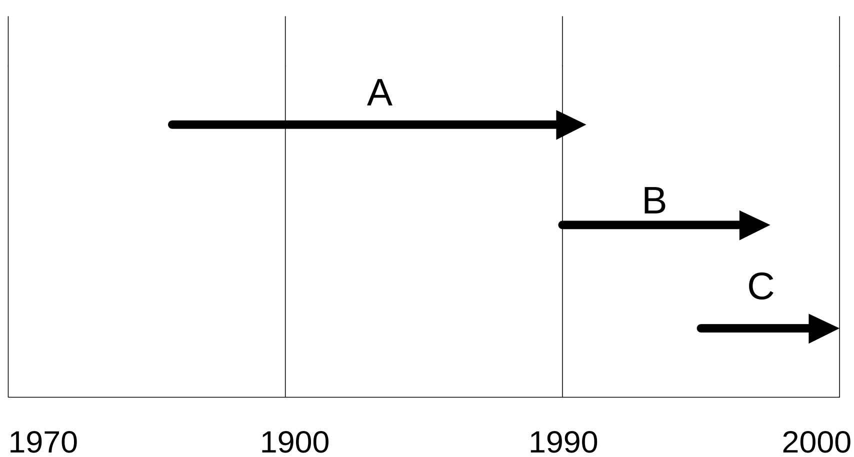
13. Frame Relay

Contents

a. Operation

Evolution of packet-switching technologies



A : Conmutación de paquetes X.25 B : Frame Relay C : ATM

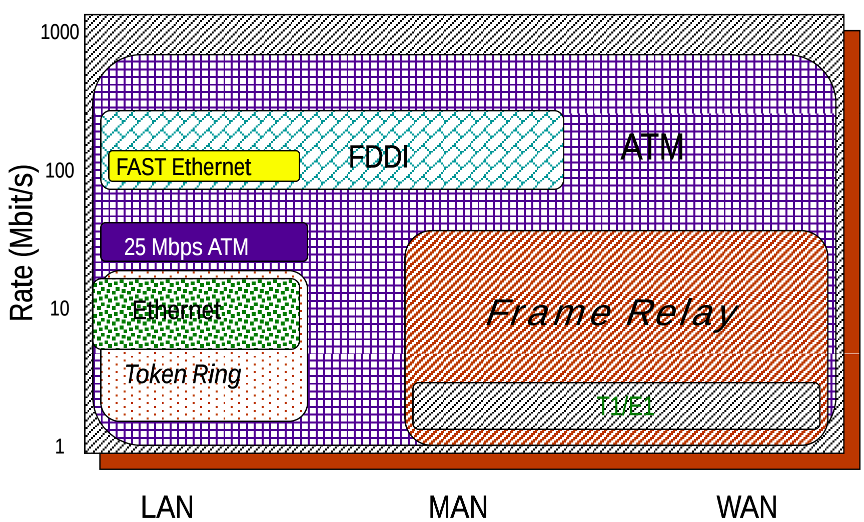
FRAME RELAY is a packet-switching technology

It is based on ITU-T standards:

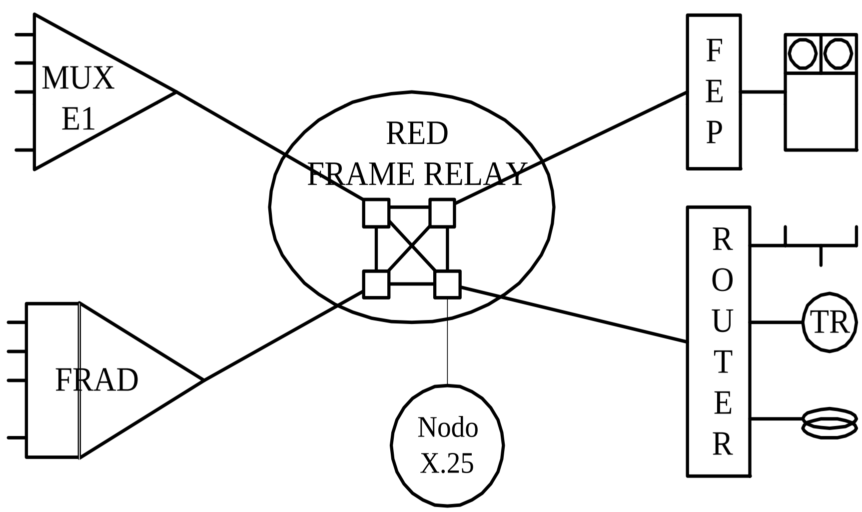
Q.922 and

Q.933

Application of the various technologies based on speed and size

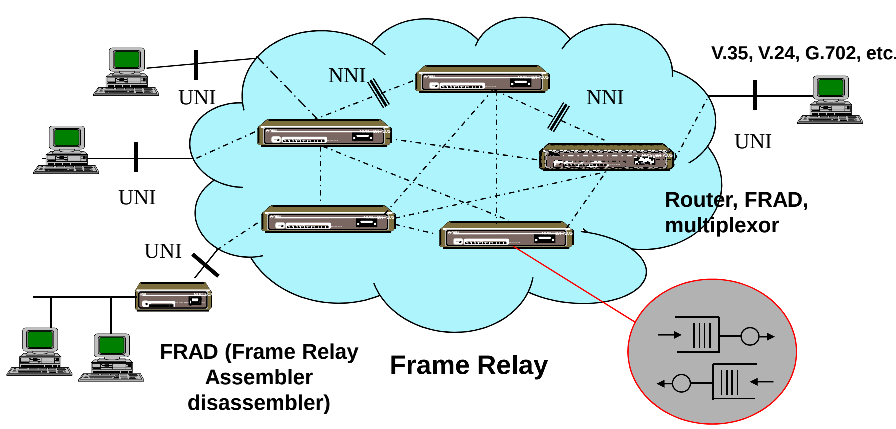


Typical Frame Relay Network

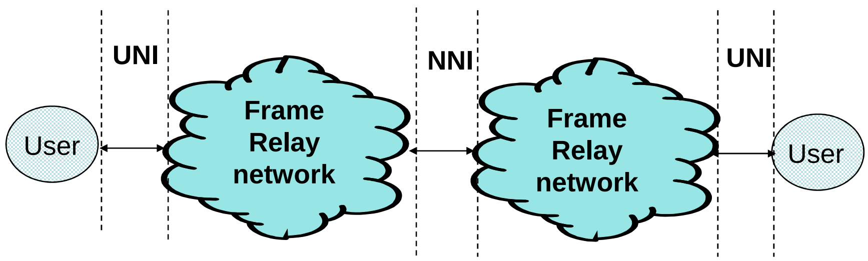


Frame Relay Network Service

Based on a packet-switching network made up by switches and concentrators linked through bidirectional medium- or high-speed lines.



Frame Relay Interfaces



Frame Relay

- Frame Relay emerged as a *de facto* standard issued by a group of equipment manufacturers.

  → Frame Relay Forum

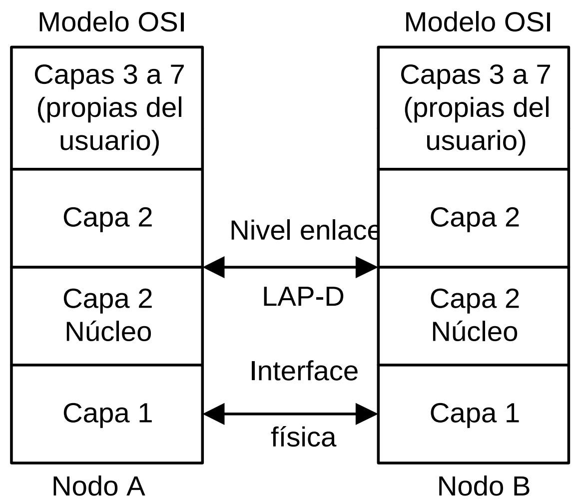
- Frame Relay, proposed in 1990 by ANSI (T1.606), evolved from the X.25 service, as a result of quality improvements in transmission and switching media.

Frame Relay

- Describes an optimised standard for the transport of data-oriented protocols in discrete information units (generic packets).
  - It statistically multiplexes data, thus sharing bandwidth and creating efficiency.
  - It eliminates much of the protocol processing by the network, thus reducing transmission latency.

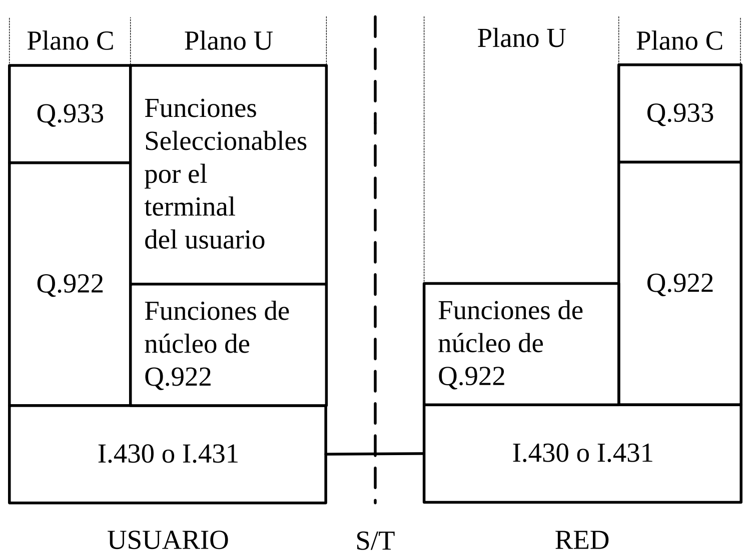
II. ARCHITECTURE

Frame Relay Architecture



Las capas 1 y 2 soportan al Frame Relay

Frame Relay Architecture



Frame Relay Architecture

The final and intermediate systems have two different and separate architectures :

- The user layer
- The control layer

Frame Relay Architecture

- **User layer**:

  Level 2: (in the ITU-T recommendation, the protocol used is LAP-F)

- **Control layer**:

  Level 2: LAP-D
  Level 3: Q.933 (recommendation similar to Q.931, used in ISDN)

Frame Relay Format

1	2 - 4	Variable	2	1 Octetos
Flag	Cabecera de dirección	Información	FCS	Flag

(a) Formato de la trama

8	7	6	5	4	3	2	1 bits	
DLCI (mayor orden)						C/R 0/1	EA 0	DLCI 10 bits
DLCI (menor orden)				FECN	BECN	DE	EA 1	

(b) Cabecera de dirección de 2 octetos
(usada por defecto)

- **Flag:** It has the same format as in LAP-B (01111110), and is also used for separating frames. When there are no frames to send, flags are generated continuously.

- **EA** (Extended Address)

  More than two octets are allowed in the control field $\Rightarrow$ EA indicates (when marked with a '0') that more octets follow behind or (when marked with a '1') that it is the last one in the control field.

- **CR** (command/response bit).

  The network does not use this bit.

- **DE** (Discard Eligibility Bit)
  - Fixed by the DTE (access device FRAD, router, etc.) or the network nodes (FR switches)
  - May be modified by the network nodes in case the user has exceeded the CIR and there is congestion in the network
  - The frames that have this bit set at "1" are subject to being discarded in case of congestion.

- **FECN (**Forward Explicit Congestion Notification**)**
  - Bit fixed by the network node (FR switch) that is experiencing congestion
  - Congestion notification in the direction of the transmission.

- **BECN (**Backward Explicit Congestion Notification**)**
  - Bit fixed by the network node that is experiencing congestion
  - Congestion notification in the opposite direction of the transmission.

DLCI (Data Link Connection Identifier**)**

Data link connection identifier.

Permits the definition of up to 1,024 virtual circuits (2^8).

The multiplexing function is performed at level 2, and the DLCI identifies the logic channel to which each frame belongs.

The logic channel numbers are assigned by contract.

DLCI (4)

DLCI values	Function (Consortium assignment)
0	Reserved for call control signalling (in-band)
1 - 15	Reserved
16 -1007	Used for assignment to *frame relay* PVCs
1008 - 1022	Reserved
1023	Local management interface (LMI)

- **User data**. This information is placed in the frame and, when received, is sent directly to the higher level.

  It has been defined with a maximum length of 8,000 octets. Manufacturers use up to 4,096 octets.

  This field is aligned to the octet, that is, the service user is required to deliver an integer number of octets.

- **FCS**. Two-octet cyclic redundancy field (Cyclic Redundancy Check – CRC-16)

  ❖ Given a message or frame of **k** bits in length, the sender generates a sequence of **n** bits, known as frame check sequence (FCS), in such a way that the resulting frame, consisting of **k + n** bits, is exactly divisible by some predetermined number.

  ❖ Then the receiver divides the incoming frame by the same predetermined number and, if there is no remainder, it is assumed that the frame arrived without errors.

III: LOCAL MANAGEMENT INTERFACE (LMI)

Local Management Interface (LMI) (1)

The LMI was defined by a consortium of companies (Cisco Systems, Digital Equipment, Northern Telecom, StrataCom) and then incorporated, with some modifications, into Rec. Q.933 Annex A and standard T1.617 Annex D

Local Management Interface (LMI) (1)

The LMI defines a *polling* protocol between the FRAD and the network for the exchange of information on the status of the interface and the PVCs, such as:

- Notification of a new PVC
- Detection of a PVC cancellation
- Notification of PVC availability
- Link integrity check (UNI)

Local Management Interface (LMI) (2)

The LMI protocol is asymmetric: The FRAD issues a periodic *polling* (STATUS ENQUIRY) to the network, and the network answers (with a STATUS*)*

– The *polling* period is 10 seconds, negotiable (between 5 and 30 seconds)

Originally, the DLCI was the DLCI 1023.

Annex D made it compatible with RDSI signalling functions, and adopted DLCI 0; this is the most widely-used version.

Local Management Interface (LMI) (2)

The *polling* basically seeks to check if the access interface is active and operating properly.

This periodic polling permits the detection of errors, such as signalling channel errors or internal problems of the network.

Local Management Interface (LMI) (3)

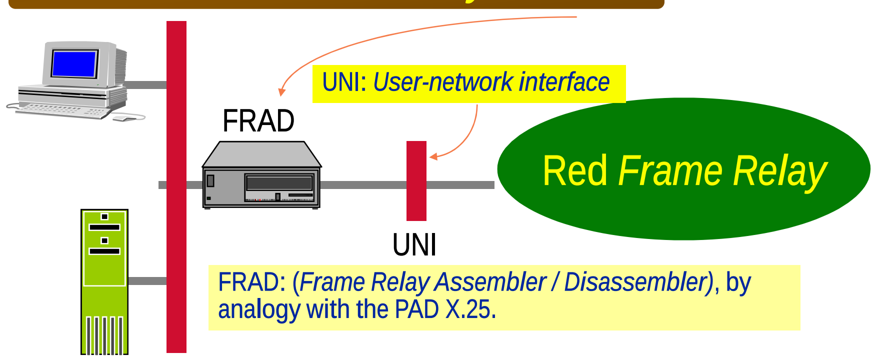
Every given number of activity-detection pollings, the FRAD requests the status of all the PVCs defined in the access interface.

This full status is generally requested every 6 pollings.

Full-status messages contain information about all the PVCs configured in the carrier channel, including recent history and availability of PVCs.

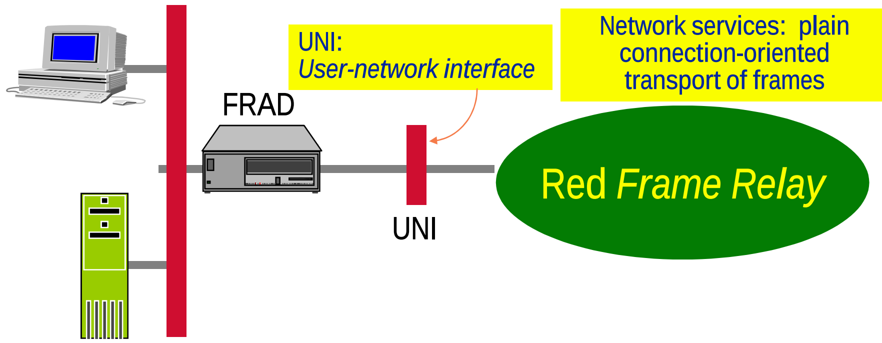
IV. PHYSICAL LEVEL

Access to the *Frame Relay* network



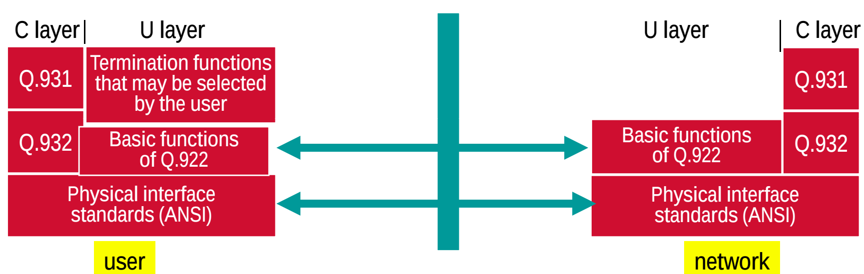
- FRAD services:
  - Transfer of files
  - Multiplexing of low-speed applications in a high-speed channel
  - Asynchronous traffic

Access to the *Frame Relay* network



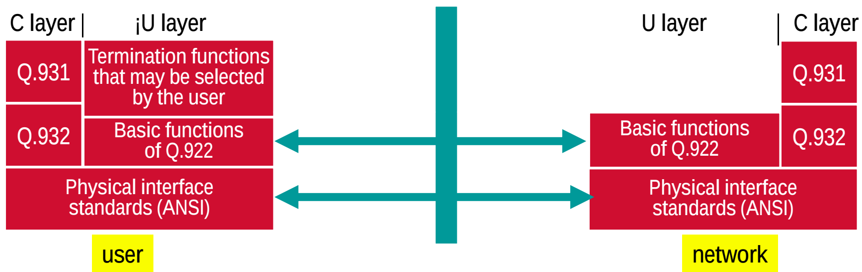
- UNI services:
  - Bidirectional frame transfer
  - Preservation of the order of frames
  - Detection of transmission, formatting and operational errors
  - There is no confirmation of frame reception

Access to the *Frame Relay* Metwork



- C layer: Executes control functions
  - Uses RDSI channel D (16 or 64 kbit/s, for control and signalling)
  - Provides call control, parameter negotiation, and management and maintenance functions

Access to the *Frame Relay* network



- U layer: interacts with the user
  - Uses channels B (64 kbit/s), D (16 / 64 kbit/s) or H (384, 1472, 1536 or 1920 kbit/s)
  - Rec. Q.922 – Functions: frame delimitation, alignment and transparency; virtual circuit multiplexing using the address field; frame check, error detection and congestion control.

Options for the Physical Access Layer

- The FRF (*Frame Relay Forum*) recommends other physical interfaces for the UNI:
  - ANSI T1.403: metallic interface at 1,5 Mbit/s
  - UIT-T V.35: duplex interface at 56 or 64 kbit/s
  - UIT-T G.703: metallic interface at 2 Mbit/s
  - UIT-T X.21: Synchronous data interface between user equipment and public networks

Access Channel

It generally refers to an access channel of the user-network interface (UNI) or of the network-network interface (NNI).

This access channel is the path for a single user data stream.

Channel E1

Used in Europe, Asia, Central and South America.

It has a bandwidth of 2.048 Mbps.

Types of E1 access lines

There are three types of channels in a E1 line:

- ❖ Non-channeled E1
- ❖ Channeled E1
- ❖ Fractional E1

Non-channeled E1

The whole line is considered as a single access channel.

Channeled E1

An access channel is one of the 30 channels.

Each access channel is made up by a single time interval E1.

Fractional E1

An access channel is a grouping of N E1 time intervals (Nx64 Kbps, where N=1 at 30 time intervals for each fractional E1 access channel) that may be assigned in a consecutive and non-consecutive manner

Physical interfaces

- ITU V.35
- ITU G.703, G.704 (2 Mbps)

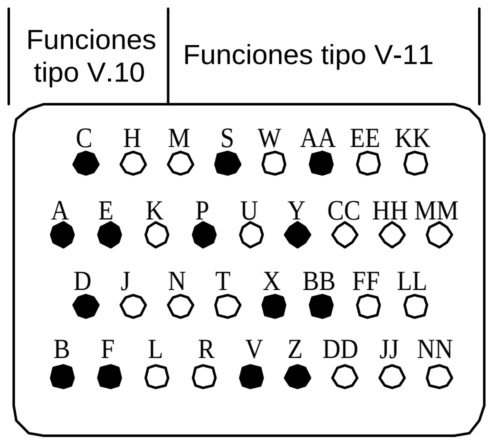
V.35 Interface

This interface is a combination of circuits under standards V.10 and V.11.

All data and timing terminals meet specification V.11 (balanced circuits and low voltage).

Control signals have V.10 voltages (non-balanced circuits).

V.35 Connector

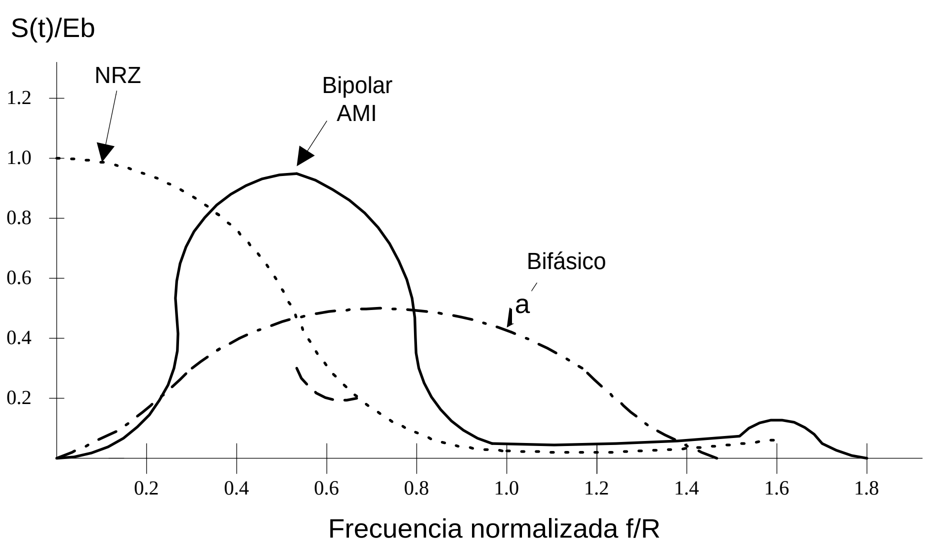


PINES DEL TIPO V.35

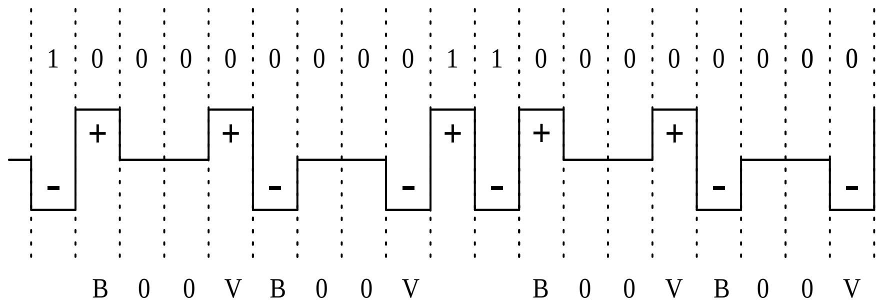
PIN	NOMBRE	FUNCIÓN	DTE DCE	NORMA
P	TxD - A	Transmisión de datos pin A	→	V.35
S	TxD - B	Transmisión de datos pin B	→	V.35
R	RD - A	Recepción de datos pin A	←	V.35
T	RD - B	Recepción de datos pin B	←	V.35
Y	TxC - A	Reloj de Transmisión pin A	←	V.35
AA	TxC - B	Reloj de Transmisión pin B	←	V.35
V	RxD - A	Reloj de recepción pin A	←	V.35
X	RxD - B	Reloj de recepción pin B	←	V.35
U	XTC - A	Reloj Externo de datos pin A	→	V.35
W	XTC - B	Reloj Externo de datos pin B	→	V.35
Z		No asignado		
BB		No asignado		
CC		No asignado		
DD		No asignado		
EE		No asignado		
FF		No asignado		
HH		No asignado		
JJ		No asignado		
KK		No asignado		
LL		No asignado		
MM		No asignado		
NN		No asignado		
PINES DEL TIPO RS -232				
A	FG	Tierra de chasis (Frame Ground)	→	RS-232
B	SG	Tierra de señal (Signal Ground)	→	
C	RTS	Request To Send	→	RS-232
D	CTS	Clear To Send	←	RS-232
E	DSR	Data Set Ready	←	RS-232
F	DCD	Detector de portadora	←	RS-232
H	DTR	Data Terminal Ready	→	RS-232
J	RI	Indicador de timbrado		
K	Test	Test local		
L		No asignado		
M		No asignado		
N		No asignado		

V. LINE CODES

Spectral density of line codes



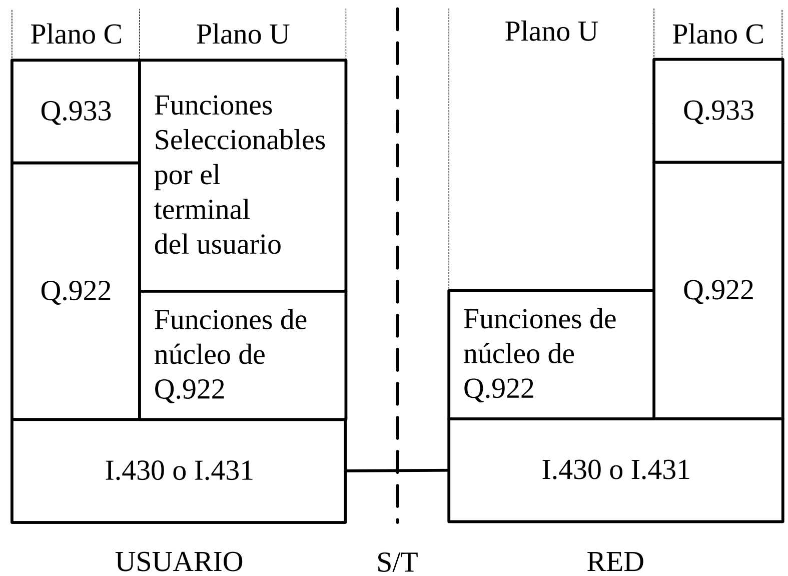
HDB3 Code



B = normal or reverse polarity
V = violation of the rule

VI. LINK LEVEL

Frame Relay Architecture



Frame Relay link level

Only one type of frame is used to transport user data. There is no check frame.

The regulated packet size is 8,193 octets, but most manufacturers support only up to 4,096 octets

Frame Relay link level

In-band signalling cannot be used;
a logic connection may only transport user data.

Flow control and error check are not possible because it has no sequence numbers.

1	2 - 4	Variable	2	1	Octetos
Flag	Cabecera de dirección	Información	FCS	Flag	

(a) Formato de la trama

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>bits</td></tr>
<tr><td colspan="6">DLCI
(mayor orden)</td><td>C/R
0/1</td><td>EA
0</td><td rowspan="2">DLCI
10 bits</td></tr>
<tr><td colspan="4">DLCI
(menor orden)</td><td>FECN</td><td>BECN</td><td>DE</td><td>EA
1</td></tr>
</table>

(b) Cabecera de dirección de 2 octetos
(usada por defecto)

DLCI (mayor orden)			C/R 0/1	EA 0	
DLCI	FECN	BECN	DE	EA 0	DLCI 17 bits
DLCI (menor orden)			D/C	EA 1	

(c) Cabecera de dirección de 3 octetos

8 7 6 5	4	3	2	1	bits
DLCI (mayor orden)			C/R 0/1	EA 0	
DLCI	FECN	BECN	DE	EA 0	
DLCI				EA 0	DLCI 24 bits
DLCI (menor orden)			D/C	EA 1	

(d) Cabecera de dirección de 4 octetos

VII. REGULATION OF FRAME RELAY

History of Frame Relay

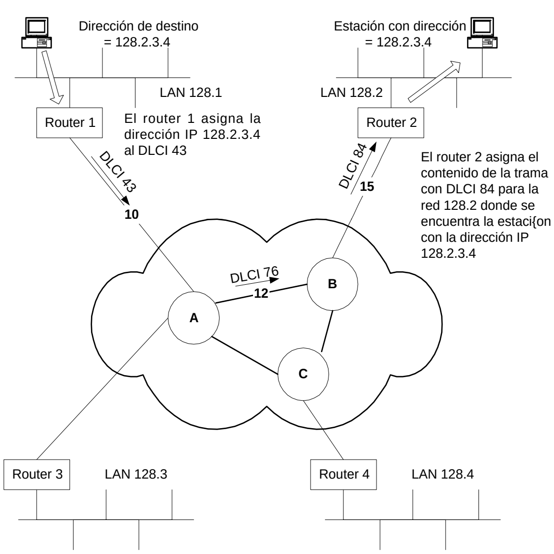
- In 1988, the UIT-T approved Rec. I.122 for packet-mode services (based on the Recs. for RDSI).
- The LAPD protocol has features that serve for other applications, such as layer-2 virtual circuit multiplexing.
- The I.122 was developed in order to use the same LAPD in an application other than RDSI signalling.

History of Frame Relay

Subsequently, the ANSI T1S1 Committee developed the other standards for Frame Relay:

1. **I.122/I.233:** Architecture and description of the service
2. **I.370:** Congestion management (T1.606a)
3. **Q.921/Q.922 Annex A:** Aspects concerning the core of the link layer (T1.618)
4. **Q.933:** Virtual connection signalling (T1.617)
5. **Q.933 Annex A:** Permanent virtual connection signalling (T1.617 Annex D)

VIII. FRAME RELAY OPERATION



Frame Relay operation and routing

Tabla de enrutamiento parcial del Siwtich A

Linea de entrada	DLCI	Línea de salida	DLCI
10	43	12	76

Tabla de enrutamiento parcial del Siwtich B

Linea de entrada	DLCI	Línea de salida	DLCI
12	76	15	84

Types of connections

- PVC ⇨ A predefined VC
  - Statistically defined in the configuration, unless PVC parameters need to be modified
  - The connection is always configured, whether or not there is information to be sent.

b. Congestion levels and control

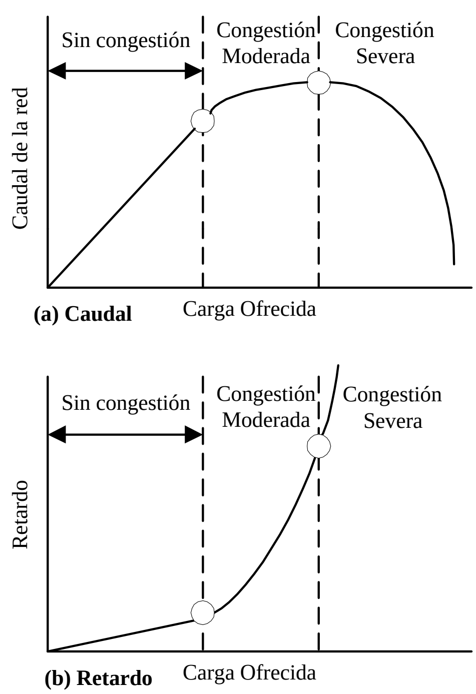
Congestion control in Frame Relay

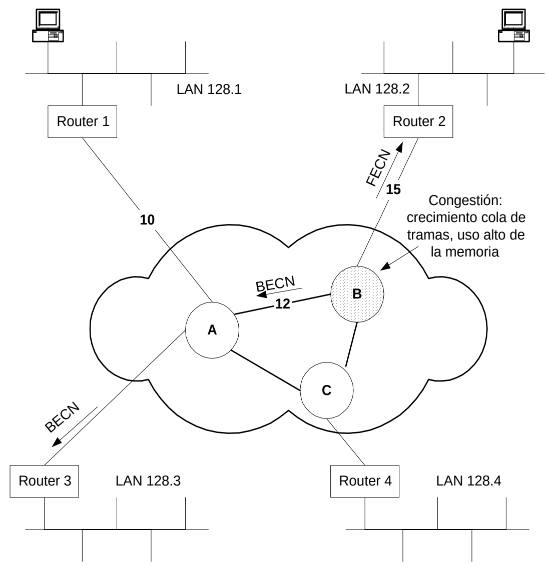
Mechanisms for avoiding congestion:

- **bits BECN and FECN**

Mechanism for recovering from congestion:

- **bit DE**



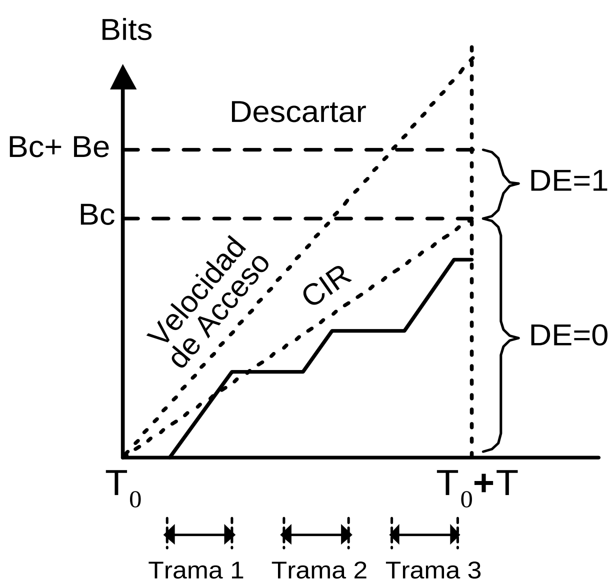


Operation of bits FECN and BECN

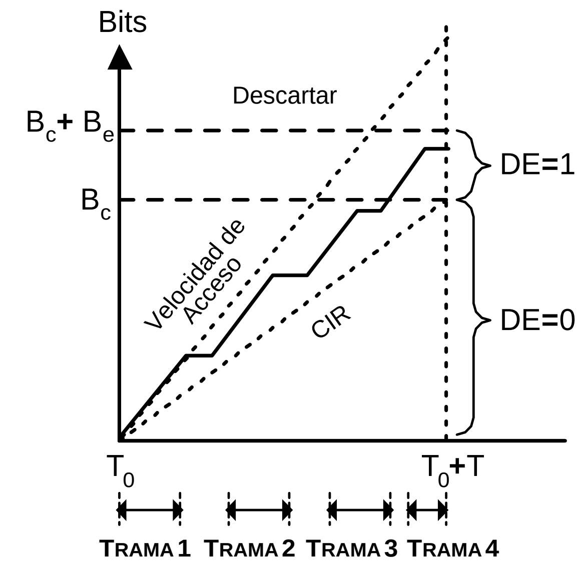
Explicit Notification Mechanisms for Avoiding Congestion

EXPLICIT NOTIFICATION MECHANISMS FOR AVOIDING CONGESTION

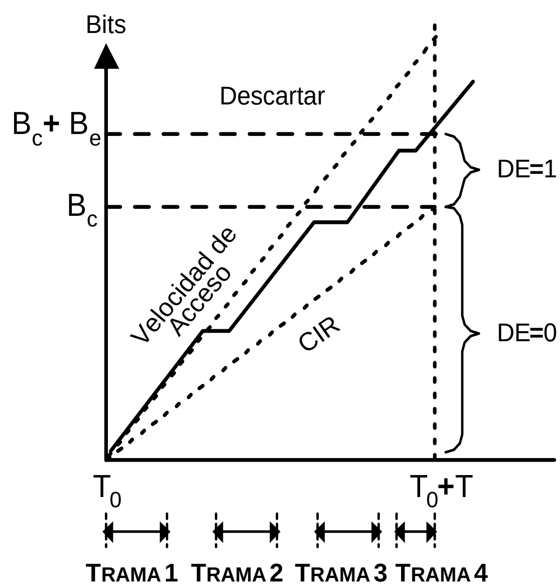
- Backward Explicit Congestion Notification (BECN)
- Forward Explicit Congestion Notification (FECN)



a) Todas las tramas dentro del CIR



b) Una trama de DE



c) Una trama marcada DE: una trama descartada

Congestion in Frame Relay

- In the Frame Relay service, congestion in the user layer may occur due to lack of resources (memory, processing capacity, bandwidth, etc.) in a given network device for processing the frames received.

- Congestion degrades the quality of the service of one or more connections, affecting:
  - flow rate
  - delay

Congestion in Frame Relay

- Congestion management mechanisms are defined for the **prevention** of**, control** of, and **recovery** from, congestion.

- Congestion levels:
  - **Mild congestion** (point A, region II).
    A load increase entails an increase of frame relay.
    From there on, the network cannot guarantee the service quality agreed with the users.

Congestion in Frame Relay

- **Heavy congestion** (point B, region III).
  The network discards frames to control congestion.

- Points A and B are dynamic points determined by the instantaneous resources of the network.

- Usually, when a frame is sent, the status of the network is unknown.

⇩

Frames above B_c are subject to be discarded when network congestion increases on the routes used by those frames.

⇩

The network notifies of the increased likelihood of frames being discarded, using bits FECN and BECN.

- Congestion is unidirectional, since the transmission may follow a different path in each direction, and while one may be having traffic problems, the other may not.

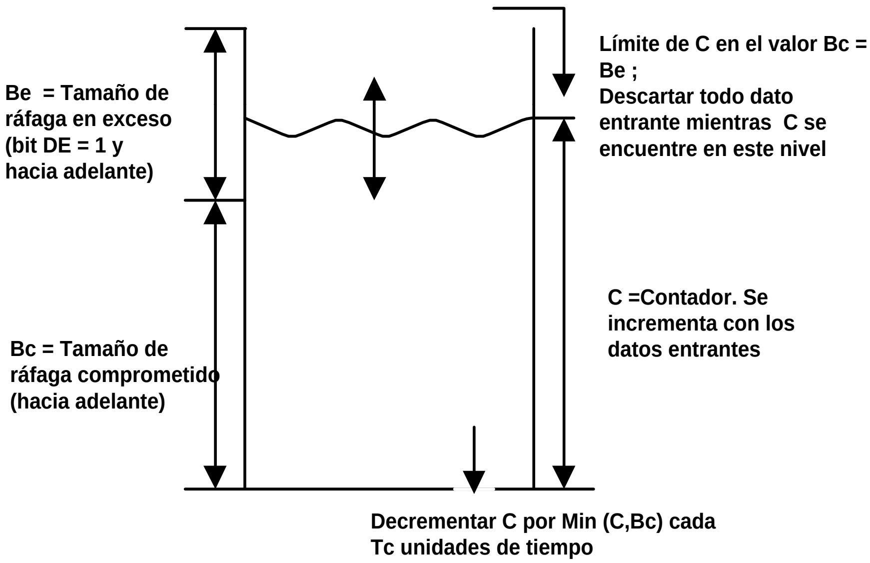
↓

Bits FECN and BECN notify the two ends of the connection about the congestion as follows: “A frame crossing a congested area is assigned FECN = '1'.

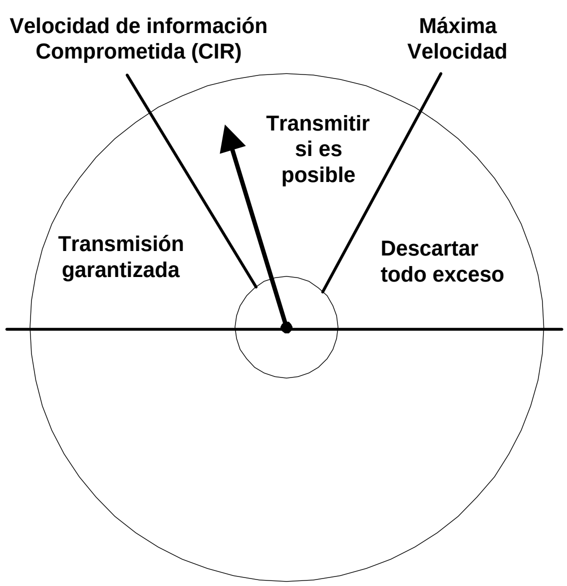
The network identifies the frames of that connection that circulate in the opposite direction, and sets their bit BECN also to '1’.

c. Traffic control

Leaking-bucket algorithm



CIR operation



CIR (Committed Information Rate)

⇓

BW defined by a VC

- The user negotiates with the network the ***agreed or committed information rate (CIR)***, which is the speed at which the network undertakes to transfer the information under any conditions.

- The CIR is averaged for a period of time $\mathbf{T_c}$.

B_c (Commited Burst Size)

⇓

Committed burst size

- Is the maximum amount of data (bits) that the network undertakes to transmit, under normal conditions, during a time interval ($\mathbf{T_c}$).

⤷ $B_c = CIR * T_c$.

B_e (Excess burst size)

Excess burst size

- Maximum amount of non-committed data--which may exceed $\mathbf{B_c}$--that the Frame Relay network may try to transmit during $\mathbf{T_c}$. The network treats $\mathbf{B_e}$ data as data eligible for being discarded.

Data that exceed $\mathbf{B_c+B_e}$ are invariably discarded.

T_c (Commited Rate Measurement Interval)

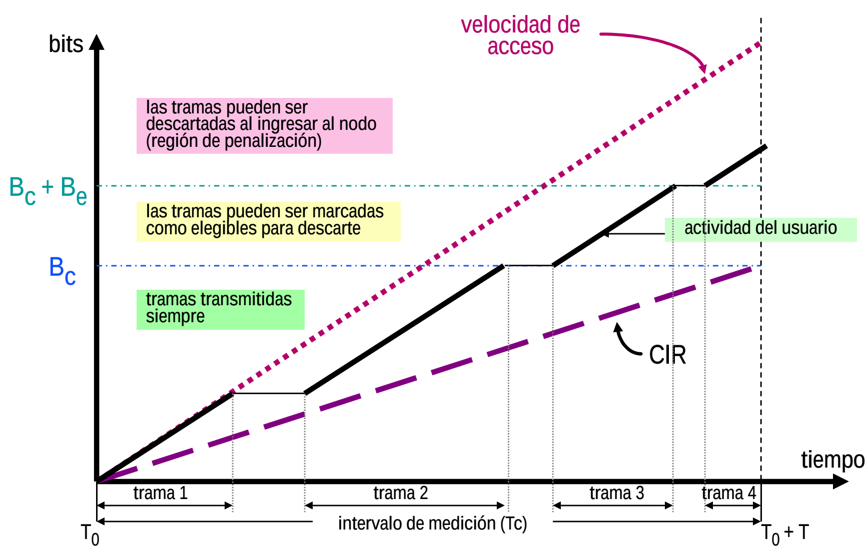
Is the time interval during which the user may only send an amount of committed data (Bc) and excess data (Be).

Tc is not a periodic time interval. It is only used for measuring incoming data, with the interval acting as a sliding window.

The incoming data trigger the Tc interval, which continues until it completes its switching period. Often, vendors have proprietary implementations of Tc.

- The bit DE is activated by the network in frames exceeding **B_c** (that is, those belonging to **B_e**) to indicate that these frames, if necessary, should be discarded prior to others.

A user may also mark this bit to indicate the relative importance of a frame with respect to others.



Traffic parameter considerations

- When starting the connection, users at the origin and destination negotiate the **CIR**, the $\mathbf{B_c}$ and the $\mathbf{B_e}$ with the network, deducting the measurement interval $\mathbf{T_c}$.

- In a link, the sum of the loads in each channel may not exceed the access rate of the link:

$$\sum CIR_i < \text{access rate}$$

- It may occur that a CIR=0 is negotiated, resulting in that all the frames introduced into the network will be marked with the activated bit DE.