4K UHD Streaming Testing

Exploring Bitrates in 4k video content on Blu-ray and Streaming Services

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Quality Variables

- **Resolution**: Pixels in width x height
- **Framerate**: Number of draws/frames per second (fps)
- **Bitrate**: Amount of data in Megabits per second (Mbps) being displayed

	DVD	HD Blu-ray	4k Blu-ray
Resolution	720 x 480	1920 x 1080	3840 x 2160
Framerate	30 fps	24 fps	24 fps
Bitrate	3 to 10 Mbps	20 to 30 Mbps	50 to 60 Mbps
Media Size (dual layer)	8.5GB	50GB	50GB

Bitrate	Transfer per hour
3 Mbps	1.4 GB
10 Mbps	4.5 GB
20 Mbps	9.0 GB
30 Mbps	13.5 GB
50 Mbps	22.5 GB

Bitrate Calculations

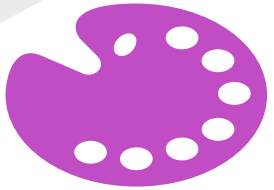
Bitrate is the most important quality component and the most expensive for streaming services.

Compression Impacts

Resolution

Blockiness

Blurring



Color

Sharpness

Color loss

Experiments

Oppenheimer 4k – Amazon Streaming vs Plex Uncompressed

Various 4k – Amazon, Hulu, Netflix, Disney+, Plex (uncompressed)

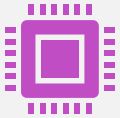
Various HD - Amazon, Hulu, Netflix, Disney+, Plex (uncompressed)

Lab Design

- 5Gbps Fiber Internet connection
- Amazon Fire TV Cube, with wired Ethernet connection and 4k Support
- Sony UHD 4k Television
- Developer Tools Menu to measure bitrate, resolution and frame rate
- MakeMKV to rip Blu-ray to Plex Server
- Highest subscription level active for all 4 streaming services
- All Devices and applications configured for highest bitrate (where available)

Oppenheimer 4k: Amazon vs Lossless

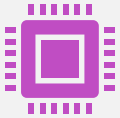
Hypothesis: Because of the high cost of shipping 22.5GB per hour to each viewer, streaming services will avoid loss-less streaming and will sample and compress bitrates to reduce their costs.



Test Plan: Utilizing the same display and networking devices, stream the same UHD 4K content from both Amazon Prime and via Local Media Server using loss-less Blu-ray. Measure resolution, bitrate and framerate on both methods.

Diverse 4k Content on Top Services

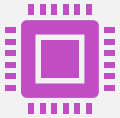
Hypothesis: Because all streaming services are constrained by similar economic and technological variables, they should all be between 25% +/- of bitrate on 4k content.



Test Plan: Stream Disney+, Amazon, Hulu and Netflix 4k content monitoring bitrate, resolution and framerate. (Note: same content cannot be set as control due to different content libraries.)

Diverse HD Content on Top Services

Hypothesis: Ratio of UHD bitrates to HD bitrates should be approximately 2.0 based on observed ratios on Blu-rays.



Test Plan: Stream native HD content from the streaming services to compare bitrate against UHD bitrates from Experiment 2. (Note: no control on content again.)

Results

Service	4k (Peak Mbps)	4k % Max	HD (Peak Mbps)	HD % Max	UHD:HD	codec
Prime	15	23%	3	10%	5.0	hevc
Netflix	3	5%	1	3%	3.0	av01
Hulu	16	25%	5	16%	3.2	hevc
Disney		0%	10	32%	-	avc
Apple	10	15%	8	26%	1.3	hevc
Plex	65	100%	31	100%	2.1	hevc

Conclusions

1) Bitrate is reduced 75 to 95% in 4k UHD streaming content (vs Blu-ray)
2) UHD:HD ratio is higher than Blu-ray on all services except Apple.
3) The 4 major streaming services deliver radically different bitrates.

Unresolved: How much does bitrate reduction effect the viewing experience?