Frame Relay Analysis and Emulation

GL Communications Inc.

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FrameRelay Analysis and Emulation over T1 E1
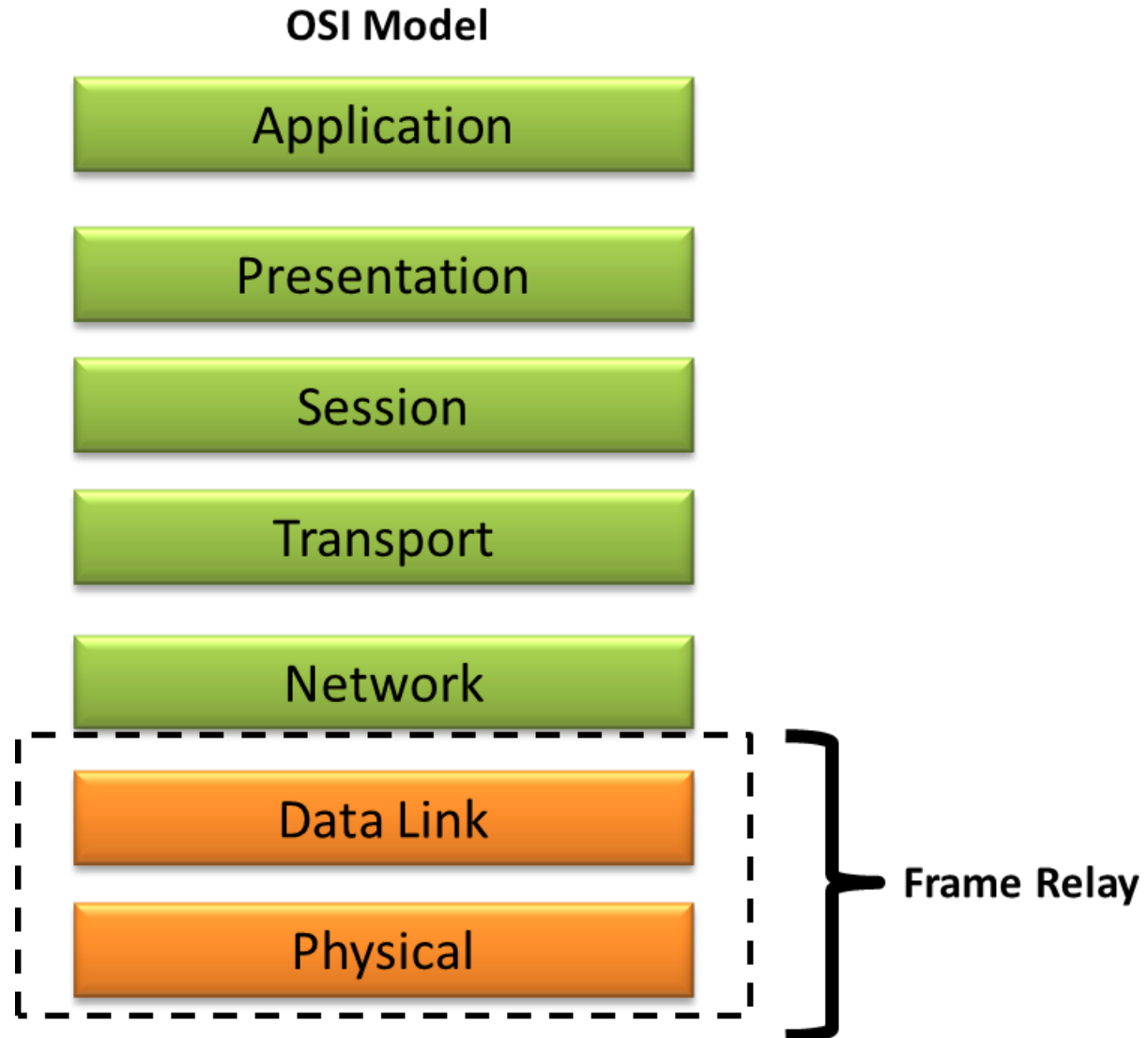
Why use Frame Relay?

- Reduced Overhead –

  - Much faster

  - Lower delays

  - Requires reliable links

- Outband signaling

- Good for bursty and variable traffic

- Cost effective multiplexed communications interface

- Congestion control

Protocol Features

- Connection –oriented WAN technology based on packet (frame) switching

- Frames of variable length (up to 4096 bytes, typically 1600 bytes)

- High data rates at user-network interfaces (2Mbps, ultimately up to 45 Mbps)

- Bandwidth on demand

- No flow control mechanisms (nearly)

- No error control (but FCS) or retransmission mechanisms

- All protocol functions implemented at 2nd level (data link) of OSI model

- No standards for physical interface: can be X.21, V.35, G.703, G.704

- Option to create multiple aggregate column groups and prioritize the groups as per the requirement to display the summary results efficiently

- Allows the user to create search/filter criteria automatically from the current screen selection
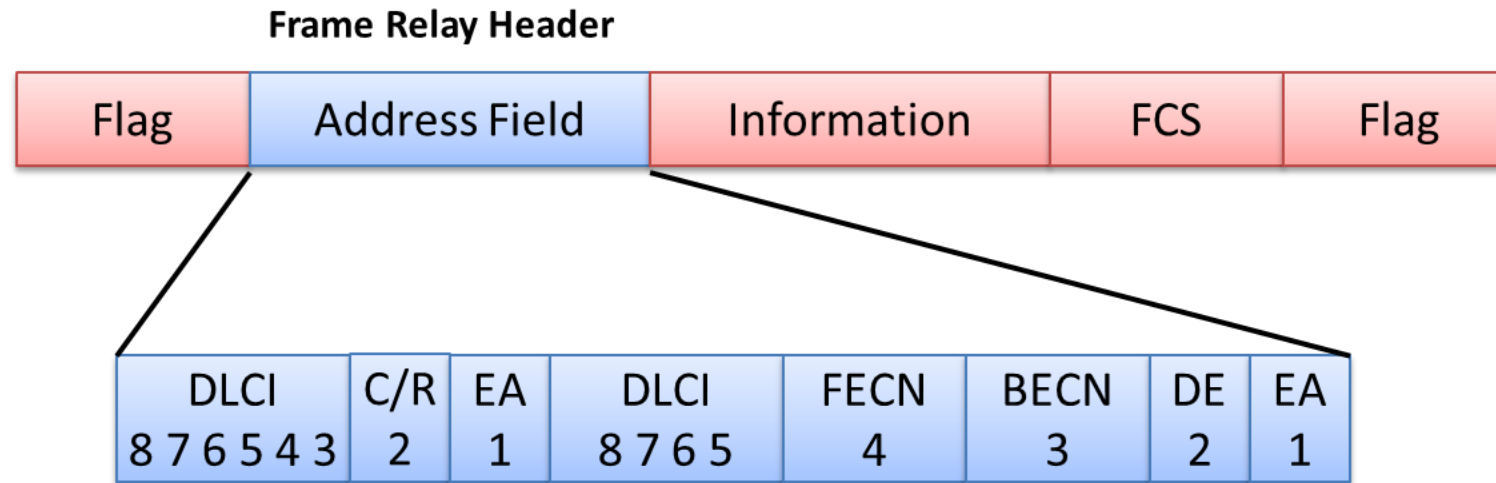
Frame Relay in OSI Layer

Frame Relay Network

- Data Terminal Equipment (DTE) – User device and the logical frame relay end-system
- Data Communication Equipment (DCE) – Comprises of modems and packet switches
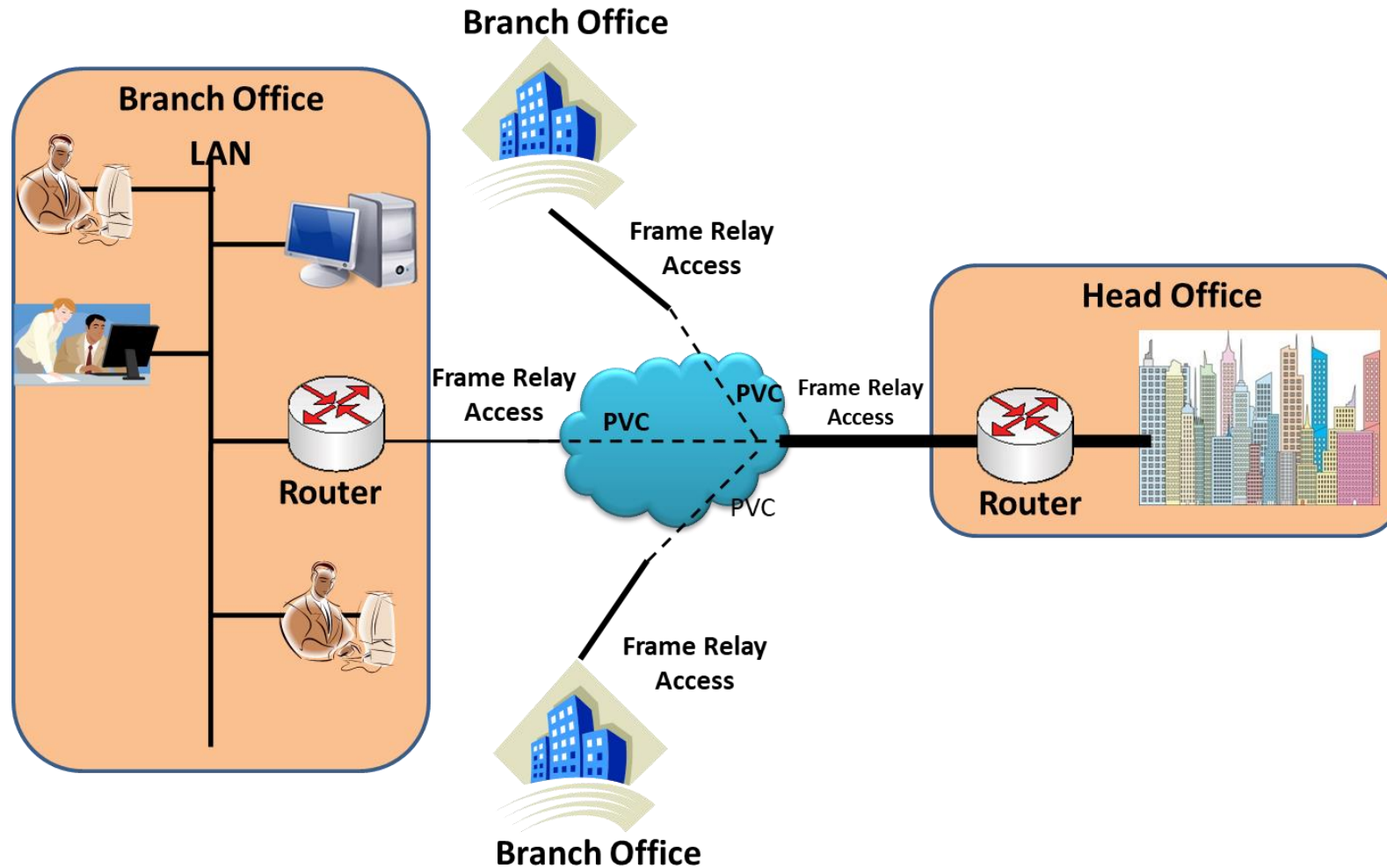
Frame Relay Structure

- Frame Relay structure is based on the LAPD protocol
- Frame Relay header consists of DLCI, C/R, EA, FECN, BECN, and DE

Frame Relay Header

Flag	Address Field	Information	FCS	Flag

DLCI 8 7 6 5 4 3	C/R 2	EA 1	DLCI 8 7 6 5	FECN 4	BECN 3	DE 2	EA 1

Frame Relay Header Structure

DLCI – Datalink Connection Identifier
C/R – Command/Response
EA – Extended Address field
FECN – Forward Explicit Congestion Notification
BECN – Backward Explicit Congestion Notification
DE – Discard Eligibility

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Communications

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Frame Relay Interface Types

- User–to–Network Interface (UNI)

  ➢ The DTE and DCE interfaces act as fragmentation and reassembly peers; UNI (DTE-DCE) fragmentation is used in order to allow real-time and data frames to share the same UNI interface between a DTE and the Frame Relay Network

- Network-to-Network Interface (NNI)

  ➢ NNI connects different Frame Relay networks together

  ➢ NNI interface standardizes DCE to DCE communication
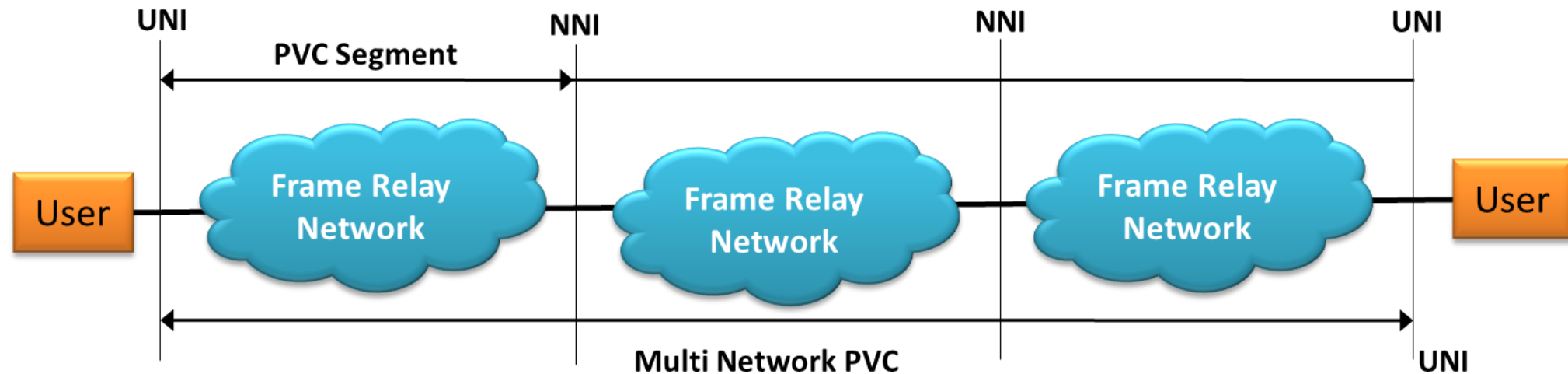
Fragmentation

- Fragmentation allows to fragment long data frames into a sequence of shorter frames that are then reassembled into the original frame by the receiving peer DTE or DCE

- FRF.12 supports three fragmentation applications:

- Locally across a Frame Relay UNI interface between the DTE/DCE peers

- Locally across a Frame Relay NNI interface between DCE peers

- End-to-End between two Frame Relay DTEs interconnected by one or more Frame Relay networks
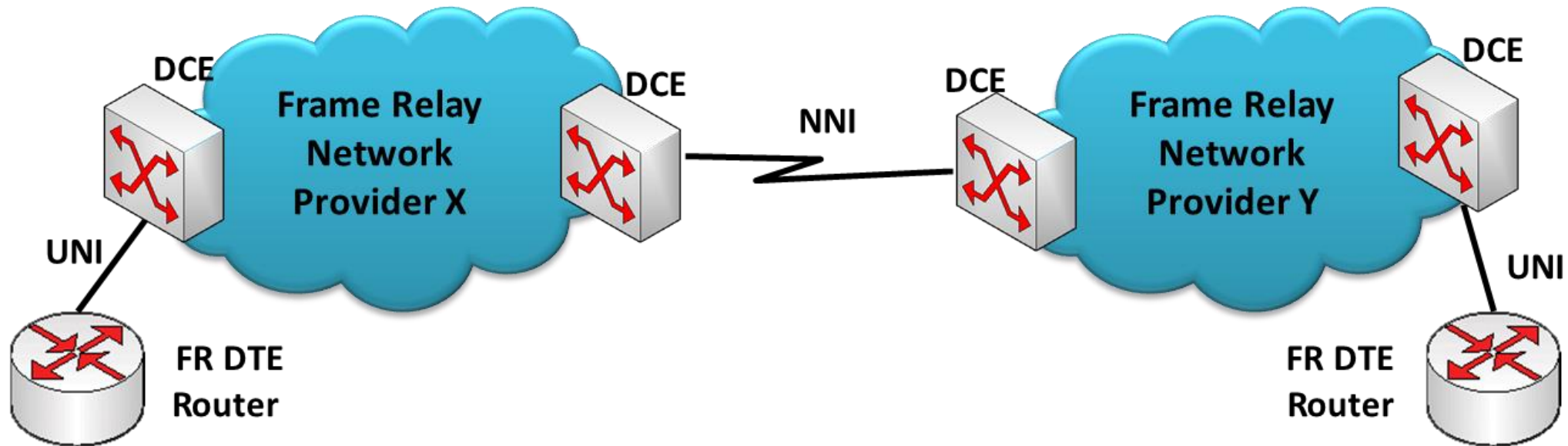
Advantages

- Multiple virtual circuits can exist simultaneously across a given transmission line since virtual circuits consume bandwidth only when they transport data

- Each device can use more of the bandwidth as necessary, and thus operate at higher speeds

- Discard erroneous frames and eliminate time-consuming error-handling processing

GL's Frame Relay Analyzer
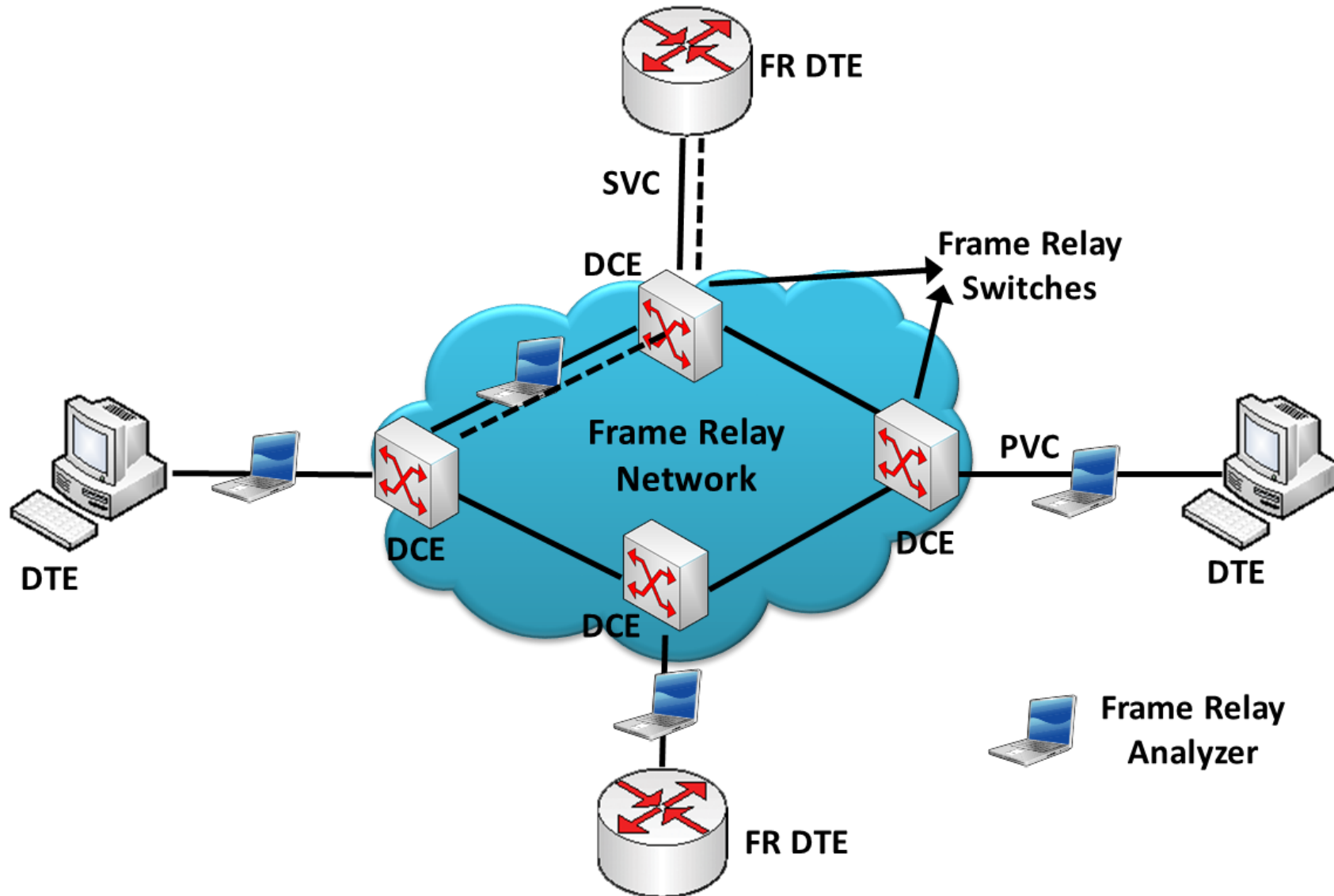
Supported Platforms

Front Panel

Back Panel

tProbe™ - Portable USB based T1 E1 VF FXO FXS and Serial Datacom Analyzer

Quad / Octal T1 E1 PCIe Card
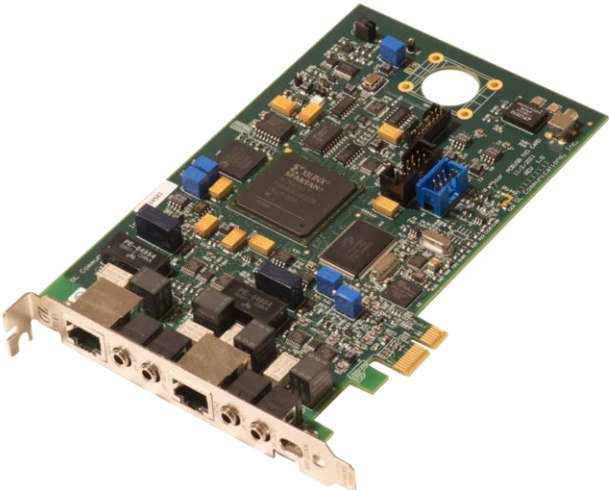
Dual T1 E1 Express (PCIe) Board

tScan16™ with 16-port T1 E1 Breakout Box
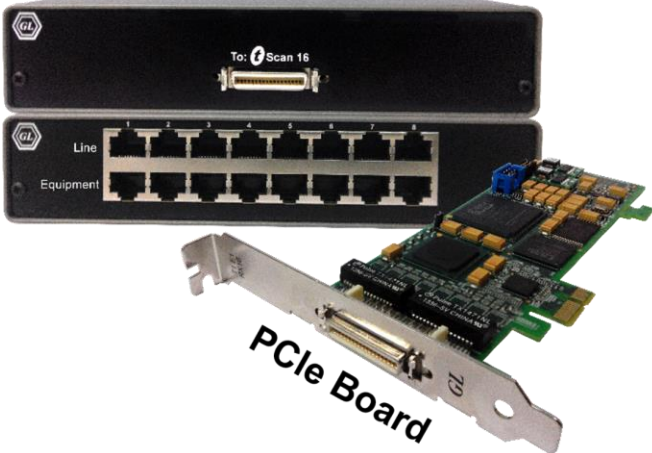
PCIe Board

Supported Protocols

- **LAPF** – Enhanced version of LAPD (Q.921) and decodes Layer 2 as Link Access Procedure/Protocol (LAPF) as defined in the ITU Q.922

Frame Relay Analysis

Different Views

- Summary View: This pane displays the columns that contain Card Number, Timeslots, Frame Number, Time, Frame Error Status, Command/Response, Length, Error, C/R, SAPI, CTL, P/F, FUNC, and more in a tabular format

- Detail View: This pane displays in detail about a frame in order to analyze and decode by selecting it in the summary view

- Hex Dump View: This pane displays the frame information in HEX and ASCII format

- Statistics View: This pane displays the Statistics that are calculated based on the protocol fields

Real-time Analysis

Real-time Analysis

- Streams can be captured on the selected time slots (contiguous or non-contiguous), sub-channels (fractional DS0 to DS1) or full bandwidth

- Frames may also be contained in either one, n x 64 kbps, or n x 56 kbps data channels

- Capture frames based on Frame Relay options such as fragments and maximum differential delay

- Frames may also be captured based on their FCS (16 bits, 32 bits, none), bit inversion, octet bit reversion, user/network side options

- Recorded trace file can then be analyzed offline, exported to ASCII file, or printed

Offline Analysis

- Off-line analysis is equivalent to capturing a file in pre-defined timeslots

- Captured frames or only the filtered frames can be exported to *.HDL file for the further off-line analysis

- Trace file for offline analysis can be loaded either through analyzer GUI or through simple command-line arguments
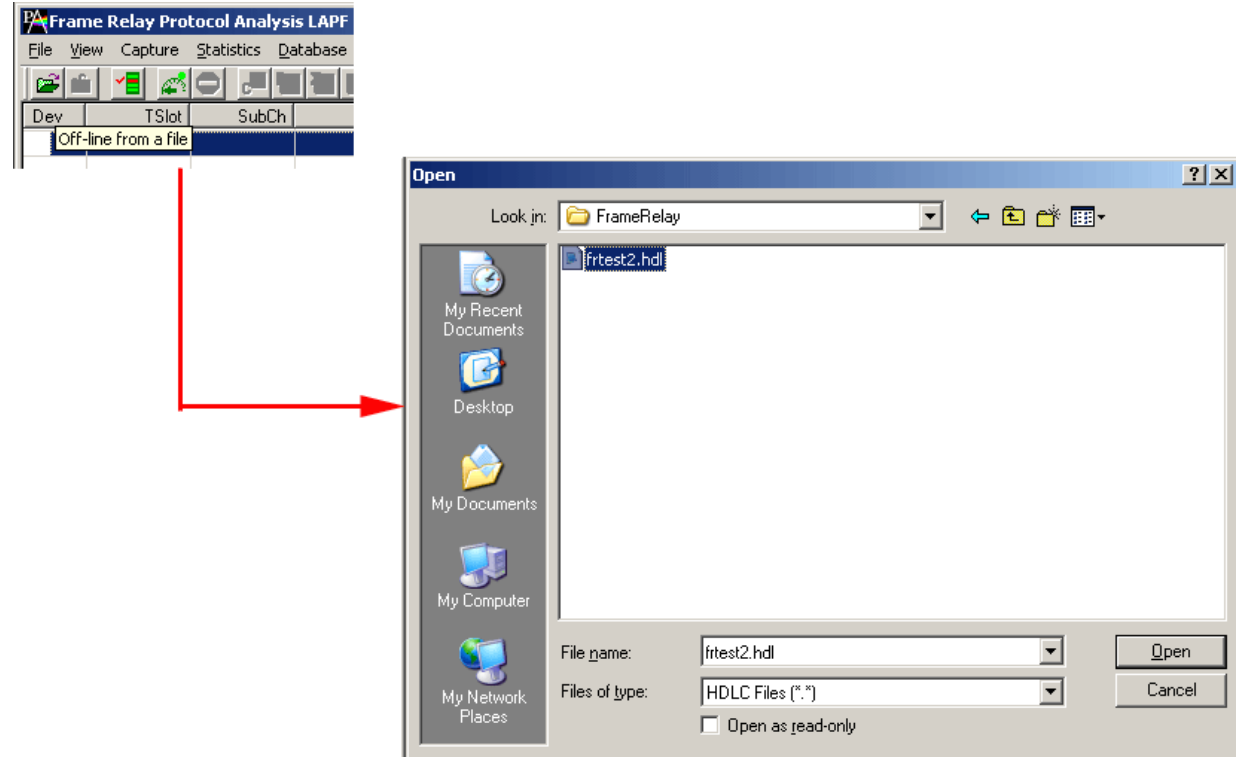
Offline Analysis using CLI

Other Features

- Call trace defining important call specific parameters such as call ID, status (active or completed), duration, calling number, called number, release complete cause etc. are displayed

- Filter Frames (Real-time): Isolate certain specific frames from all frames in real-time as well as offline

- Filter Frames (Offline): The frames can be filtered after completion of capture based on BECN, FECN, DLCI, DE, NLPID, IP source and destination address, TCP & UDP source and destination port.

- Search features helps users to search for a particular frame based on specific search criteria

- Capability to export summary view details to comma separated values (CSV) format for subsequent import into a database or spreadsheet

- Capability to export detail decode information to an ASCII file

Filter Frames (Real-time)

- Isolate certain specific frames from all frames in real-time as well as offline

- Real-time Filter applies to the frames being captured and is based on the frame length
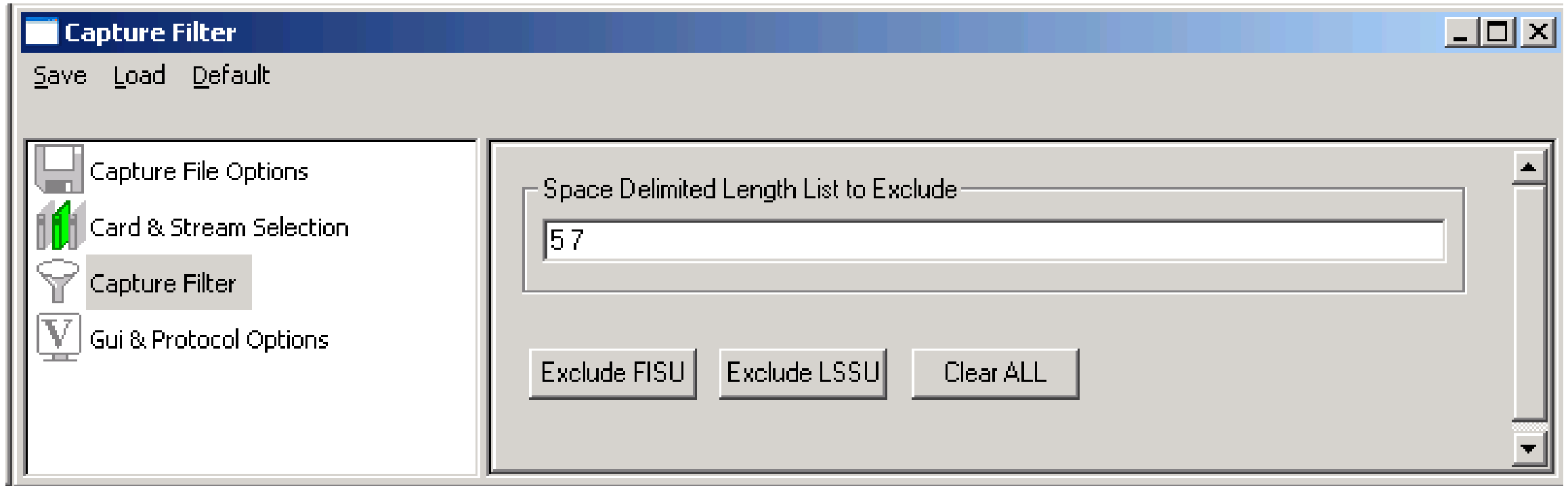
Filter Frames (Offline)

- Isolates required frames from all frames in real-time, as well as offline
- The frames can be filtered after completion of capture based on BECN, FECN, DLCI, DE, NLPID, IP source and destination address, TCP & UDP source and destination
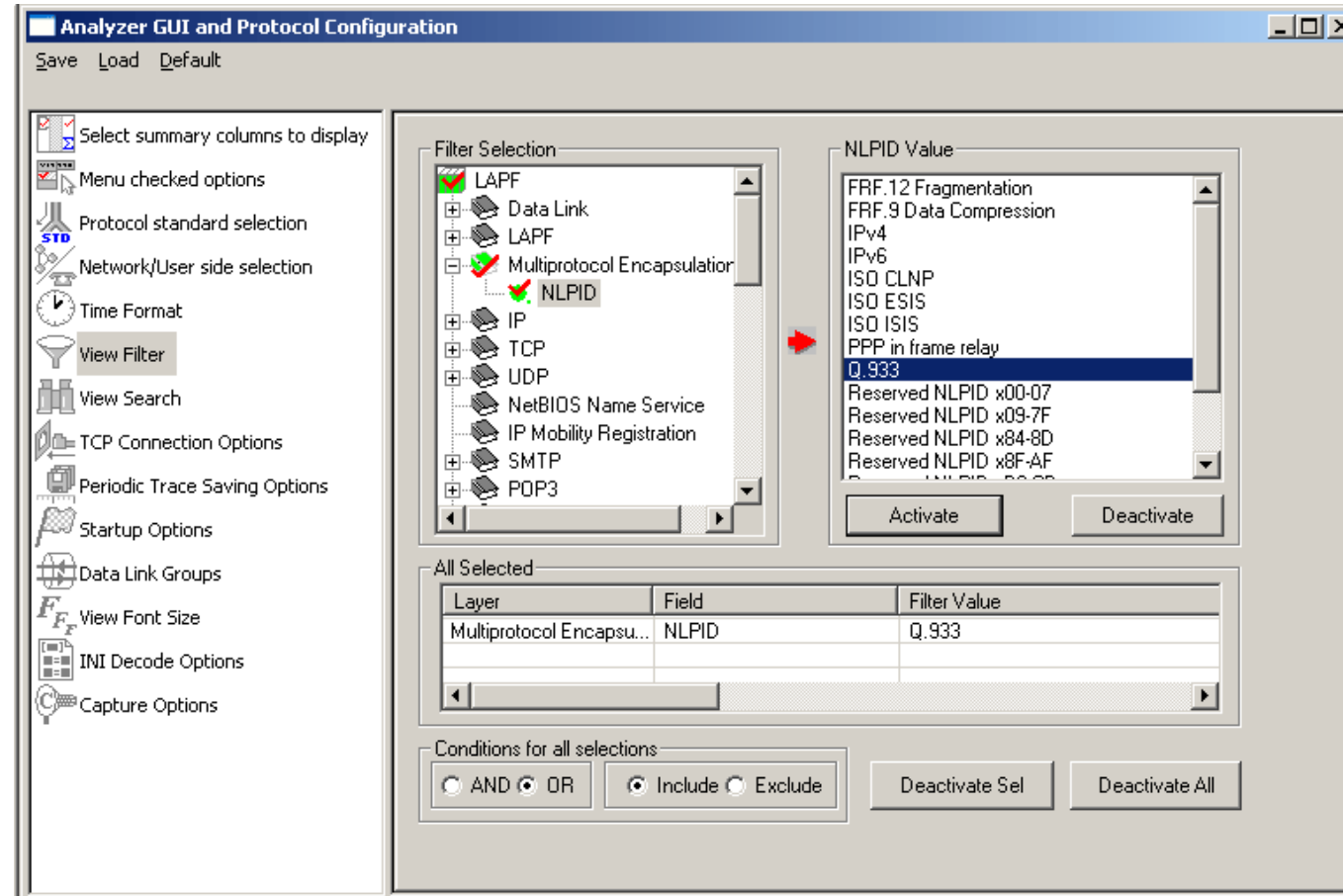
Search Frames

- Search features helps users to search for a particular frame based on specific search criteria
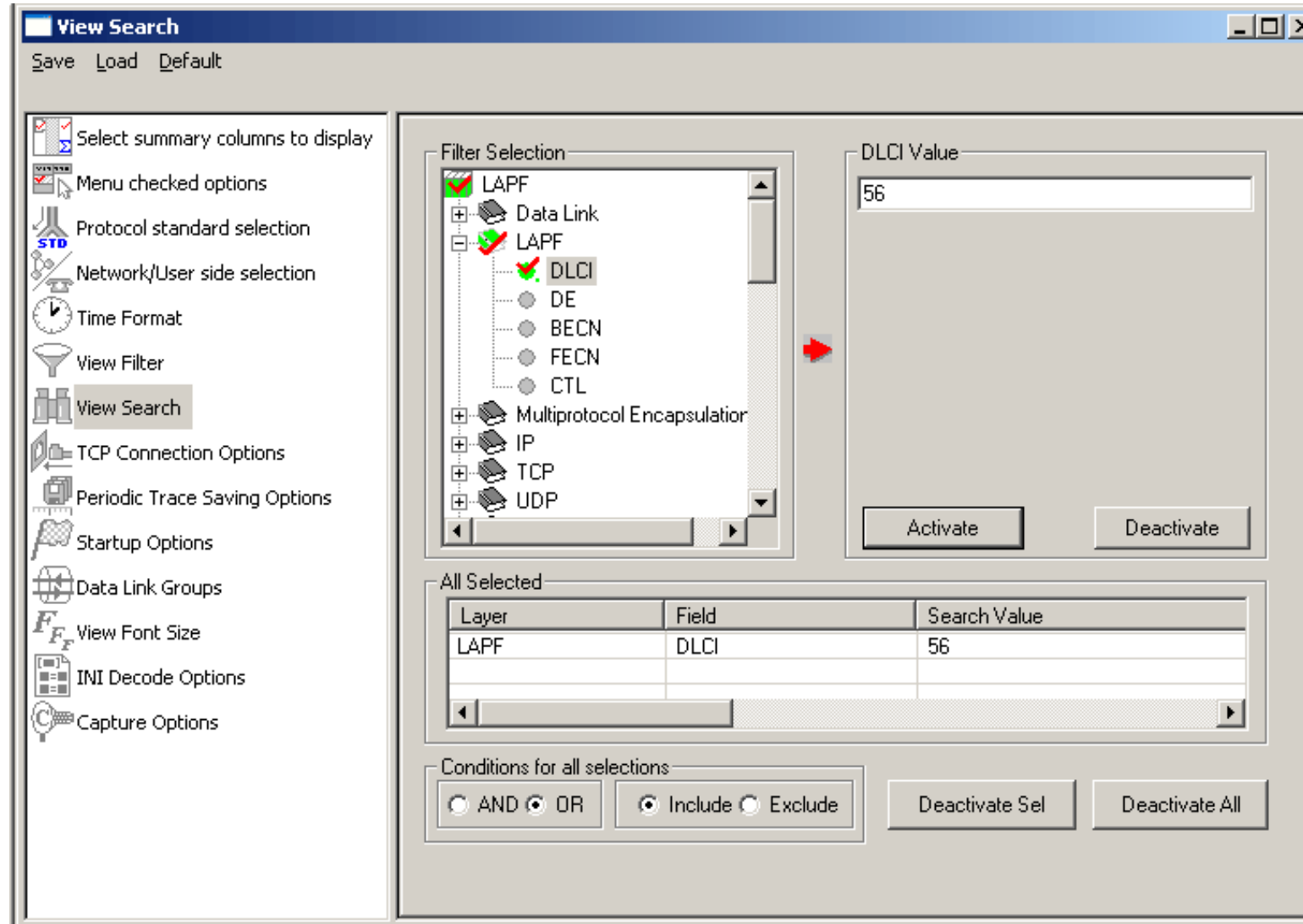
Filtering Criteria From Screen Selection

- Allows the user to create filter criteria automatically from the current screen selection

Search Criteria From Screen Selection

- Allows the user to create search criteria automatically from the current screen selection

Statistics

- Numerous statistics can be obtained to study the performance and trend in the network

Call Detail Records View

- Call trace defining important call specific parameters such as call ID, status (active or completed), duration, calling number, called number, release complete cause etc. are displayed

Saving a File

- Captured trace files can be controlled by saving the trace using different conventions such as –

  - ➢ Trace files with user-defined prefixes

  - ➢ Trace file with date-time prefixes

  - ➢ Slider control to indicate the total number of files, file size, frame count, or time limit

Define Summary Columns

- Add or remove any protocol fields through Define Summary Column option

Selection of Summary Column

Output display in analyzer

Aggregate Group Column

- The user can create multiple aggregate column groups and prioritize the groups as per the requirement to display the summary results efficiently

Data Link Group

- Data link groups that help in defining the direction of the calls in each network and form logical groups comprised of unidirectional (either 'Forward' or 'Backward') data links

TCP Connection Options

- Used for Network Surveillance and Monitoring

- Designed to send protocol summary information and binary frame data via TCP- IP connection to a Database Loader to load data into a database
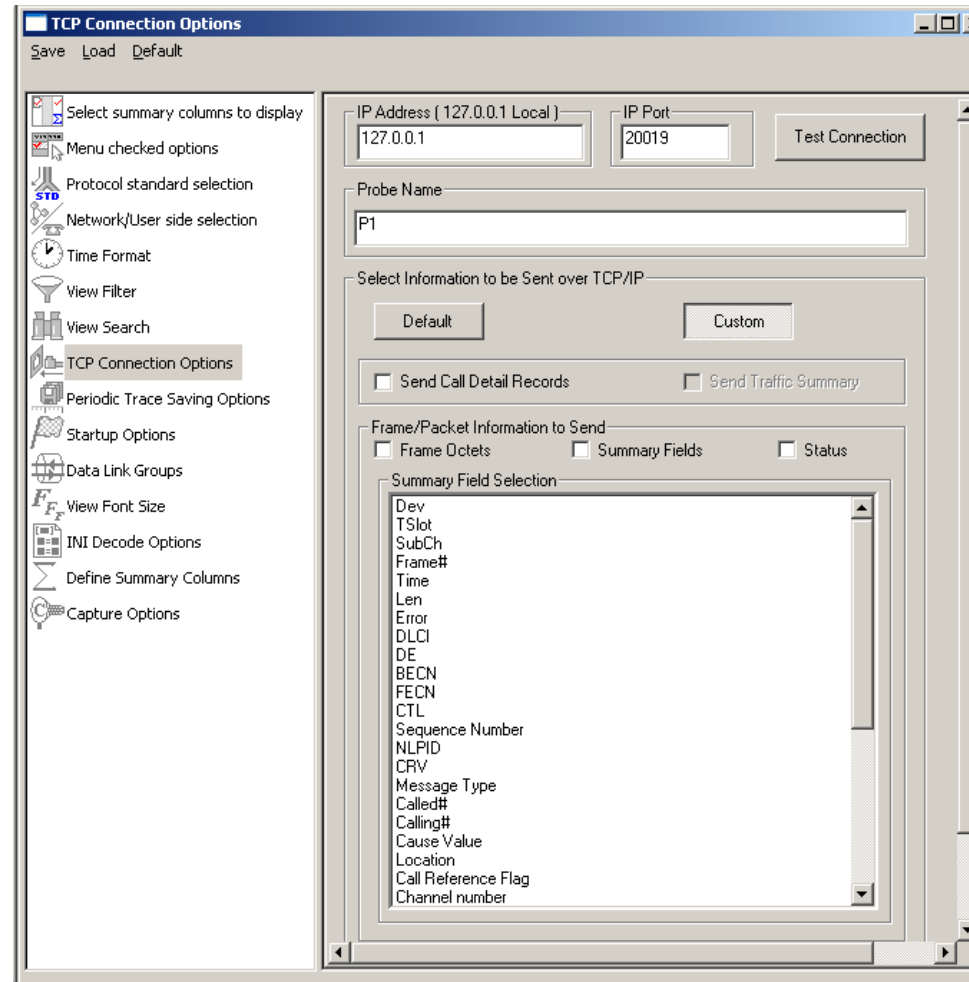
Save/Load All Configuration Settings

- Protocol Configuration window provides a consolidated interface for all the settings required in the analyzer such as protocol selection, filter criteria, search criteria, and so on

- Configuration settings can be saved to a file, loaded from a configuration file, or user may just revert to the default values using the default option
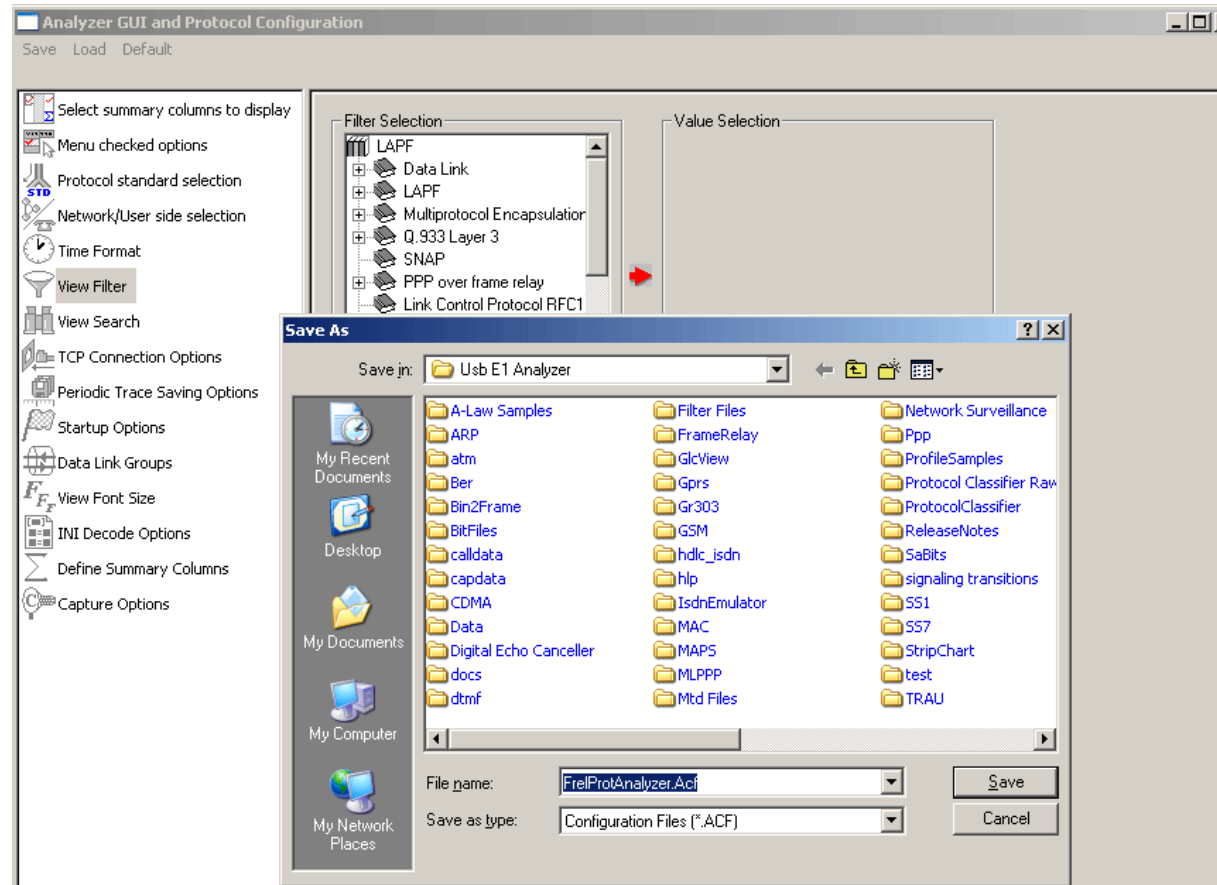
Applications

- Can be used as independent standalone units as "probes" integrated in a network surveillance systems

- Triggering, collecting, and filtering for unique subscriber information and relaying such information to a back-end processor

- Collecting Call Detail Records (CDR) information for billing

- Numerous statistics can be obtained to study the performance and trend in the network

Multi-Link Frame Relay Emulation using Client-Server

MFR Emulator

- GUI based WCS client, which simulates Multi-Link Frame Relay Emulation
- Capable of generating and receiving MFR/FR traffic (with or without impairments)
- Traffic source can be sequence number, HDL files (containing packets/frames), flat binary file, user-defined frames (ASCII HEX file), and Ethernet data

FR Simulation

MFR Simulation

Supported Standards

- FRF12 – This supports Frame Relay Fragmentation Implementation Agreement

Features

- Performs MFR as well as FR simulation on up to 16 T1 E1 lines; Group FR links to create a MFR bundle with each bundle/link configured with multiple virtual channels for traffic Tx/Rx

- FR links can be created on Full or Fractional Timeslots

- Supports hyper channels with discontinuous (sparse) timeslots

- Dynamically add/remove (open/close) of Frame Relay links without loss in data

- Multiple MFR Bundles/FR links can be created

- Generate and verify end to end traffic on each Virtual Channel

- User configurable FR/MFR packet and fragment size, bandwidth using flags, and maximum link differential delay

- Payload traffic generation and verification using Sequence number, pre-captured HDL files (containing packets/frames), Flat Binary file, and User defined frame (ASCII HEX file) for each Virtual Channel independently

Features

- Supports both Interface (UNI and NNI) and End-to-End fragmentation

- Transmit and receive Ethernet traffic over T1 E1 links by operating either in bridge or router mode

- Supports various Byte level, Frame level , CRC error, and Frame error impairments at link level

- Supports various Byte level and Frame level impairments at Fragment/Packet level for each Virtual Channel

- Provides detailed statistics for each bundle and virtual channels associated with a bundle

- Provides end to end traffic verification statistics

- Ideal solution for automated testing using command line scripts

FR Simulation

Adding Links

- Supports up to 16 T1 E1 links

- Timeslot of 64 Kbps or a Hyper Channels of n*64 Kbps or sub channels can also be used

- Supports hyper channels with continuous or discontinuous timeslots

- Each link is independent and can be configured with the selected 'Link Config' options

Added Links
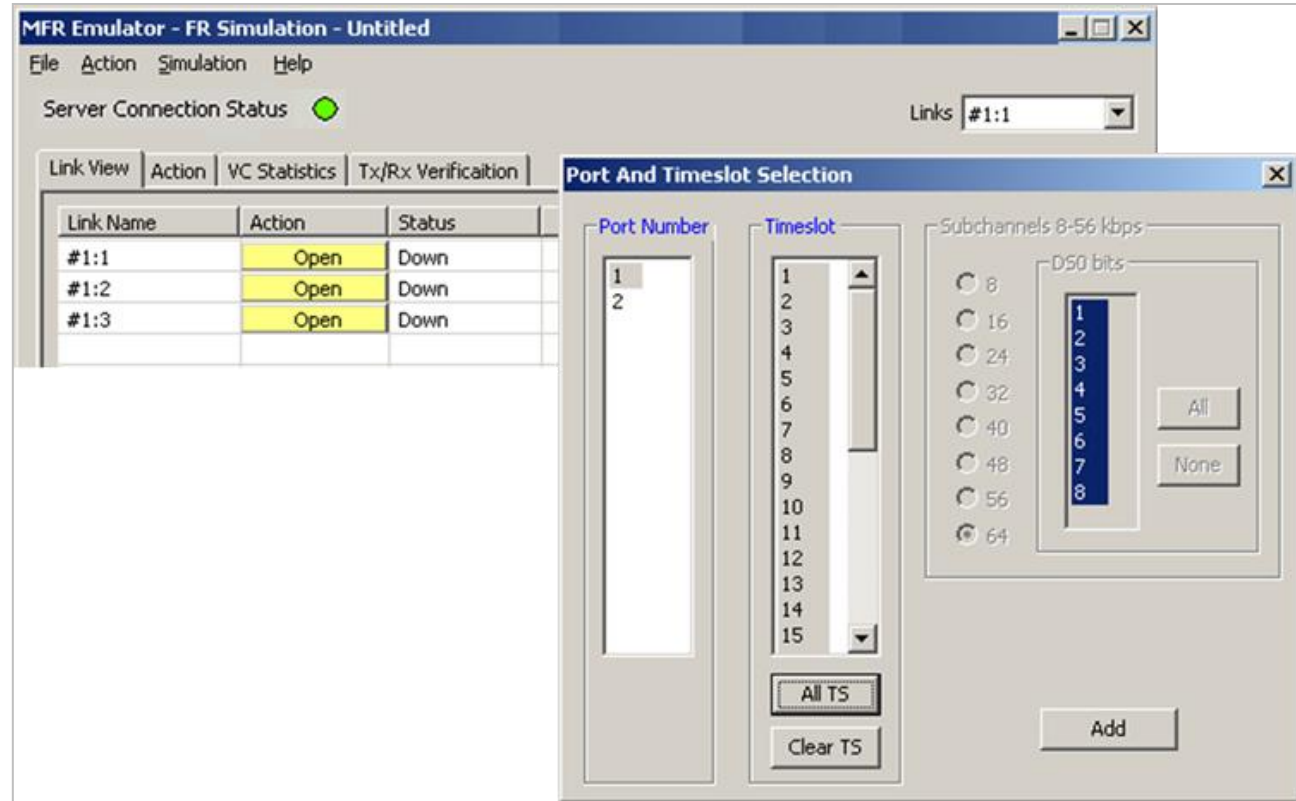
Link Configuration

Link configuration is an optional feature, and the following values are negotiated when enabled

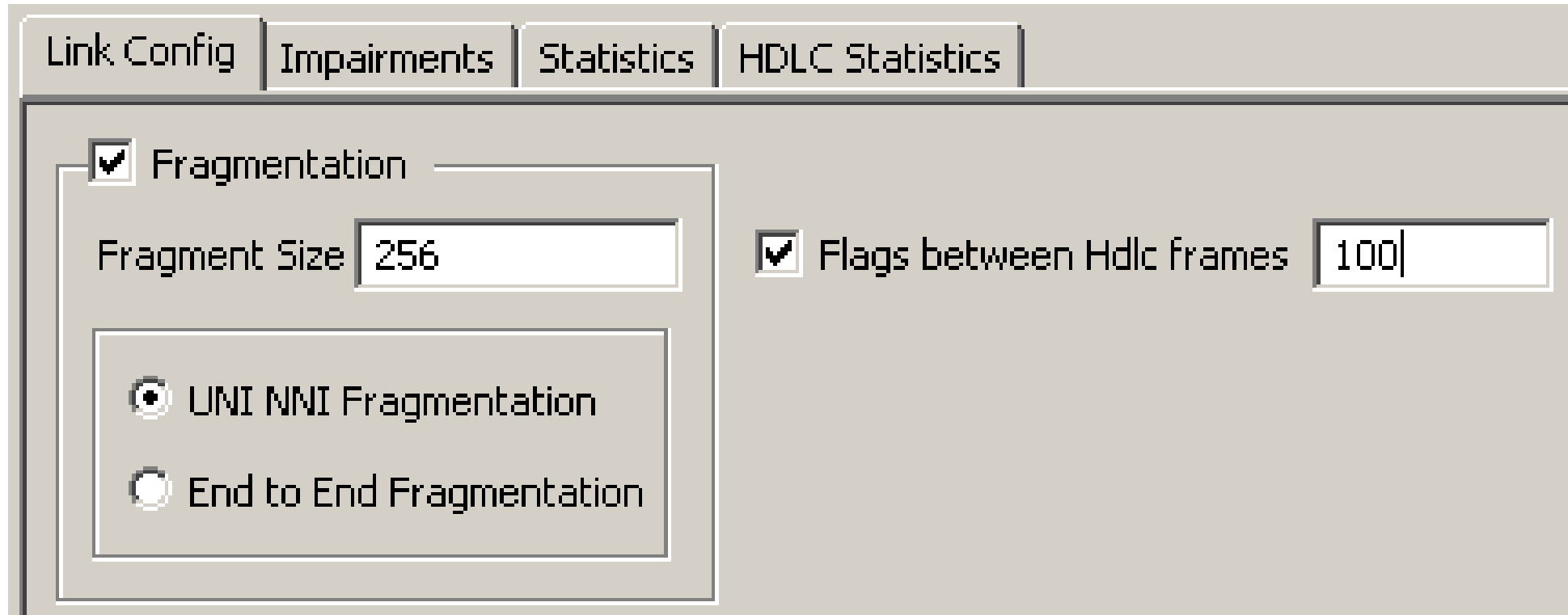- Fragmentation Size: By default, the fragment size is 256. User can specify Fragment Size as required
- UNI NNI Fragmentation
- End to End Fragmentation
- Flags between Hdlc frames: This defines the number of flags to be inserted between HDLC frames the default value is 100

UNI NNI Fragmentation

- UNI NNI Fragmentation: In UNI and NNI fragmentation, the frame starts with the fragmentation header, followed by the Frame Relay header
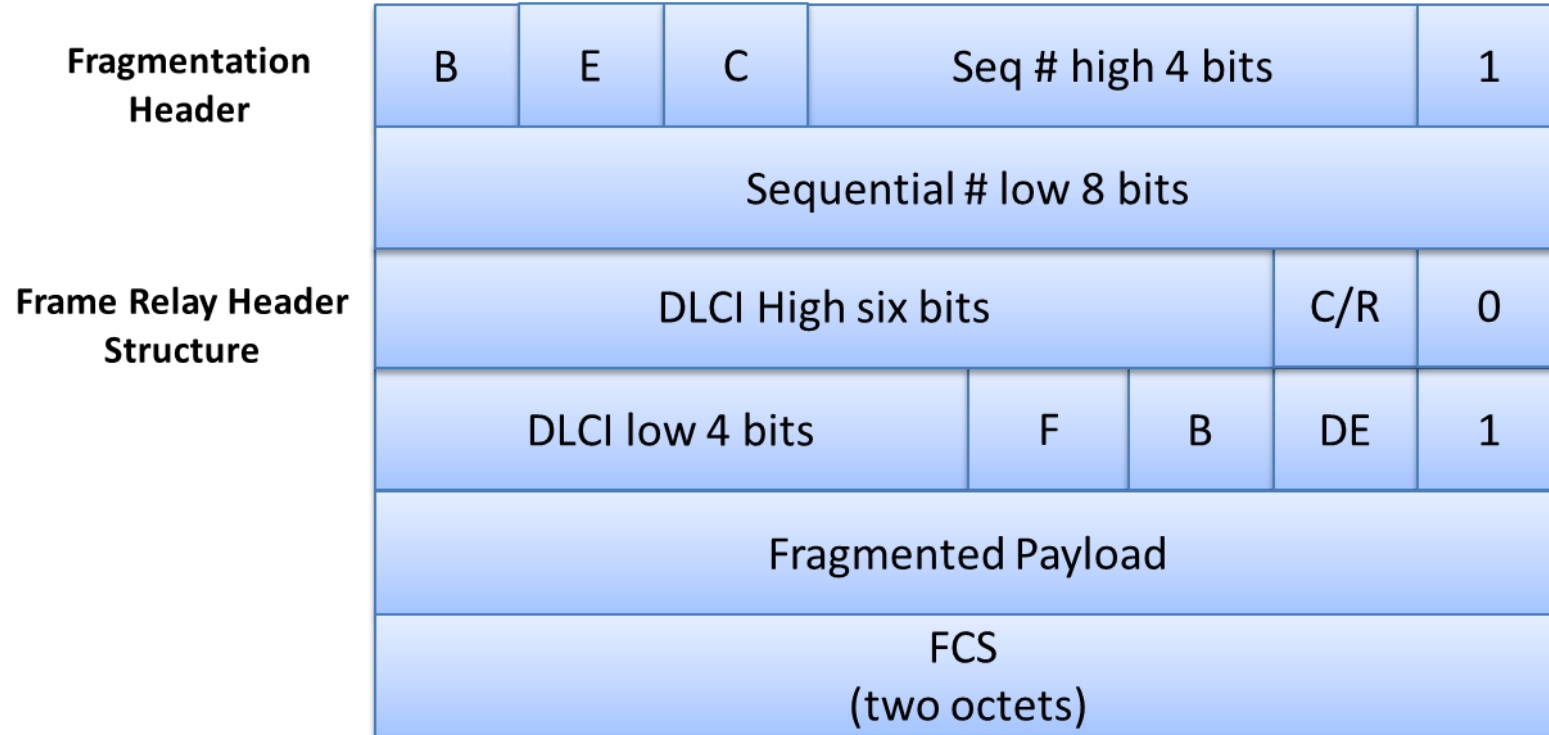
DLCI – Datalink Connection Identifier
C/R – Command/Response
DE – Discard Eligibility

B – Beginning Fragment Bit
E – Ending Fragment Bit
C – Control Bit

End to End Fragmentation

- End to End Fragmentation: End-to-End fragmentation is used between peer DTEs and is restricted to use on PVCs only. The Network Layer Protocol ID (NLPID) will be set to 0xB1

Row label									
Frame Relay Header Structure	DLCI High six bits						C/R	0	
	DLCI High 4 bits			F	B	DE	1		
UI (0X03)	0	0	0	0	0	0	1	1	
NLPD (0XB1)	1	0	1	1	0	0	0	1	
Fragmentation Header	B	E	C	Seq # high 4 bits			0		
	Sequential # low 8 bits								
	Fragmented Payload								
	FCS (two octets)								

DLCI – Datalink Connection Identifier
C/R – Command/Response
DE – Discard Eligibility

B – Beginning Fragment Bit
E – Ending Fragment Bit
C – Control Bit
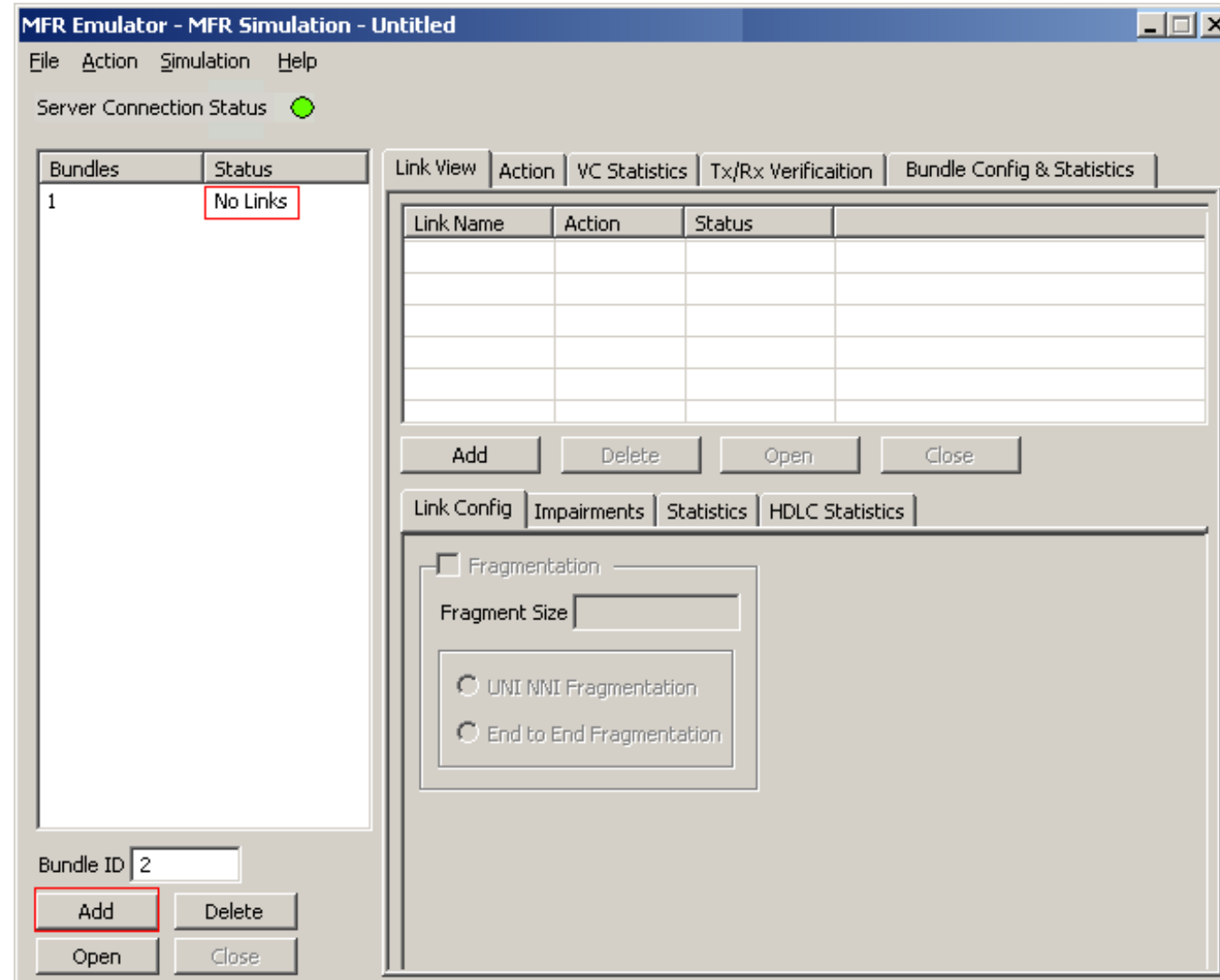
Adding VC in FR Simulation

- In FR simulation virtual channels are added on the selected link
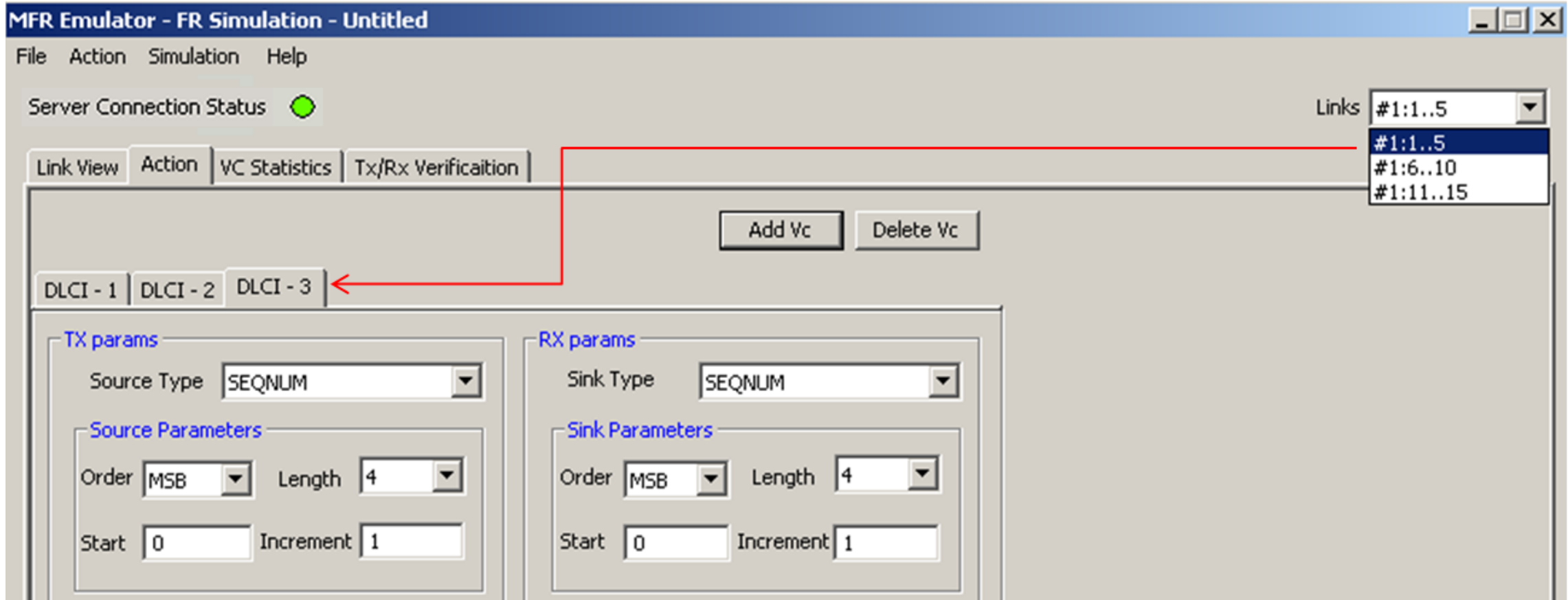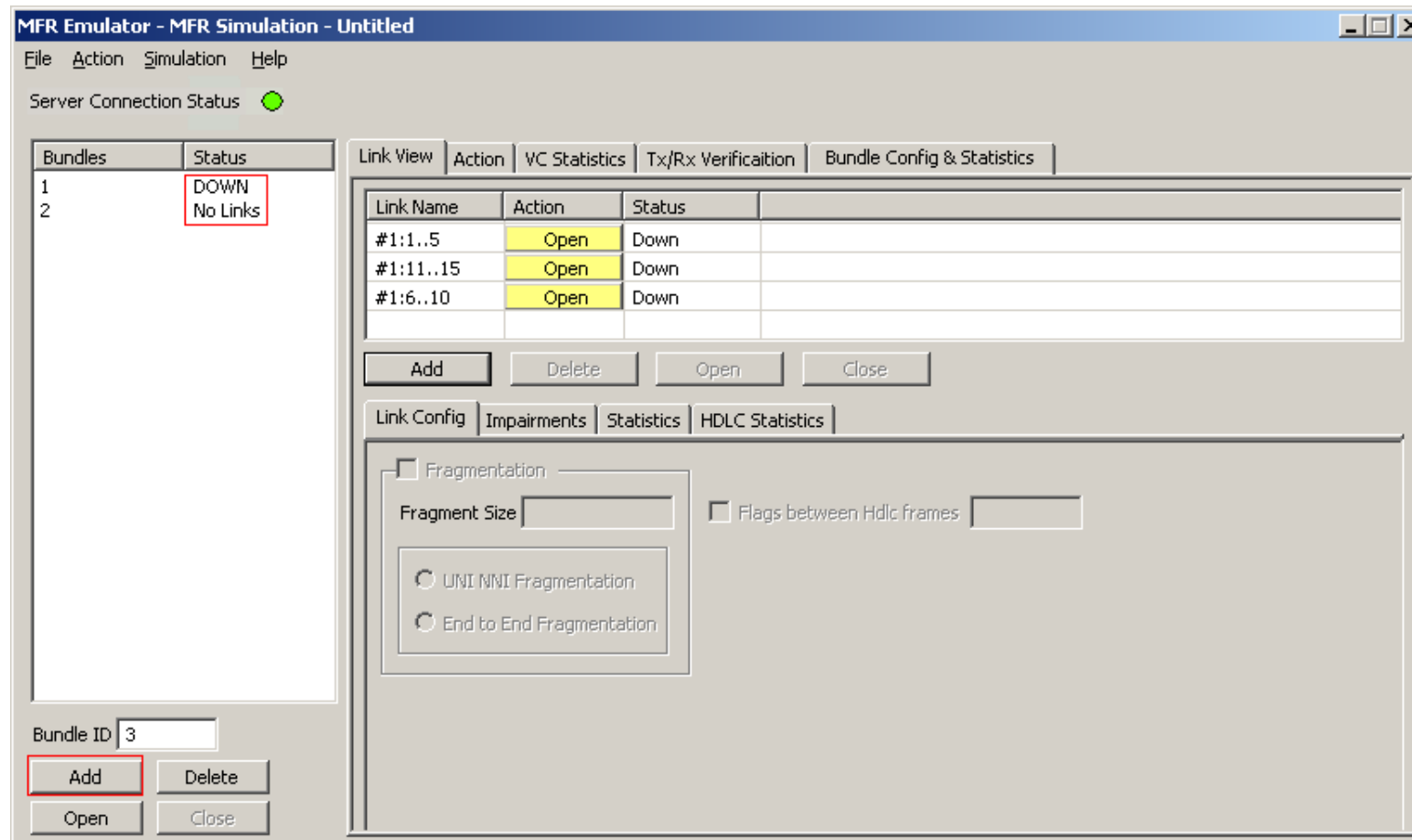
MFR Simulation

Adding a Bundle

- User can add a bundle by Clicking on Add button in the bundle pane, number of links constitute a bundle

Adding links to form an MFR bundle

- Various links (of any bandwidth varying from 64Kbps to n*64Kpbs or sub channels) can be added to form the MFR bundle

- MFR bundles multiple link-layer channels into a single network-layer channel

Bundle Config and Statistics

- Bundle Statistics will show statistics of transmitted frames, received frames, transmitted octets, and received octets for a selected bundle

Adding VC in MFR Simulation

- In MFR Simulation virtual channels are added on the selected bundle
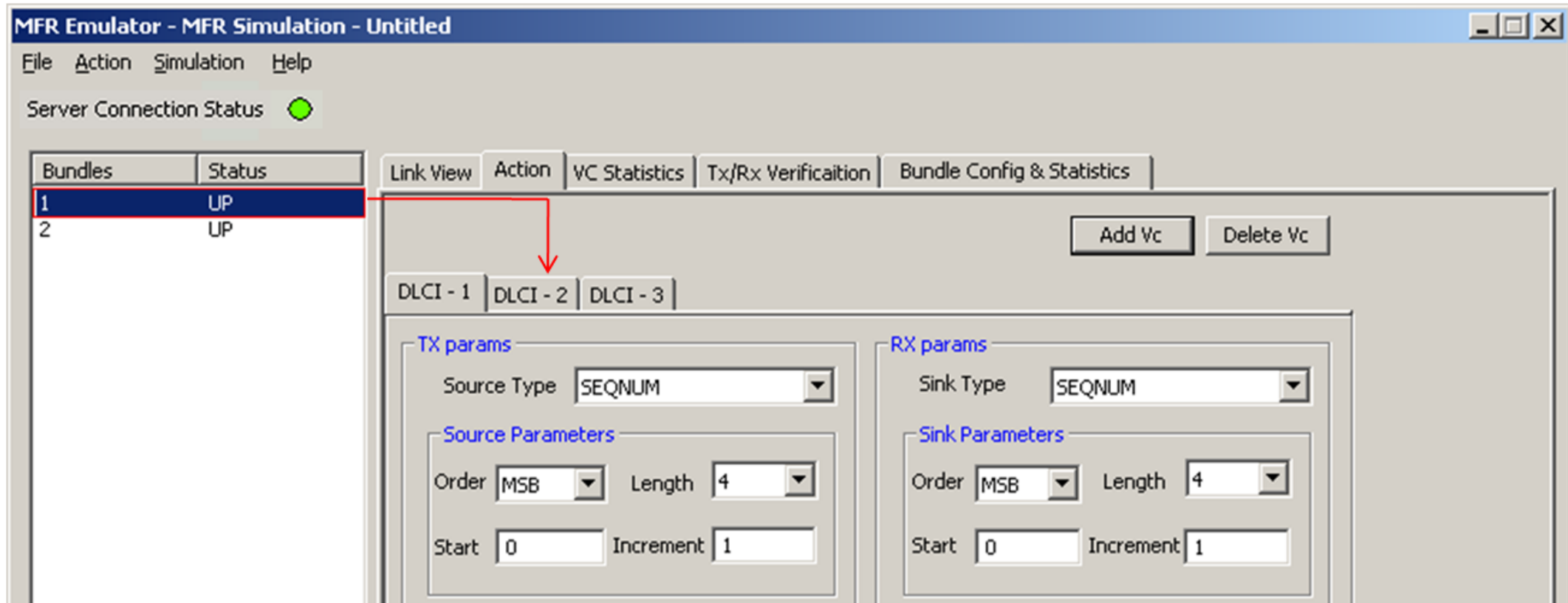
Tx and Rx Parameters

- Tx parameters are used to generate the FR traffic and Rx parameters are used as reference to verify the received frames. The results of the verification are displayed in Tx/Rx Verification tab

Transmit Function

Receive Function
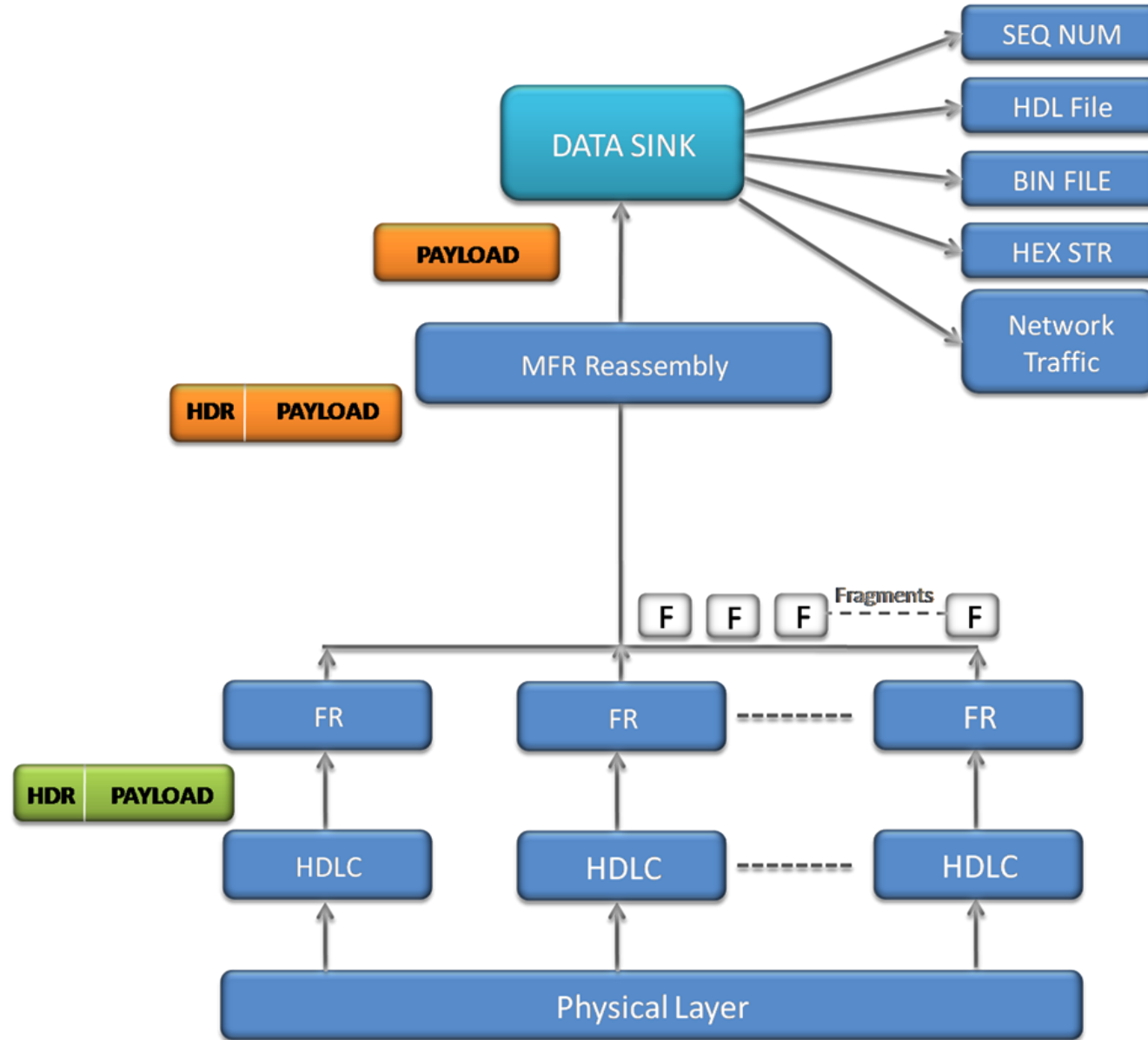
VC Statistics

- The Statistics for each of the added VCs are available in VC Statistics tab
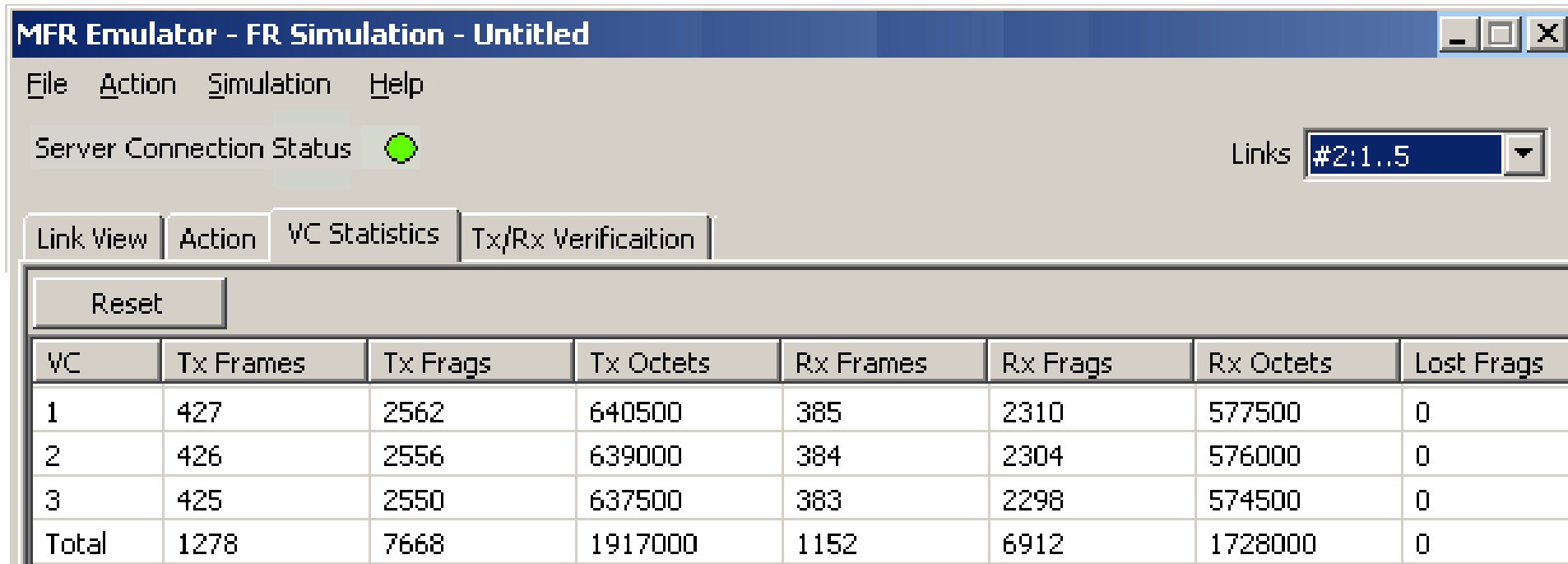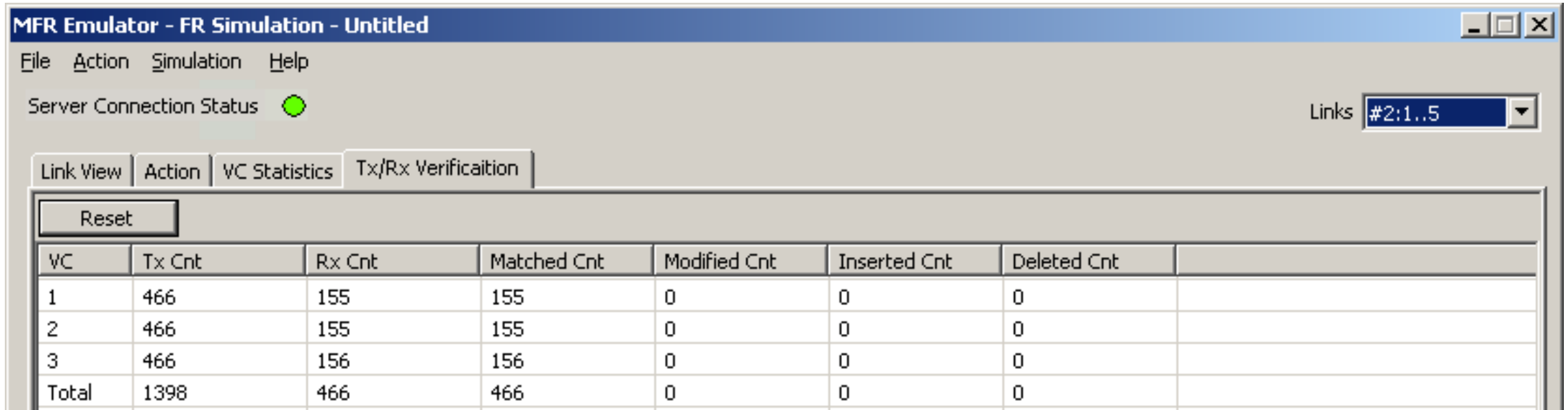- The statistics include number of Transmitted and received frames, Fragments, Octets, and Lost fragments

MFR Emulator - FR Simulation - Untitled

File   Action   Simulation   Help

Server Connection Status   🟢   Links   #2:1..5

| Link View | Action | VC Statistics | Tx/Rx Verificaition |

Reset

VC	Tx Frames	Tx Frags	Tx Octets	Rx Frames	Rx Frags	Rx Octets	Lost Frags
1	427	2562	640500	385	2310	577500	0
2	426	2556	639000	384	2304	576000	0
3	425	2550	637500	383	2298	574500	0
Total	1278	7668	1917000	1152	6912	1728000	0

Tx/Rx Verification

- The results of the verification for each of the added VCs are available in Tx/Rx Verification
- The statistics include number of frames Transmitted, Received, Matched, Modified, Inserted and Deleted

Impairments

- Supports various Byte level, Frame level , CRC error, and Frame error impairments at link level
- Supports various Byte level and Frame level impairments at Fragment/Packet level for each Virtual Channel
- Impairments that affect an entire frame:
  - ➢ Delete Frame
  - ➢ Insert Frame
  - ➢ CRC error
  - ➢ Frame error
  - ➢ Duplicate Frame
- Impairments that modify a byte or few bytes in a frame at specified offset :
  - ➢ Insert Bytes
  - ➢ Delete Bytes
  - ➢ Bitwise ANDing octets
  - ➢ Bitwise Oring octets
  - ➢ Bitwise XORing octets
- Differential link delay insertion during transmission

Link Level Impairments

- Different kinds of impairments are available, namely:
- Impairments that affect an entire FR frame -
  - ➢ DELETE FRAME
  - ➢ INSERT FRAME
  - ➢ CRC
  - ➢ FRAME
  - ➢ DUPLICATE FRAME

Link Level Impairments

Original Frame

00	11	00	00	00	00	00	00
00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00

Original Frame

00	11	AB	01	DE	87	46	31
68	AB	01	DE	87	46	31	68
AB	01	DE	87	46	31	68	AB
01	DE	87	46	31	68	AB	01
DE	87	46	31	68	AB	01	DE
87	46	31	68	AB	01	DE	87

Impairment : INS ABCD, OFF 10

00	11	00	00	00	01	00	00
00	01	AB	CD	00	00	00	01
00	00	00	01	00	00	00	01
00	00	00	01	00	00	00	01
00	00	00	01	00	00	00	01
00	00	00	01	00	00	00	01
00	00						

Impairment : DEL 6, OFF 10

00	11	AB	01	DE	87	46	31
68	AB	AB	01	DE	87	46	31
68	AB	01	DE	87	46	31	68
AB	01	DE	87	46	31	68	AB
01	DE	87	46	31	68	AB	01
DE	87						

Link Level Impairments

Original Frame

00	11	AB	01	DE	87	46	31
68	AB	01	DE	87	46	31	68
AB	01	DE	87	46	31	68	AB
01	DE	87	46	31	68	AB	01
DE	87	46	31	68	AB	01	DE
87	46	31	68	AB	01	DE	87

Impairment : AND 0x00, OFF 10

00	11	AB	01	DE	87	46	31
68	AB	00	DE	87	46	31	68
AB	01	DE	87	46	31	68	AB
01	DE	87	46	31	68	AB	01
DE	87	46	31	68	AB	01	DE
87	46	31	68	AB	01	DE	87

Link Level Impairments Verification

VC Impairments

- Impairments in Action layer can be applied for individual VCs

VC Impairments Verification

Link Statistics

- Provides important statistics information for the selected link, such as
- Number of frames transmitted
- Received frames
- Number of Octets Transmitted
- Number of Octets Received

Link Config	Impairments	**Statistics**	HDLC Statistics

Number of Frames Transmitted	893	Reset
Number of Frames Received	967	
Number of Octets Transmitted	1343072	
Number of Octets Received	1454368	

Hdlc Statistics

- The following error statistics are shown in Hdlc tab –

- Tx Under/Over Runs

- Rx Under/Over Runs

- Number of FR packets with bad FCS

- Number of packets with Frame Error

Client-Server MFR Emulation

- Sample script for Transmission & Reception of MFR Frames

Features

- WCS Multi-Link Frame Relay is also available as a CLI application. Following functions are supported suing simple commands:

- Activate/deactivate the individual bundle links in the MFR bundle

- Create/delete the virtual channels on the links

- Sends MFR frames with or without impairments

- Receives MFR frames

- Generates & receives traffic using source and sink types

    - Sequence numbers

    - Hex string frame

    - Binary flat files

    - HDL trace files (GL's proprietary file format)

- Various impairments can be applied on each individual FR links and virtual channels

Thank You