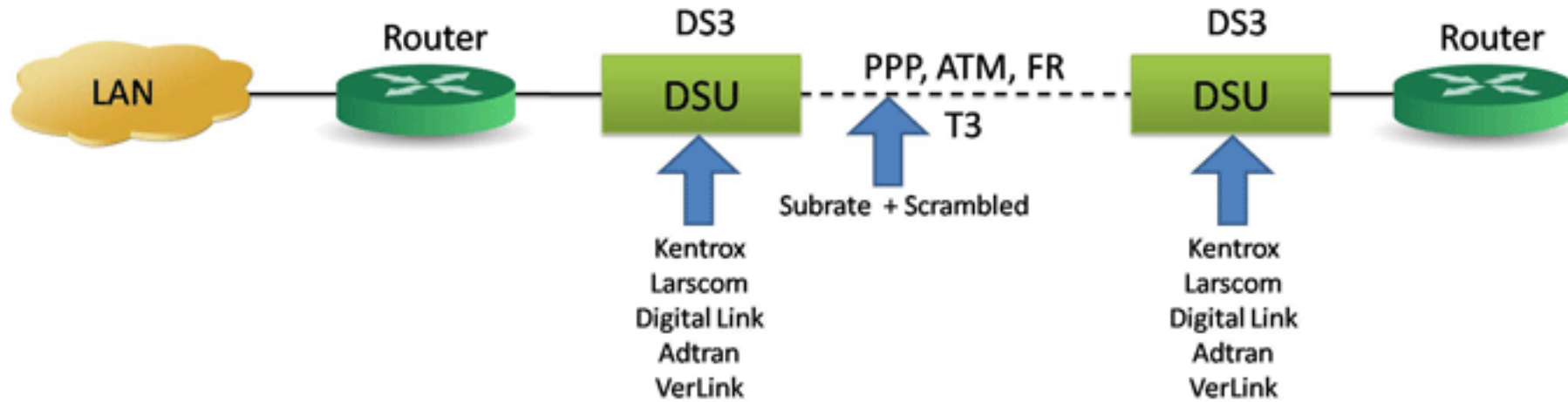

DS3 Scrambling and Subrate Feature



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Phone: (301) 670-4784 Fax: (301) 670-9187 Email: info@gl.com
Website: <https://www.gl.com>

T3 (DS3) Subrate and Scrambling



DS3 DSU Subrate Vendors Supported

- DSU Subrates Supported
- Digital Link
 - 300K,600K, 900K, 900K, 1.2M, 1.5M, 1.8M, 2.1M, 2.4M, 2.7M, 3M, 3.3M 3.6M, 3.9M, 4.2M, 4.5M, 4.8M, 5.1M, 5.4M, 5.7M, 6M, 6.3M, 6.6M, 6.9M, 7.2M, 7.5M, 7.8M, 8.1M, 8.4M, 8.7M, 9.0M, 9.3M, 9.6M, 9.9M, 10.2M, 10.5M, 10.8M, 11.1M, 11.4M, 11.7M, 12M, 12.3M, 12.6M, 12.9M, 13.2M, 13.5M, 13.8M, 14.1M, 14.7M, 15M, 15.3M, 15.6M, 15.9M, 16.2M, 16.5M, 16.8M, 17.1M, 17.4M, 17.7M, 18M, 18.3M, 18.6M, 18.9M, 19.2M, 19.5M, 19.8M, 20.1M, 20.5M, 20.8M, 21.1M, 21.4M, 21.7M, 22M, 22.3M, 22.6M, 22.9M, 23.2M, 23.5M, 23.8M, 24.1M, 24.4M, 24.7M, 25M, 25.3M, 25.6M, 25.9M, 26.2M, 26.5M, 26.8M, 27.1M, 27.4M, 27.7M, 28M, 28.3M, 28.6M, 28.9M, 29.2M, 29.5M, 29.8M, 30.1M, 30.4M, 30.7M, 31M, 31.3M, 31.6M, 31.9M, 32.2M, 32.5M, 32.8M, 33.1M, 33.4M, 33.7M, 34M, 34.3M, 34.6M, 34.9M, 35.2M, 35.5M, 35.8M, 36.1M, 36.4M, 36.7M, 37M, 37.3M, 37.6M, 37.9M, 38.2M, 38.5M, 38.8M, 39.1M, 39.4M, 39.7M, 40M, 40.3M, 40.6M, 40.9M, 41.2M, 41.5M, 41.8M, 42.1M, 42.4M, 42.7M, 43M, 43.3M, 43.6M, 43.9M, 44.21M

DS3 DSU Subrate Vendors Supported (Contd.)

- DSU Subrates Supported

- Larscom

- 3.2M, 6.3M, 9.5M, 12.6M, 15.8M,
18.9M, 22.1M, 25.3M, 28.4M,
31.6M, 34.7M, 37.9M, 41.1M, 44.2M

- DSU Subrates Supported

- Adtran

- In (Kilobytes)

- 80,150,230,300,380,450,530,600,680,750,830,900,980

- In (Megabytes)

- 1.05,1.13,1.2,1.28,1.35,1.43,1.5,1.58,1.65,1.73,1.8,1.88,1.95,
- 2.03,2.11,2.18,2.26,2.33,2.41,2.48,2.56,2.63,2.71,2.78,2.86,2.93,
- 3.01,3.08,3.16,3.23,3.31,3.38,3.46,3.53,3.61,3.68,3.76,3.83,3.91,3.98
- 4.06,4.14,4.21,4.21,4.29,4.36,4.44,4.51,4.59,4.66,4.74,4.81,4.89,4.96
- 5.04,5.11,5.19,5.26,5.34,5.41,5.49,5.56,5.64,5.71,5.79,5.86,5.94
- 6.01,6.09,6.17,6.24,6.32,6.39,6.47,6.54,6.62,6.6M,6.77,6.84,6.92,6.99
- 7.07,7.14,7.22,7.29,7.37,7.44,7.52,7.59,7.67,7.74,7.82,7.89,7.97
- 8.04,8.12,8.2,8.27,8.35,8.42,8.5,8.57,8.65,8.72,8.8,8.87,8.95
- 9.02,9.1,9.17,9.25,9.32,9.4,9.47,9.55,9.62,9.7,9.77,9.85,9.92
- 10,10.07,10.15,10.23,10.3,10.38,10.45,10.53,10.6,10.75,10.83,10.9,
10.98

DS3 DSU Subrate Vendors Supported (Contd.)

- Adtran (contd.)
 - 11.050,11.13,11.2,11.28,11.35,11.43,11.5,11.58,11.65,11.73,11.8,11.88,11.95
 - 12.03,12.11,12.18,12.26,12.33,12.41,12.48, 12.56,12.63,12.71,12.78,12.86,12.93
 - 13.08,13.16,13.23,13.31,13.38,13.46,13.53, 13.61,13.68,13.76,13.83,13.91,13.98
 - 14.06,14.14,14.21,14.29,14.36,14.44,14.51, 14.59,14.66,14.74,14.81,14.89,14.96
 - 15.04,15.11,15.19,15.26,15.34,15.41,15.49,15.56,15.64,15.71,15.79,15.86,15.94
 - 16.01,16.09,16.17,16.24,16.32,16.39,16.47,16.54,16.62,16.69,16.77,16.84,16.92,16.99
 - 17.07,17.14,17.22,17.29,17.37,17.44,17.52,17.59,17.67,17.74,17.82,17.89,17.97
 - 18.04,18.12,18.2,18.27,18.35,18.42,18.5,18.57,18.65,18.72,18.8,18.87, 18.95
 - 19.02,19.1,19.17,19.25,19.32,19.4,19.47,19.55,19.62,19.7,19.77,19.85,19.92
 - 20,20.07,20.15,20.23,20.3,20.38,20.45,20.53,20.6,20.68,20.75,20.83,20.9,20.98
 - 21.05,21.2,21.28,21.35,21.43,21.5,21.58,21.65,21.73,21.8,21.88,21.95
 - 22.03,22.1,22.26,22.33,22.41,22.48,22.56,22.63,22.71,22.78,22.86,22.93,
 - 23.01,23.08,23.16,23.23,23.31,23.38,23.46,23.53,23.61,23.68,23.76,23.83,23.91, 23.98
 - 24.06,24.13,24.21,24.29,24.36,24.44,24.51,24.59,24.66,24.74,24.81,24.89,24.96
 - 25.04,25.11,25.19,25.26,25.34,25.41,25.49,25.56,25.64,25.71,25.79,25.86,25.94

DS3 DSU Subrate Vendors Supported (Contd.)

- Adtran (contd.)
 - 26.01,26.16,26.24,26.32,26.39,26.47,26.54,26.62,26.69,26.77,26.84,26.92
 - 27.07,27.14,27.22,27.29,27.37,27.44,27.52,27.59,27.67,27.74,27.82,27.89,27.97
 - 28.04,28.12,28.19,28.27,28.35,28.42,28.5, 28.57,28.65,28.72,28.8,28.87,28.95,
 - 29.02,29.1,29.17,29.25,29.32,29.4,29.47, 29.55,29.62,29.7,29.77,29.85,29.92
 - 30,30.07,30.15,30.22,30.3,30.38,30.45,30.53,30.6, 30.68,30.75,30.83,30.9,30.98
 - 31.05,31.2,31.28,31.35,31.43,31.5,31.58,31.65,31.73,31.8,31.95
 - 32.03,32.1,32.18,32.26,32.33,32.41,32.48,32.56,32.63,32.71, 32.78,32.86,32.93
 - 33.01,33.08,33.16,33.23,33.38,33.46,33.53,33.61,33.68,33.76,33.83, 33.83,33.91,33.98
 - 34.06,34.21,34.29,34.36,34.44,34.51,34.59,34.66,34.74,34.81,34.89,34.96
 - 35.04,35.11,35.19,35.26,35.34,35.41,35.49,35.49,35.56,35.71,35.79,35.86,35.94
 - 36.01,36.09,36.16,36.24,36.32,36.39,36.47,36.54,36.62,36.69,36.77,36.84, 36.92,36.99
 - 37.07,37.14,37.22,37.29,37.37,37.44,37.52,37.59,37.67,37.74,37.82,37.89,37.97
 - 38.04,38.12,38.27,38.35,38.42,38.5,38.57,38.65,38.72,38.8,38.87,38.95
 - 39.02,39.10,39.17,39.25,39.32,39.4,39.47,39.55,39.62,39.7,39.77,39.85,39.92
 - 40,40.07,40.15,40.22,40.3,40.38,40.45,40.53,40.6,40.68,40.75,40.83,40.9,40.98
 - 41.05,41.13,41.2,41.28,41.35,41.43,41.50,41.58,41.65,41.73,41.8,41.88,41.95
 - 42.03,42.1,42.18,42.25,42.33,42.41,42.48,42.56,42.63,42.71,42.78,42.86,45.93
 - 43.01,43.16,43.23,43.23,43.31,43.38,43.46,43.53,43.61,43.68,43.76,43.83,43.91,43.98,
44.13,44.21

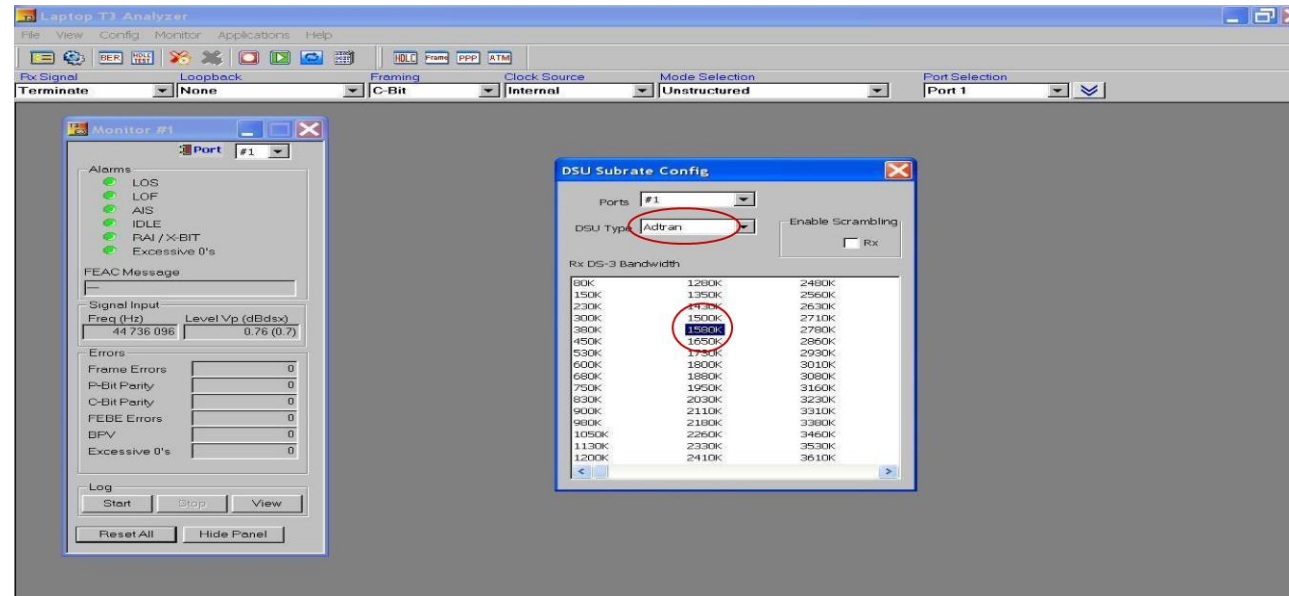
DS3 DSU Subrate Vendors Supported (Contd.)

- DSU Subrates Supported
- Verilink
 - 1.6M, 3.2M, 4.7M, 6.3M, 7.9M, 9.5M, 11.1M, 12.6M, 14.2M, 15.8M,
17.4M, 18.9M, 20.5M, 22.1M, 23.7M, 25.3M, 26.8M, 28.4M, 30M,
31.6M
- All vendors and rates with and without scrambling

DS3 Subrate Definition

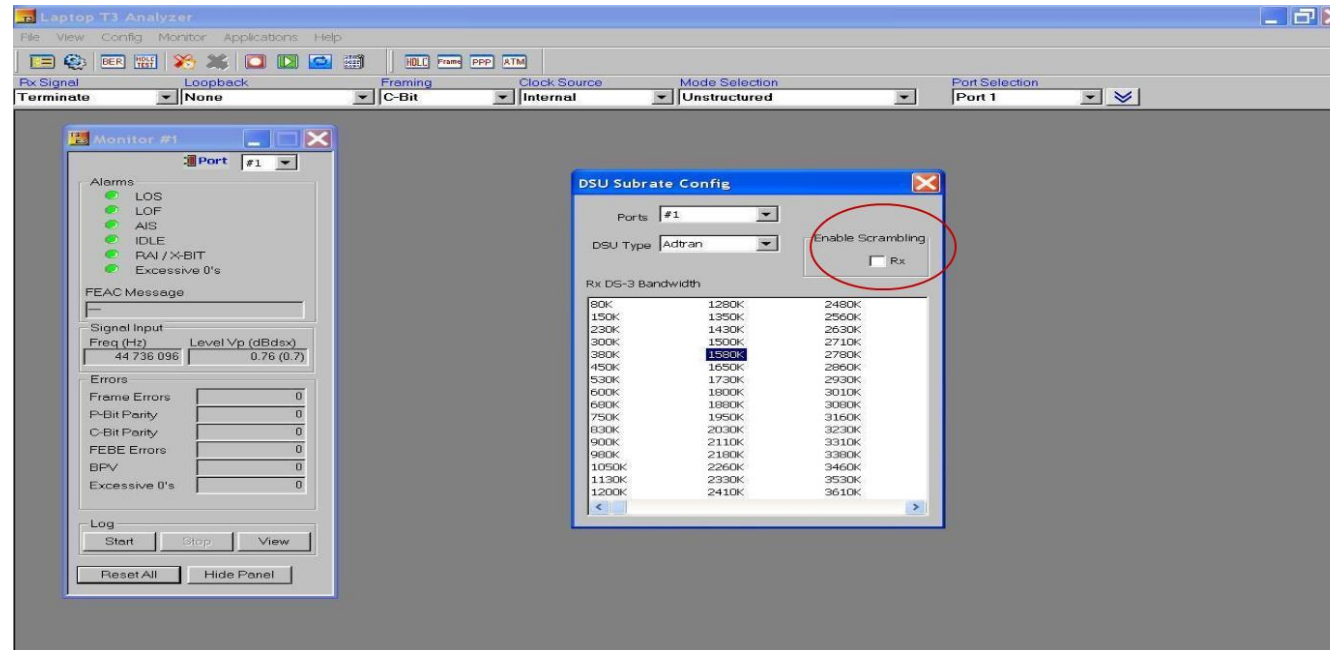
- The Cisco routers and multiple DSU vendors provide the ability to configure the DS3 network for a lower bandwidth service
- Each DSU vendor has its own configuration of the service rates which is supported by the Cisco routers

DS3 Subrate Configuration Setup



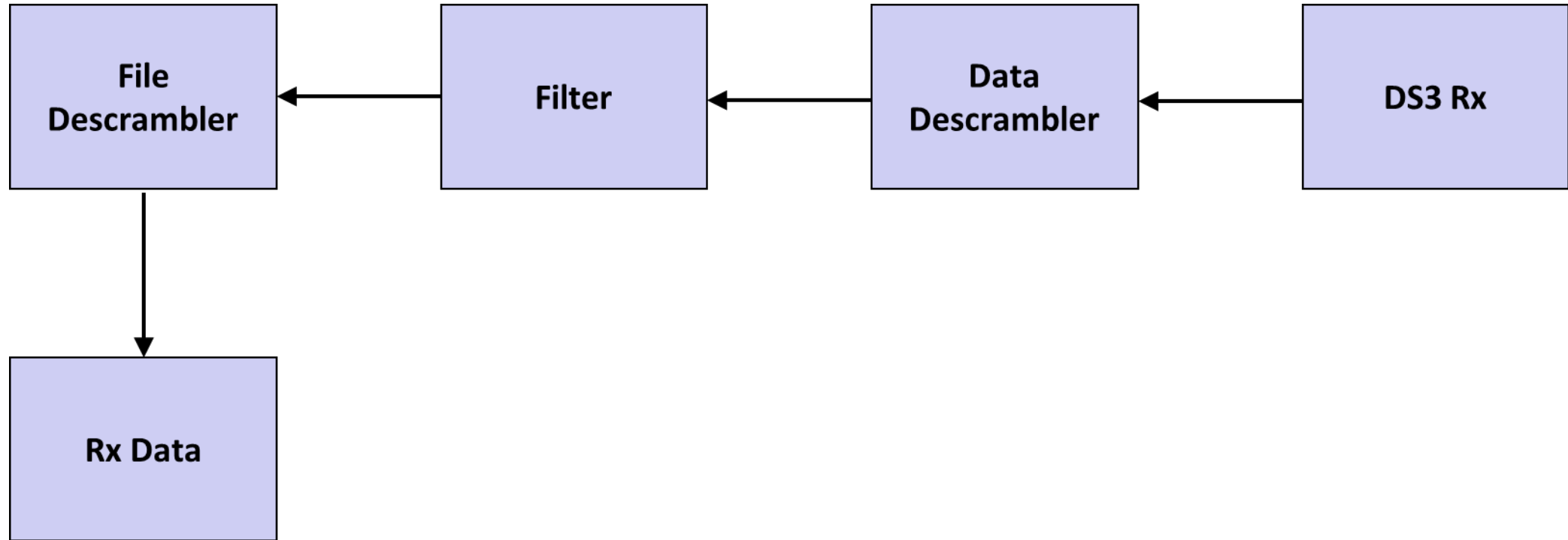
- The user has the ability with the USB T3 E3 unit to configure the DSU and the rate using the DS3 Subrate Config window as shown in the screen capture

DS3 Subrate Configuration Setup



- The user also has the ability to accept network scrambled data from the Cisco router

DS3 Subrate Block Diagram



Hardware/Software Implementation (Data Descrambler)

- After the data is descrambled, the data descrambler block is used to descramble incoming data using a configured polynomial
- The scrambler can be turned off for data not using descrambling
- This block uses a normal descrambling serial polynomial which can be configured for multiple polynomials

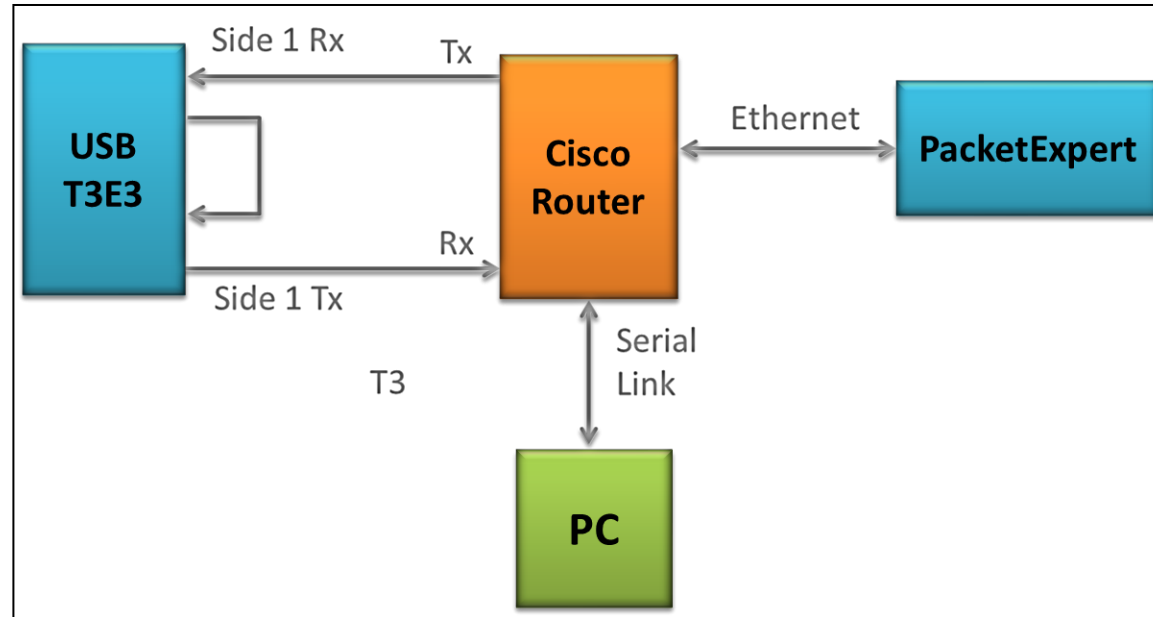
Hardware/Software Implementation (Data Filter)

- The Data filter uses a multi-framed aligned block ram which is used to enable or disable the incoming data
- By enabling or disabling the incoming data, software can configure the incoming data to support the different DS3 DSU vendor subrates

Hardware/Software Implementation (Filter Descrambler)

- Some Vendors only support scrambled data of the subrate. The unused payload is left unscrambled
- This block descrambles the data using a similar polynomial descrambler as the first descrambler block but only on the incoming filtered bandwidth data

Testing Block Diagram



Router Setup

- Connect RS-232 port to console using USB to Ethernet converter
- 9600, 8, N , 1, no flow control
- Turn off number lock and scroll lock
- Type no for initial configuration dialog
- Type enable > conf t > card type t3 1 > controller t3 1/0 > clock source internal
- Each > is a CRLF

Router Setup (Contd.)

- Type int s1/0 > encapsulation ppp > bridge-group 1 > bridge-group 1 spanning-disabled > exit >
- Type int gi0/0 > bridge-group 1 > bridge-group1 spanning-disabled > no shutdown > exit >
- Type bridge irb > bridge 1 protocol dec > bridge 1 route ip > exit >
- Type enable > conf t > int s1/0 > dsu mode (0-4) > dsu bandwidth (set bandwidth setting) > Scramble or no scramble
- Repeat this last setup for each bandwidth setting

PacketExpert™ Setup

GL PacketExpert10GX - BERT

File View System Windows Help

Application: All Port Bert

All Port Bert

- Port 1
 - Interface
 - Bert
 - Tx Config
 - Rx Config
 - Results
 - Bit Error Insertion Graph
 - FCS Error Insertion Statistics
- Port 2
 - Interface
 - Bert
 - Tx Config
 - Rx Config
 - Results
 - Bit Error Insertion Graph
 - FCS Error Insertion Statistics
- All Ports Reports

Interface

Port Selection: Port 1

Details

Hardware MAC address: 00-21-C2-00-2C-65

Tx Pause Frame

Pause Duration: 100 Quanta

Settings

Interface Type: Optical

Link Speed: 10000Mbps

IP Address

IP Address: 192.168.1.11

Subnet Mask: 255.255.255.0

Default Gateway: 192.168.1.1

Results

Port Selection: Port 1

Bert Status	
Rx Traffic	●
Sync Status	●
Bit Errors	●
Out Of Sequence Packets	●

Bert Statistics	Values
Bert Status	Sync
Test Time	00:20:09
Bits Received	11 539 343 172 976
Bit Error Count	0
Bit Error Rate	0.000E+00
Bit Error Seconds	0
Sync Loss Count	0
Sync Loss Seconds	0
Out of Sequence Count	0
Out of Sequence Seconds	0
Error Free Seconds	1 209

All Ports

	Port 1	Port 2
Tx		
Total Frames	982 858 924	982 911 726
Valid Frames	982 859 797	982 912 536
Bad Frames	0	0
Number of Bytes	1 491 982 500 096	1 492 063 533 954
Link Utilisation(%)	100.000	100.000
Data Rate(Mbps)	9869.963	9869.963
Frame Rate(Frames/sec)	812744	812744
Non Test Frames	n	n
Rx		
Total Frames	982 872 829	982 928 312
Valid Frames	982 873 610	982 929 095
Bad Frames	0	0
Number of Bytes	1 492 004 474 664	1 492 088 746 416
Link Utilisation(%)	100.000	100.000
Data Rate(Mbps)	9869.963	9869.963
Frame Rate(Frames/sec)	812744	812744
Non Test Frames	n	n

Bert Status	Port 1	Port 2
Rx Traffic	●	●
Sync Status	●	●
Bit Errors	●	●
Out Of Sequence Packets	●	●

Bert Statistics	Port 1	Port 2
Bert Status	Sync	Sync
Test Time	00:20:09	00:20:09

Graph

Real-Time Display Graph Duration: 10 sec 04-10-22 12:35:26

10/04/2022-12:25:54 Graph Start - (10/04/2022-12:45:53) Graph End - (10/04/2022-12:46:02) 10/04/2022-12:45:59

Port1 Port2

Throughput(Mbps) Bit Errors

USB T3 E3 Setup

- Set Side 1 and Side 2 to outward loopback
- Set the DSU config for the correct DSU and Rate
- In the DSU config select the proper scrambling
- After starting the HDLC analyzer, verify good packets of 1500 bytes in length with no CRC counts

USB T3 DSU Setup

The screenshot shows the 'Laptop T3 Analyzer' software interface. The 'Outward Loopback' and 'C-Bit' options in the 'Rx Signal' section are circled in red. The main window displays a table of HDLC frames with columns for Dev, TS/Slot, SubCh, Frame#, TIME, Len, Error, C/R, SAPI, TEI, CTL, P/F, N(S), N(R), and FUNC. The status bar at the bottom shows 'Running, Utilization 62.45%' and 'Captured 154,459 frames'.

Dev	TS/Slot	SubCh	Frame#	TIME	Len	Error	C/R	SAPI	TEI	CTL	P/F	N(S)	N(R)	FUNC
1	0		0	00:00:00...	887	frame error								
1	0		1	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
2	0		2	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
1	0		3	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
1	0		4	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
2	0		5	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
2	0		6	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
1	0		7	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
2	0		8	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
1	0		9	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR
2	0		10	00:00:00...	1502		Res...	3	0	Sup...	0		44	RNR

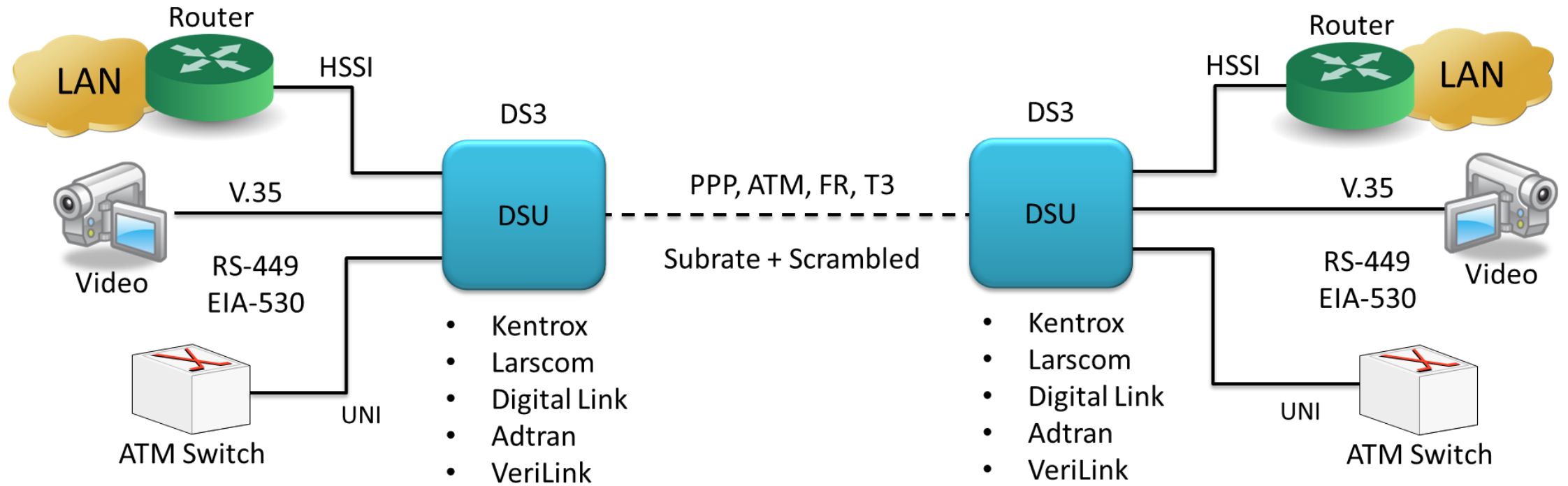
```
Card2 TimeSlot=0 Frame=6 at 00:00:00.001148 OK Len=1502
HDLC Frame Data + FCS
----- LAPD Layer -----
0000 C/R = .....1. Response(User), Command(Network)
0000 SAPI = 000011.. (3)
0001 TEI = 00000000.. (0)
0002 Ctl = .....01 Supervisory
0002 Supervisory Function = ....01.. RNR
0003 P/F = .....0 (0)
0003 N(R) = 0101100.. (44)

Hex Dump of the Frame Data
-----
0F 00 65 58 00 21 C2 00 04 81 00 21 C2 00 04 80 eX IÃ I IÃ I
88 47 00 00 01 00 2B 1B D4 E4 CD F6 B1 2E 18 32 IG + 0aioi. 2
75 6E 39 2A 3B 3B BF DE E7 B1 AA 79 0B 23 75 EA un9*;;dçt#y #uè
58 13 6D 20 6C AC CF E7 35 CB 40 5D 38 A6 98 70 X m l-ig5E@]p
45 F2 92 27 D2 82 AB F5 A9 68 8F C6 2D 85 15 DE Eò"0!«G hIz-1 0
CC 7A 12 65 E2 1E 00 F6 41 D1 9B ED 62 5C 30 64 Iz eà eAR1ib\0d

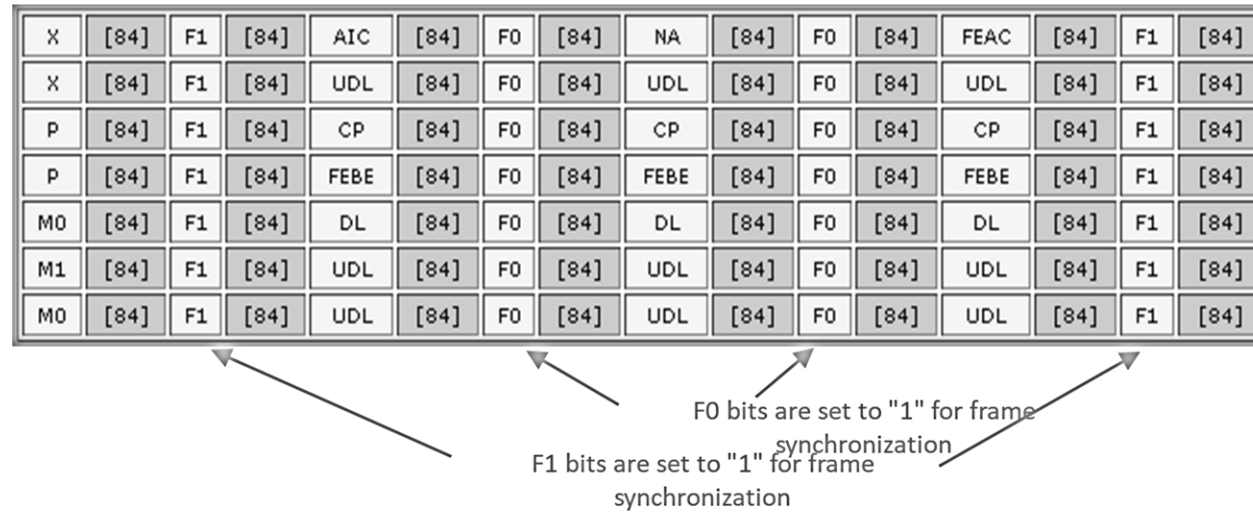
Running, Utilization 62.45% C:\Temp.Hdl Captured 154,459 frames Errors 0 CRC, 1 Frame
```

Scrambling and Subrate

- For Data, Packetized Voice, and Video and other Unchanneled Uses
- Generally, not for 28 T1s



Some Simple Math & DS-3 C-bit Parity Format



- DS3 Rate is 44.736 Mbps
- Multiframe Rate is 9398.3 mf/sec
- Multiframe Size is 4760 bits
- 7 rows x 680 bits
- 8 overhead bits per row ==> 56 bits

How are Subrates Calculated and Allocated?

An Example - different for different DSU Vendors

84	84	84	84	84	84	84	84
84	84	84	84	84	84	84	84
84	84	84	84	84	84	84	84
84	84	84	84	84	84	84	84
84	84	84	84	84	84	84	84
84	84	84	84	84	84	84	84
84	84	84	84	84	84	84	84

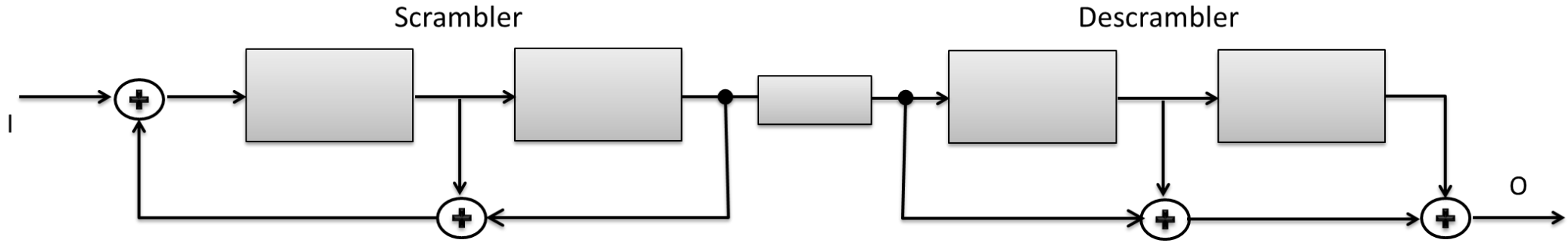
- Horizontal allocation shown above, but also vertical allocation is possible
- Fill the unused capacity with FF

$(84 + 84) \times 9398.3 = \text{approx } 1.6 \text{ Mbps}$ is the subrate

$(4704 - 168) \times 9398.3 = 42.6 \text{ Mbps}$ is idle or other applications?

Digital Link = $32\text{bits} \times 9398.3 = \text{approx. } 300 \text{ kbps}$ increments
Larscom = approx. 3.15 Mbps increments
Adtran = approx. 80 kbps increments
Verilink = approx. 1.6 Mbps increments
Kentrox = approx. 0.5 Mbps increments

Scrambler Example



Input	IReg1	IReg2	Channel	OReg1	OReg2	Output
1	0	0	0	0	0	0
1	1	0	0	0	0	0
1	0	1	1	0	0	1
1	0	0	0	1	0	1
1	1	0	0	0	1	1
1	0	1	1	0	0	1
1	0	0	0	1	0	1
1	1	0	1	0	1	0
1	0	1	1	1	0	0
1	0	0	0	1	1	0
1	1	0	0	0	1	1
1	0	1	1	0	1	1

Properties of Self Synchronizing Scramblers

- Pros
 - Prevent long sequences of 1s, 0s, or other repetitive patterns - that may cause clock recovery or synchronization problems - random data is best for clock recovery and frame synchronization
 - When DS-3 is used for data - Flags and FF fill are very frequent
 - Self synchronization for simplicity - produce unscrambled data quickly
- Cons
 - Error multiplication by the number of "taps", i.e., $1 \times 10E-6 \implies 5 \times 10E-6$
 - Lockup possibility
 - Unless designed properly, long sequences of 0s and repetitive patterns could be a common occurrence

Unscrambling Strategies for DS-3 (Depends on Vendor)

- Unscramble all the available data capacity whether used by the customer or not, then filter out the data
- Filter out the customer data, then unscramble the data
- Do not descramble, just filter for Kentrox

Discovery Process (Auto Config)

- Implement an efficient search algorithm to determine - whether "scrambled" and "at what substrate"
- Check for reliable HDLC frames
- Do the most common vendor and most common rate first
- Do both ports if requested, permit manual setting, store settings once discovered

Auto Config

DSU Subrate Config

Ports: #1 Apply to all Ports

DSU Type: Digitalink Enable Scrambling
Rx

Rx DS-3 Bandwidth

300000K	3900000K	7500000K
600000K	4200000K	7800000K
900000K	4500000K	8100000K
1200000K	4800000K	8400000K
1500000K	5100000K	8700000K
1800000K	5400000K	9000000K
2100000K	5700000K	9300000K
2400000K	6000000K	9600000K
2700000K	6300000K	9900000K
3000000K	6600000K	10200000K
3300000K	6900000K	10500000K
3600000K	7200000K	10800000K

Auto Config

Trying Port#1, Adtran, 44130000

Thank you