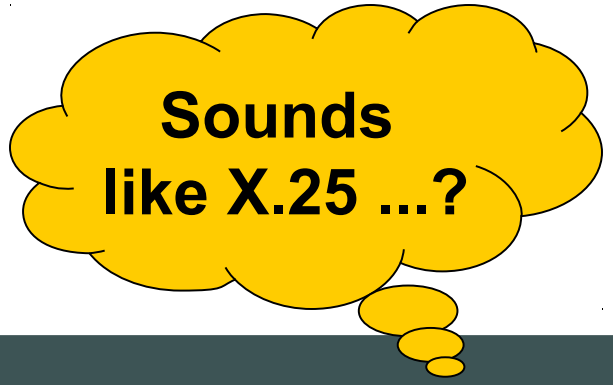
Frame Relay

Bigger, Longer, Uncut

What is Frame Relay?

- Connection-oriented packet switching (Virtual Circuit)
- WAN Technology
- Specifies User to Network Interface (UNI)
- Does not specify network itself (!)



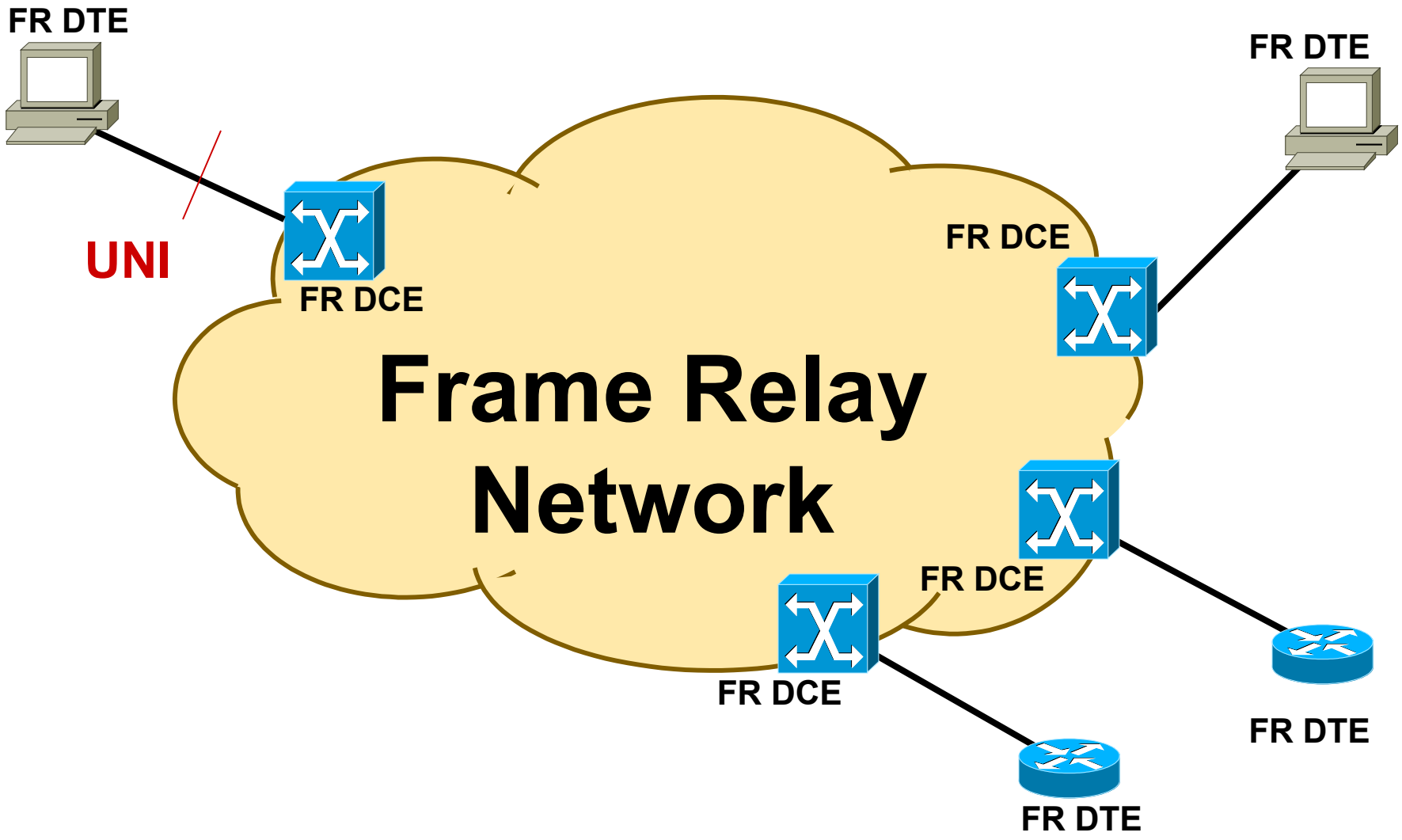
Basic Difference to X.25

- Reduced overhead
  - No error recovery (!)
  - Hence much faster
  - Requires reliable links (!)
- Outband signaling
- Good for bursty and variable traffic
  - Quality of Service *Ideas*
- Congestion control

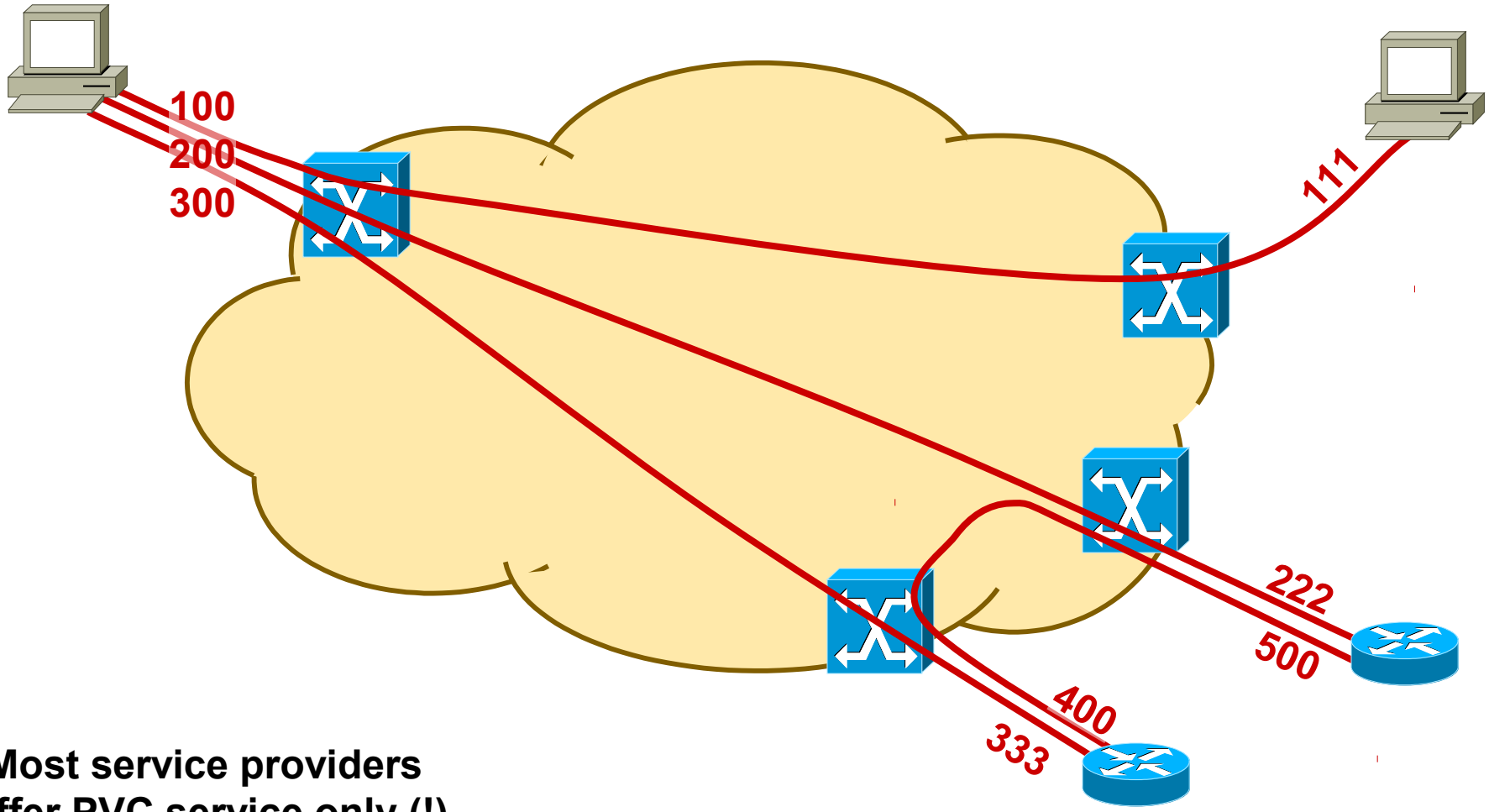
History of Frame Relay

- First proposals 1984 by CCITT
  - Original plan was to put Frame Relay on top of ISDN
  - Slow progress
- 1990: Cisco, Northern Telecom, StrataCom, and DEC founded the Gang of Four (GoF)
  - Focus on Frame-Relay development
  - Collaborating with CCITT
- ANSI specified Frame Relay for USA
- GoF became Frame Relay Forum (FRF)
  - Joined by many switch manufacturers

Frame Relay Network



Logical Channels (1)

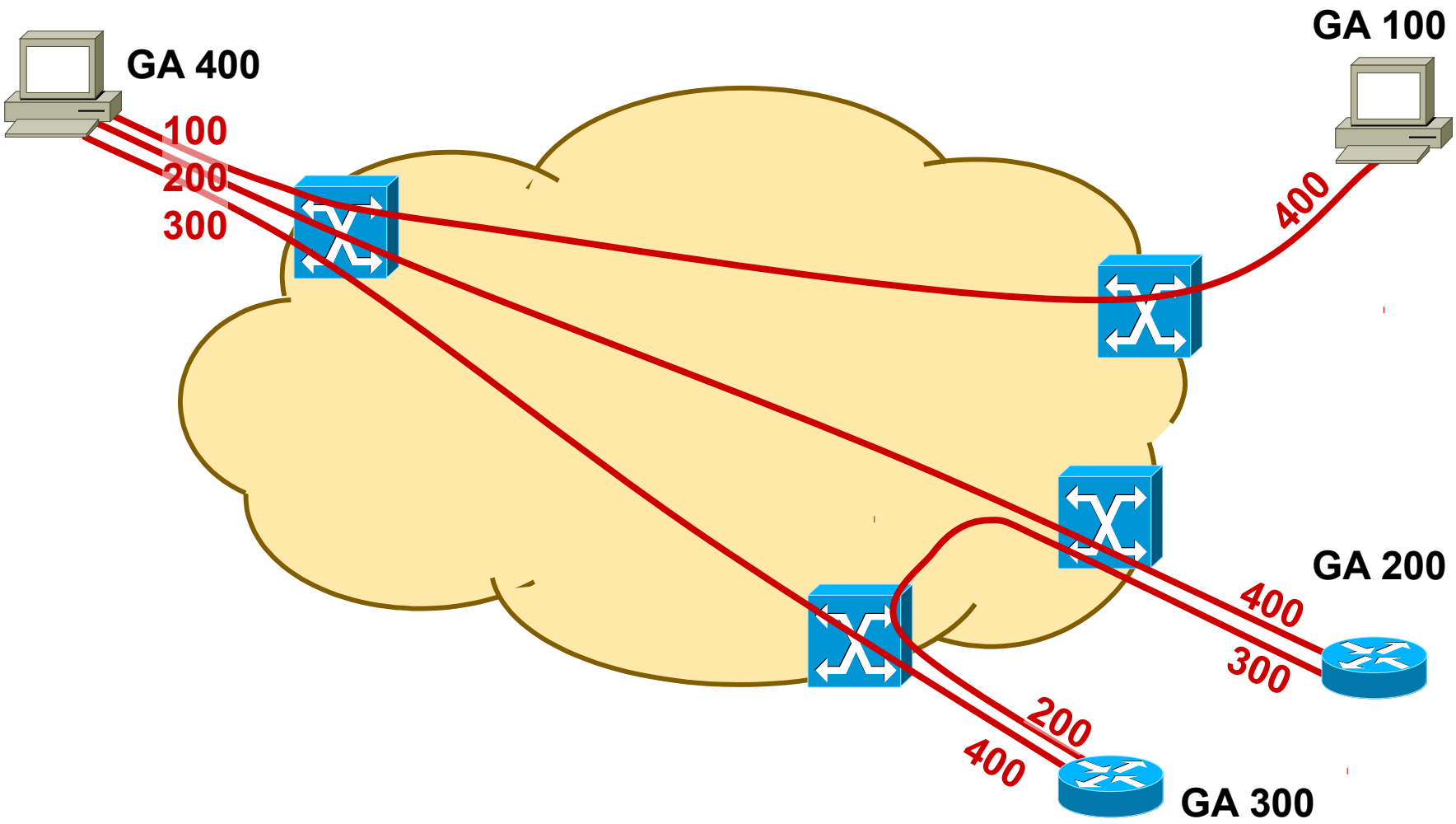


Most service providers offer PVC service only (!)

Logical Channels (2)

- Data Link Connection Identifier (DLCI)
  - Identifies connection
  - Only locally significant
- Some implementation support so-called "Global addresses"
  - Actually also locally significant
  - Destination address = DLCI

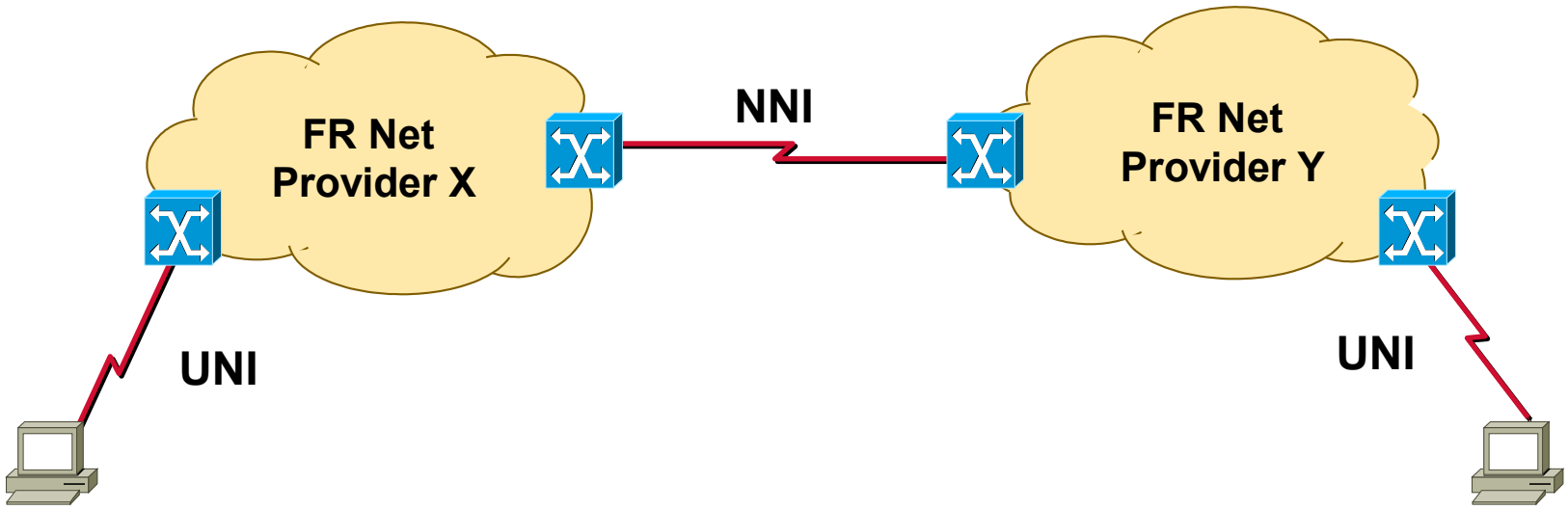
Global Addresses



Addressings for SVCs

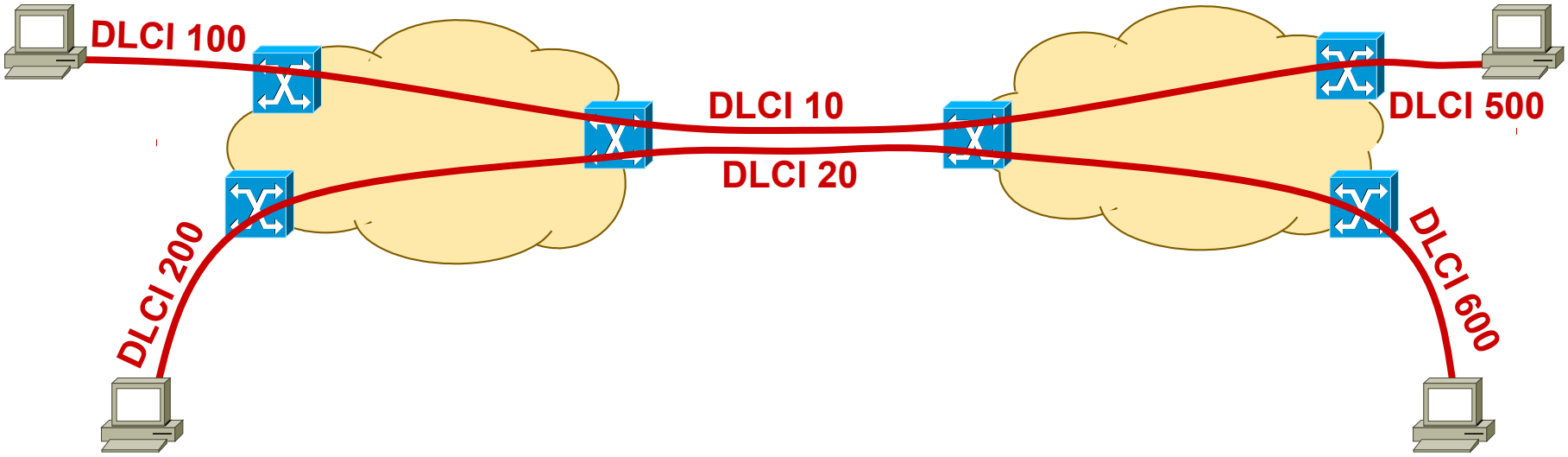
- (Public) FR networks using SVCs use either
  - X.121 addresses (X.25)
  - E.164 addresses (ISDN)
- Advantage of X.121 addresses:
  - Contain DNICs (Data Network Identification Codes) which are obligatory

NNI (1)



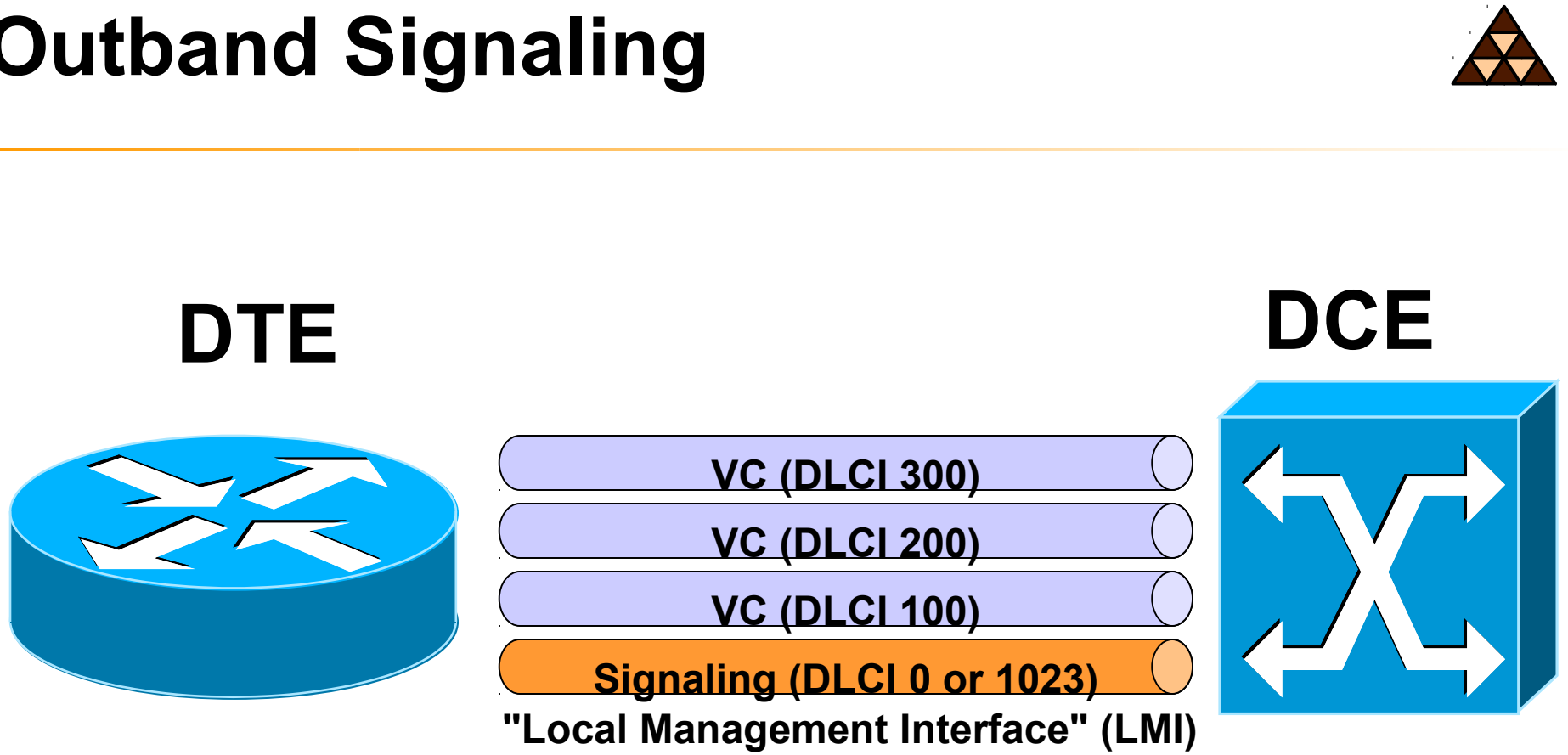
- NNI had been defined to connect different Frame Relay networks together
- Example: Public FR Net with Private

NNI (2)



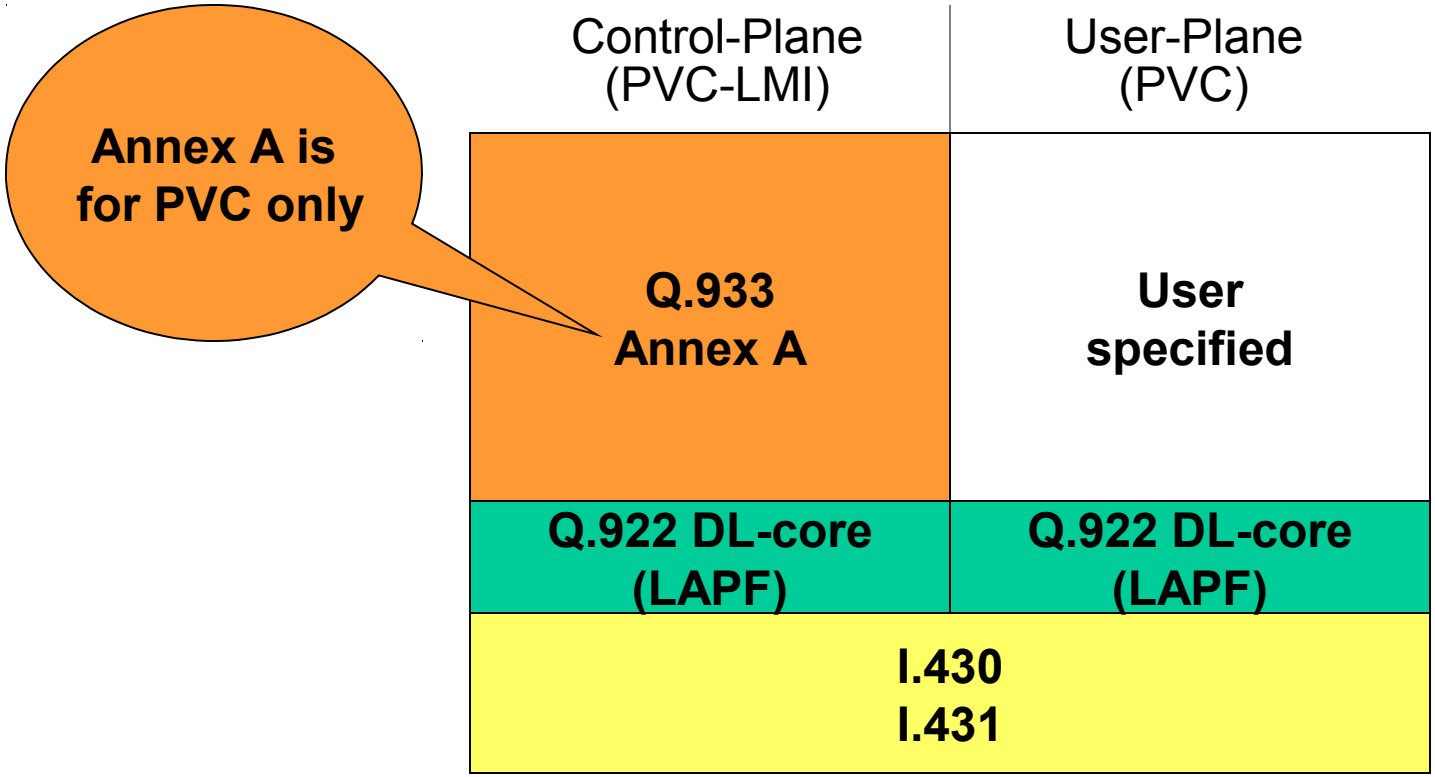
- Sequence of DLCIs associated to each VC

Outband Signaling

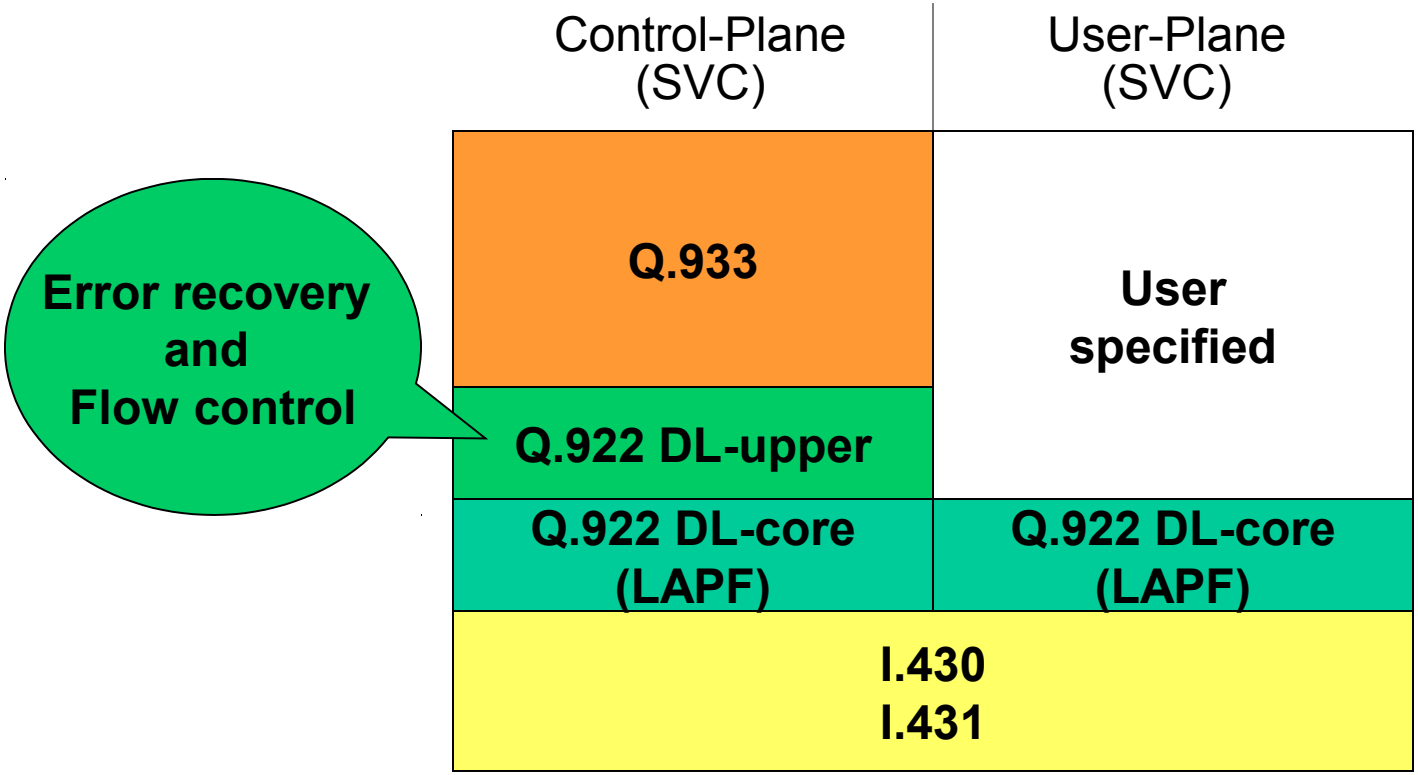


- Signaling through dedicated virtual ciruit = "Outband Signaling"
- Signaling protocol is LMI

ITU-T PVC Service Model



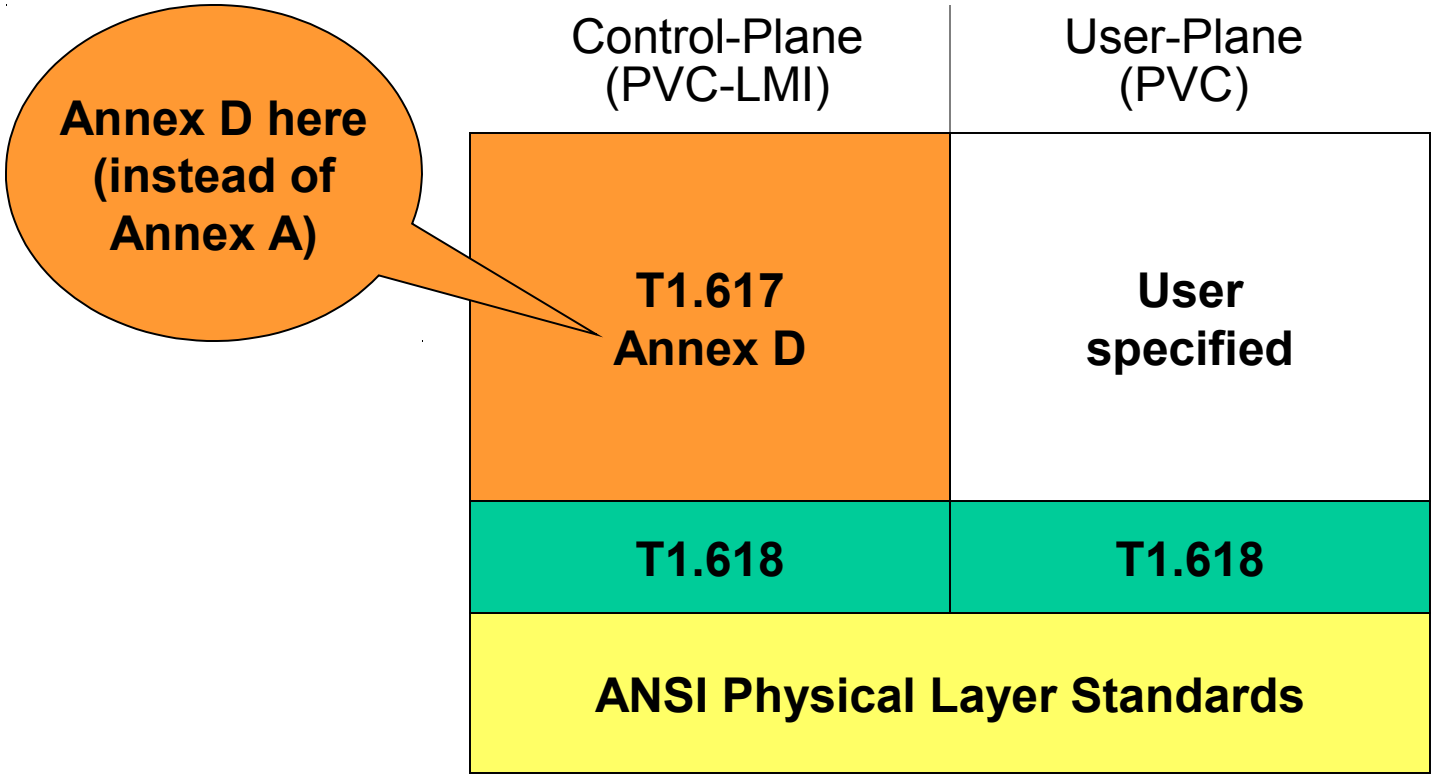
ITU-T SVC Service Model



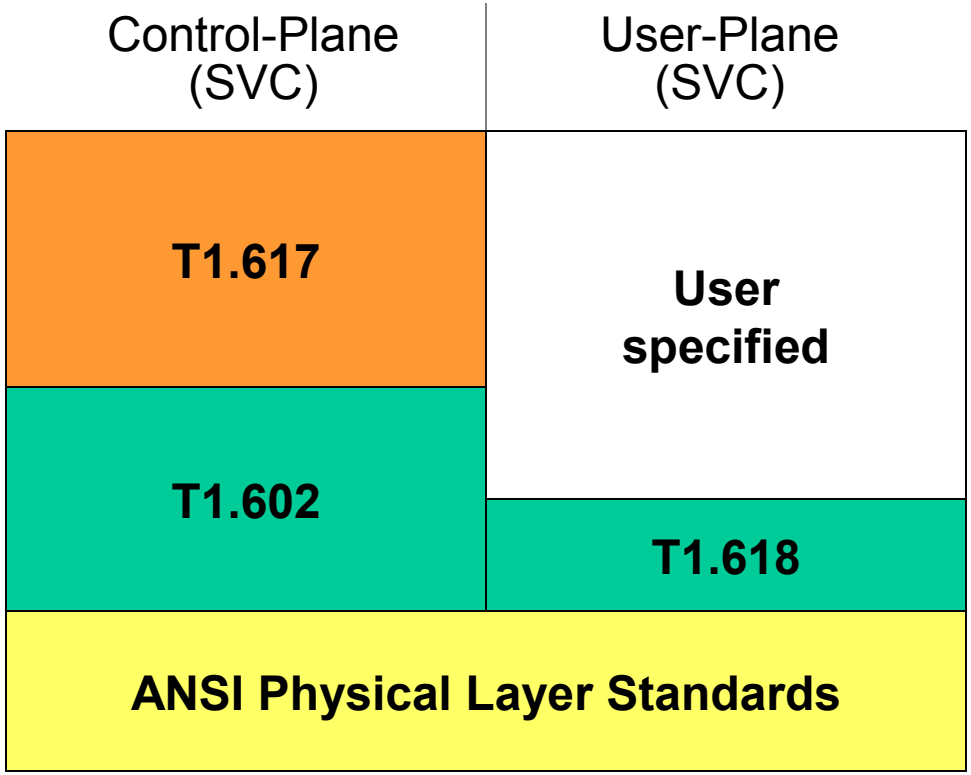
Layer Description

- LAPF is a modified LAPD (ISDN)
  - Specified in Q.922
- Q.922 consists of
  - Q.922 core (DLCIs, F/BECN, DE, CRC)
  - Q.922 upper (ARQ and Flow Control)
- Q.933 is based on Q.931 (ISDN)
  - Annex A for PVC management (LMI)

ANSI PVC Service Model



ANSI SVC Service Model



ANSI Layer Description

- T1.602 specifies LAPD
  - Based on Q.921
- T1.618 is based on a subset of T1.602 called the "core aspects"
  - DLCIs, F/BECN, DE, CRC
- T1.617
  - Signaling specification for Frame Relay Bearer Service
  - Annex D for PVCs (LMI)

Frame Relay Forum (FRF)

FRF.1.1	User to Network Interface (UNI)
FRF.2.1	Network to Network Interface (NNI)
FRF.3.1	Multiprotocol Encapsulation
FRF.4	SVC
FRF.5	FR/ATM Network Interworking
FRF.6	Customer Network Management (MIB)
FRF.7	Multicasting Service Description
FRF.8	FR/ATM Service Interworking
FRF.9	Data Compression
FRF.10	Network to Network SVC
FRF.11	Voice over Frame Relay
FRF.12	Fragmentation
FRF.13	Service Level Agreements
FRF.14	Physical Layer Interface
FRF.15	End-to-End Multilink
FRF.16	Multilink UNI/NNI

Voice over FR

- VoFR Standard FRF.11 (Annex C)
  - Multiple subframes in a single FR-Frame
  - 30 Byte Voice Payload per subframe
  - Additional identifier CID (Channed ID) to identify separate streams
  - Dedicated CID for signaling (Cisco: CID 0)
- Voice + Data in same PVC: Delay Problem
  - Solution: FRF.12 (Fragmentation)
  - Data packets are fragmented and interleaved with voice packets
  - Voice-frames should keep "inter-frame-delay" <10ms
  - Adjustments of fragment-size based on AR
    - Cisco: fr-fragment-size

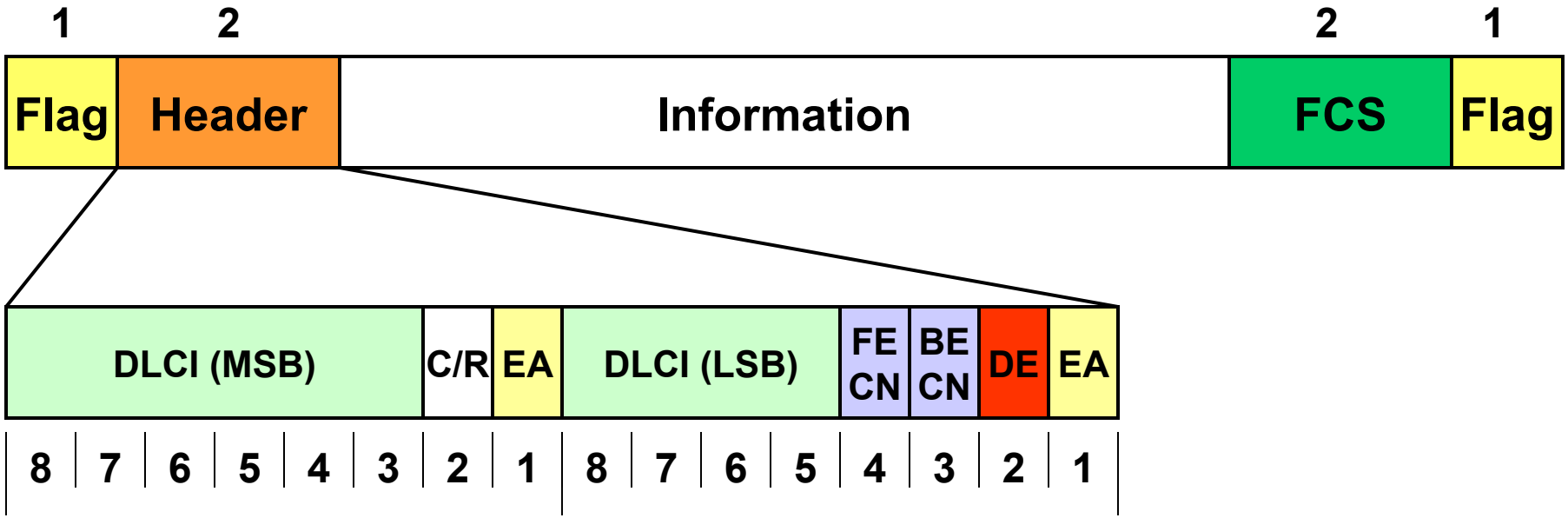
Physical Interfaces

- Some UNI Specifications (FRF.1)
  - ITU-T G.703 (2.048 Mbps)
  - ITU-T G.704 (E1, 2.048 Mbps)
  - ITU G.703 (E3, 34.368 Mbps)
  - ITU-T X.21
  - ANSI T1.403 (DS1, 1.544 Mbps)
  - ITU-T V.35
  - ANSI/EIA/TIA 613 A 1993 High Speed Serial Interface (HSSI, 53 Mbps)
  - ANSI T1.107a (DS3, 44.736 Mbps)
  - ITU V.36/V.37 congestion control

Layer 2 Tasks

- Q.922 Annex A (LAPF) or T1.618 specifies
  - Frame multiplexing according DLCI
  - Frame alignment (HDLC Flag)
  - Bit stuffing
  - 16-bit CRC error detection but no correction
  - Checks minimum size and maximum frame size
  - Congestion control

The Frame Relay Frame

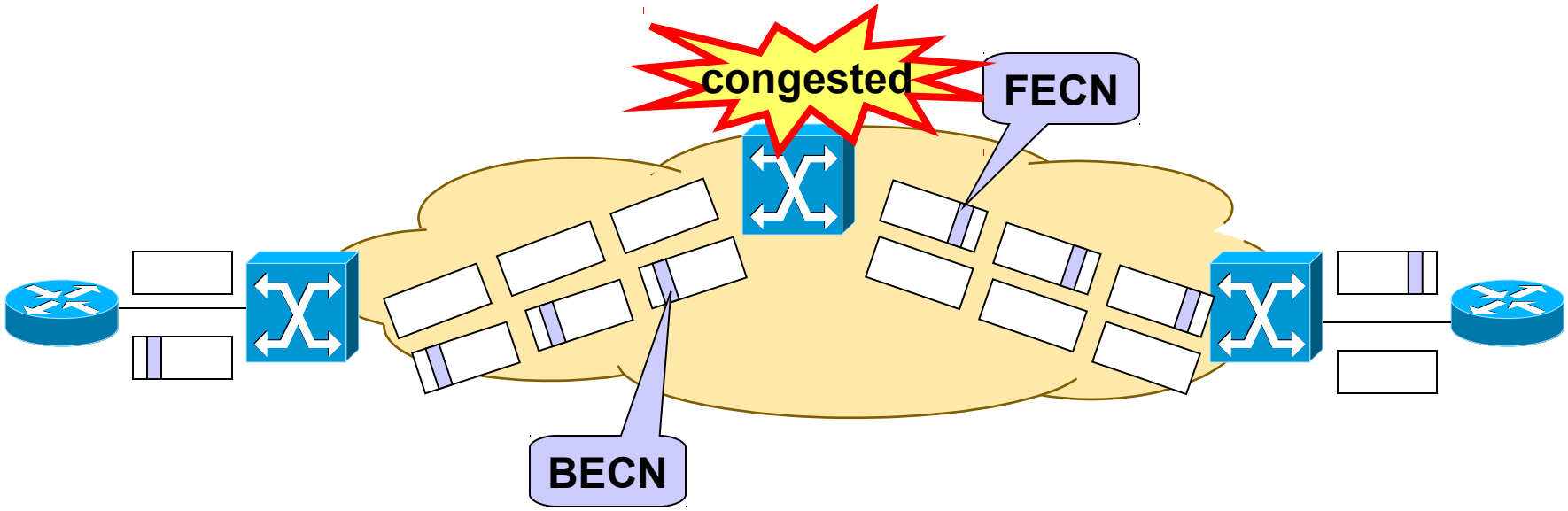


Legend:

DLCI	Data Link Connection Identifier
C/R	Command/Respond
EA	Extended Addressing
FECN	Forward Explicit Congestion Notification
BECN	Backward Explicit Congestion Notification
DE	Discard Eligibility

Congestion Control (1)

- FECN indicates congestion to the receiver
- BECN indicates congestion to the sender
- Problem: DTEs do not need to react (!)



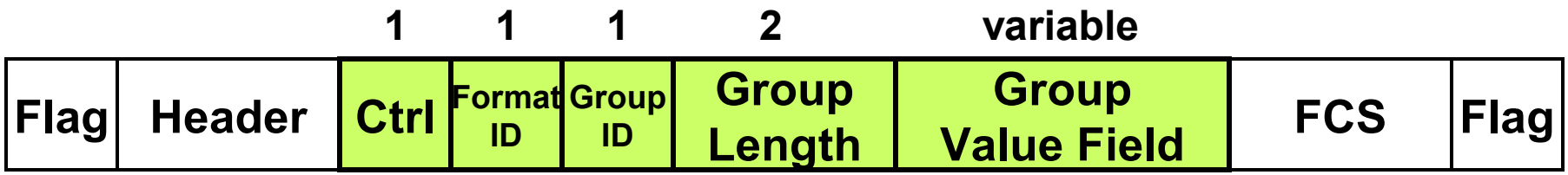
Congestion Control (2)

- Routers can be configured to react upon receiving a BECN
- Only a few higher layer protocols react upon receiving a FECN
  - Only some OSI and ITU-T protocols
  - TCP does not

CLLM

- Consolidated Link Layer Management
- ITU-T and ANSI development
- Optional out-band signaling for congestion indication messages
  - DLCI 1023
- Before congestion, DCE sends CLLM message to DTE
  - Associated DLCIs specified

CLLM Message

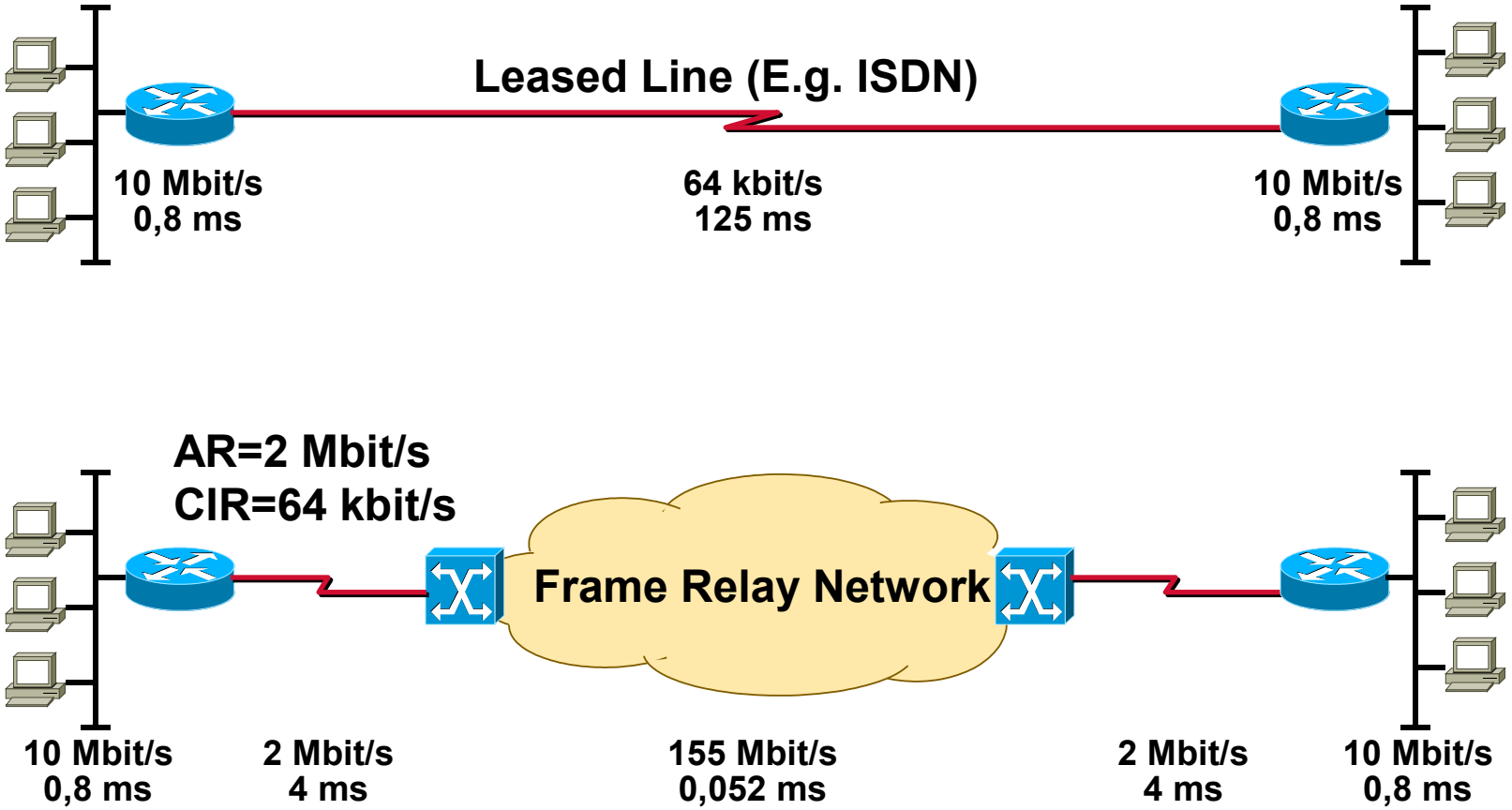


- CLLM message is carried inside LAPF Frame
- Ctrl = 0xAF (XID)
- Format ID = 10000010 (ANSI/ITU)
- Group ID = 00001111
- Group Value Field
  - Parameter-ID (1 octet)
  - Parameter Length (1 octet)
  - Parameter Value (n octets)

Traffic Control

- Statistical multiplexing is cheaper for service providers than deterministic-synchronous multiplexing
- Users are supposed to require less than the access rate on average
- Otherwise congestion will occur and frames are dropped
  - Which causes the end-stations to retransmit...and further overload the network

Time to Transmit 1 kByte



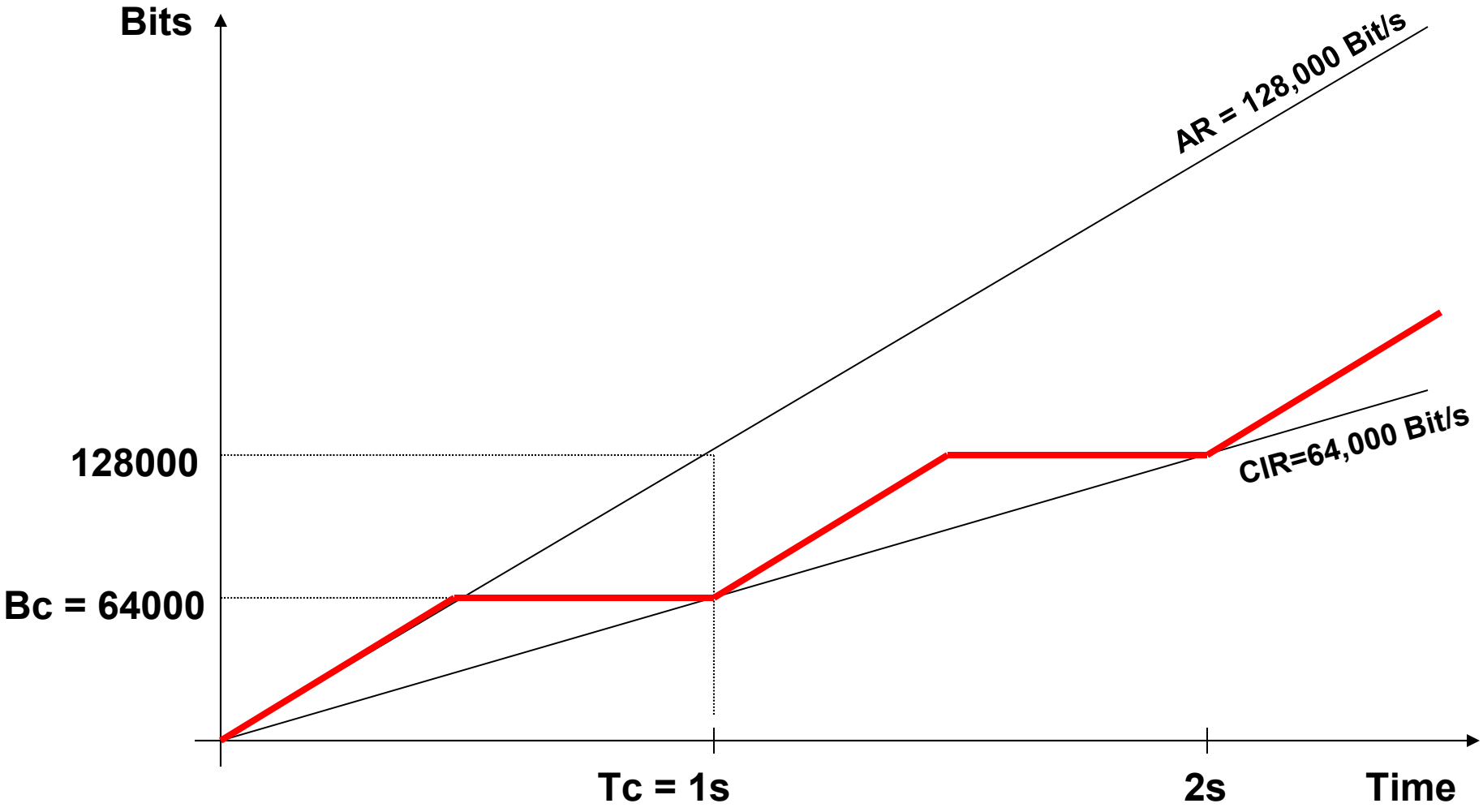
Bursty Traffic (1)

- FR allows to differentiate between Access Rate (AR) and Commited Information Rate (CIR)
  - CIR corresponds to average data rate
  - AR > CIR
- Sporadic bursts can use line up to AR
- Optionally limited by Excess Information Rate (EIR)

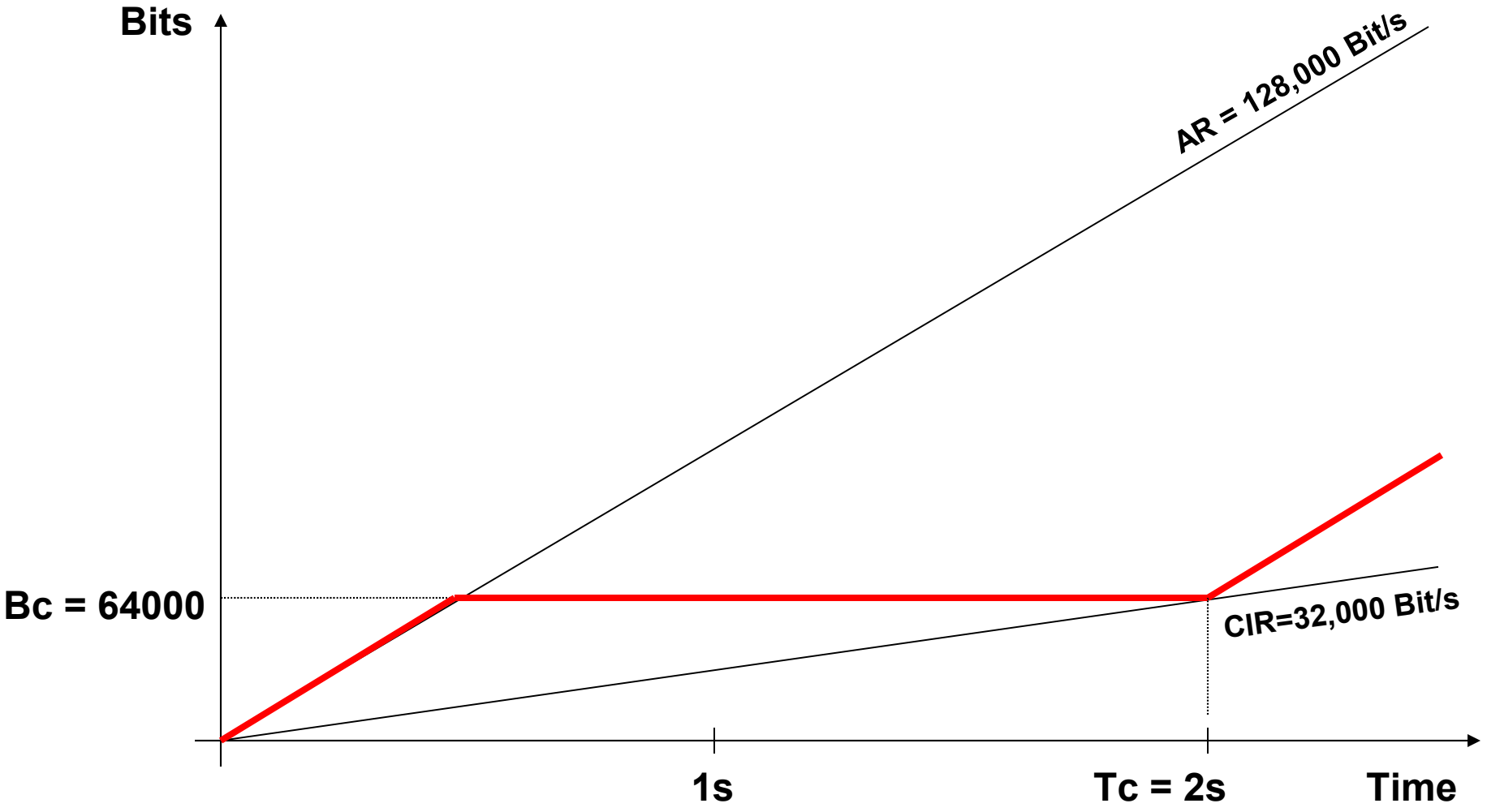
Bursty Traffic (2)

- CIR and EIR are defined via a measurement interval Tc
  - CIR = Bc / Tc (Bc...Commited Burst Size)
  - EIR = (Bc+Be) / Tc (Be...Excess Burst Size)
- When traffic can be mapped on these parameters (provided by provider) then FR is ideal for bursty traffic
  - Example: LAN to LAN connection
- Parameters (Bc, Be, Tc, AR) are defined in a traffic contract

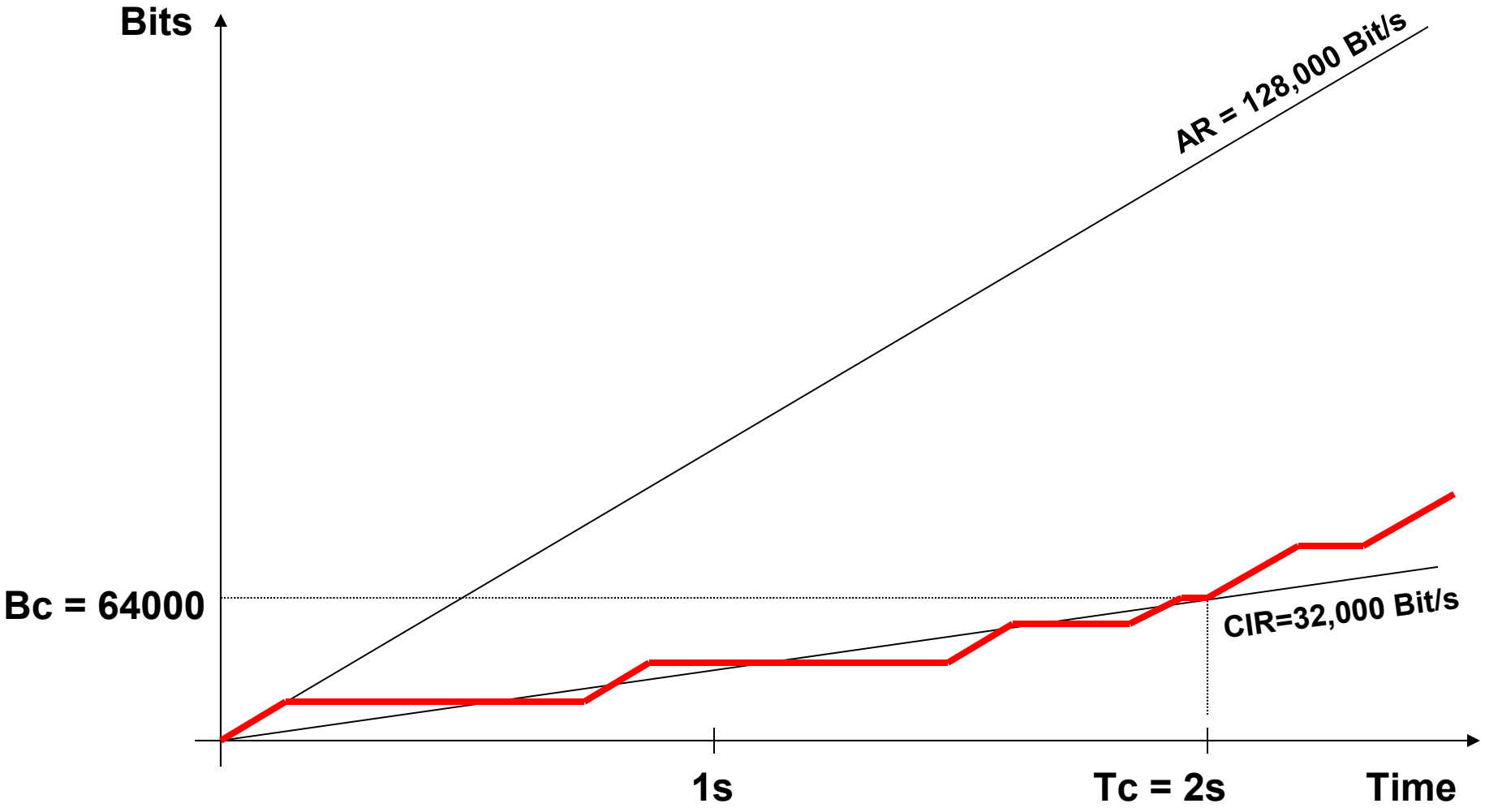
Parameter Example (1)



Parameter Example (2)



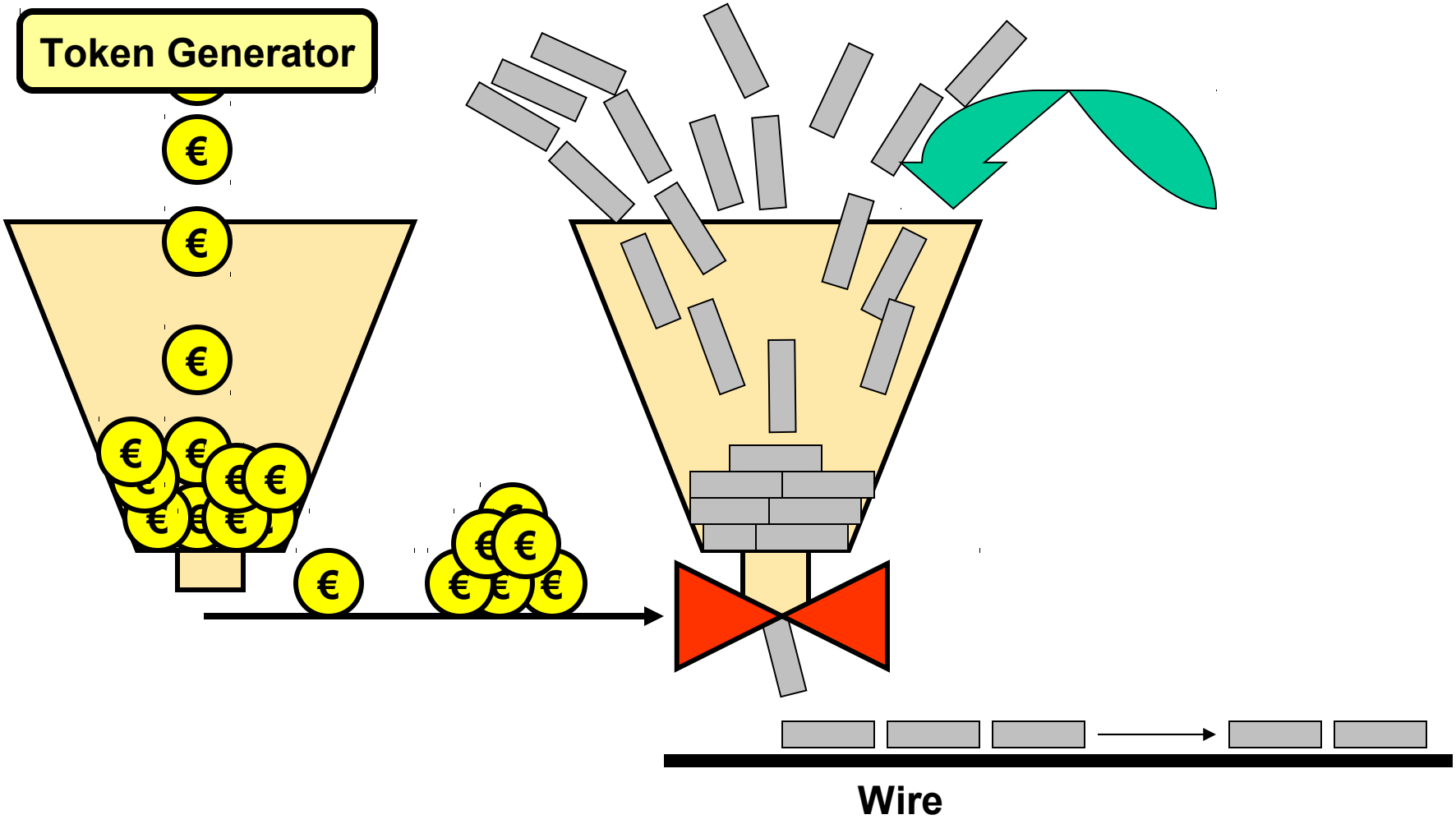
Parameter Example (3)



Traffic Management

- Traffic Shaping
  - Users task
  - Goal: smooth traffic profile, mitigiate bursts
  - Token bucket methods
- Traffic Policing
  - Provider's task
  - Goal: Drop (excess) frames violating the traffic contract

Token Bucket



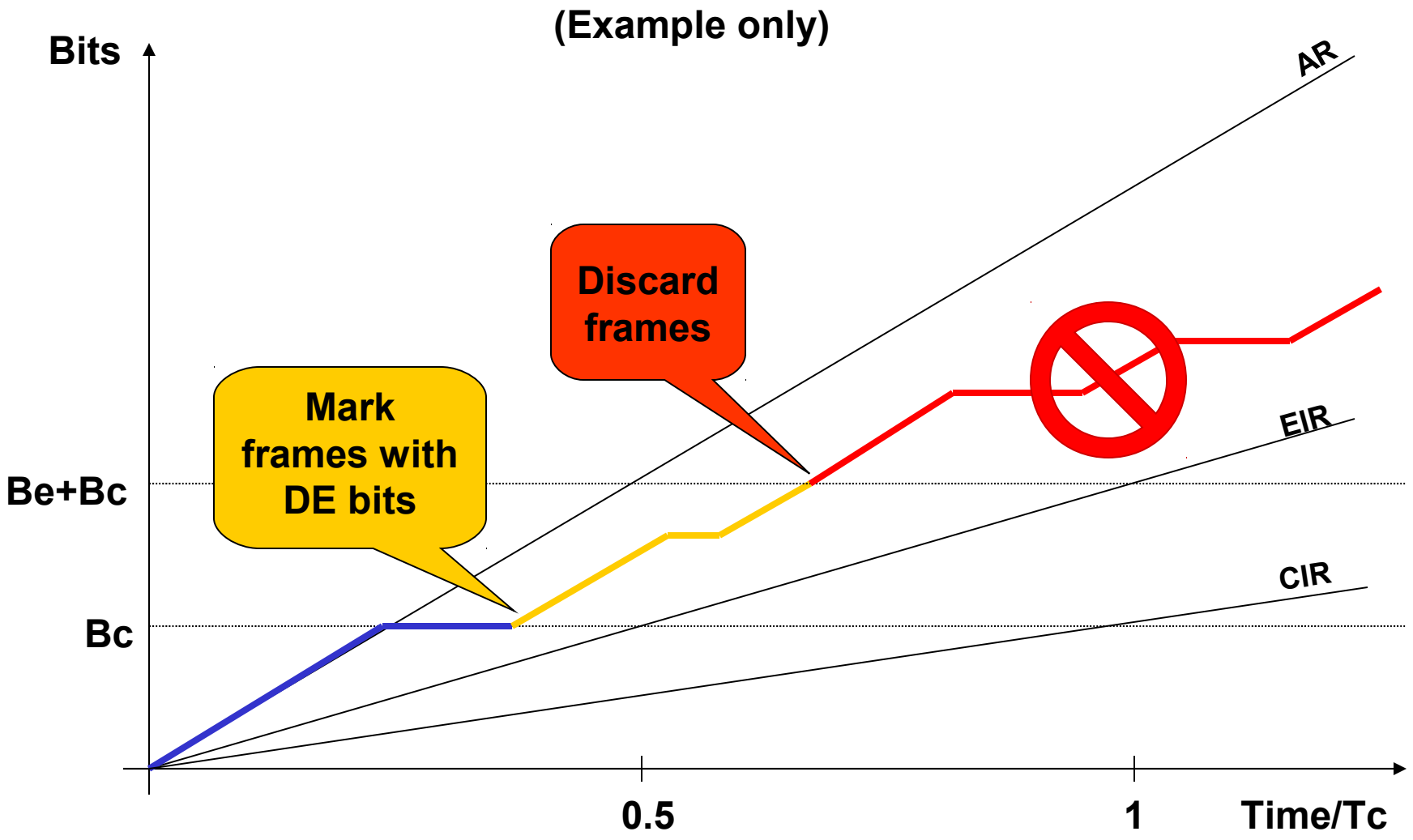
Traffic Shaping

- TB = Token Bucket (=Bc+Be)
- Maximal speed = TB/Tc
- Typically, traffic above maximal speed is buffered in a traffic shaping queue

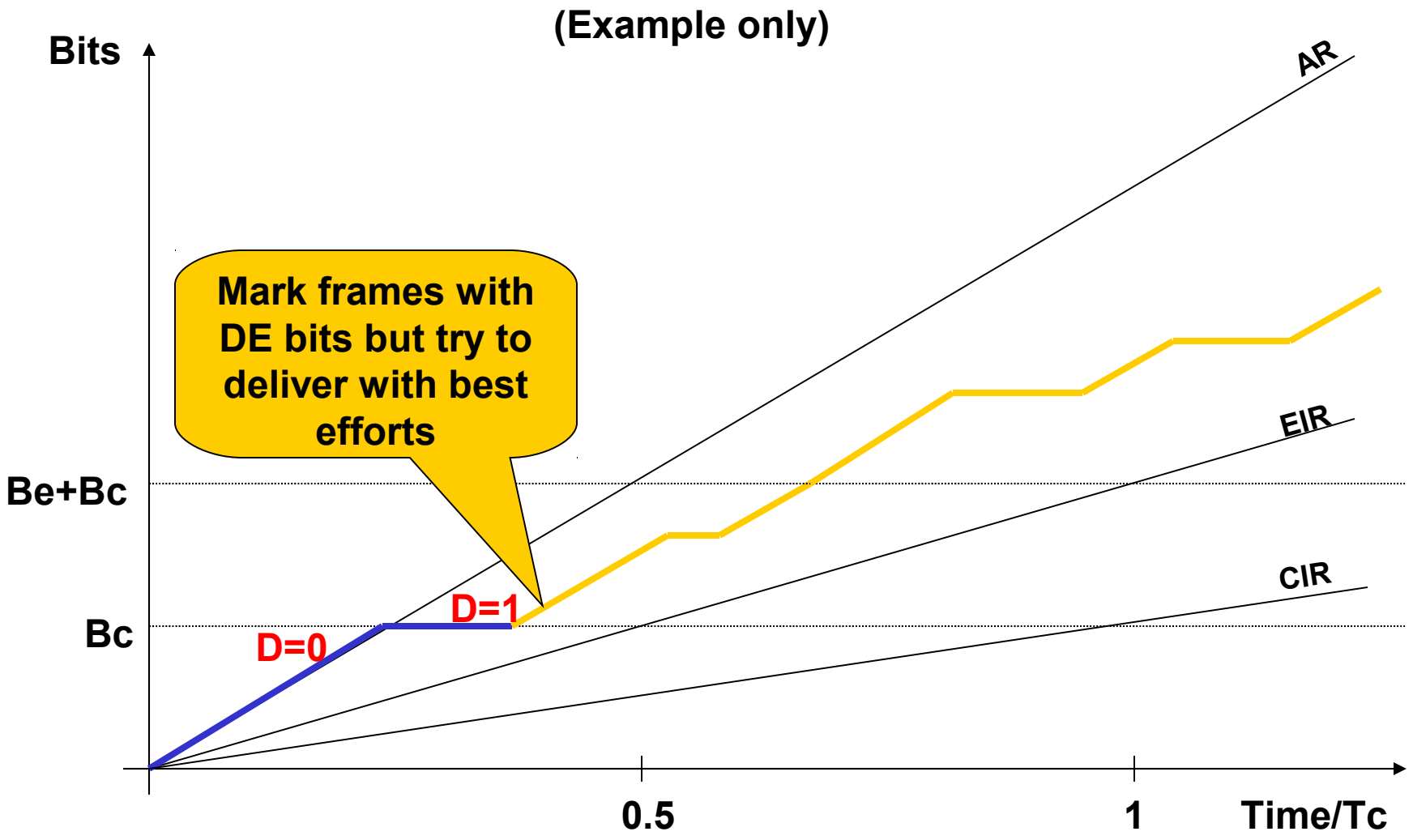
Traffic Shaping for Voice

- Tc<=10ms
  - Provides continuous traffic flow
- Additionally BECN can be used to decrease CIR
  - Cisco: MinCIR – Traffic shaping not calculated using provider-CIR but for higher values
  - On receiving of BECN traffic-rate is reduced to MinCIR (= Provider CIR)
- Cisco Proactive Trafficshaping: "Forsight"
  - Throttles traffic before congestion occurs
  - Only supported on Cisco FR-Switches

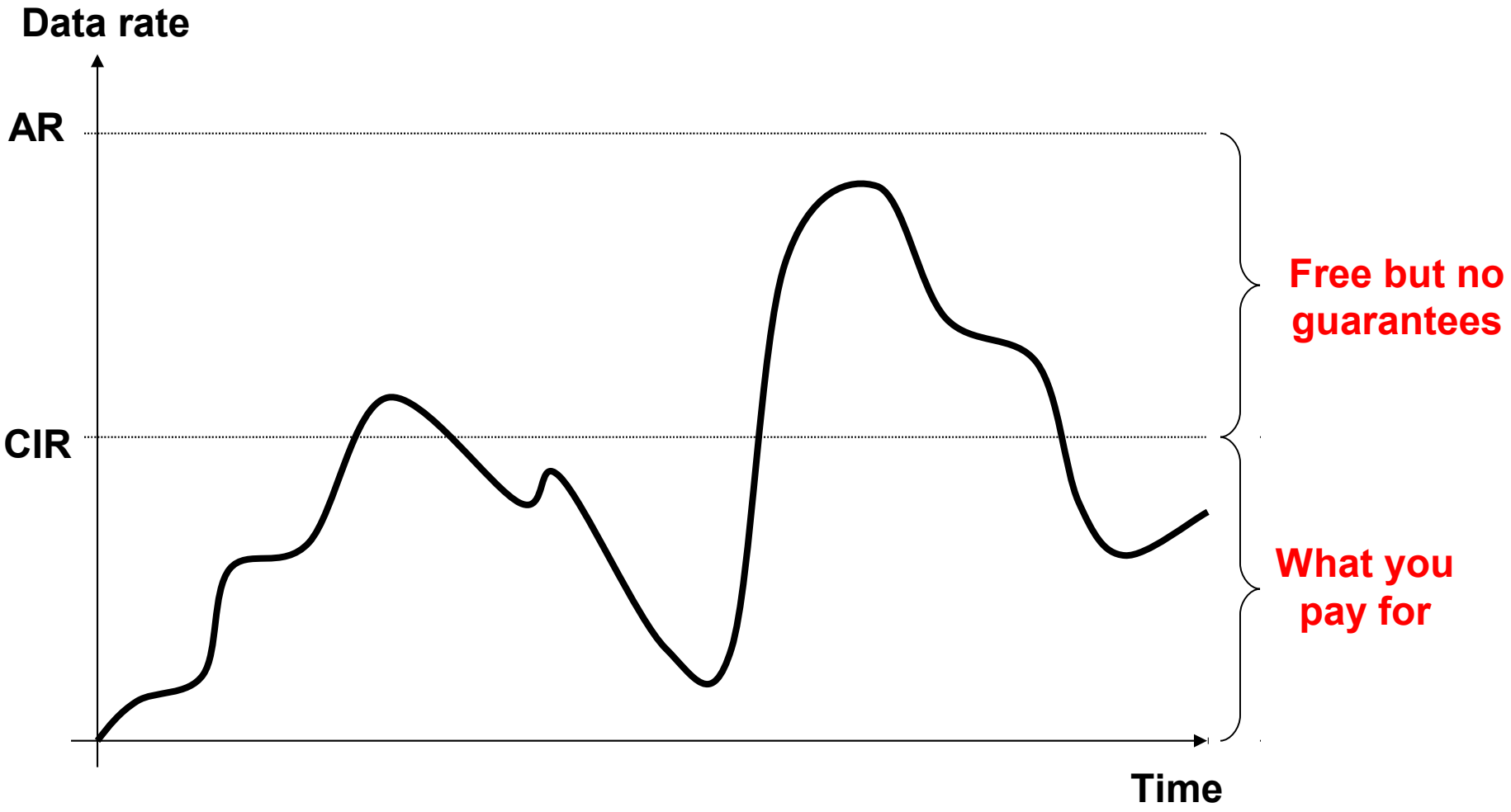
Traffic Management



Traffic Management (4)



Typical Provider Offering



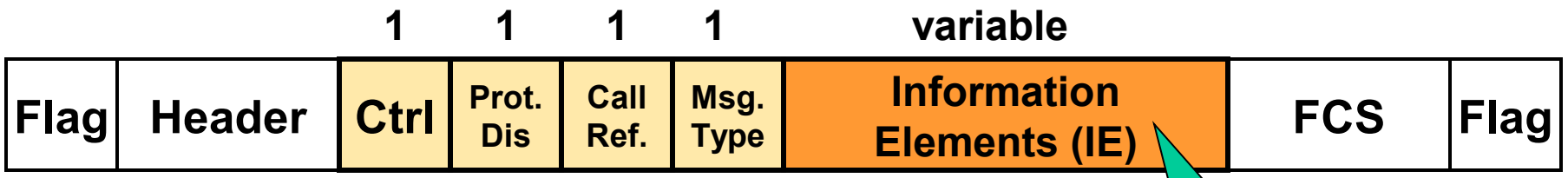
Local Management Interface

- LMI extends Frame Relay
  - Global Addressing
  - Status messages
  - Multicasting
- LMI is more of a protocol than an interface (!)

LMI Details

- Three LMI Types
  - ANSI T1.617 (Annex D)
  - ITU-T Q.933 (Annex A)
  - LMI (Original, FRF)
- No fragmentation of LMI messages (!)
  - MTU determines maximal PVC number
  - E.g. MTU 1500 allows 296 DLCIs

LMI Message Format



- LMI message is carried inside LAPF Frame
- Ctrl = 0x03 (UI)
- Protocol Discriminator
  - 00001000 (ANSI/ITU)
  - 00001001 (GOF)
- Call Reference
  - 00000000 (only used for SVC)
- Message Type
  - 0111 1101 (Status)
  - 0111 0101 (Status Enquiry)
  - 0111 1011 (Status Update, GOF only)

Contain PVC status information

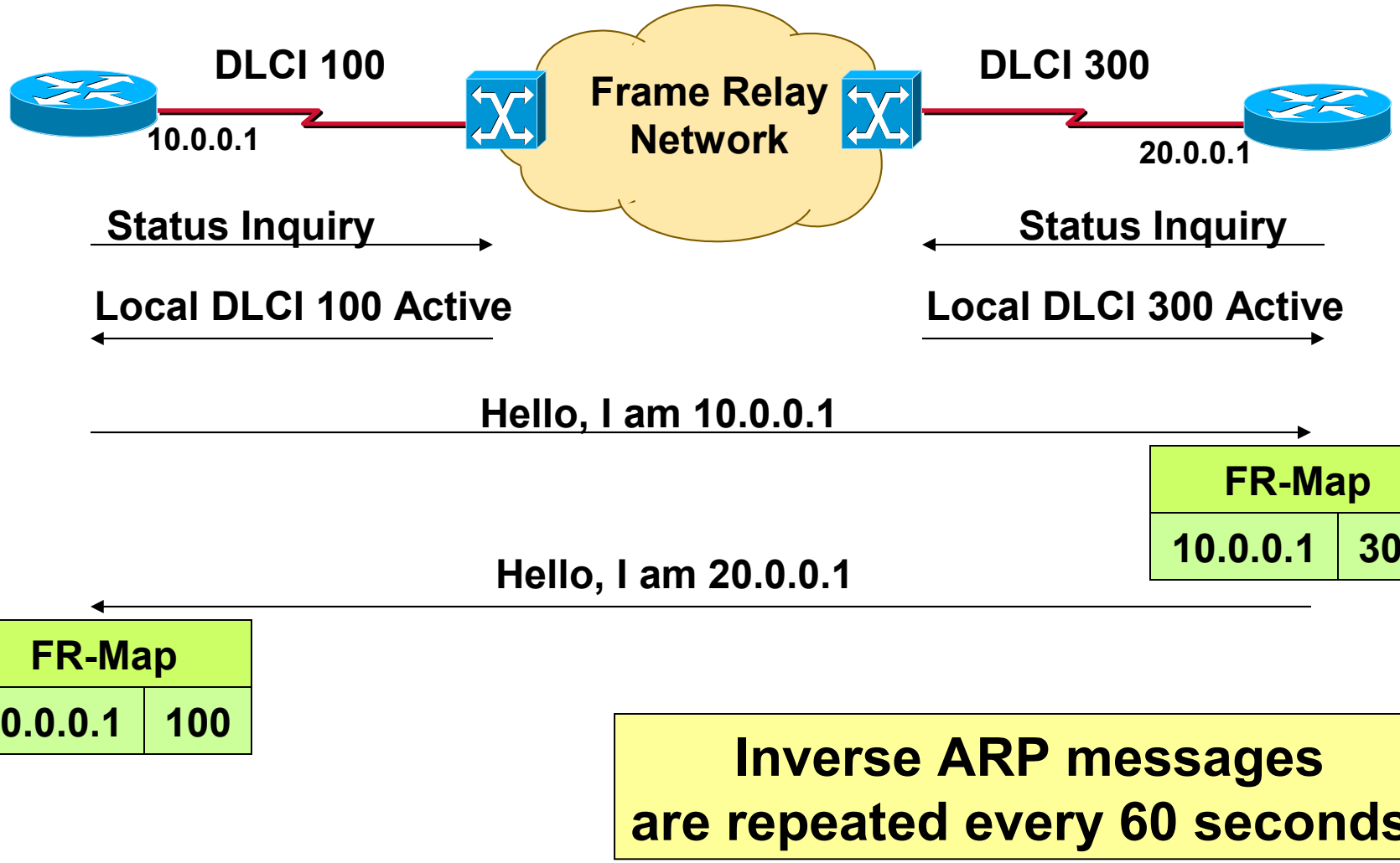
LMI Operation

- Every 10 seconds the DTE polls the DCE with a Status Enquiry message
  - Either for a dumb response ("Yes I'm here")
  - Or for a Channel status information
- (Full) Status Response
  - Contains information about VCs

Inverse ARP

- Automatic remote-node-address to local-DLCI mapping
  - Supports IP, IPX, XNS, DECnet, Banyan VINES, AppleTalk
- Extension of existing ARP
- Not only for Frame Relay
- RFC 1293

Inverse ARP and LMI Operation

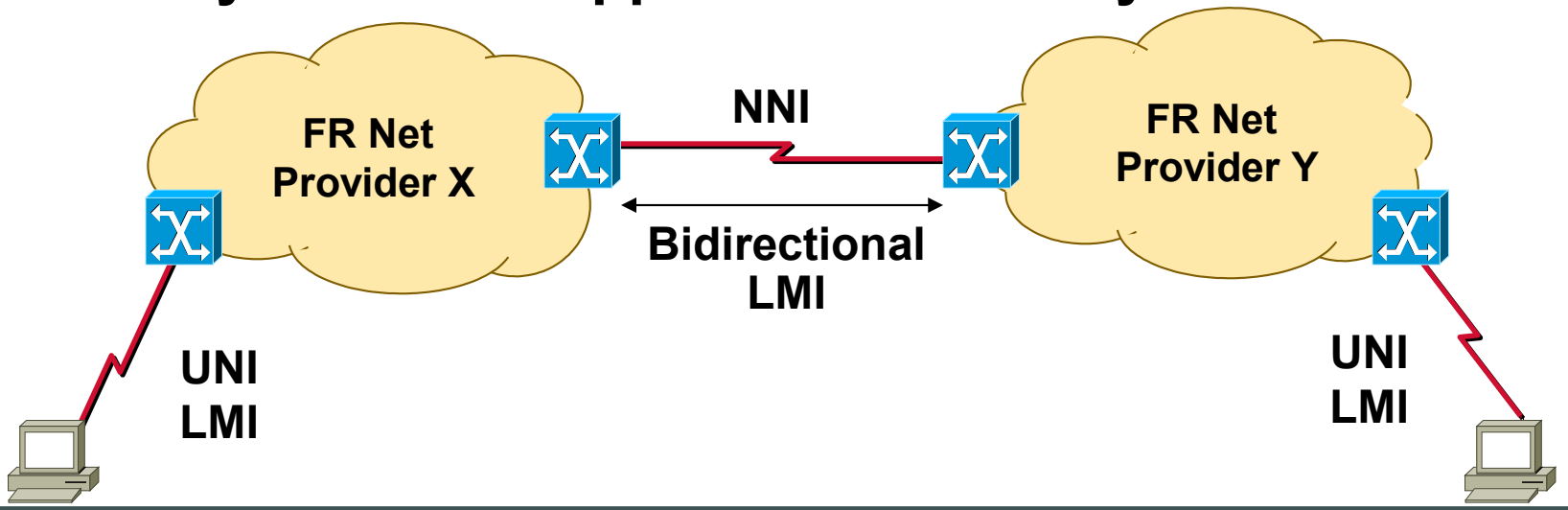


DLCI Plan

- 0 — LMI (ANSI, ITU-T) or FRF In-channel signaling
- 1023 — LMI (FRF) or ITU-T/ANSI In-channel signaling
- 1-15 — reserved
- 993-1007 — Frame Relay bearer service Layer 2 management (ANSI/ITU-T)
- 1008-1018 — reserved
- 1019-1022 — multicast connections
- FRF: Usable DLCIs from 16 to 1007
- ANSI/ITU-T: Usable DLCIs from 16 to 992

Bi-directional LMI (1)

- Standards LMI is unidirectional
  - Sufficient for UNI signaling
- NNI signaling requires a bi-directional LMI variant
  - PVC status must be reported in both directions
  - Symmetrical approach necessary



Bi-directional LMI (2)

- Using Bi-LMI each network is notified about PVC status in the other network
- Only supported by ITU-T and ANSI
  - DLCI 0
  - Not defined by GOF
- Additional fields
  - Inactivity reason, country code, national network identifier

Summary

- Frame Relay has reduced overhead compared to X.25
- Outband signaling (LMI)
- Efficient for bursty traffic
  - Parameters (Bc, Be, Tc or CIR, EIR)
- Congestion Notification
  - FECN, BECN
- Frame Relay Forum, ITU-T, and ANSI

Quiz

- What's the Tc when using Voice over Frame Relay?
- What's the main difference between FR and Ethernet, when putting IP upon them?
- What's the typical practical usage of BECN?

Hints

- Q1: Milliseconds (min 10 ms)
- Q2: Broadcast medium. Main problem with routing protocols
- Q3: BECN is used by the provider to throttle the customer if he violates the traffic contract