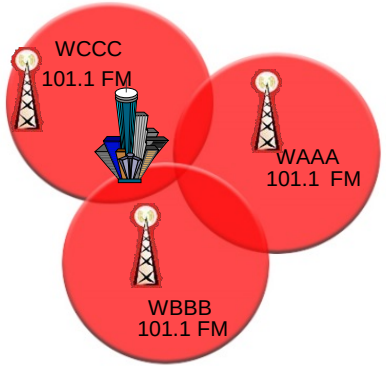
Signal Alignment of FM Plus HD SFN Across IP STLs

Agenda

- Overview of SFN and requirements for signal alignment
- Challenges with IP STLs
- GatesAir Intraplex solution for FM only SFN applications
- Changes for FM+HD SFN applications
  - Changes in transport protocol and FM SFN solution
  - Changes in Exciter/Exgen software
- Typical topologies

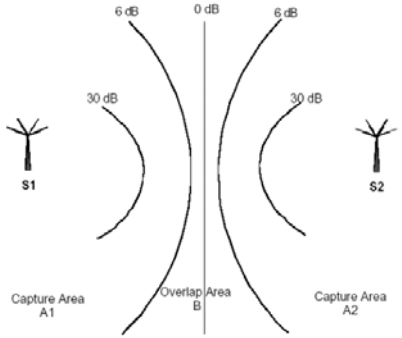
FM+HD Single Frequency Network

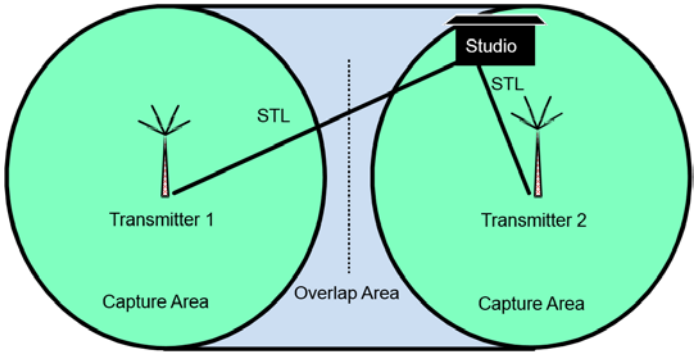
- Multiple transmitters operating on the RF frequency within a region – also referred to as simulcasting
- Applications
  - Expansion of RF coverage area
  - Filling coverage gaps



Effects of RF Simulcasting

- The signals from multiple transmitters in the overlap region must be aligned, otherwise interference is destructive
- Signal alignment requires analyzing the end-to-end delay of the signal arriving in the overlap region
- System engineering is a critical step in determining the end-to-end delay of signals from multiple transmitters to overlap region
- Result of the system engineering is the user programmable delay at transmitter site equipment





Understanding End-to-End Delay

- The signal leaving the studio experiences both **uncontrolled STL network delay** as well as several **constant delays** at the transmitter site equipment
- Constant delays includes processing within the various elements in the signal chain and the RF “flight” time in the air
- RF “flight” time is calculated based on speed of light ~300,000 km/hr – equates to 300m for every 1usec of delay
- Uncontrolled STL delay needs to be made deterministic – **Patented Intraplex SynchroCast® technology** has been used for analog FM
- The FM transmitters must also produce constant processing delay

Analog FM Signal Data Rate

- Standard practice distributes FM MPX or AES192 signal as opposed to discreet L and R audio
- MPX distribution simplifies SFN implementation – Pilot timing is same across all sites
- IP transport reliability when transporting MPX or AES192 becomes critical – lost packets have more adverse effect.
- MPX/AES193 signal bandwidth varies based on encoding as show below: Intraplex Synchrocast works with any of these available signal configuration

Sample Rate (kHz)	Word Size Range (Bits)	Data rate range (Mbps)
132	**12** to 24	**1.64** to 3.3
162	12 to 24	2 to 4
192	12 to 24	2.4 to 4.8
216	12 to 24	2.6 to 5.4

Most common MPX/AES192 configuration in use today:
132 kHz at 12 bits – 1.64 Mbps

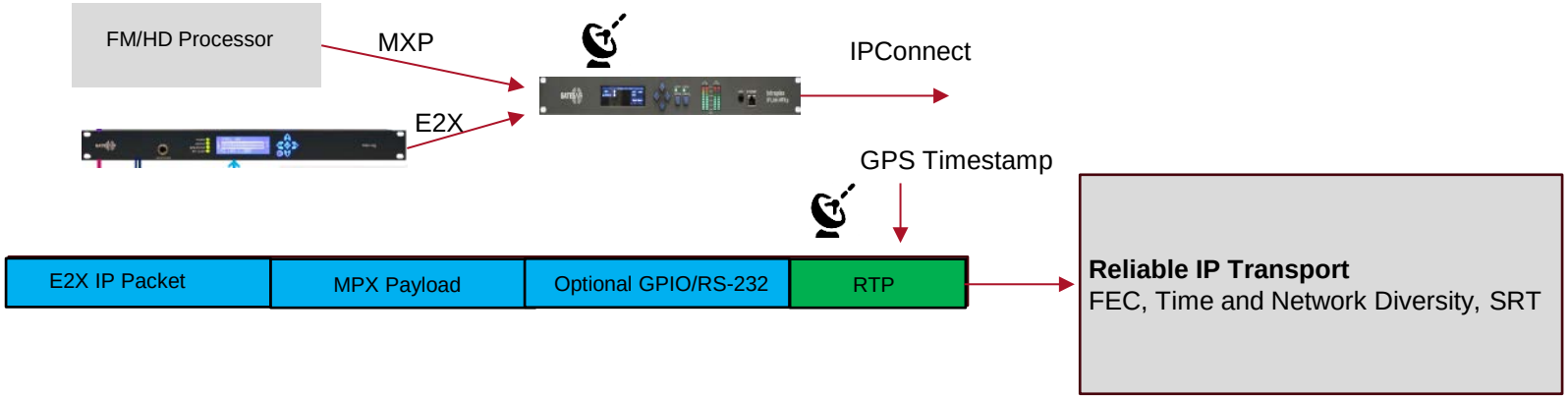
MicroMPX is also supported at 320 and 576 kbps

Challenges With FM+HD Use cases

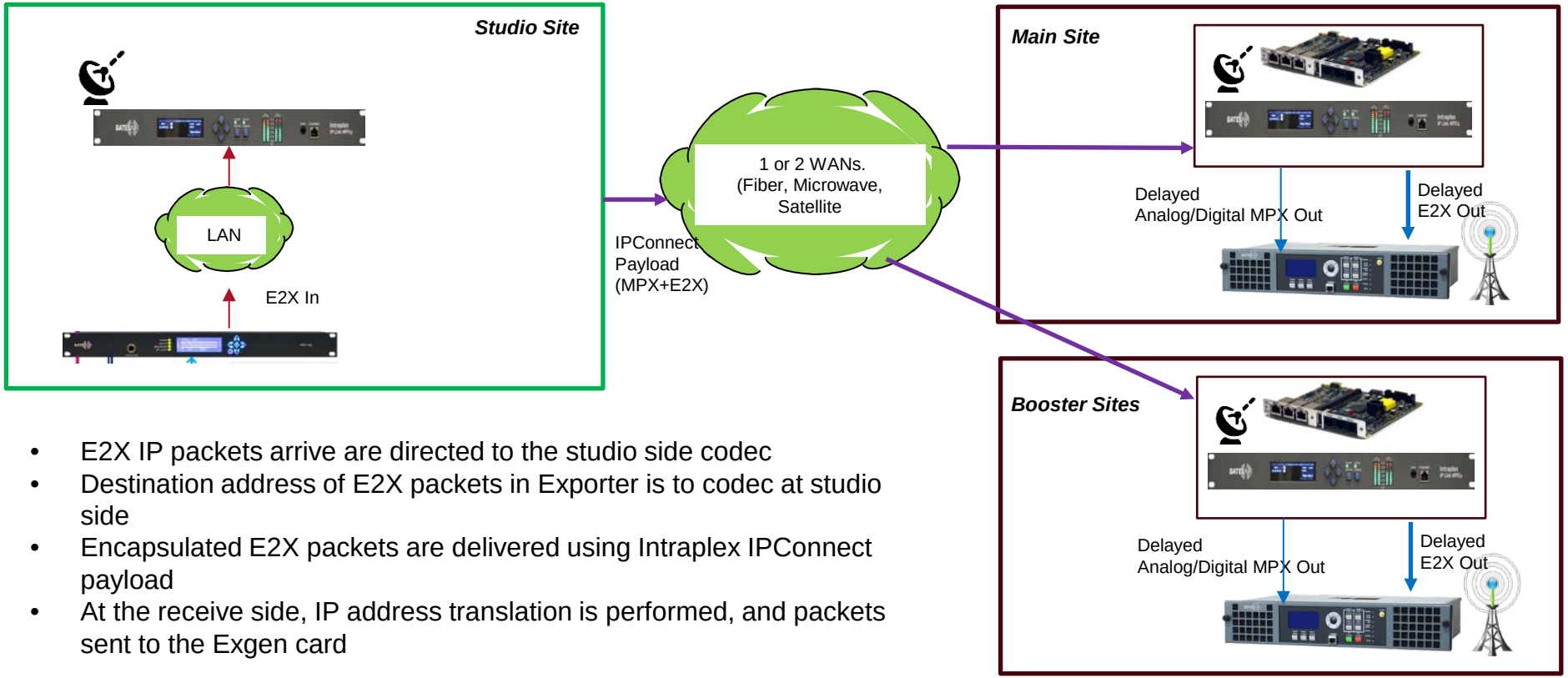
- Analog FM SFN use cases has been well proven for both Broadcast and Land Mobile Radio applications using SynchroCast technology
- HD adds following challenges:
  - Very sensitive to packet losses. No inherent protection for packet losses in E2X
  - Synchronizing HD signal processing across all transmitters
- To address the above challenges, following changes were made
  - New transport payload **IPConnect** was created to leverage existing packet loss protection schemes
  - SynchroCast was enhanced in the Intraplex codecs to align delay of FM and E2X stream across IP STL
  - Software changes in Exciter/Exgen to precisely align HD signals across multiple transmitters

What is IPConnect

- Proprietary GatesAir payload multiplexes Analog FM (MPX or Discreet audio) and other data (External IP packet (E2X or any), GPIO, Serial Data)
- Synchrocast works with the entire IPConnect payload to maintain constant delay of Analog FM plus all other data
- Smooths out burstiness of E2X stream and adds protection of packet losses
- IPConnect uses reliability schemes of RTP/UDP or Secure Reliable Transport (SRT)



Ingress and Egress Of E2X Packets

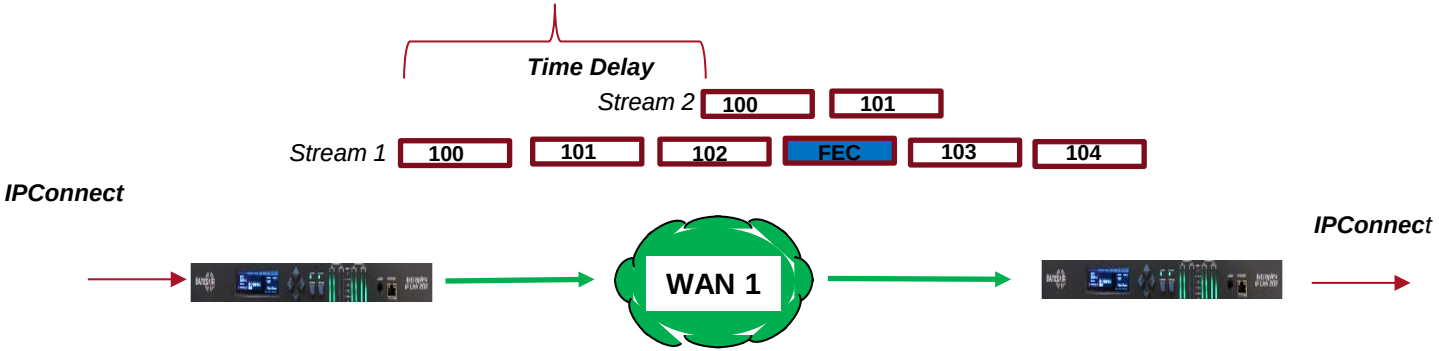


- E2X IP packets arrive are directed to the studio side codec
- Destination address of E2X packets in Exporter is to codec at studio side
- Encapsulated E2X packets are delivered using Intraplex IPConnect payload
- At the receive side, IP address translation is performed, and packets sent to the Exgen card

Protecting IPConnect Across WAN

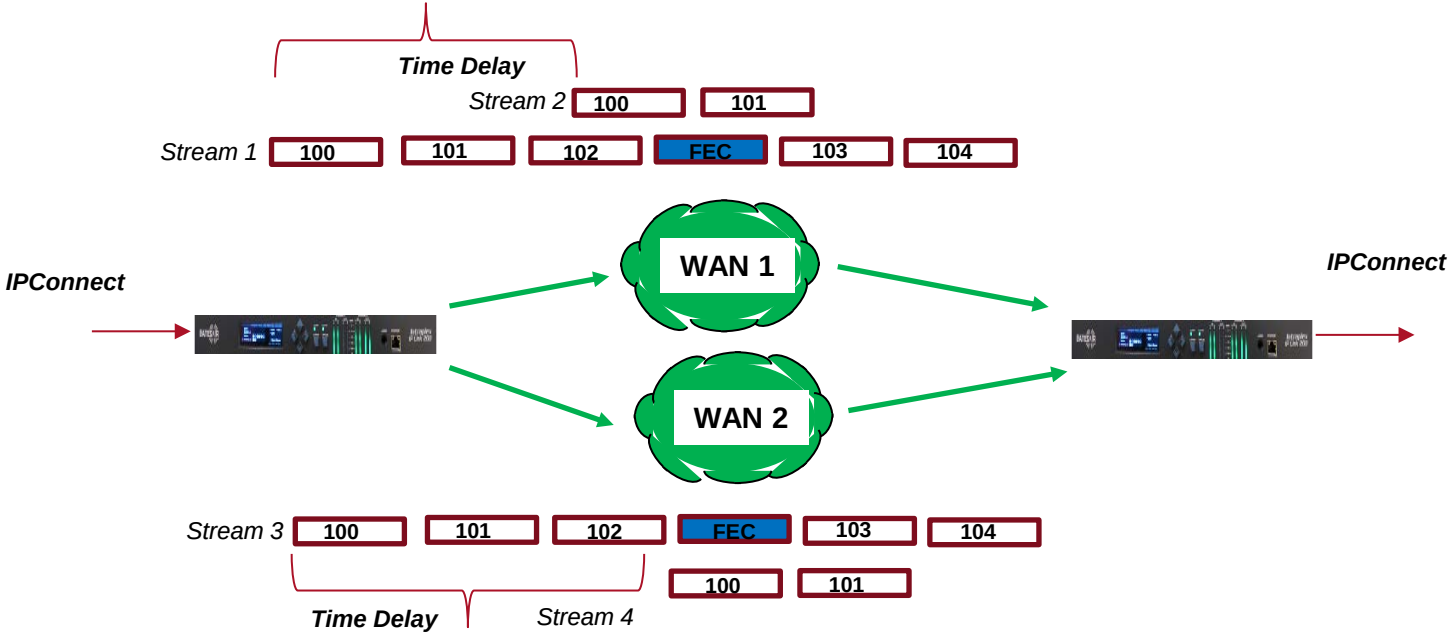
- 3 independent network ports provides WAN diversity
- 2 modes of protection: RTP/UDP and Secure Reliable Transport (SRT)
- RTP/UDP – default transport mode. Can be used on uni-directional links
  - Forward Error Correction (FEC). Selection of matrix size and overhead (25%,50%, 66%,100%)
  - FEC is effective for random losses
- Stream Splicing (Intraplex Technology)
  - Creates duplicate packet streams to be send with **time** and/or **network** diversity
  - Programmable time delay up to several seconds
  - Network diversity can use up to 3 ports
  - Effective for burst packet loss patterns, **widely used in current deployments**.
- Secure Reliable Transport (SRT)
  - Real-time retransmission protocol using UDP
  - Has shown to be very effective for high level of random losses.

RTP/UDP Protection For Single WAN



- FEC is very effective and efficient for random losses
- Time Delay is user programmable and can be recommended by LiveLook software
- Supports diversity delays up to **multiple seconds** to accommodate high burst losses seen in satellite distribution
- Stream grouping allows multiple streams with different time delay and/or FEC

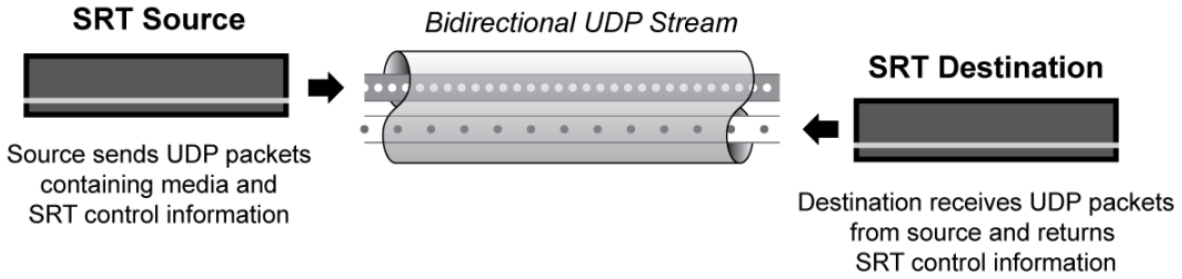
RTP/UDP For Multiple WANs



- Grouping of stream with network and time diversity, and FEC
- Protects against complete network failures, burst packet losses, isolated packet losses and high jitter

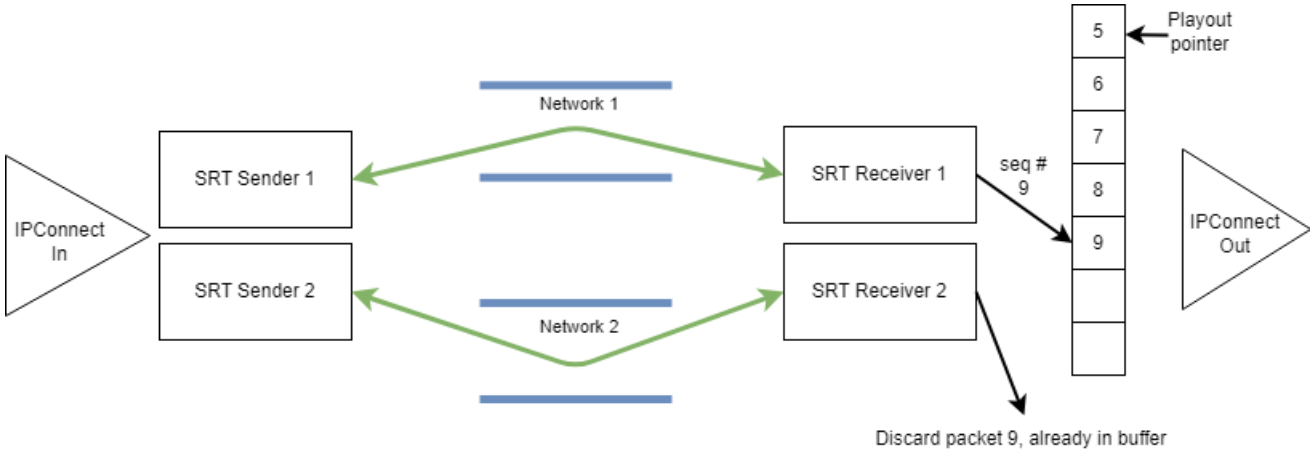
Using SRT

- SRT – Secure Reliable Transport (point to point, no support for multicast)
  - Packet loss recovery through advanced low latency retransmission techniques
  - AES 128/256 bit encryption
  - Ability to designate any endpoint as “sender”, “receiver”, or “rendezvous” mode
  - The protocol relies on bi-directional UDP traffic to optimize streaming
  - Constant exchange of control information between endpoints
    - Including “keep alive” packets (if needed) aprox. every 10ms
    - SRT streams can be automatically restored after connection loss



SRT with Dual Networks

- SRT + Intraplex Stream Splicing
  - Encapsulate GatesAir RTP packet in 2 SRT tunnels



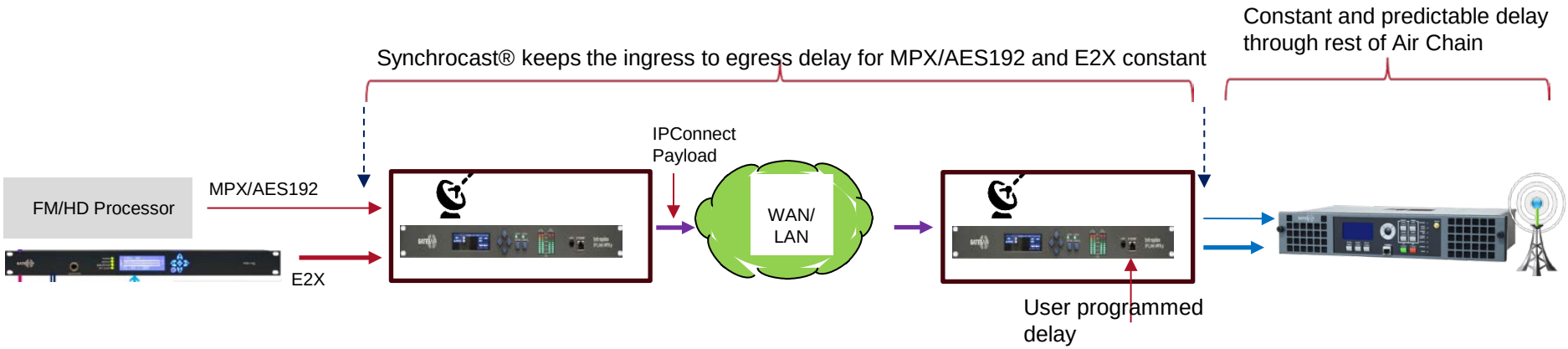
Overview Of SynchroCast

- Patented technology in Intraplex audio products to support synchronization of RF signals in overlap region for FM or AM SFNs. Technology has been in use since 1990s, we are now on generation 3
- 3 active patents for the technology
- Uses GPS timing and proprietary algorithm to precisely maintain user programmed end-to-end delay (input from encoder through output on decoder). The delay is maintained within **1 uSec** of the user programmed
- **Automatically adjusts** the internal buffer to compensate for any changes in the network or processing delay
- GatesAir **FM+HD SFN solution relies on Synchrocast to deliver E2X to all sites with same delay**

Modes Of Synchrocast

- Normal Mode
  - User configured delay is limited to less than 1 second.
  - Doesn’t require internal GPS. Externally fed 10 Mhz and 1 PPS is sufficient
- Extended Mode
  - Allows user configured delay up to **10 seconds**
  - Requires GPS module to be installed in all codecs
  - Utilized for use cases where large stream splicing delay is necessary for reliability
  - Has proven to be extremely useful to the quality of SFN operation

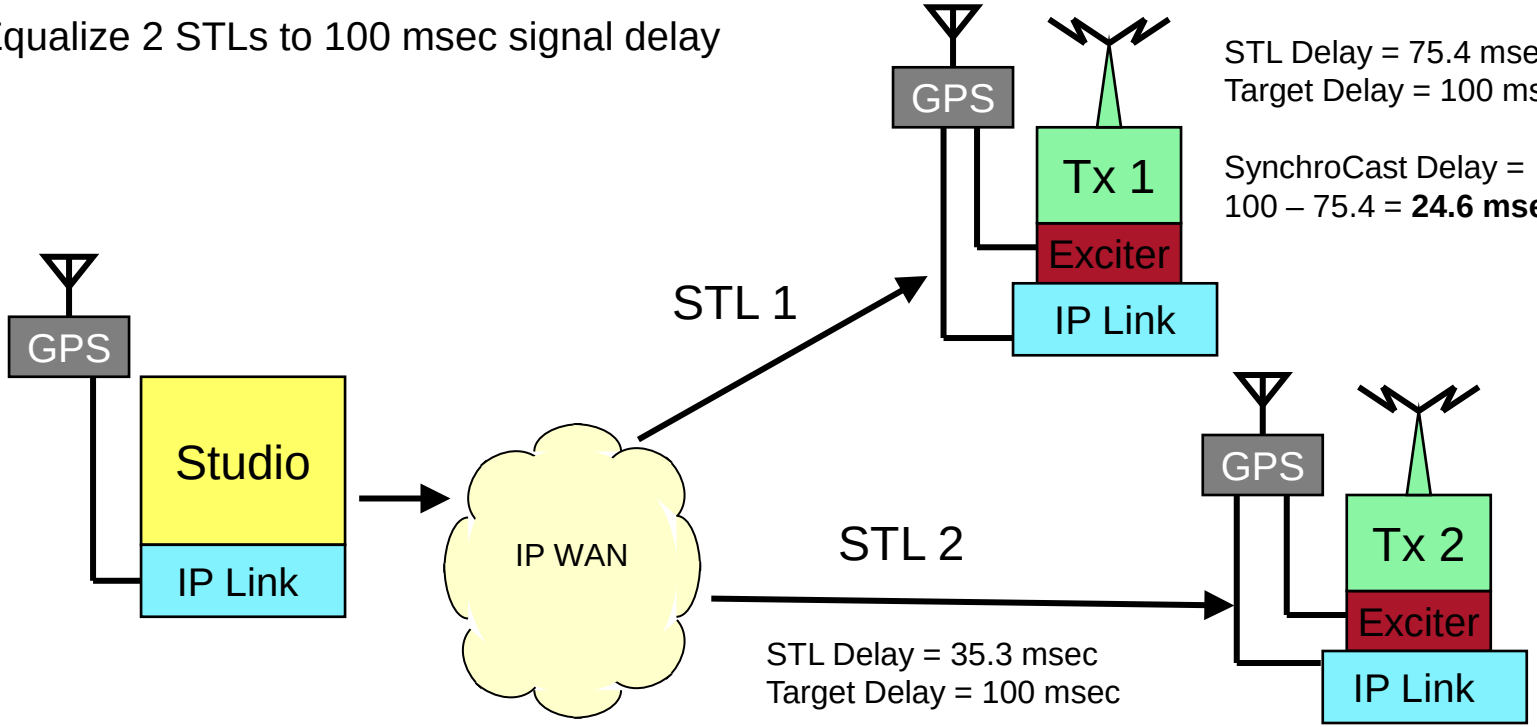
Role of SynchroCast



- Delay of MPX/AES192 and E2X from ingress to egress remains **constant** to the **user configured value.** Dynamically adjusted to account for any variation in network or codec processing
- User programs the delay based on analysis of following: Network delay, processing delay and RF path delay

SynchroCast Target Delay Adjustment - Example

Example: Equalize 2 STLs to 100 msec signal delay



STL Delay = 75.4 msec
Target Delay = 100 msec

SynchroCast Delay =
100 – 75.4 = **24.6 msec**

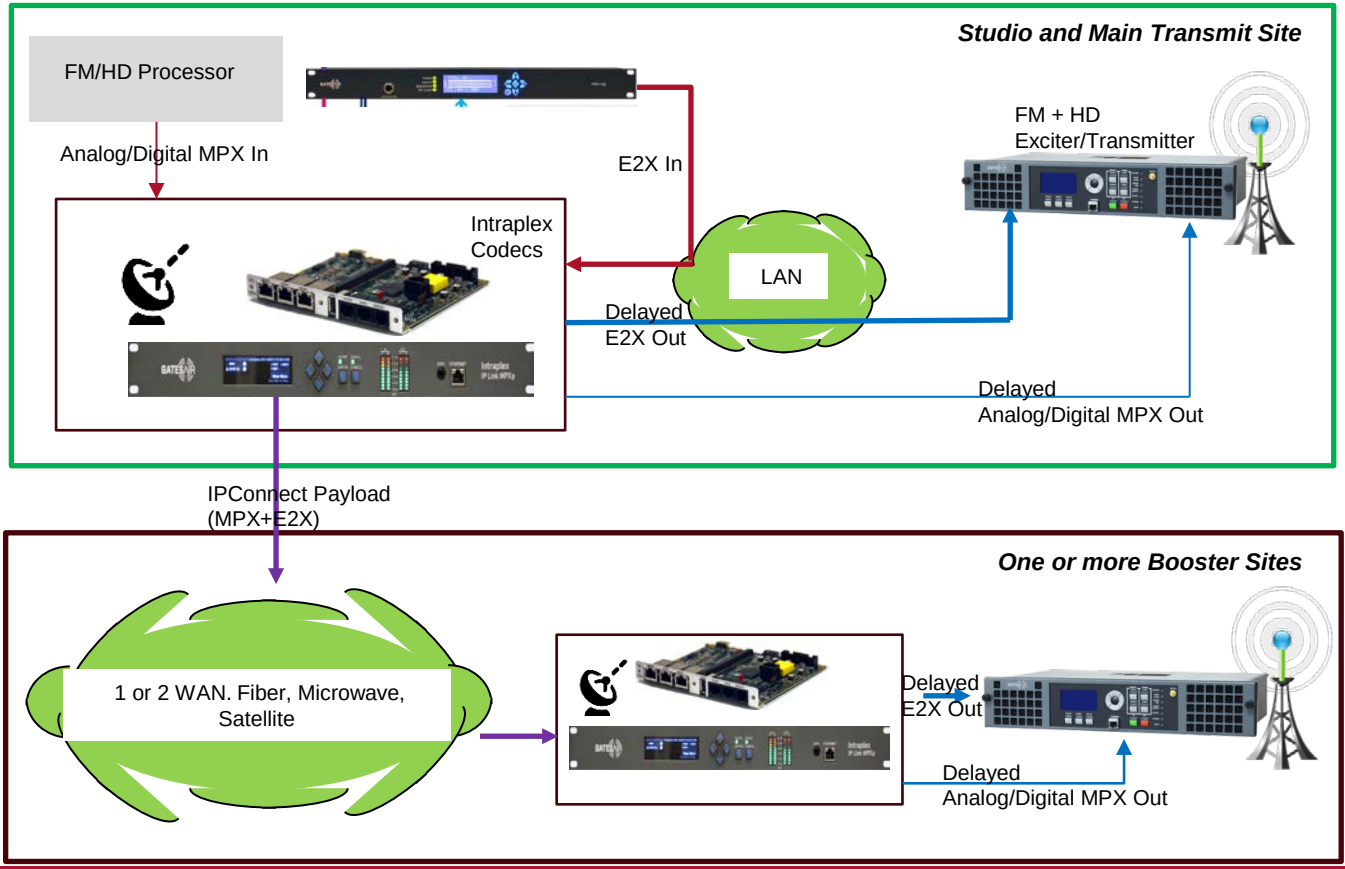
STL Delay = 35.3 msec
Target Delay = 100 msec

SynchroCast Delay =
100 – 35.3 = **64.7 msec**

Enhancements Within Exciter

- Creating local ALFN timing at each exciter based on local GPS 1 PPS. This is then used to synchronize the processing to start of the E2X frames
- In addition, the software was enhanced to ensure that the processing delay of HD signal is constant across the Exciter system
- Combination of above and Synchrocast to deliver the E2X packets at the same time to all exciters allows ALFN timing to be same
- User configurable delay from 1 to 340 usec to move the HD SFN overlap zone for optimal performance

Topology: Studio And Main Co-Located



Studio Side (Transmit Side)

- MPX ingested via Analog or AES3 interface
- E2X traffic ingested from Local LAN.
- Encode and create Multi-destination streams, including one for local loop back and across WANs to Booster sites

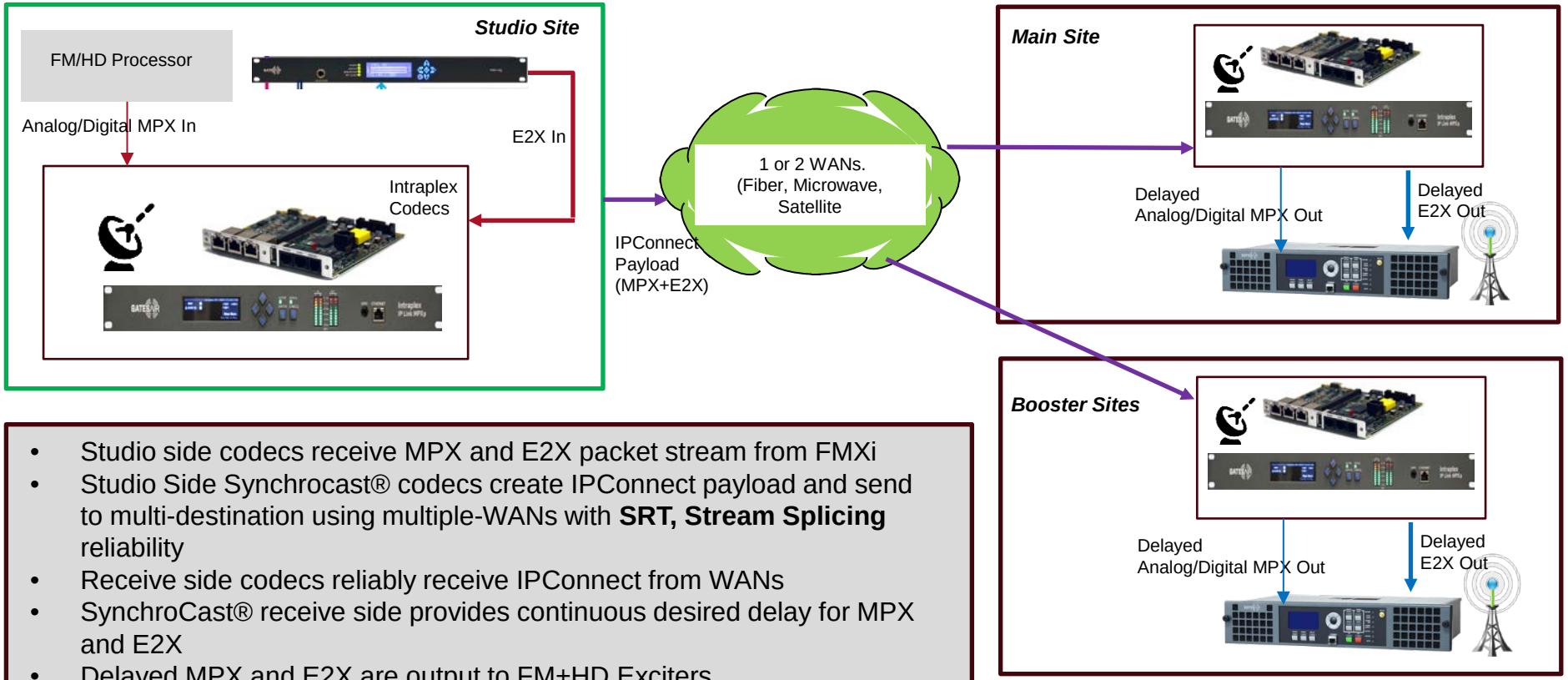
Studio Side (Receive Side)

- Receive local loopback IPConnect traffic
- SynchroCast® provides the desired delay for both MPX and E2X
- Delayed MPX signal is output to FM Exciter
- Delay E2X packets are IP address translated and output via Local LAN to Exgen card

Booster Sites(Receive Side)

- Receive and recover IPConnect packets
- SynchroCast® provides the desired delay for both MPX and E2X
- Delayed MPX signal is output to FM Exciter
- Delay E2X packets are IP address translated and output via Local LAN to Exgen card

Separate Studio Site



- Studio side codecs receive MPX and E2X packet stream from FMXi
- Studio Side Synchrocast® codecs create IPConnect payload and send to multi-destination using multiple-WANs with **SRT, Stream Splicing** reliability
- Receive side codecs reliably receive IPConnect from WANs
- SynchroCast® receive side provides continuous desired delay for MPX and E2X
- Delayed MPX and E2X are output to FM+HD Exciters

Summary

- Reliable IP transport of MPX and E2X is critical
- Deterministic delay for MPX and E2X signals across IP STLs
- Synchronizing HD frame processing in Exgen
- Deterministic processing in Exciter and Exgen
- Resiliency to outage events: network, power, GPS

Thank You!