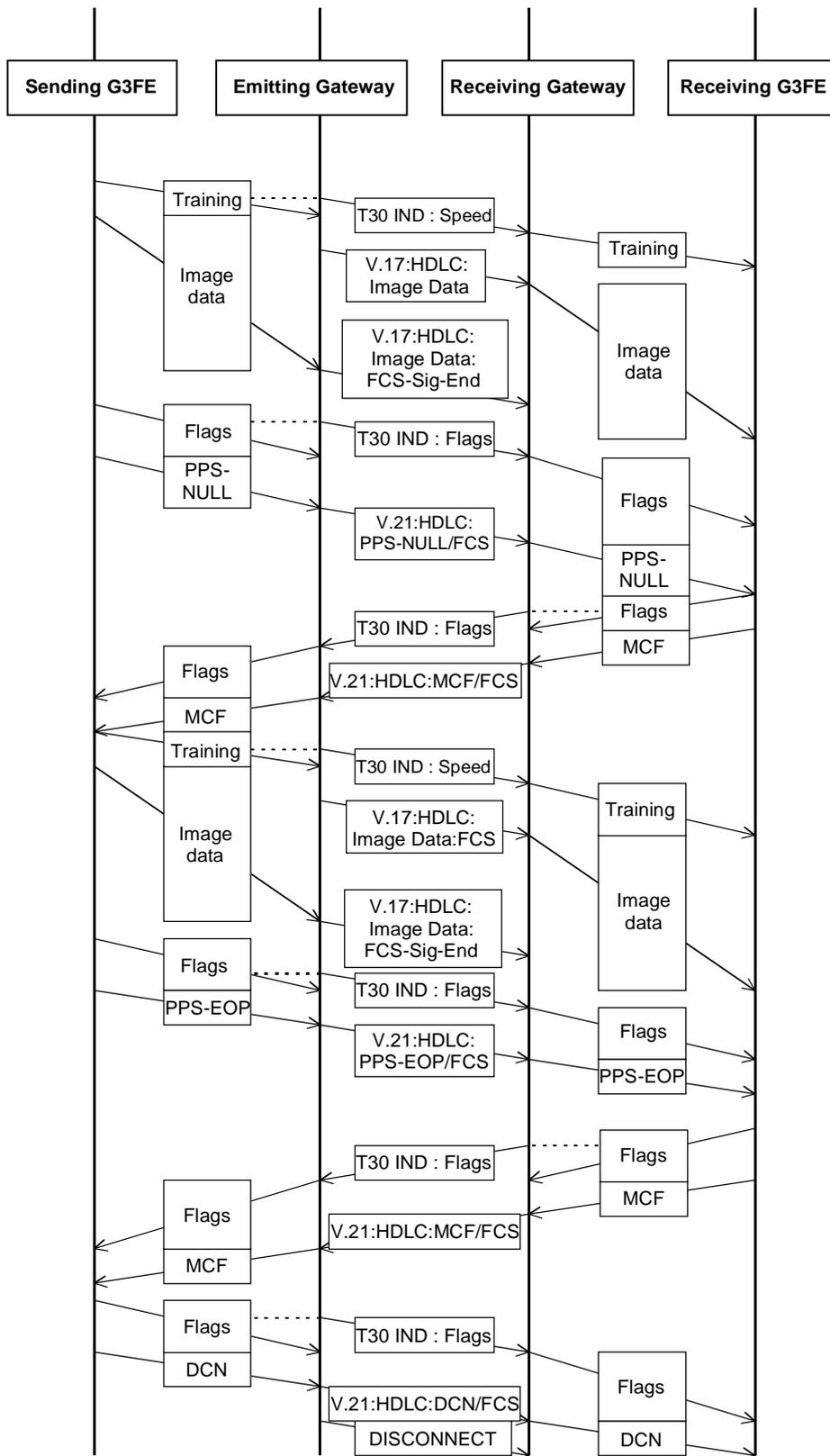
I.1.3 Two traditional facsimile devices using frequent frames

Figure I.3 shows two traditional Group 3 facsimile devices which use the PSTN for communicating with facsimile gateways. It is similar to the scenario described in I.1.1 except that the image transfer does not use ECM and the receiving gateway does not wait for complete HDLC BCS sequences before beginning to send frames.



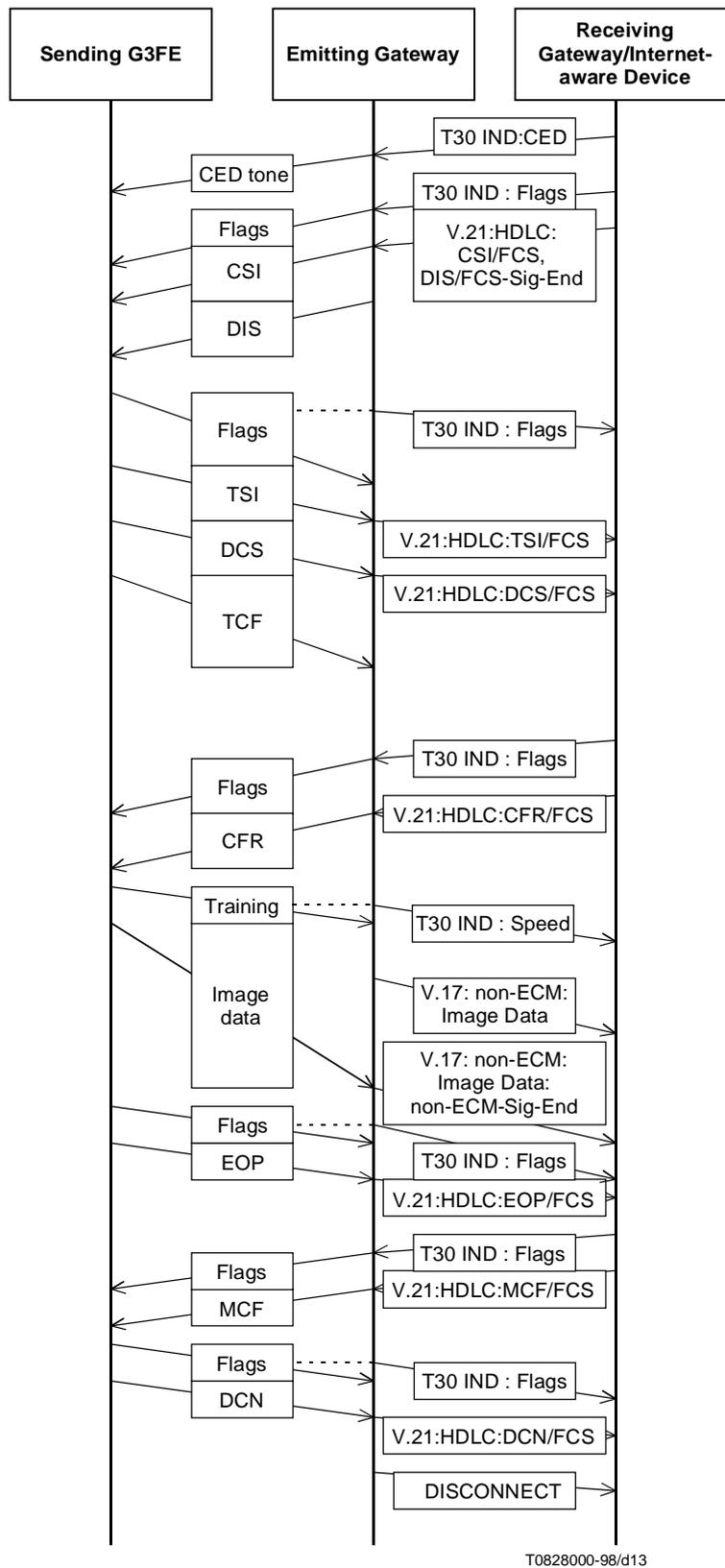
T0827980-98/d11

Figure I.1/T.38 (Sheet 1 of 2) – Two Group 3 facsimile devices communicating through gateways



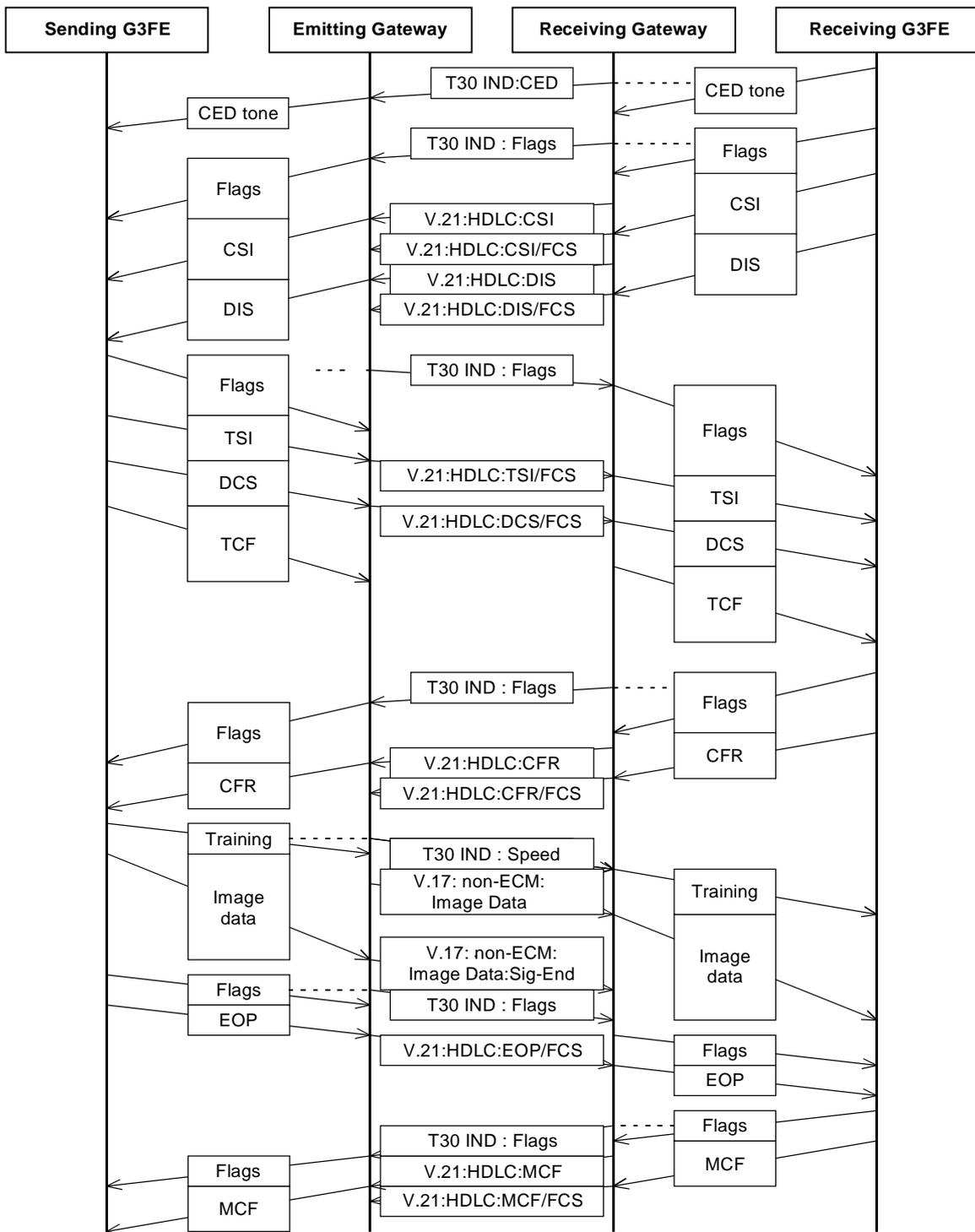
T0827990-98/d12

Figure I.1/T.38 (Sheet 2 of 2) – Two Group 3 facsimile devices communicating through gateways



T0828000-98/d13

Figure I.2/T.38 – Traditional facsimile device and internet-aware device



T0828010-98/d14

Figure I.3/T38 – Use of multiple frames per BCS sequence

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