Adapting the Transport Stream Bit Rate to Ensure Service Continuity

VidTrans 2019

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Presentation Outline

- Problem description
- Diverse path
- Dynamic load share over diverse path
- Source bit rate adaptation
- Source bit rate adaptation with dynamic load share
- SPTS distribution to multiple destinations
- MPTS distribution to multiple destinations
- Future work
- Q&A

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Problem Description

Data networks	• Lost packets are recovered by ARQ • Packet jitter is eliminated by a jitter buffer • No solution for bandwidth fluctuations
Bandwidth fluctuations	• Packet traffic patterns • Network devices congestion • Link utilization
Solution must support	• Point-to-Point contribution • Point-to-Multipoint distribution • SPTS and MPTS

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Diverse Path Solution – Hitless Redundancy

- The Sender sends duplicates of the stream to the Receiver via two (or more) paths
- The Sender connects, possibly to different ISPs or data networks, to ensure diversity
- The Receiver merges the two (or more) duplicates of the stream it receives into a single stream output
- The Receiver could connect via multiple paths to increase reliability even further
- Any bandwidth problem causing packets to drop in one path is compensated by the other path (or paths)

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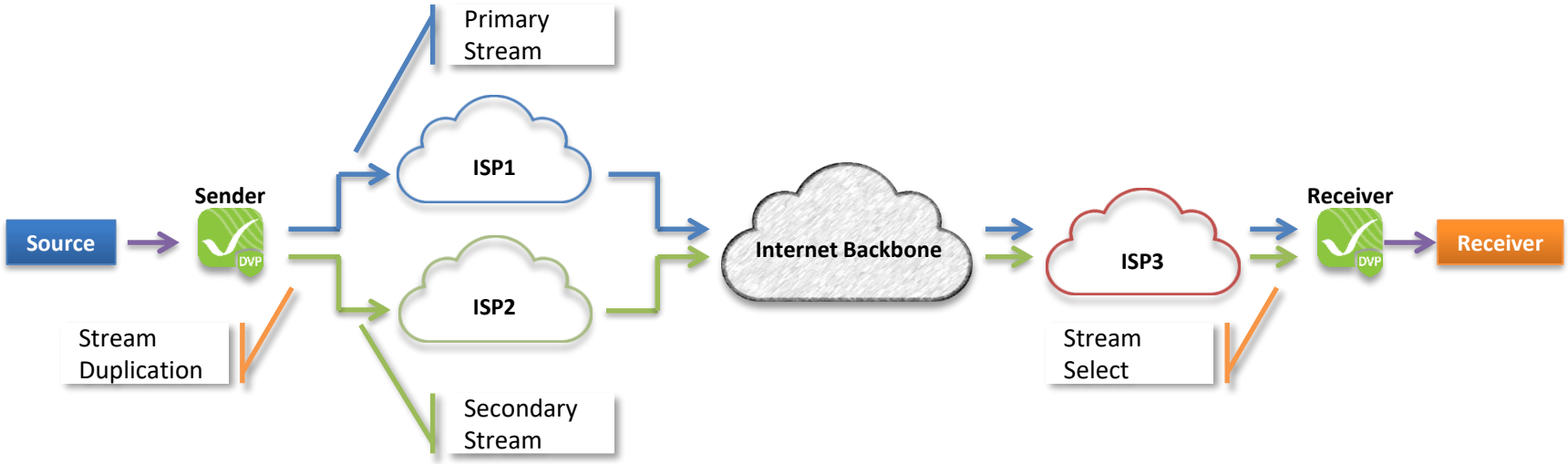
Diverse Path – Hitless Redundancy



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Dynamic Load Share over Diverse Paths

- Stream duplication requires substantial amount of network resources
- Increasing the use of network resources increases bandwidth and packet loss problems
- The solution is to segregate the stream's bit rate to multiple paths and to compensate dynamically for the bit rate fluctuations of each one
- Packet loss in each path is recovered locally and can be used to recover lost packets from other paths as well
- The Receiver aggregates the stream bit rate from multiple paths
- This solution works as long as the total bit rate capacity of all paths is sufficient to carry the stream

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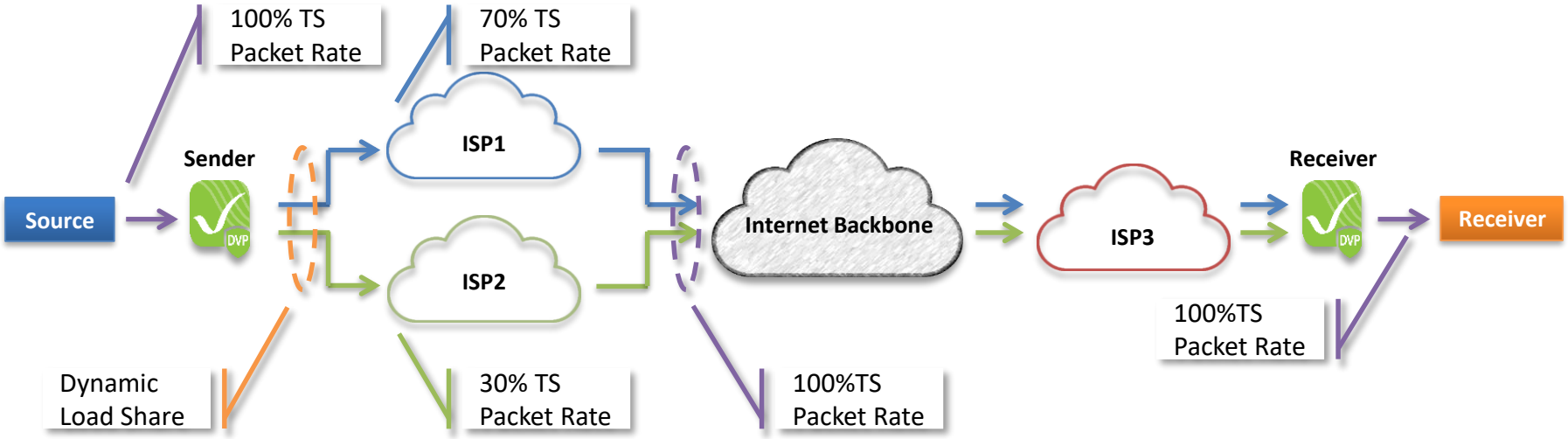
Dynamic Load Share over Diverse Paths



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Dynamic Load Share Added Value

More reliable	• Lower packet rate in a path decreases the number of packet loss problems • Multiple paths allow to divert traffic from a faulty paths or ISP's to other paths
More stable	• The Sender can prioritize traffic through higher SLA paths • Very slim chance that a problem will happen in all paths at the same time
More complete	• Complete path redundancy solution • Can be extended to path and equipment redundancy solution

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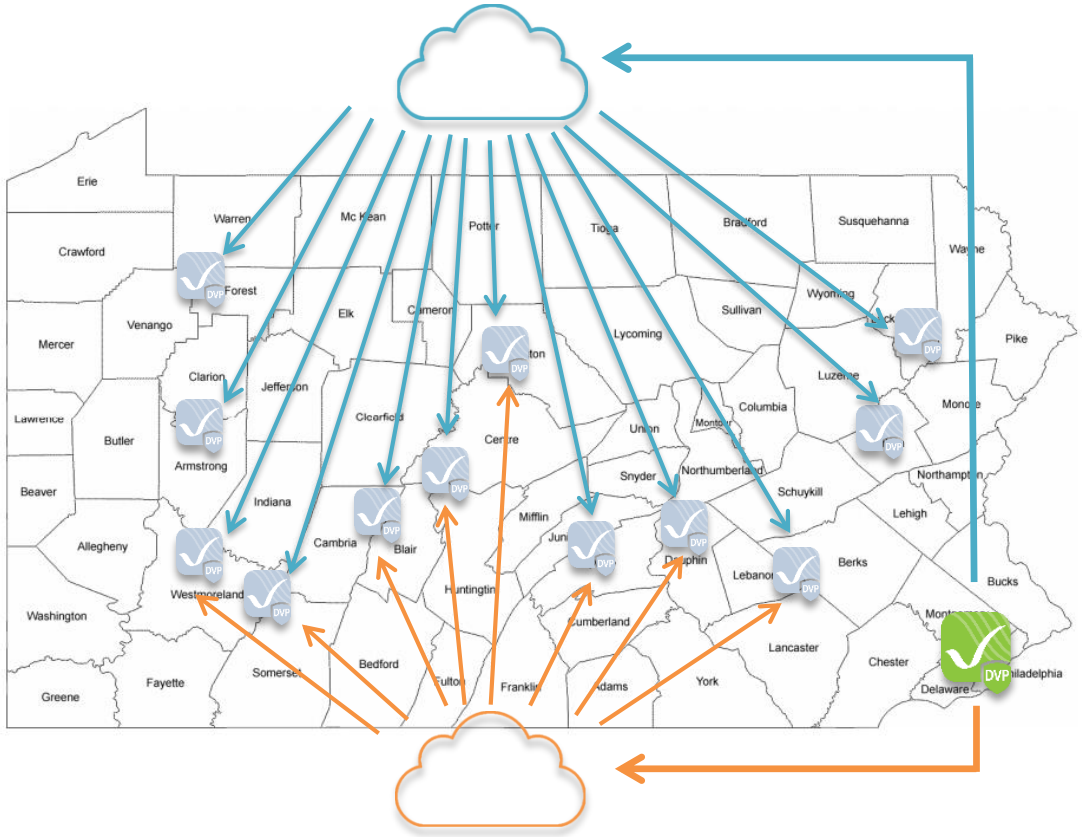
Dynamic Load Share Application Example



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Source Bit Rate Adaptation

WHAT TO DO WHEN THE NETWORK'S BIT RATE DROPS BELOW THE STREAM'S BIT RATE?

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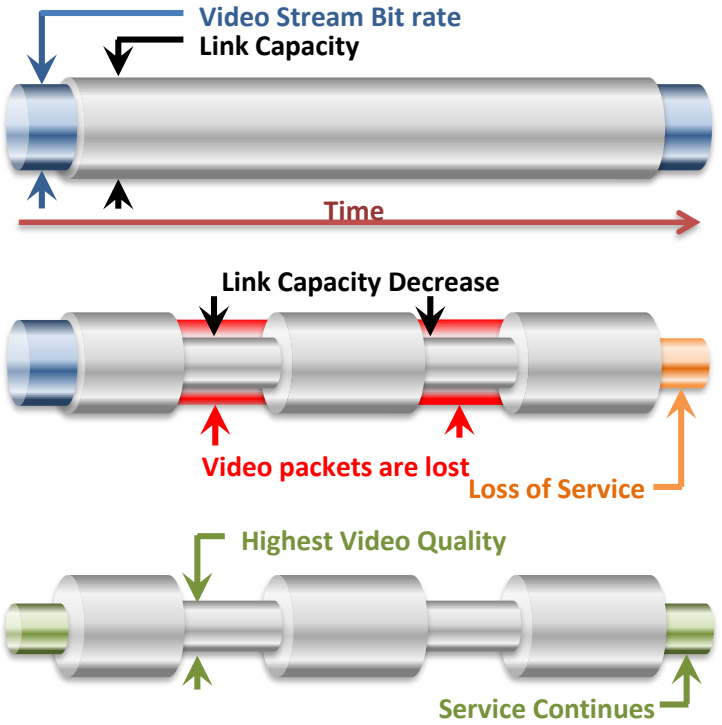
Understanding the Problem

- Extremely hard to predict bit rate fluctuations as they are depending on the network's behavior
- ARQ cannot protect against a drop in link capacity. In fact, ARQ's behavior intensifies the problem by creating a camelback effect that leads to a loss of service
- The only solution is to adapt the transport stream's bit rate to the network's capacity in real time



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Source Adaptation

- Despite of using diverse path and load share, bit rate capacity can be lower than the stream's bit rate due to network problems or unexpected traffic load
- Keep on pushing an 8 Mbps stream through a 6 Mbps connection means losing 25% of the stream's packets ➔ No video
- The only option to continue the service is to give up some video quality and to lower the stream's bit rate in real time to fit the network's bit rate
- Adapting the bit rate in the Sender gives the best performance. Source adaptation is achieved by either changing the stream's bit rate or by selecting a different stream source
- The innovation behind bit rate adaptation is to lower the bit rate on time. A greater innovation is to increase it when the network's capacity is back

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The Contribution Eco System

- Command an encoder that is capable of changing the video rate on-the-fly, while keeping a constant transport stream rate
- The encoder shall accept external commands via NMS, REST, or HTTP and shall change the video rate without a stream reset
- Use NULL packets suppression to reduce the output packet rate while maintaining constant transport stream rate
- Use ARQ to recover lost packets as well as to create a protection budget in order to push for the highest video quality (bit rate) possible
- This technique is detailed in VideoFlow's patent US9781488B2

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Encoder Video Bit Rate Adaptation

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Adapting The Video Rate to the Network Bit Rate

- The Sender and Receiver have a bi-directional link (RTCP) and use ARQ for lost packets recovery
- The Receiver sends lost packets event reports and general stream bit rate statistics
- The Sender monitors the lost packets event reports against its buffer occupancy to determine if there is enough headroom to recover all lost packets (protection budget)
- If there is no headroom, the Sender commands the encoder to lower the bitrate
- The Sender sends probing beacons in parallel to the stream and waits for the Receiver's reports to analyze the effect of the beacons
- Upon receiving several consecutive reports with no loss events the Sender will command the encoder to increase the bit rate one step at a time until reaching the optimal rate

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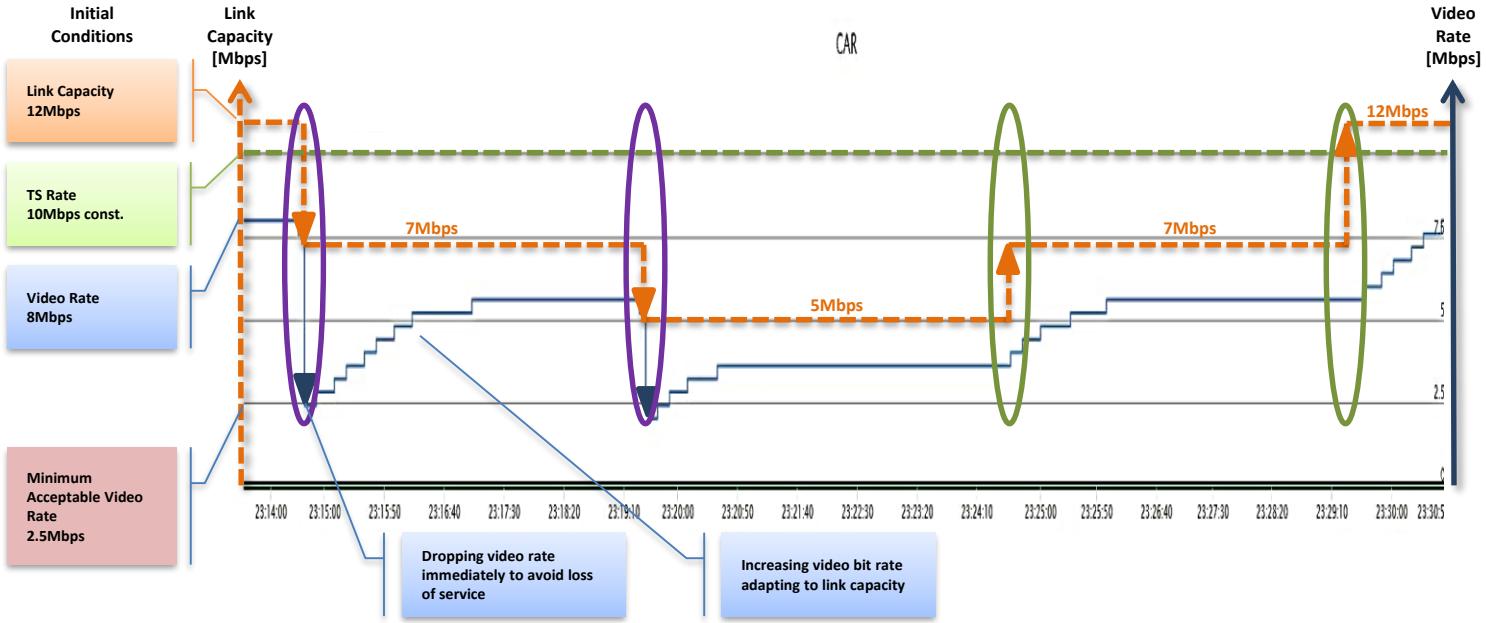
Rate Adaptation Example



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Source Adaptation with Dynamic Load Share

Adding dynamic load share to source adaptation will increase reliability

- The rate adaptation algorithm kicks in only when the Sender reports it has no headroom to guarantee error-free video
- The source is continuously adapted in real time to the network's capacity
- The Sender continuously sends probing beacons on all paths to find the highest possible bit rate

Similar to cellular bonding but with professional broadcast equipment

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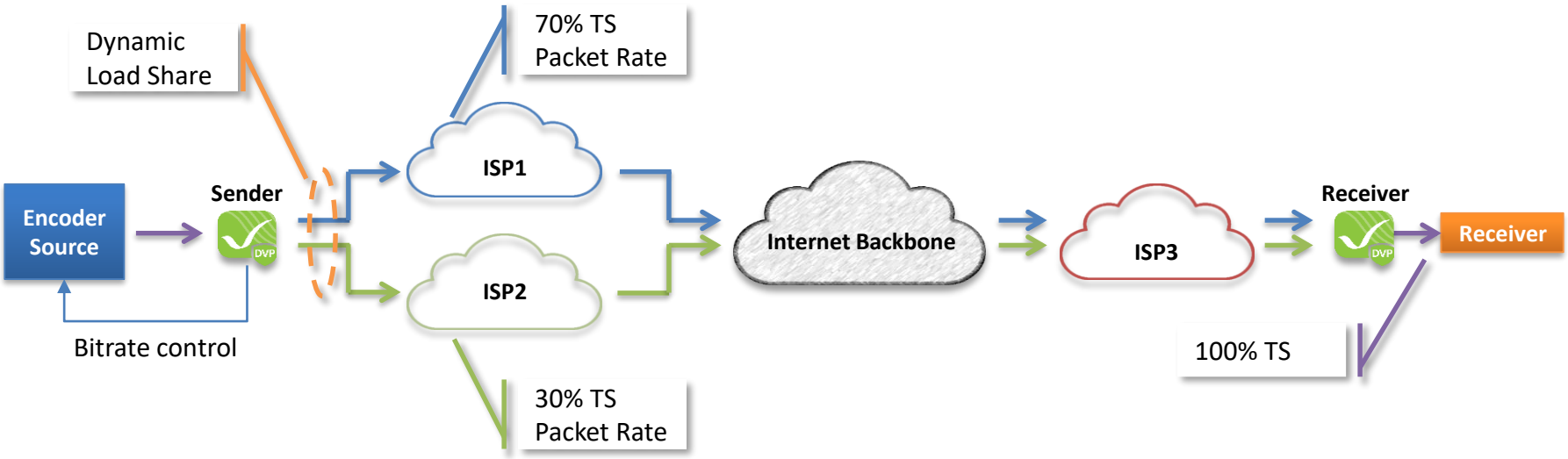
Source Adaptation with Dynamic Load Share



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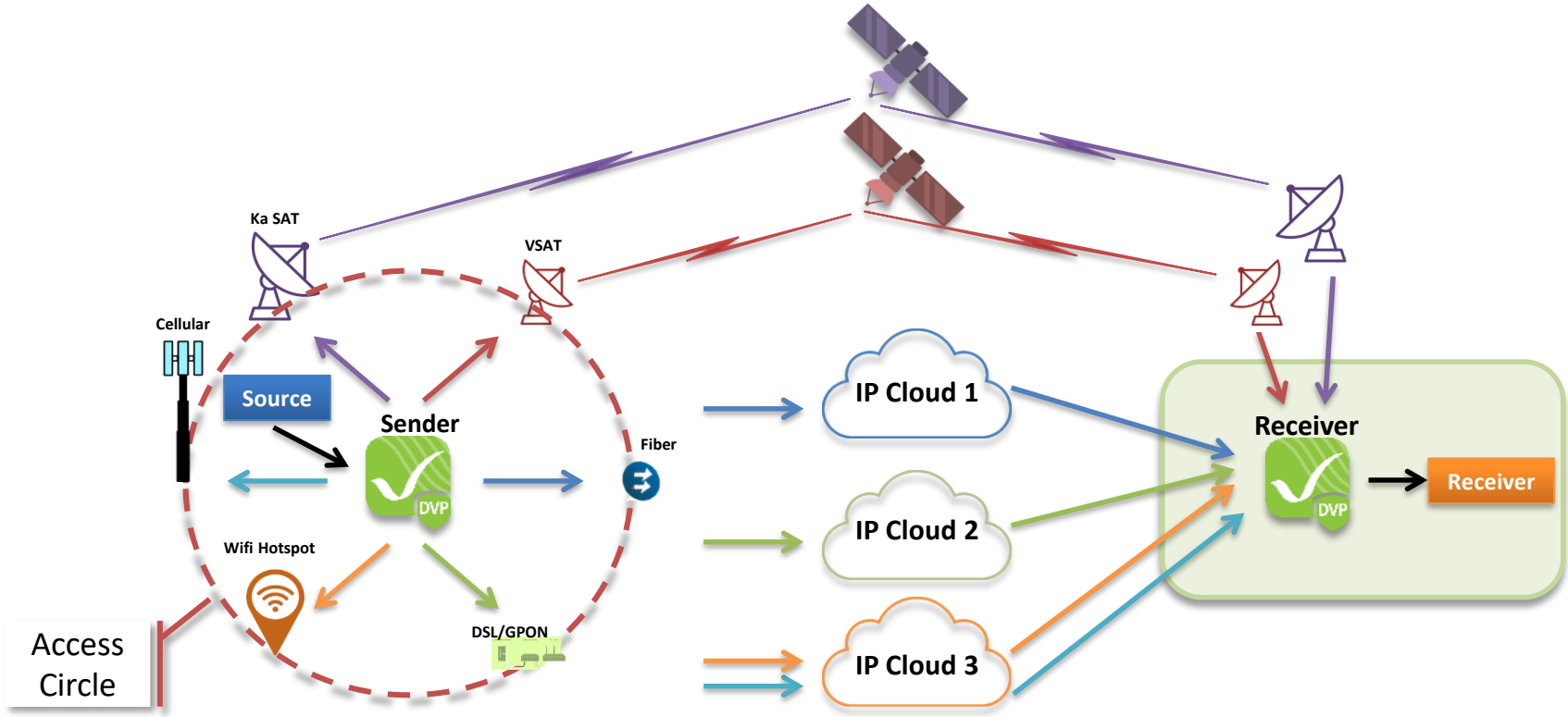
Outside Broadcast Application Example



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How to Adapt In Case of Multiple Destinations

Point to multipoint is more challenging	• Each destination has its own unique path behavior • Encoder per destination can be a solution, but a very expensive one • A single encoder for all destinations will force using the bit rate dictated by the destination with the lowest bit rate connection
VideoFlow have a solution	• Use a probing algorithm per destination • Create a “virtual source” per destination by using multiple synchronized profiles (similar to HTTP adaptive origin server) • Select a profile per destination independent of the other destinations according to its path bit rate • Detailed in VideoFlow patent number US9565482B1

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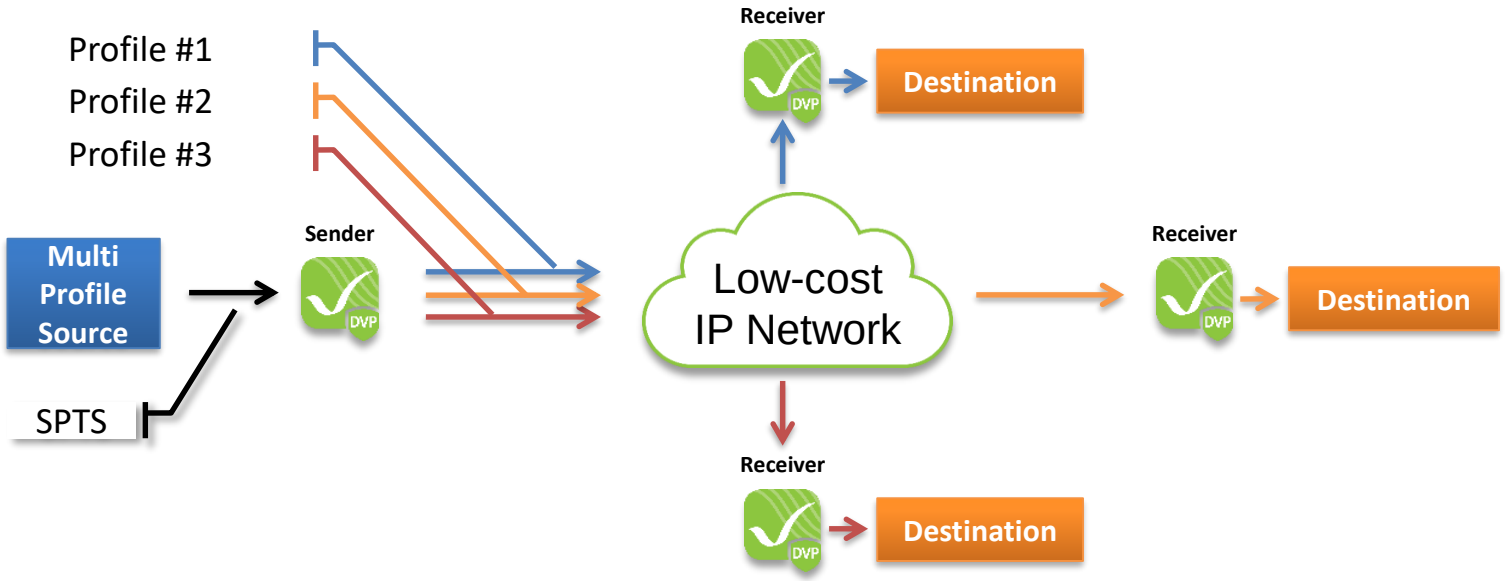
Multi Profile Distribution Solution



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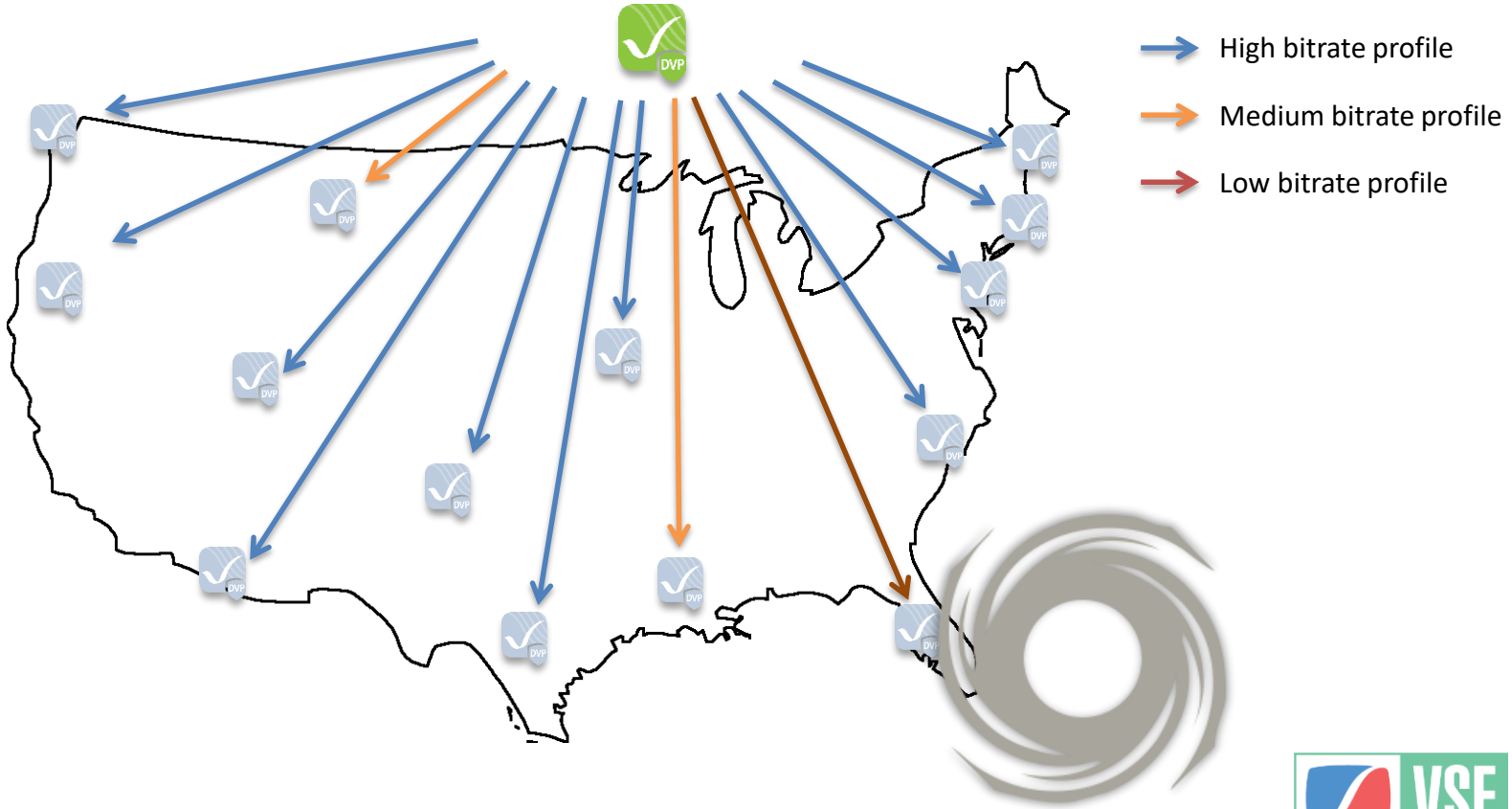
Multi Profile Distribution During a Hurricane



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MPTS Dynamic Adaptation

- MPTS is common in satellite as well as in dense delivery of streams
- Replacing a Satellite link, creating a backup or disaster recovery to one or more locations requires means to adapt the MPTS bit rate
- Creating MPTS profiles and switching between them could break the internal structure of the programs in the MPTS
- The transport stream bit rate must be constant as Receivers are expecting a fixed rate (CBR) transport stream with the same PAT/PMT

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Adapting MPTS

- Use the same network probing algorithm to test the bit rate in the path between the source and the destination
- Attach a priority level to each program in the MPTS to create a QoS list
- Analyze the PAT/PMT for the SID and PID of each program
- The bit rate of each program is measured in real time
- Changes to the network's bit rate determines which programs will be dropped or added according to the QoS list

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Adapting MPTS

Network bit rate drop

- PIDs are scanned based on the QoS list
- Selects the program or programs to remove according to the priority level
- Nullify the program by replacing its packets with NULL packets

Network bit rate increase

- PIDs are scanned based on the QoS list
- Selects the program or programs to add according to priority level
- Stops Nullify the program or programs

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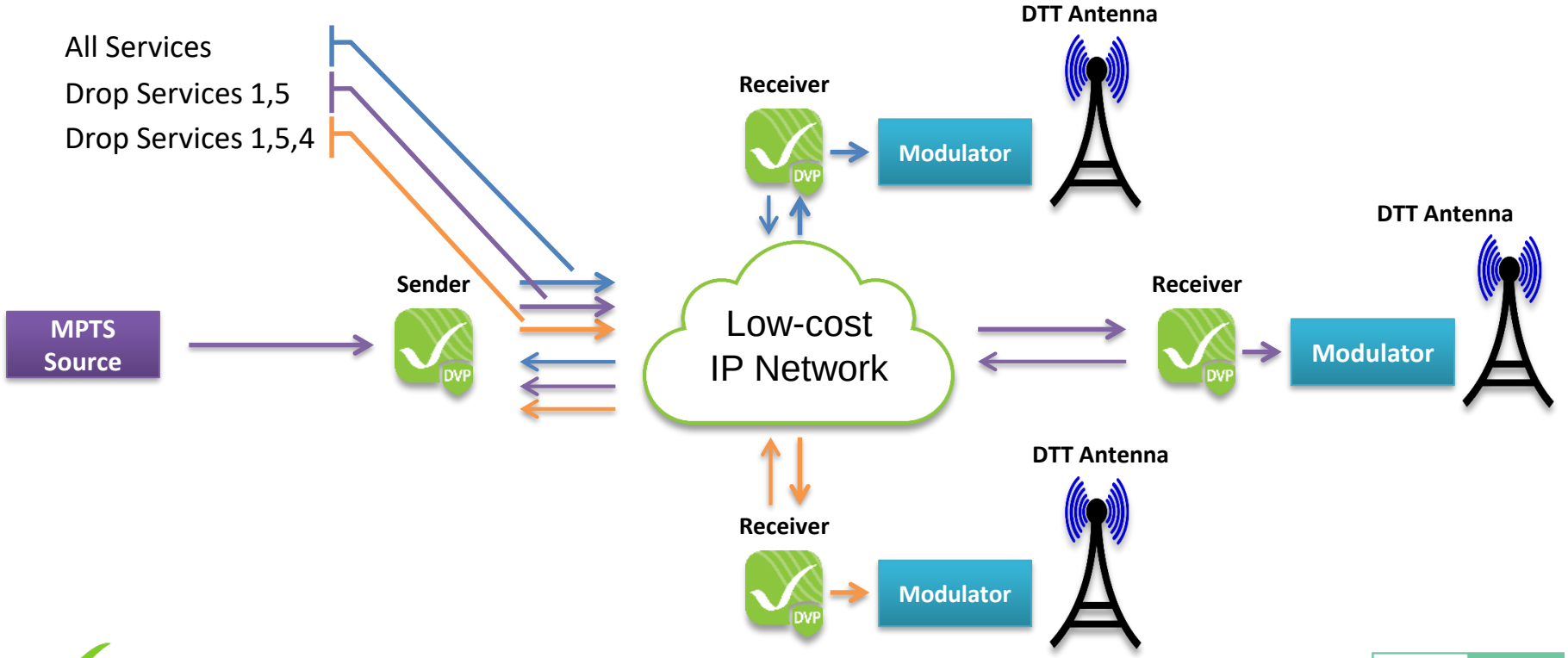
Adapting MPTS to One or More Destinations



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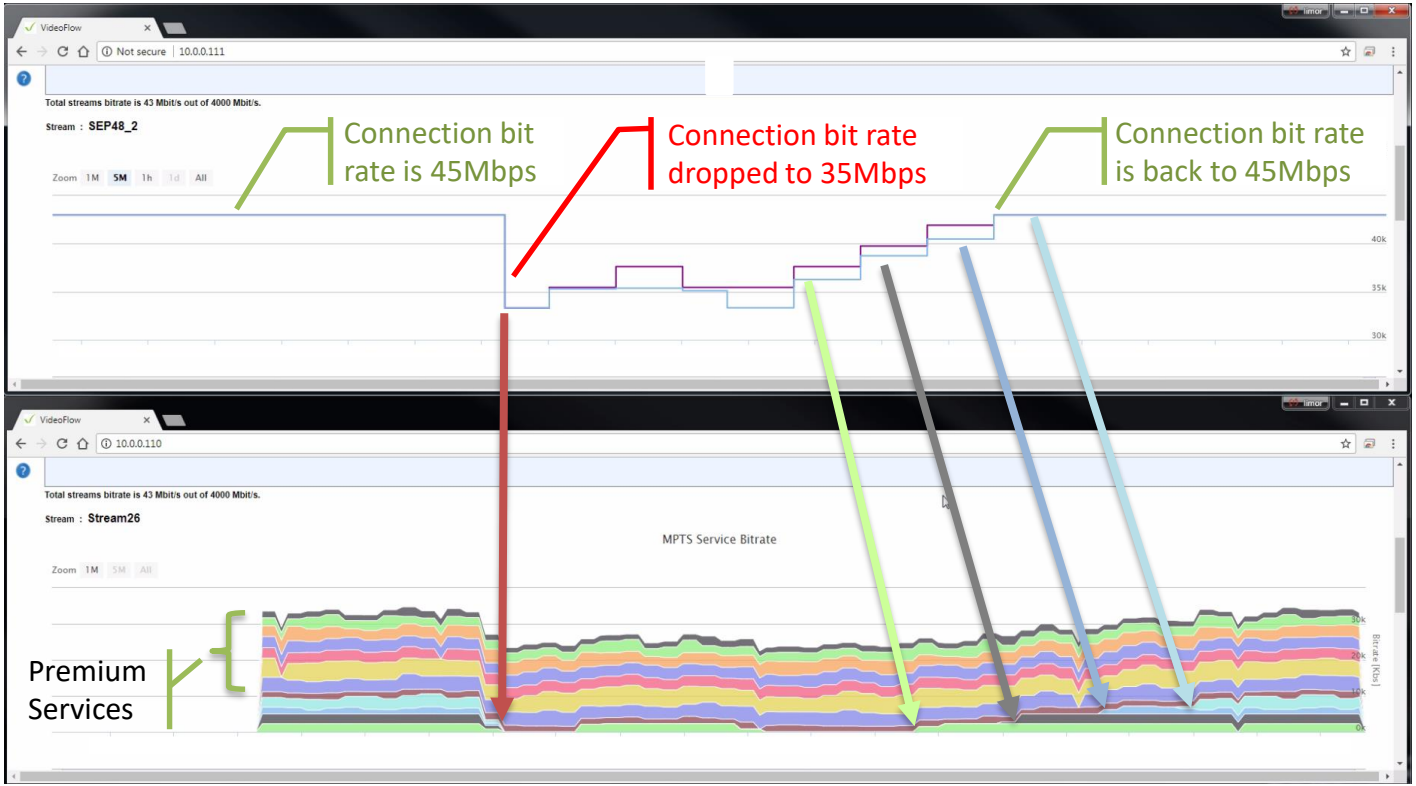
MPTS Example



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Future Work

- VideoFlow proposes the RIST WG to adopt the techniques described in this presentation
- New activity for additional capabilities based on these techniques

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Questions?

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