Creating Infinite Possibilities.

Measuring IP Video Playback QoE

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Agenda

- IP Video Architecture - Intro

- Customer Impacting Issues

- Importance of Measuring IP Video Playback QoE

- Video Viewing Quality (VVQ), model metrics, formula

- VVQ Implementation

- Video QoE Management using VVQ

IP Video Architecture
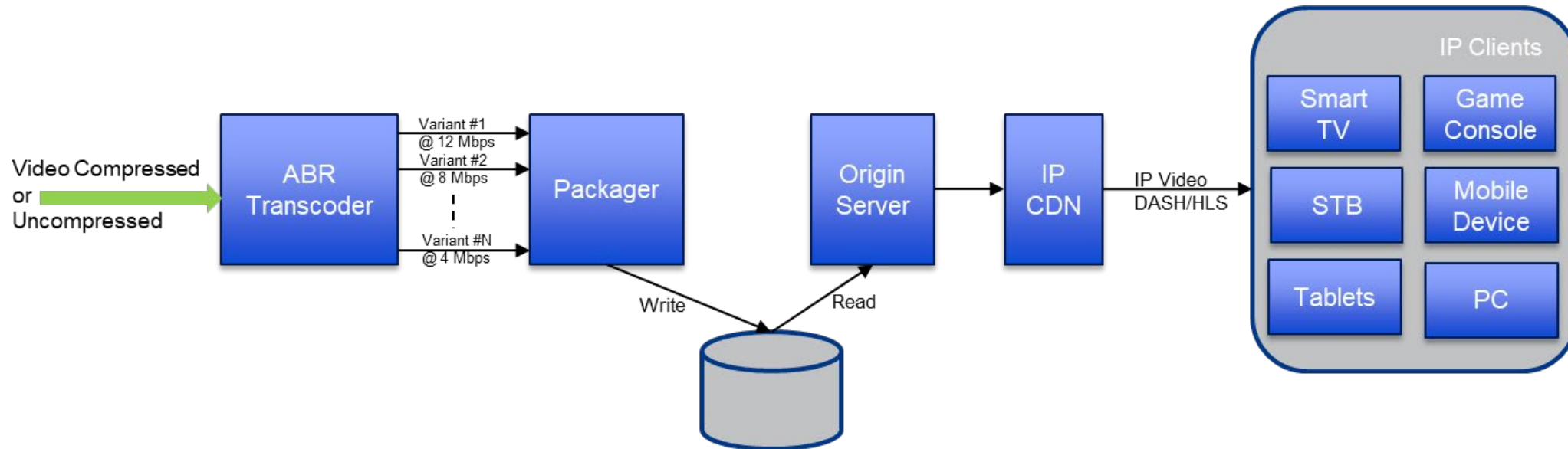
Customer Impacting Issues

- Rebuffering or video stalling

- Low-quality video playback during extended durations

- Encoding Artifacts
  - Macroblocking, blurry, out of lip sync, missing audio

- Large startup latency

- Media playback failures

- Playback control failures
  - Trickmode failures

- Live latency

- Multiple and frequent occurrences of the above issues

Importance of Measuring IP Video Playback QoE

- Seamless transition to IP video from QAM

- Early detection of IP video infrastructure issues and enable self-healing

- Validation of new streaming technologies
    - Content adaptive streaming, new players, codecs

- Facilitate IP video component upgrades

- Video customer retention

- Lead the detection of streaming video issues

Video Viewing Quality(VVQ)

- Single final overall score
  - Holistic metric
  - Objectively determines the IP Video Playback Quality of Experience (QoE) as perceived by the end user
  - Rather than tracking distinct metrics individually
    - average video bitrate, startup latency, rebuffering duration, rebuffering count, top errors/failures, encoded video quality

- Based on a mathematical model
  - Model parameters are determined using training examples
    - Examples from production and publicly available MOS scores

VVQ Model Metrics

- Video Quality (as a result of lossy encoding)
  - Variants/Segments in ABR ladder classified into three categories Low, Medium, High. Based on either bitrate or complex video analysis or PSNR or SSIM
- Quality switching (downshift to Low/Medium video quality segments)
  - Peak frequency, number of downshifts
- Low/Medium video segments playback duration
- Rebuffering events
  - Peak frequency, number of events, duration
- Startup latency (Primacy)
- Last bad video quality impact (Recency)

VVQ Model Metrics (continued)

- Playback failures/errors
    - Applicable to the ones that disrupt video playback
- End-user actions
    - Latency from trick mode commands
- Display dimensions

VVQ Formula

Video Viewing Quality Score = 100 - Impact from Low Quality Video Playback - Impact from Medium Quality Video Playback - Rebuffering impact - Impact from the time interval between bad quality events - Playback startup times impact - Impact from Playback Errors - Impact from trick play latency

Expanding this to the actual terms used in the formula we would have,

$$
\begin{aligned}
VideoViewingQualityScore = 100 - (&LowQualVideoImpact + ContinuousLowQualityImpact + \\
&DownshiftToLowQualImpact + MediumQualVideoImpact + ContinuousMediumQualityImpact + \\
&DownshiftToMediumQualImpact + ContinuousRebufferingImpact \\
&+ RebufferingFrequencyImpact + OverallRebufferingImpact + LastBadQualityEventImpact + \\
&StartupTimeImpact + PlaybackFailureImpact + ContinuousErrorImpact + \\
&ErrorPeakFrequencyImpact + OverallErrorImpact + SeekLatencyImpact)
\end{aligned}
$$

VVQ Formula (Continued)

- LowQualVideoImpact: Measures the overall impact from the playback of low quality video at certain times or during the entire measurement period.

- MediumQualVideoImpact: Measures the overall impact from the playback of medium quality video at certain times or during the entire measurement period.

- ContinuousLowQualityImpact: Computes impact based on how long the user client device is playing low quality video before it switches to either medium or optimal quality video.

- ContinuousMediumQualityImpact: Computes impact based on how long the user client device is playing medium quality video before it switches to either optimal or medium quality video.

- DownshiftToLowQualImpact: Computes impact when user client device is downshifting to low quality video during playback, uses peak downshift frequency and total number of downshift events.

- DownshiftToMediumQualImpact: Computes impact when user client device is downshifting to medium quality video during playback, uses peak downshift frequency and total number of downshift events.

- ContinuousRebufferingImpact: Computes impact based on how long the user client device is rebuffering before it restarts video playout.

- RebufferingFrequencyImpact: Computes impact based on how often the user client device is rebuffering.

- OverallRebufferingImpact: Computes the overall impact from rebuffering during the entire video playback.
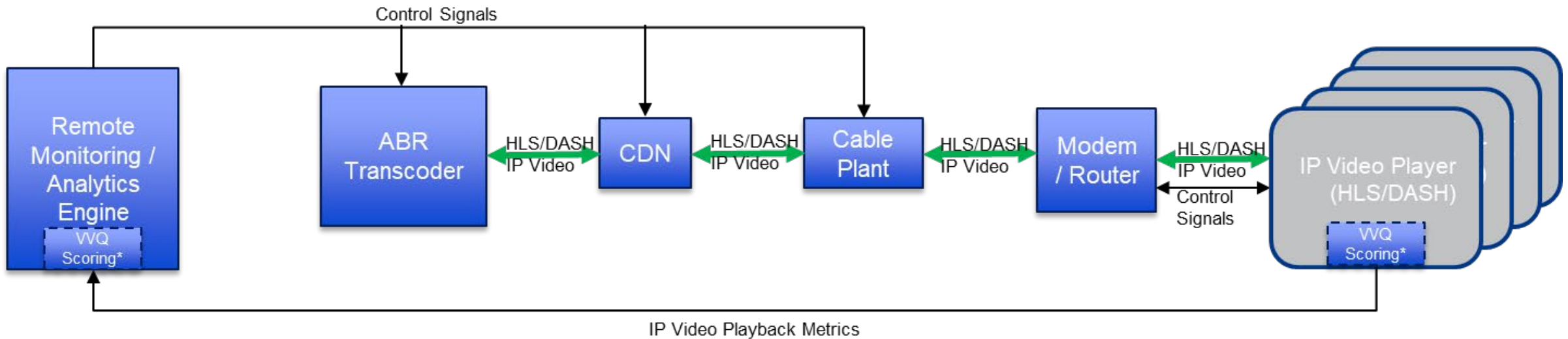
VVQ Formula (Continued)

- LastBadQualityEventImpact: Computes impact for the time intervals between bad video quality events such as downshift to a low quality video, rebuffering.

- PlaybackFailureImpact: Computes impact from fatal playback failures such as unable to decode video, download segments, manifest.

- StartupTimeImpact: Computes impact based on how long it takes for video playback to start after the user has initiated it.

- SeekLatencyImpact: Computes impact based on how long it takes for video playback to start after the user has initiated a seek or trick mode operation like FFWD or RWD.

- ContinuousErrorImpact: Computes impact based on how long the user client device is in error state before it restarts video playout.

- ErrorPeakFrequencyImpact: Computes impact when the player runs into error events, uses peak error frequency and total number of error events.

- OverallErrorImpact: Computes the overall impact from errors during the entire video playback.
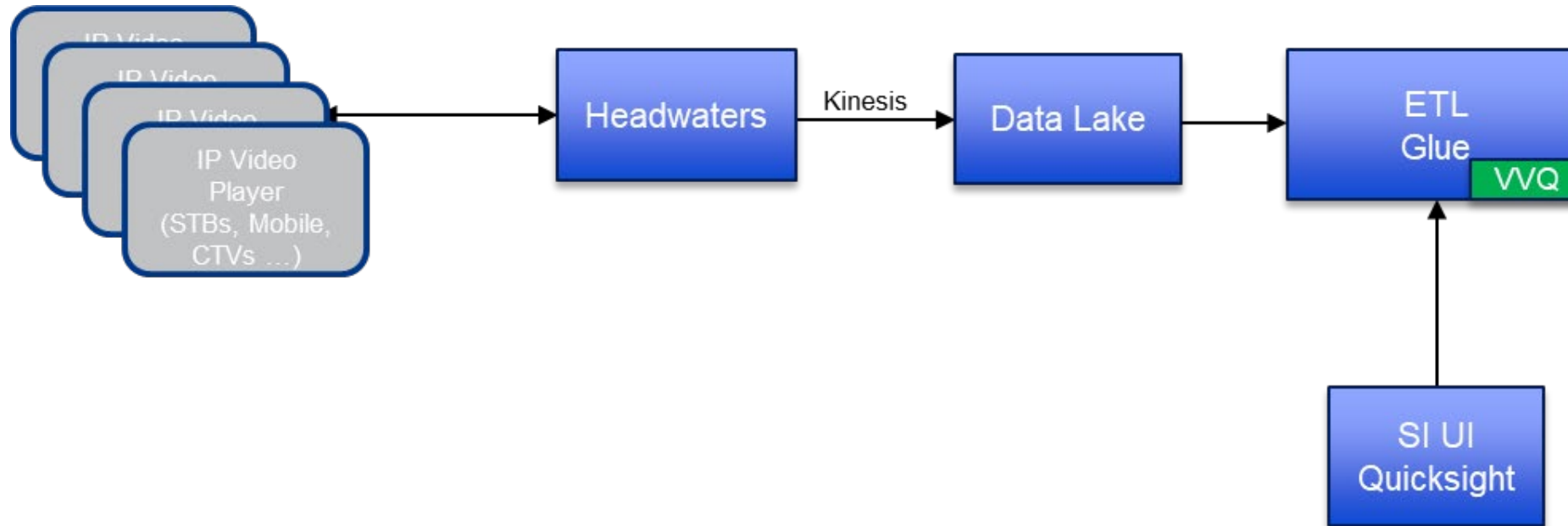
* Details on each of the terms in the above equation is available in the paper

Video QoE Management
Scoring in Analytics Engine or IP Video Player

# VVQ Implementation in Analytics Engine

Sample VVQ Scores

Device	VVQ Score	Description
STB	0	Total Linear playback duration: 88 mins 2 Rebuffering events, Max duration 7 mins 6 downshifts to bitrate 0.8Mbps (34s on low bitrate video*) 26 downshifts from 6 to 2Mbps (4mins on medium bitrate video*) In home issue, attributed to packet loss and Wi-Fi latency
STB	73.34	Total Recorded content playback duration: 51 mins 5 downshifts to 2.1Mbps Video (13mins on medium bitrate video*)
iPhone	0	Total VOD playback duration: 35 mins 9 mins on low bitrate video**
iPhone	82	Total VOD playback duration: 36 mins 3 Rebuffering events, Max duration 8s 2 downshifts to bitrate 0.7Mbps (31s on low bitrate video**)
Desktop Edge	0	Total Linear playback duration: 48 mins 2 downshifts to low bitrate video (20mins on low bitrate video**) 3 downshifts to medium bitrate video (28mins on medium bitrate video**) 1 Rebuffering event, Max duration 3s
Android	20	Total Linear playback duration: 19 mins 17. downshifts to bitrate 0.5Mbps (3 mins on low bitrate video**) 56 downshifts to medium bitrate video 2Mbps (7mins on medium bitrate video**)

* Low bitrate video < 1.8Mbps, Medium bitrate video < 3Mbps, Video compression – AVC

** Low bitrate video < 0.75Mbps, Medium bitrate video < 1.5Mbps, Video compression - AVC

Reference Implementation VVQ Scores

Linear Playback Sessions (Average VVQ scores)
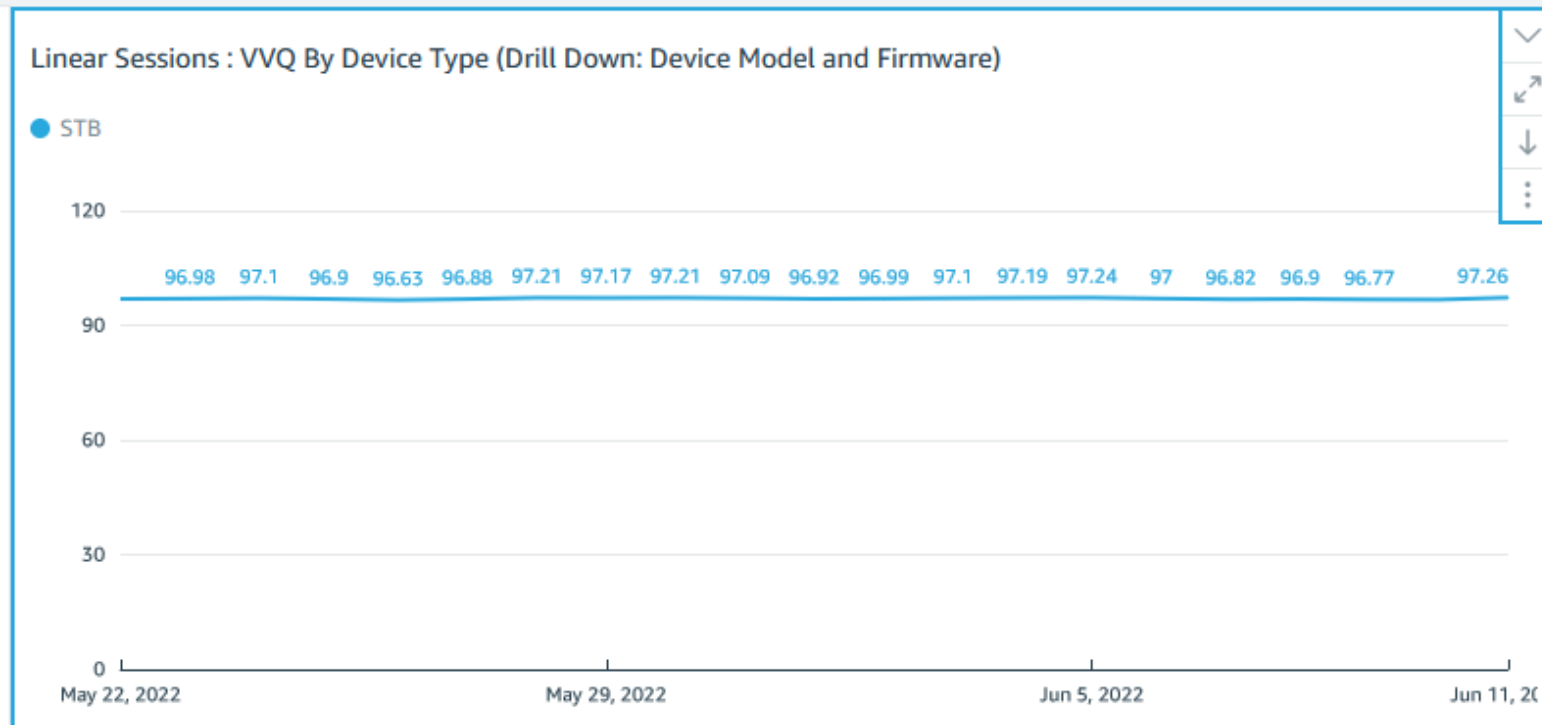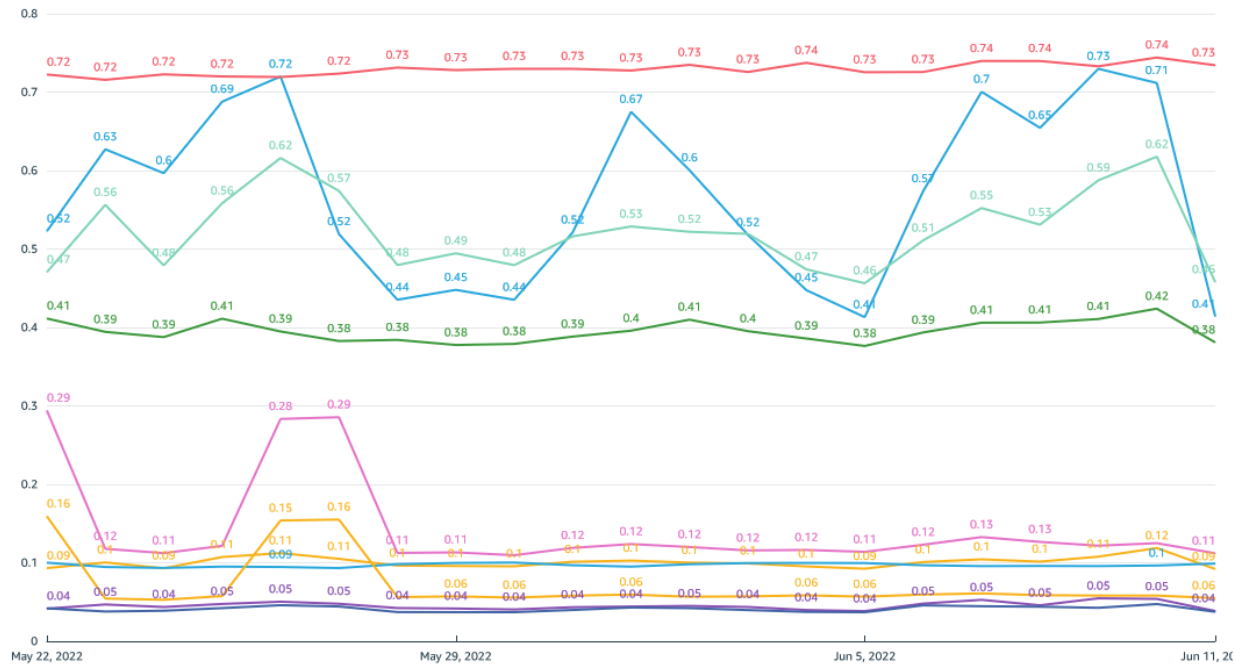
Reference Implementation VVQ Scores
Linear Playback Sessions (VVQ Individual Impact average values)

Linear Sessions: Daily Average of VVQ Components

VVQ based QoE Management

- Detect in home Wi-Fi issues and interface with router and user to resolve them

- Early detection of issues with new SW/FW releases, hardware upgrades

- Drive automatic switching to redundant video delivery paths and CDNs

- Drive automatic allocation of additional resources BW, compute power, memory

- Manage transcoder highest profile bitrate to address network BW saturation

- Interface with mobile carriers to help them manage BW allocation and channels

- Proactive user messages for potential video outages

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Thank You!

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