Transporting Robust and Secure FM Composite over an IP based STL

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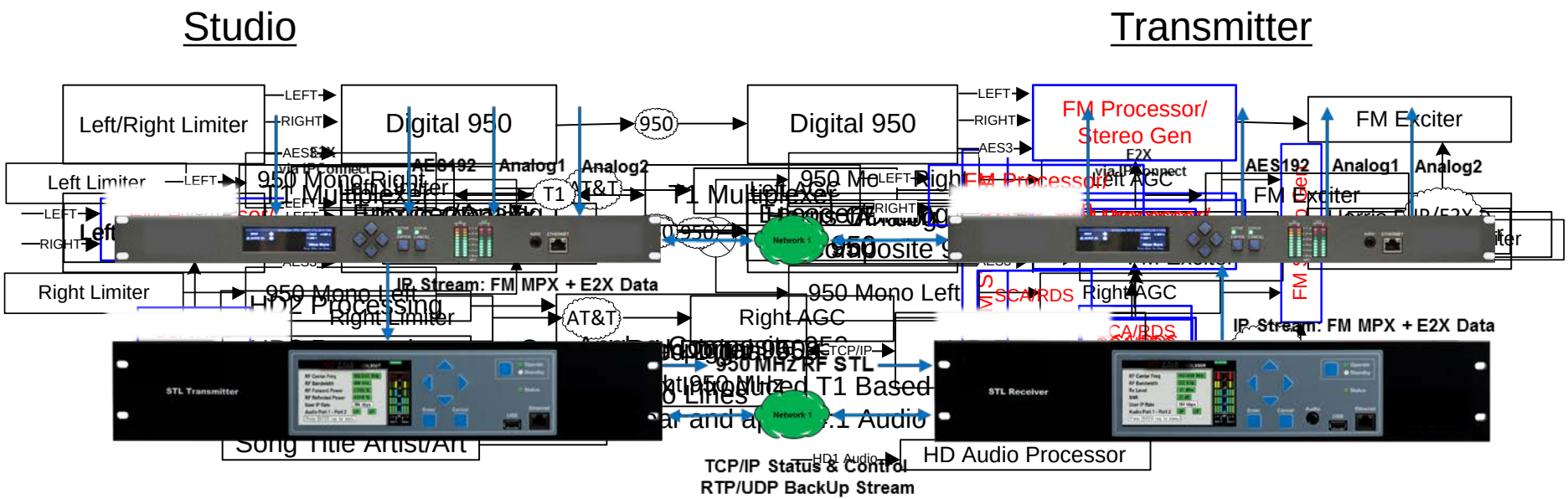
Topics

- STL Topology & Audio Chain Review
- Composite Audio Components & Digital Composite Standard
- New Data Rates for FM Composite Audio Over IP
- Transporting Composite & HD E2X Reliably and Securely Over IP
- Overview on applications and benefits of Delivering Composite

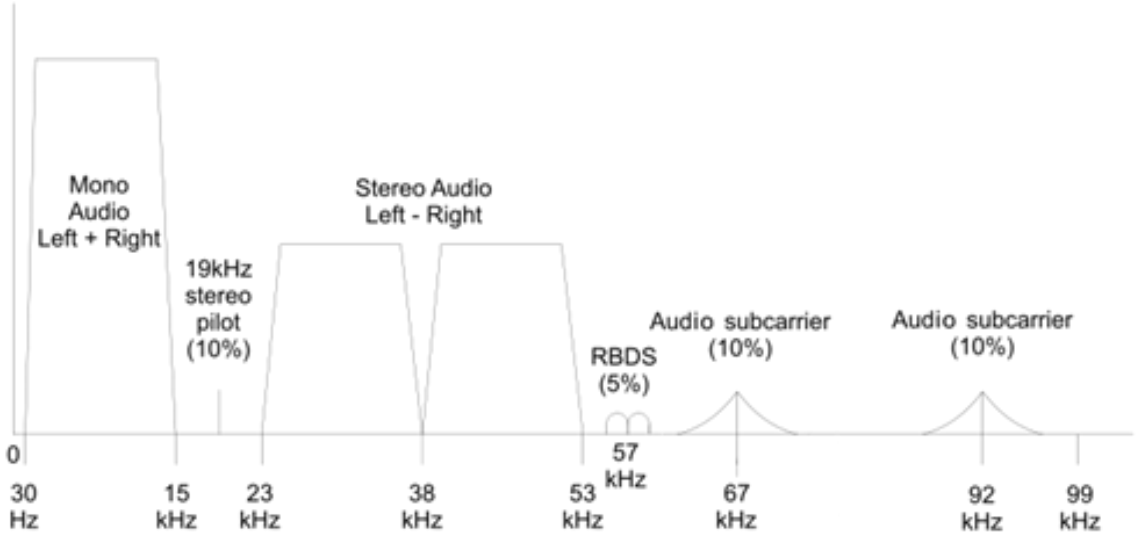
STL & Processing Chain



FM + HD Radio

FM Composite Frequency Spectrum

- FM Composite Components:
  - 20 Hz - 17 kHz: L+R
  - 19 kHz Pilot
  - 23-53 kHz: L-R
  - 57 kHz SCA for RDS
  - 67 kHz SCA
  - 92 kHz SCA
- E2X Date for HD Radio: ~300kbps



Digital Composite Audio over AES3

- Introduced as a standard in 2013
- Digital Composite Audio Standard is AES 192
- 192 kHz sample rate
- Left channel
- 192 kHz sample rate = 96 kHz bandwidth due to Nyquist
- This does not quite cover a 92 kHz subcarrier
- Allows composite signal plus 57 kHz and 67 kHz SCA
- AES3 at 192 kHz sample rate with 24-bit word resolution results in a data rate of 4.8 Mbps

Digital Composite Audio Data Rate

Manageable bandwidth with configurable sample rate and bit resolution

Sample Rate (kHz)	Services	12 Bits (Mbps)	14 Bits (Mbps)	16 Bits (Mbps)	20 Bits (Mbps)	24 Bits (Mbps)
132	Audio + RDS	1.64	1.93	2.2	2.7	3.3
162	Audio + RDS + SCA1	2.1	2.3	2.8	3.4	4.1
192	Audio + RDS + SCA 1	2.4	2.8	3.2	4.0	4.8
216	Audio + RDS + SCA + SCA2	2.7	3.1	3.6	4.5	5.4

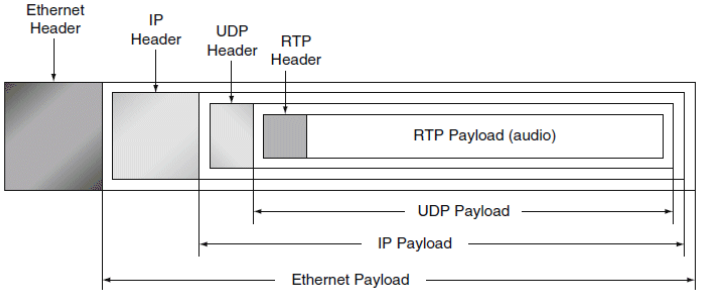
Uncompressed Composite Audio Data Rates

Reliable IP Transport – Network Choices

- What kinds of networks are available:
  - Public Internet
  - Business Class Public Internet
  - Point to Point Private Ethernet, MPLS, etc.
  - Private networks – Using licensed or unlicensed GHz microwave radios

Reliable IP Transport - Challenges

- IP Transport Challenges:
  - The data rate (bps), packet size and packet rate all impact devices in the network
  - Real-time audio requires use of connectionless transport protocol
    - Typically RTP over UDP



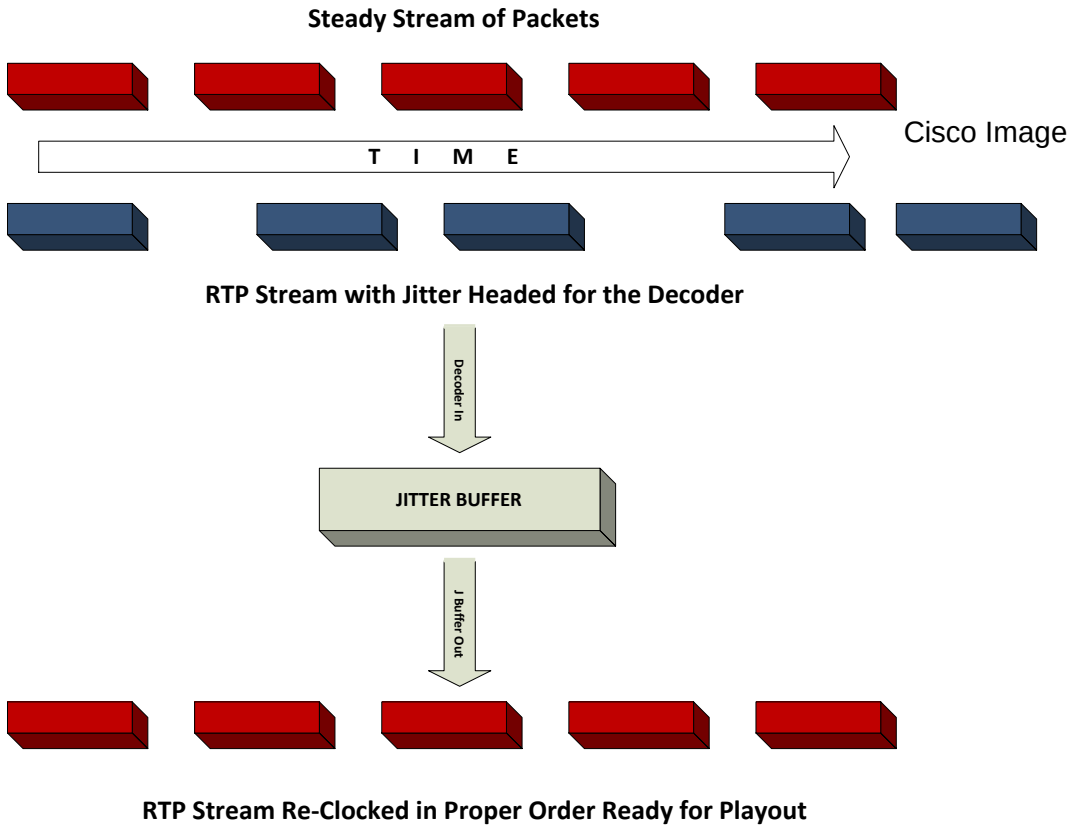
  - We need a way to overcome or mitigate packet delivery errors caused by issues across the network

Reliable IP Transport – Problems

- Network Problems Transporting Audio over IP
  - Network Jitter
    - Packets don’t all arrive with same latency or delay
    - Packets Arrive Out of Order
    - Router (layer 3) events causing packets to take a different route
  - Lost Packets (layer 2 or 3)
    - Random packet loss
    - Burst packet loss
  - Network Failure (layer 1 usually, but could occur at 2 or 3)

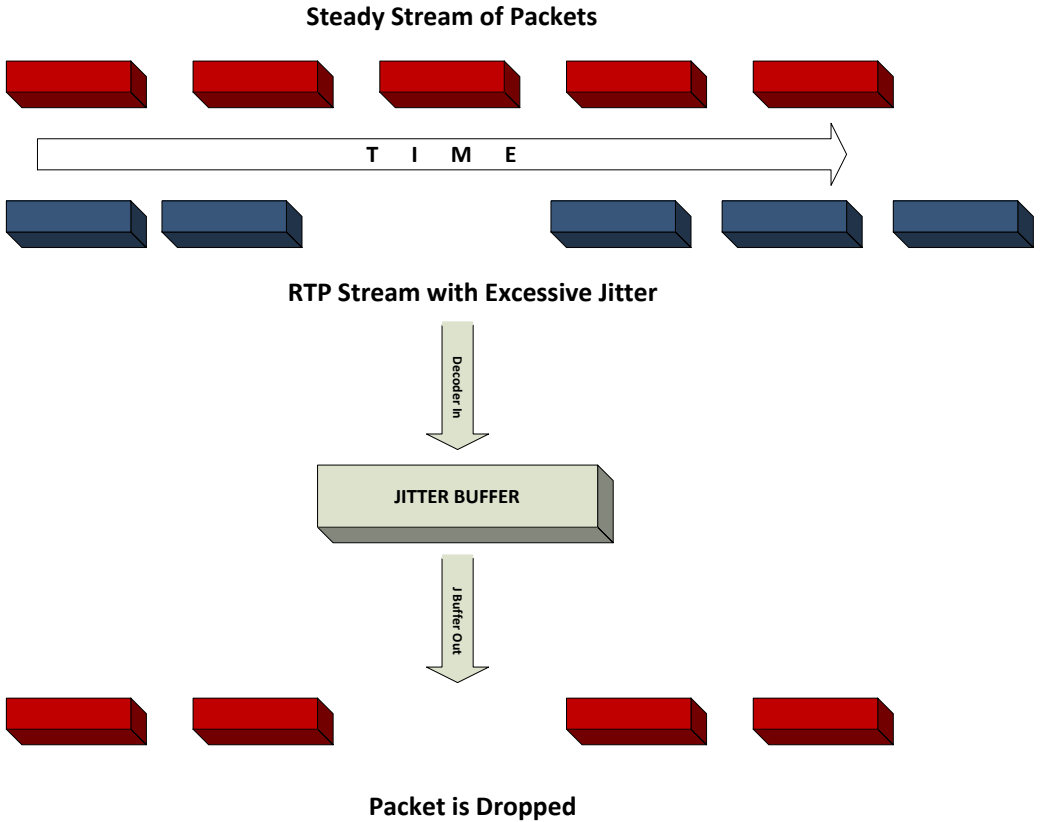
Network Jitter - Typical

- Jitter Buffer size is configurable and setting is important to ensure proper playout at decoder
- Dynamic Jitter Buffer allows stretching the buffer to prevent packet loss



Network Jitter – Excessive Jitter

- If amount of Jitter exceeds buffer size then packets drop



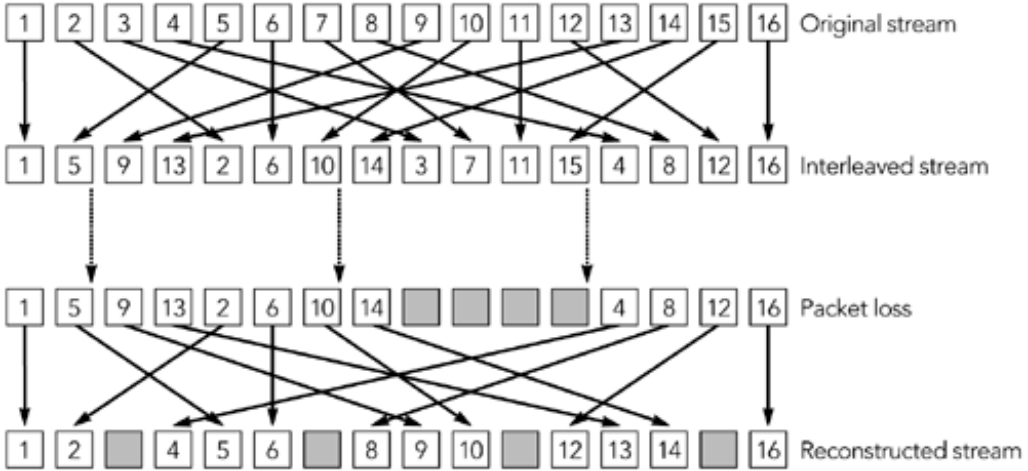
Forward Error Correction

- Forward Error Correction
  - FEC parity packets created by arranging RTP packets into a matrix and XORing the packets

	Col 1	Col 2	Col 3	Col 4	F(x)
Row 1	1	2	3	4	XOR (1, 2, 3, 4)
Row 2	5	6	7	8	XOR (5, 6, 7, 8)
Row 3	9	10	11	12	XOR (9, 10, 11, 12)
Row 4	13	14	15	16	XOR (13, 14, 15, 16)
F(x)	XOR (1, 5, 9, 13)	XOR (2, 6, 10, 14)	XOR (3, 7, 11, 15)	XOR (4, 8, 12, 16)	

Interleaving an FEC Matrix

- Packet Interleaving:
  - Mathematically rearrange the blocks prior to transmission
  - This requires extra buffering at both the encoder and decoder end
  - Provides protection against burst packet loss, makes FEC more robust



Time Diversity & Network Diversity

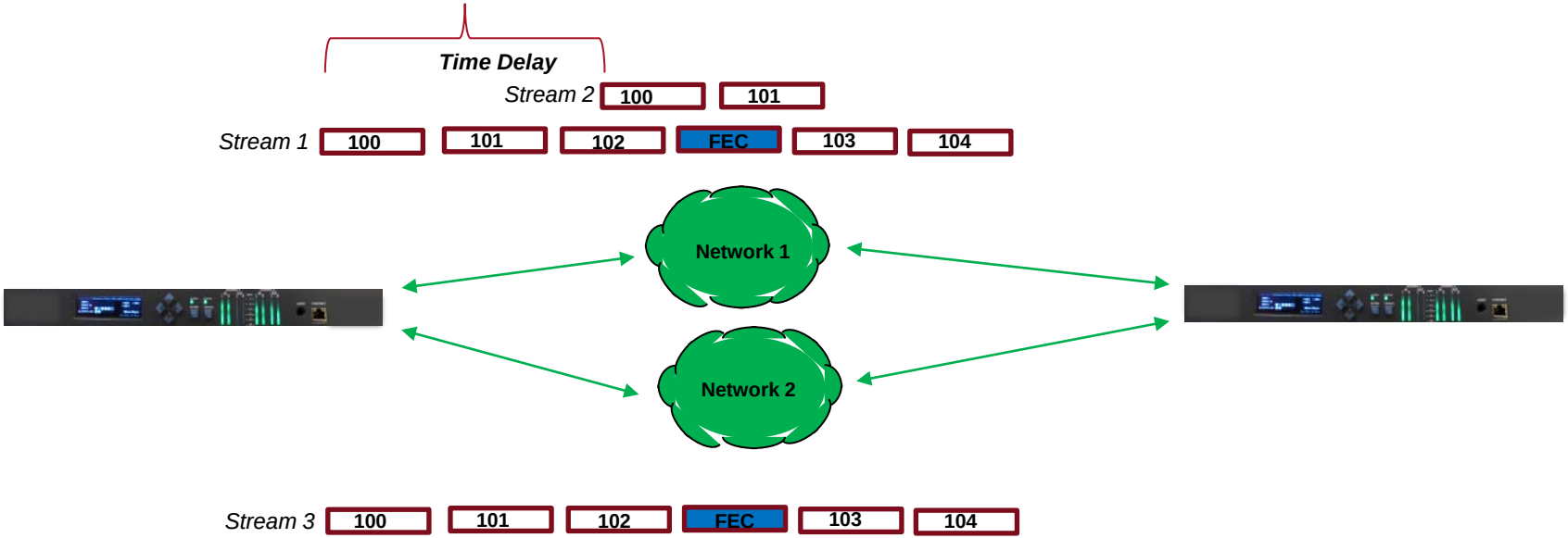
- Time Diversity

  - Can be used if there is only a single network path available
    - First stream is sent out
    - Second identical stream is sent with preset delay

  - The receiver takes in both streams, buffers them, and picks packets to make “one complete stream”

  - This obviously doubles the bandwidth requirement of the network path but provides excellent reliability and redundancy.

Stream Splicing Packet Protection



- Grouped streams sent across diverse network paths
- Scalable protection per network based on capacity
- “Hitless” operation with packet and network losses

Concealment

- Conceals a lost packet replay the last packet received
- If consecutive packets are lost, concealment plays out silence to avoid stutter output
- Concealment takes place after other error recovery methods have done the best they can and have attempted to recover lost packets

With Errors

With Corrected Errors

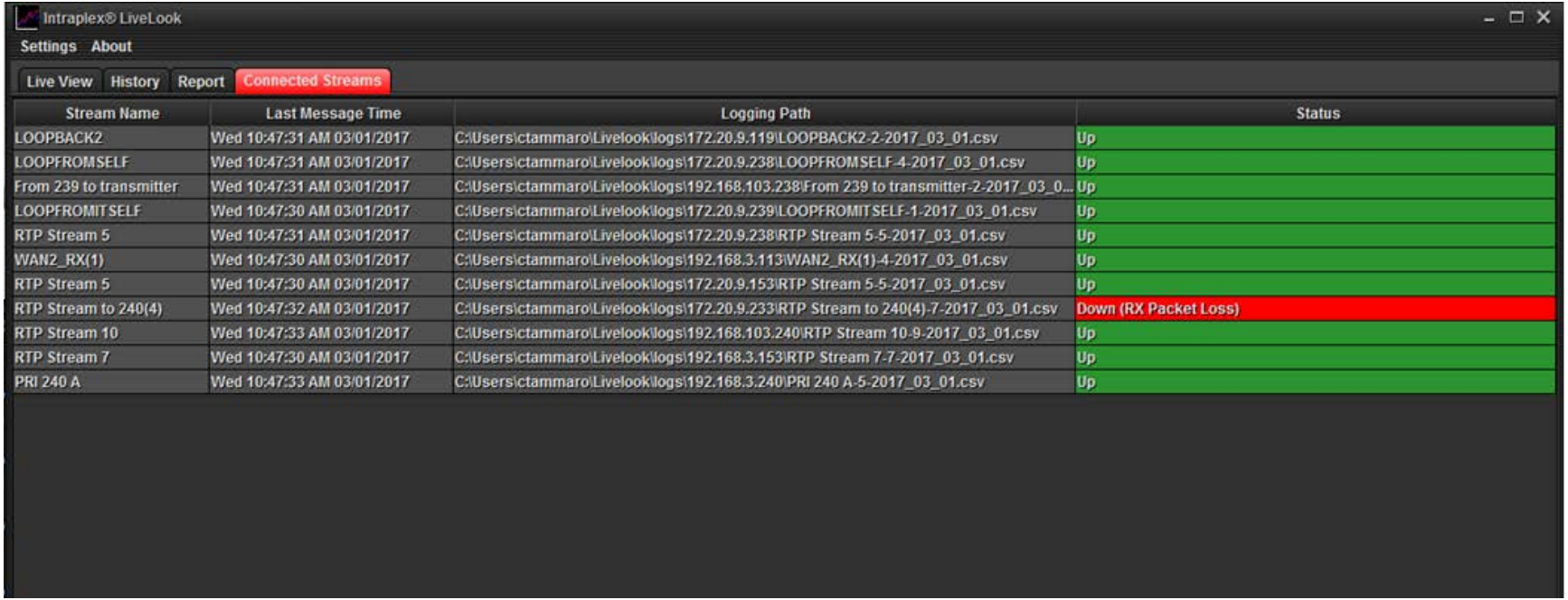
Network Analytics

Statistics and Status from IP Links

PC based Application

- Graphical network monitoring, analytics, logging tools
- Recommends which error mitigation settings will be most effective
- Logging of data helps with troubleshooting and SLA monitoring
- Dash board view of monitored audio streams with Email notification

Stream Monitoring



Stream Name	Last Message Time	Logging Path	Status
LOOPBACK2	Wed 10:47:31 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\172.20.9.119\LOOPBACK2-2-2017_03_01.csv	Up
LOOPFROMSELF	Wed 10:47:31 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\172.20.9.238\LOOPFROMSELF-4-2017_03_01.csv	Up
From 239 to transmitter	Wed 10:47:31 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\192.168.103.238\From 239 to transmitter-2-2017_03_0...	Up
LOOPFROMITSELF	Wed 10:47:30 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\172.20.9.239\LOOPFROMITSELF-1-2017_03_01.csv	Up
RTP Stream 5	Wed 10:47:31 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\172.20.9.238\RTP Stream 5-5-2017_03_01.csv	Up
WAN2_RX(1)	Wed 10:47:30 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\192.168.3.113\WAN2_RX(1)-4-2017_03_01.csv	Up
RTP Stream 5	Wed 10:47:30 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\172.20.9.153\RTP Stream 5-5-2017_03_01.csv	Up
RTP Stream to 240(4)	Wed 10:47:32 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\172.20.9.233\RTP Stream to 240(4)-7-2017_03_01.csv	Down (RX Packet Loss)
RTP Stream 10	Wed 10:47:33 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\192.168.103.240\RTP Stream 10-9-2017_03_01.csv	Up
RTP Stream 7	Wed 10:47:30 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\192.168.3.153\RTP Stream 7-7-2017_03_01.csv	Up
PRI 240 A	Wed 10:47:33 AM 03/01/2017	C:\Users\ctammaro\Livelook\logs\192.168.3.240\PRI 240 A-5-2017_03_01.csv	Up

- Provides a single screen to monitor status of all stream on all codecs

Network Security

- Multiple Network Interface Controllers (NICS) to segregate internal and external traffic as needed

- Built-in Firewall in all NIC's
  - IP Address ACL to restrict incoming and outgoing traffic on the network port
  - Protocol access may be disabled Web, SNMP, FTP, HTTP on the network port

- Web access protection
  - Multiple account types: Admin, Engineer, Operator to restrict control to the device
  - Enhanced password protection with a "secret answer" to protect against dictionary hacking attempts

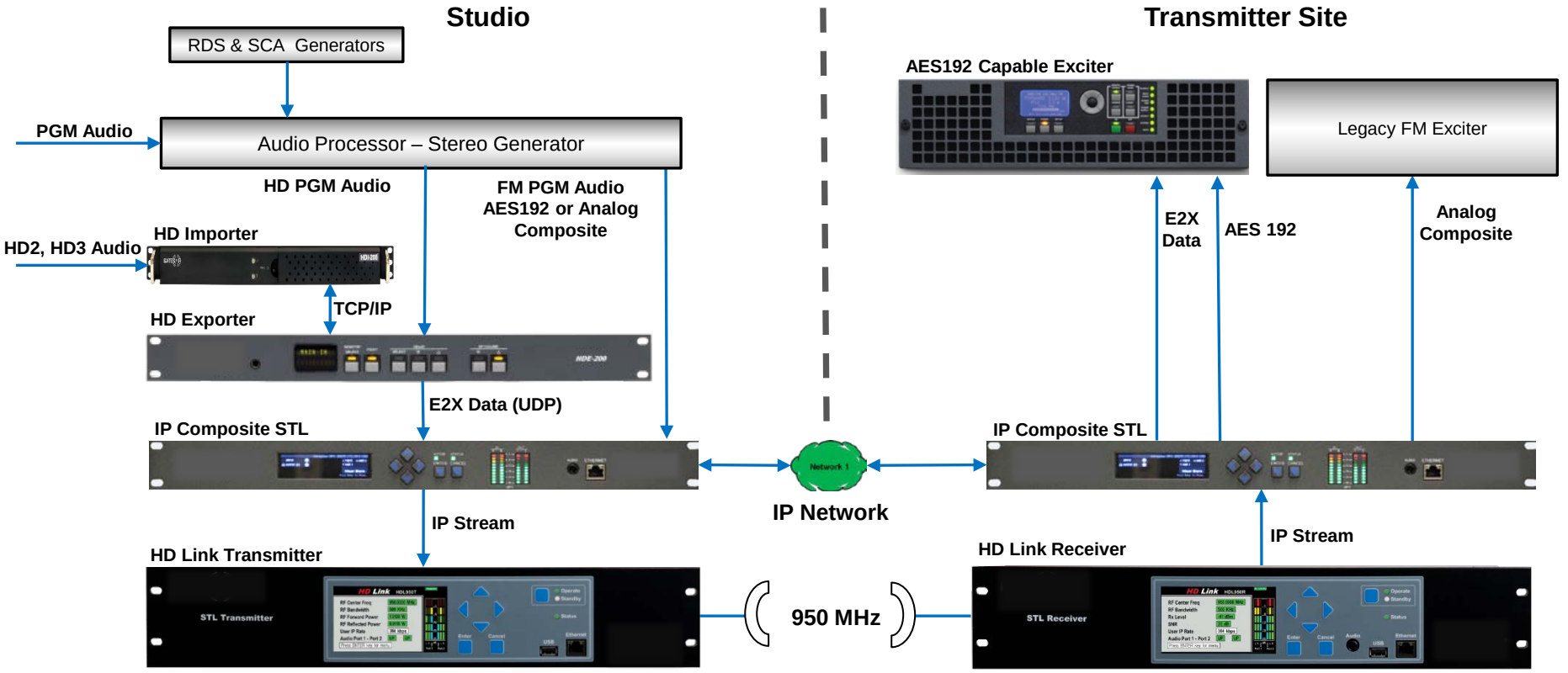
Network Security

- Secure Web access using Secure Socket Layer (SSL), uses encrypted link between web server and browser
- Stream Security via Authentication
  - Stream should allow authentication using Program Identification code
- Secure SNMP access (V3) – adds Users, Authentication and Encrpytion

Reliable IP Transport – Tools Available

- Tools we use in IP Link to reliably move audio over IP:
  - Configuarable Data Rates – 1.6 to 5 Mbps
  - Dynamic & Static Jitter Buffering
  - Forward Error Correction (FEC)
  - Packet Interleaving
  - Packet Loss Concealment
  - Stream Splicing using Time and Network Diversity
  - Network analytics, monitoring, email alerts and real-time logging
  - Network Security

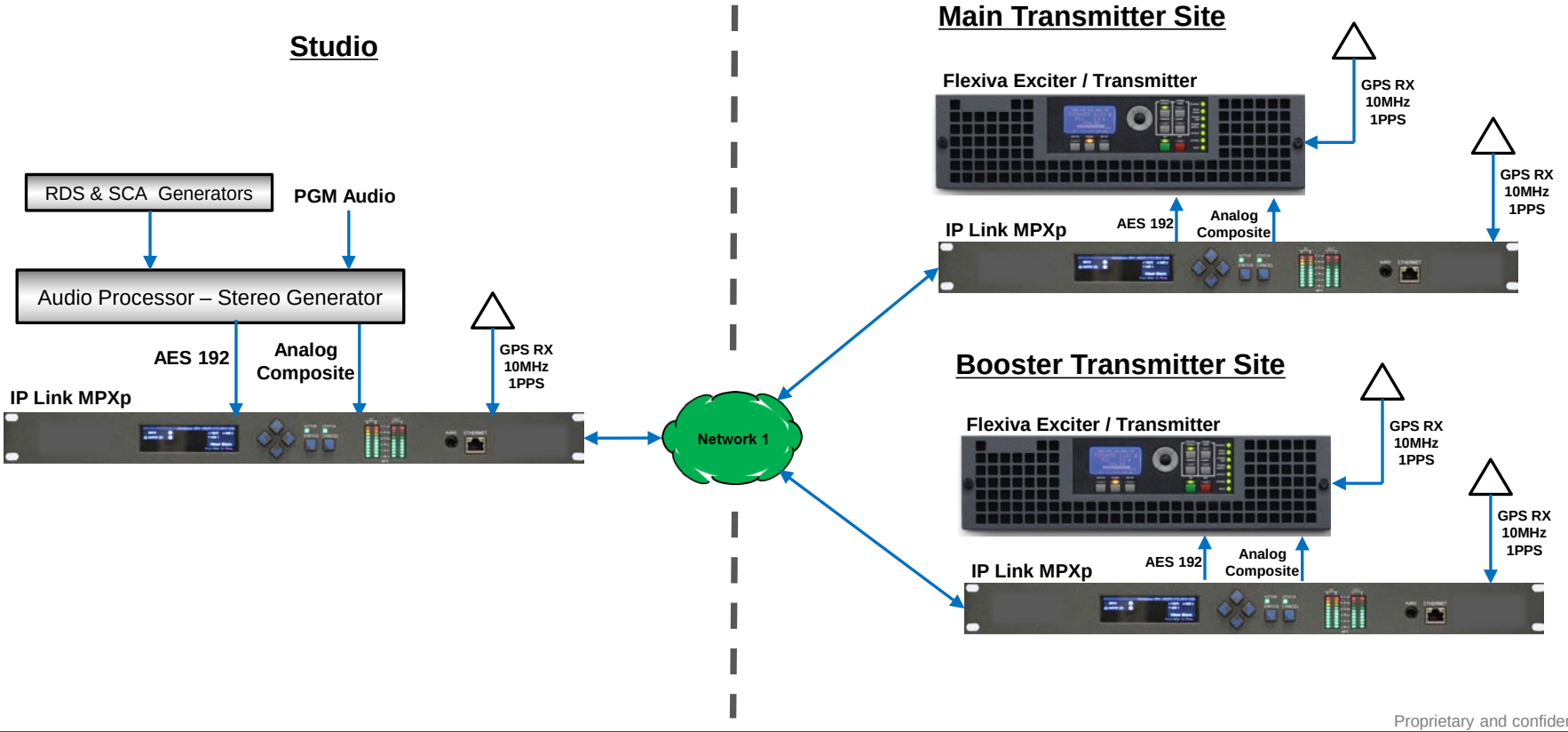
FM Composite over IP & 950 MHz STL



Data Rates for Composite over 950 STL

Sample Rate	Services Shaded Rates for HDL	12 Bits (Mbps)	14 Bits (Mbps)	16 Bits (Mbps)	20 Bits (Mbps)	24 Bits (Mbps)		Bandwidth kHz	RX Level (dBm)	Data Rate (Mbps)	QAM Order
132 kHz	Audio+RDS	1.64	1.93	2.2	2.7	3.3		500	-82	3.2	256
162 kHz	Audio+RDS+SCA1	2.1	2.3	2.8	3.4	4.1		500	-84	2.8	128
192 kHz	Audio+RDS+SCA1	2.4	2.8	3.2	4.0	4.8		500	-87	2.4	64
216 kHz	Audio+RDS+SCA1+SCA2	2.7	3.1	3.6	4.5	5.4		500	-90	2.0	32

Composite FM in Single Frequency Networks



Summary

- Lower data rates are an enabler for composite over IP & 950
- Composite STL brings all critical FM and HD hardware back to studio
- On-Air processor can now be used for studio pre-delay processing
- IP based Composite improves SFN, and multicasting to aux sites
- Interoperability is employed for analog or digital composite audio
- Powerful correction tools ensure reliable STL performance
- Transport HD Radio E2X stream reliably and hold diversity delay
- Secure operation of audio over IP is supported via multiple NIC's, stream authentication, user authentication, dictionary attack protection, firewalls, ACL's, etc
- Simultaneous operation over 950 STL and IP connection in a main/alt config

Thank You!

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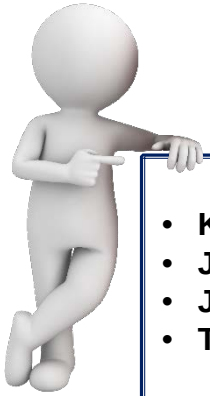

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GatesAir