LevelUp: A Thin-cloud Approach to Game Livestreaming

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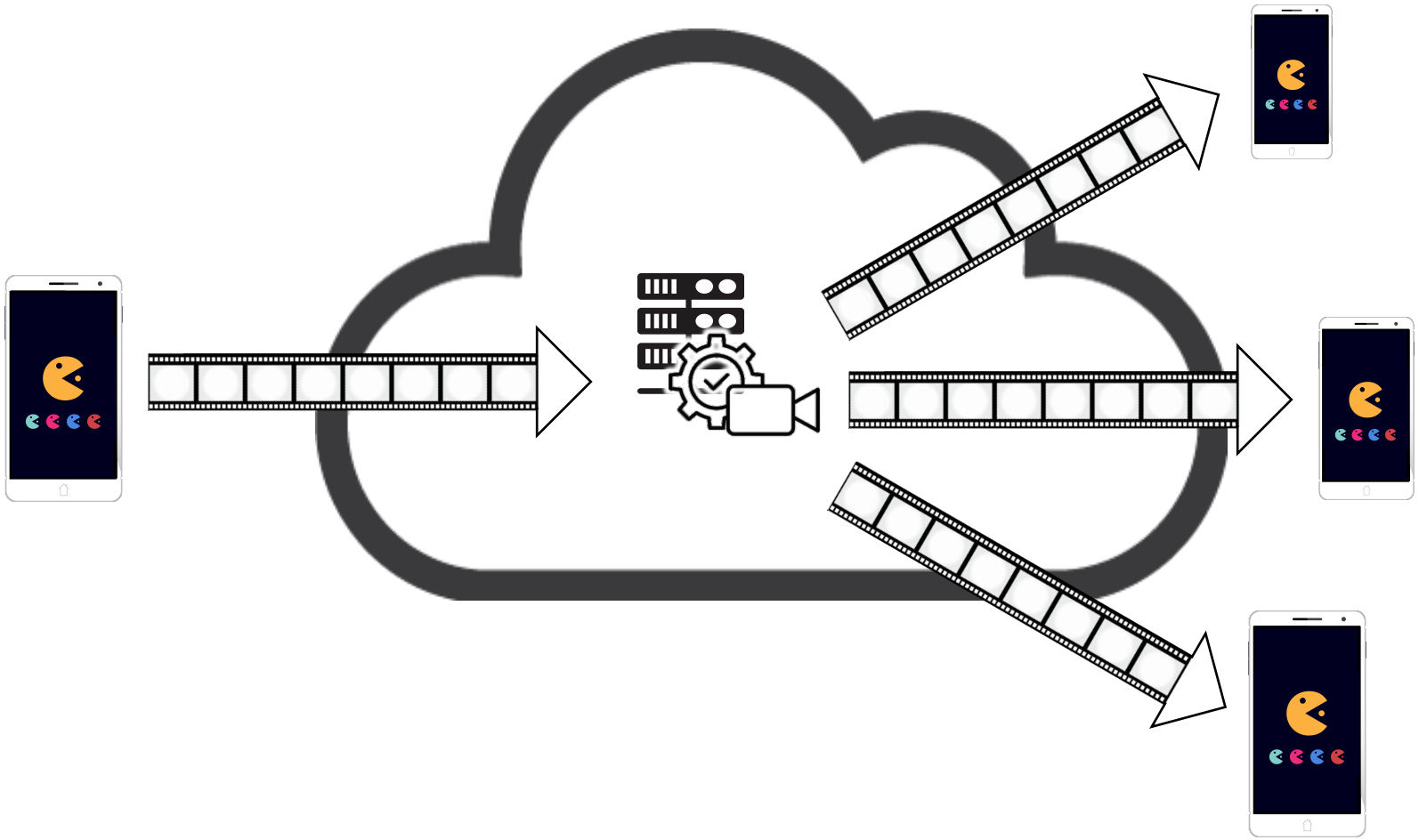
Game Livestreaming

- Twitch
  - Average >2m concurrent viewers and >90k concurrent channels
  - >65m hours streamed and >1.5b hours watched per month
- Market size $40b, expected to grow 18% per year

Game Livestreaming

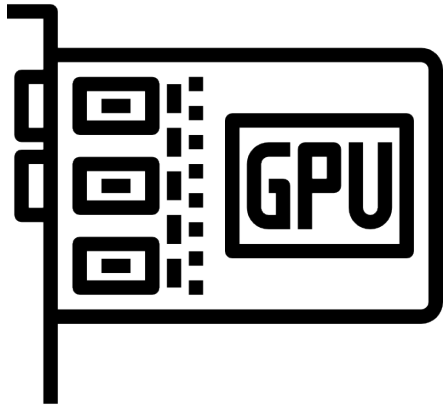


Cloud-based Video Transcoding Is Expensive

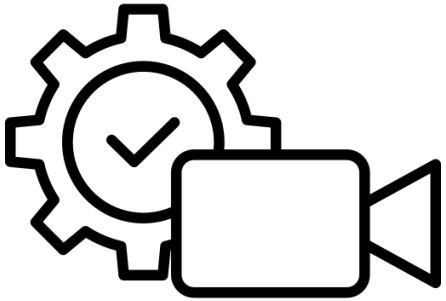
- $300+ to transcode 100 hours of video on Azure
- <$20 to livestream 100 hours of single-bitrate video on Wowza

- Reason: Video transcoding is resource demanding, usually requires hardware accelerators in the cloud

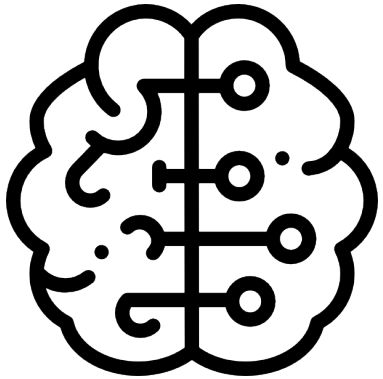
Mobile Hardware Trends



GPU



video codec



ML

Mobile Hardware Trends

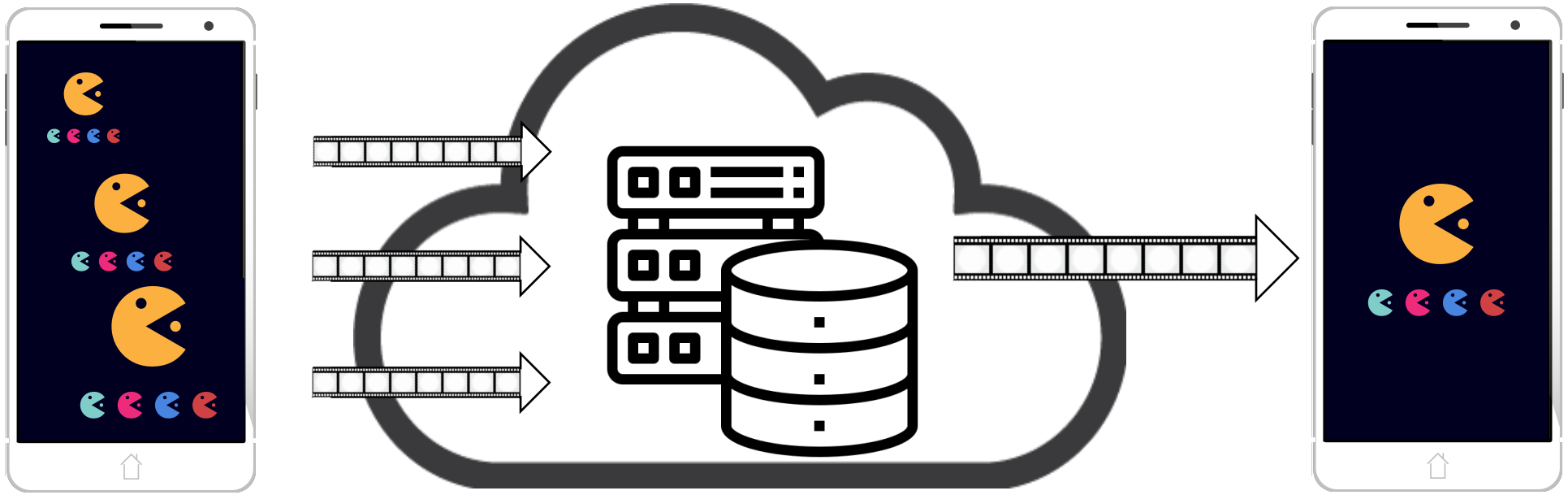
- As of May 2018, hundreds of millions devices equipped with powerful GPU/hardware codec/ML accelerators
- Most smartphones are expected to have ML accelerators in few years
- Combined capabilities of hardware accelerators on mobile devices are greater than the cloud

- The edge is ready to play a more central role in video livestreaming

LevelUp: A Thin-cloud Approach to Game Livestreaming

- Offload cloud-based transcoding by encoding multi-bitrate videos on broadcasters' smartphones
- In case of bandwidth constraints, viewers boost reduced-resolution video quality with super-resolution using ML
- Adopt game-specific CNN models to improve quality

LevelUp Design



What if bandwidth is not enough?

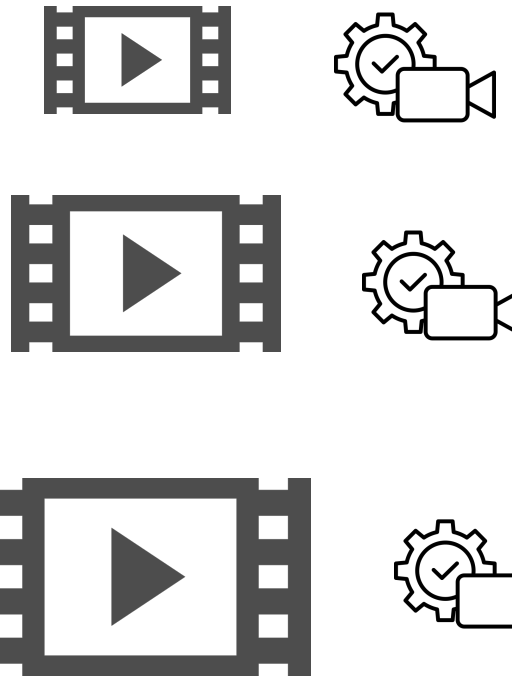
LevelUp Design – bandwidth constrained

Single-image super resolution (SR)

- CNNs upscale resolution of reduced-resolution images
- Mobile ML accelerators enable fast NN computation
- A lightweight CNN model of 4 layers is sufficient for LevelUp
- Different games have visual features, require different models
- Models are trained offline, downloaded to viewers before streaming

Broadcaster’s video pipeline

Capture screen



Resize to 3 resolutions

Send to HW encoder queue

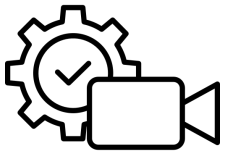
Encode segments

Upload to server

Viewer’s video pipeline – without SR

Download video segment

Decode

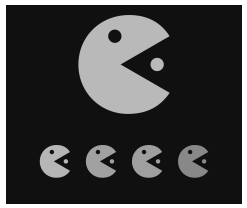


Display

Viewer’s video pipeline – with SR

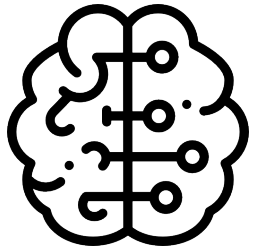
Download video segment

Decode



Separate grayscale, chroma

SR



Bicubic interpolate

Merge, display

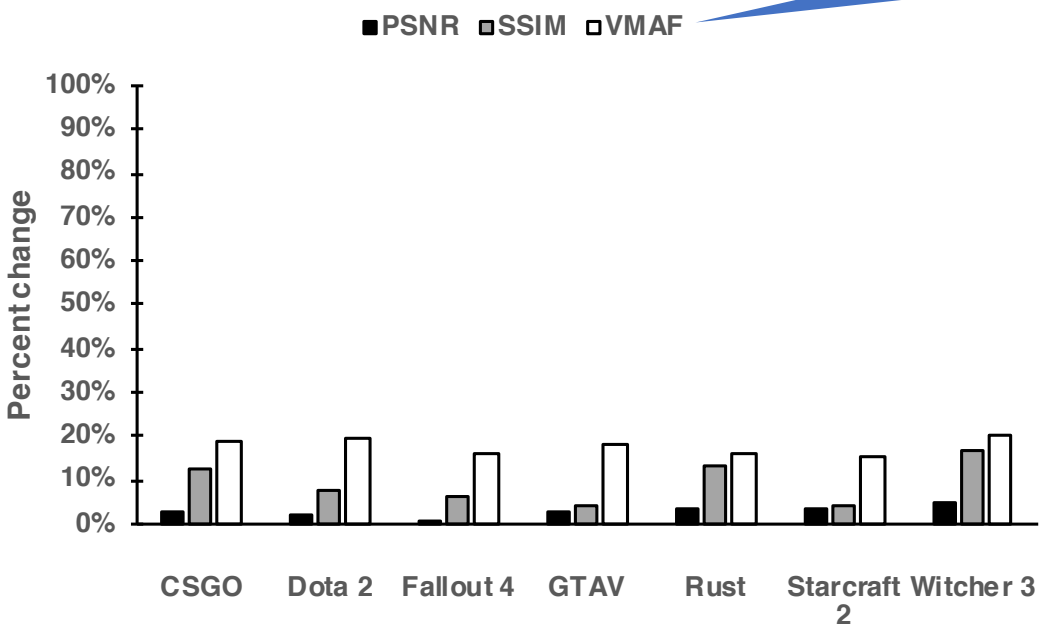
Evaluation

- Can super resolution improve the visual quality of reduced-resolution game streams?
- Can broadcasters perform multi-bitrate encoding in realtime?
- Can viewers super-resolve reduced-resolution video streams in realtime?
- What is LevelUp’s energy overhead?

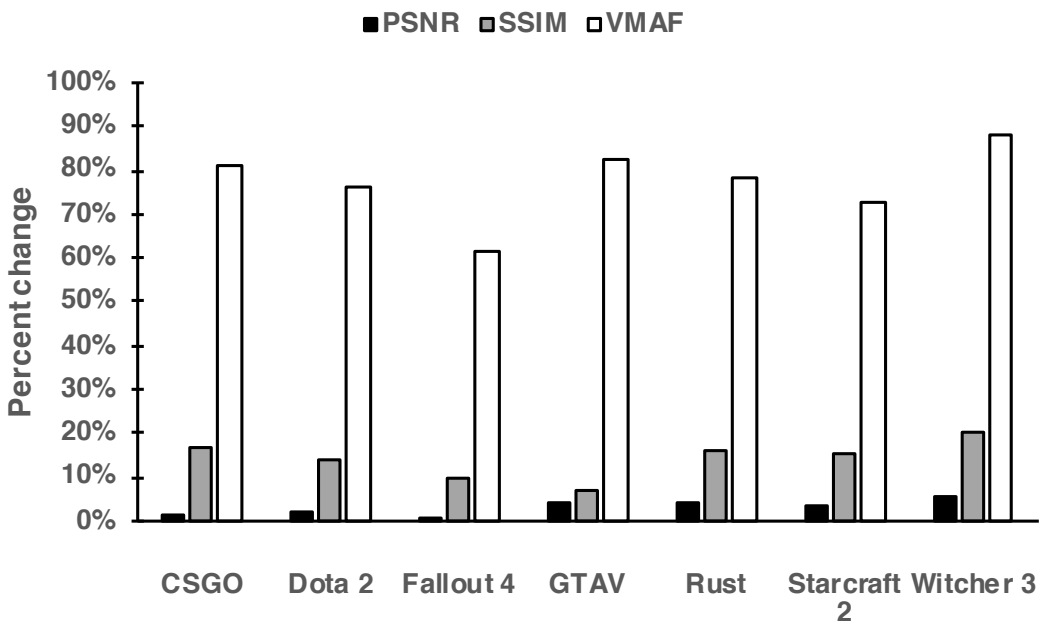
Game stream super-resolution

of improvements with SR

PSNR: per-pixel, SSIM: structural,
VMAF[1]: ML model of human perception



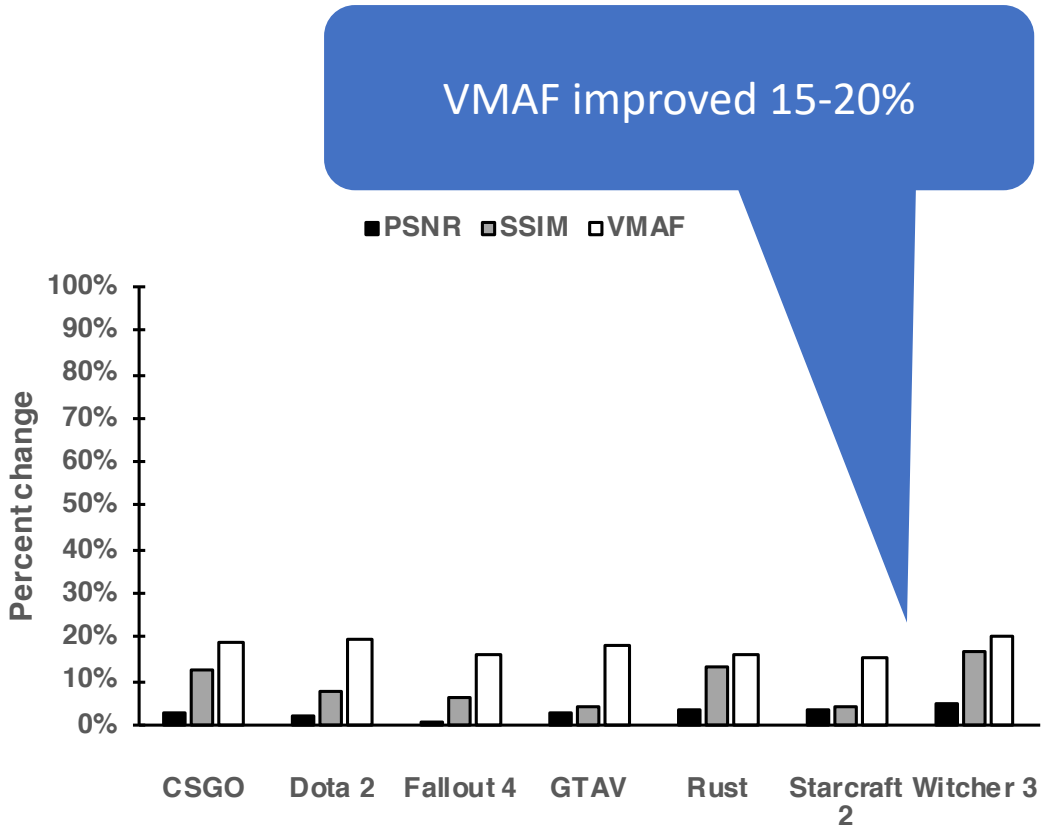
480p + SR



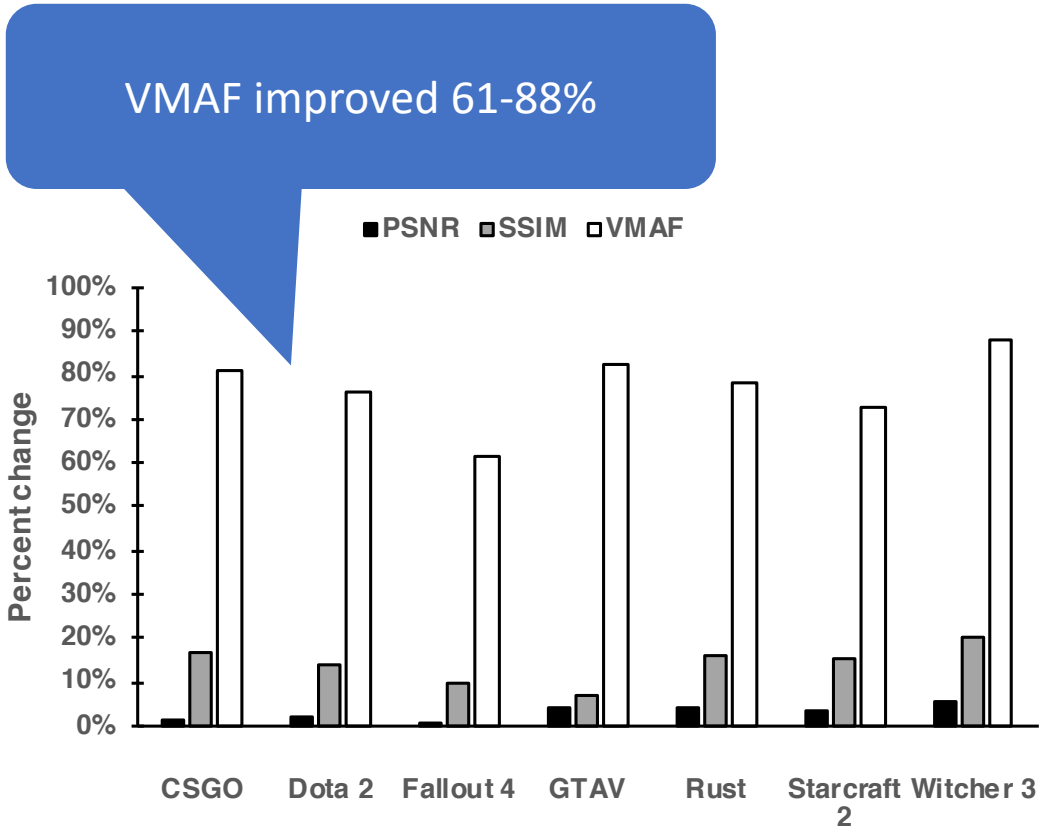
270p + SR

[1] https://github.com/Netflix/vmaf

Game stream super-resolution



480p + SR



270p + SR

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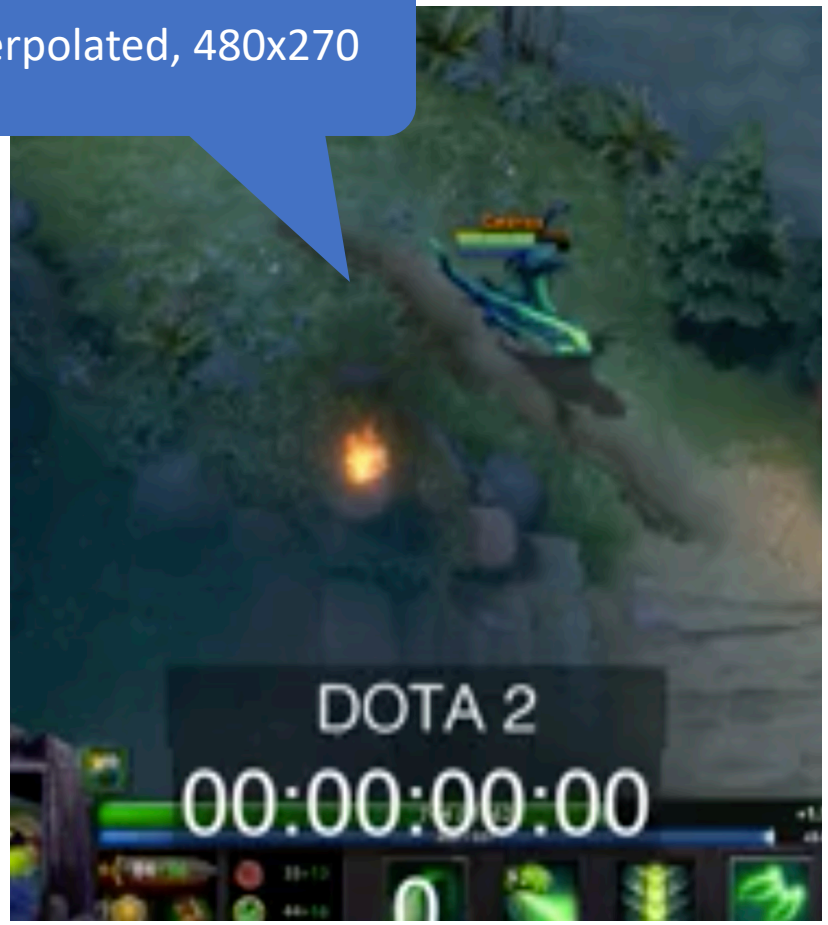
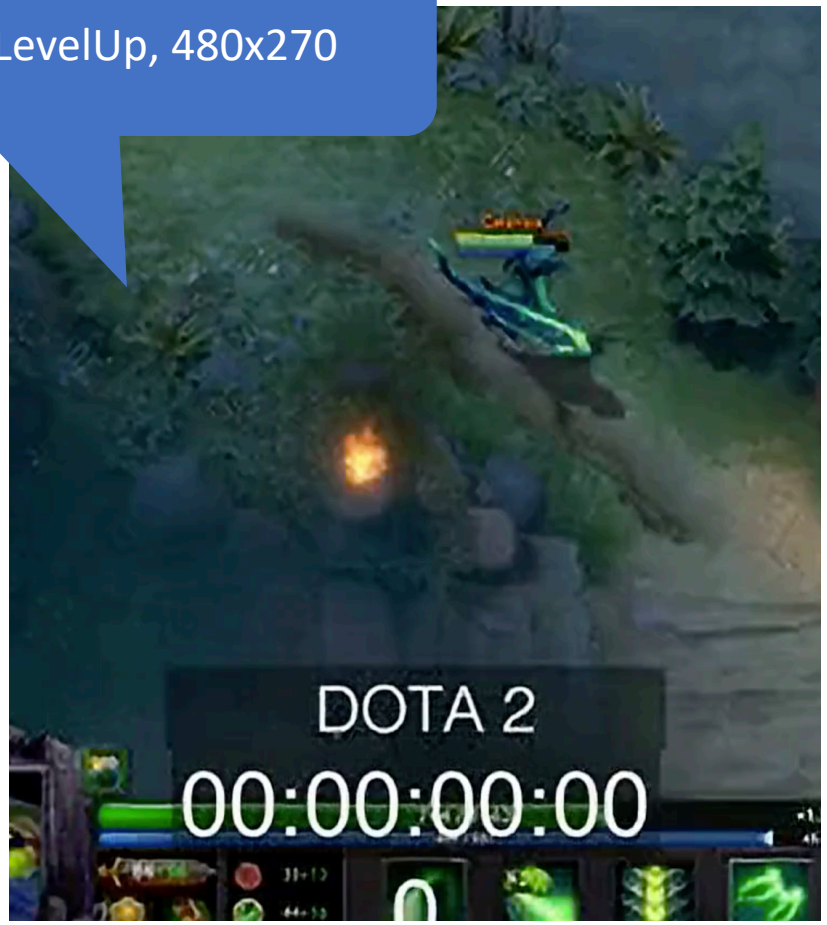
Game stream super-resolution

Interpolated, 480x270



LevelUp, 480x270



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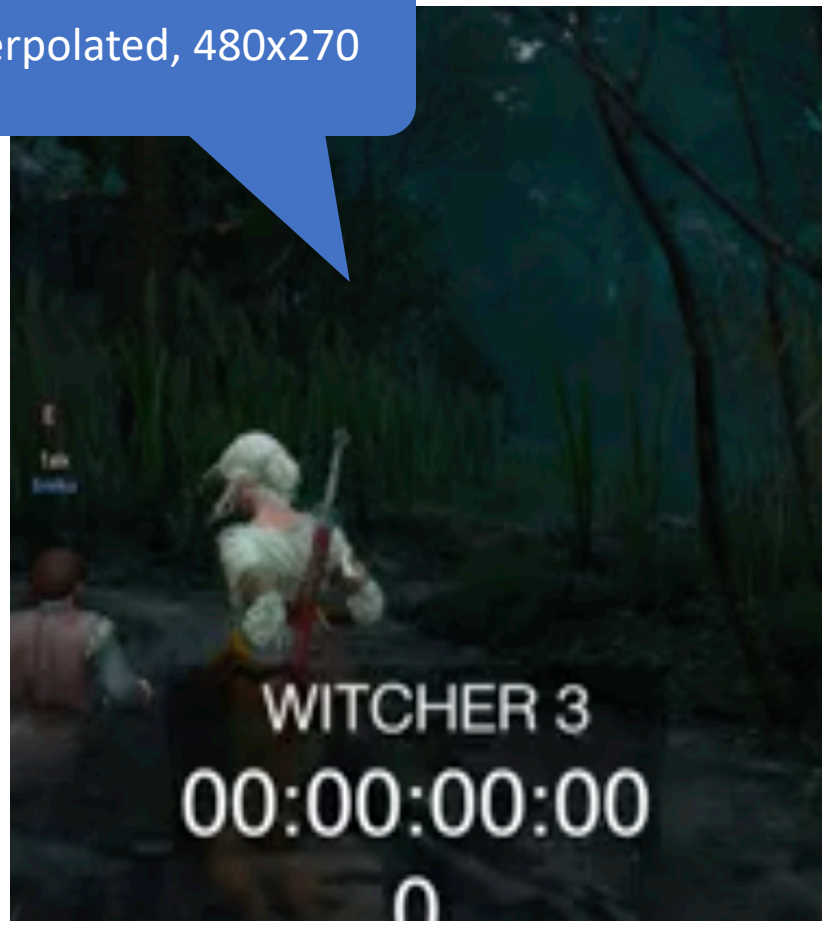
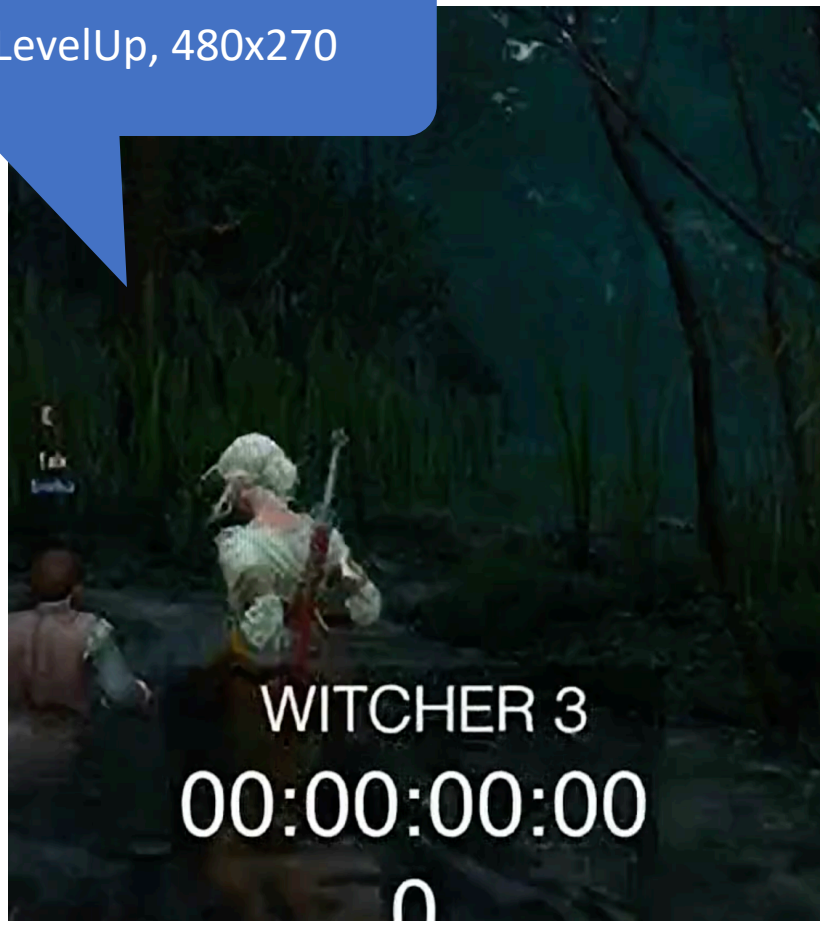
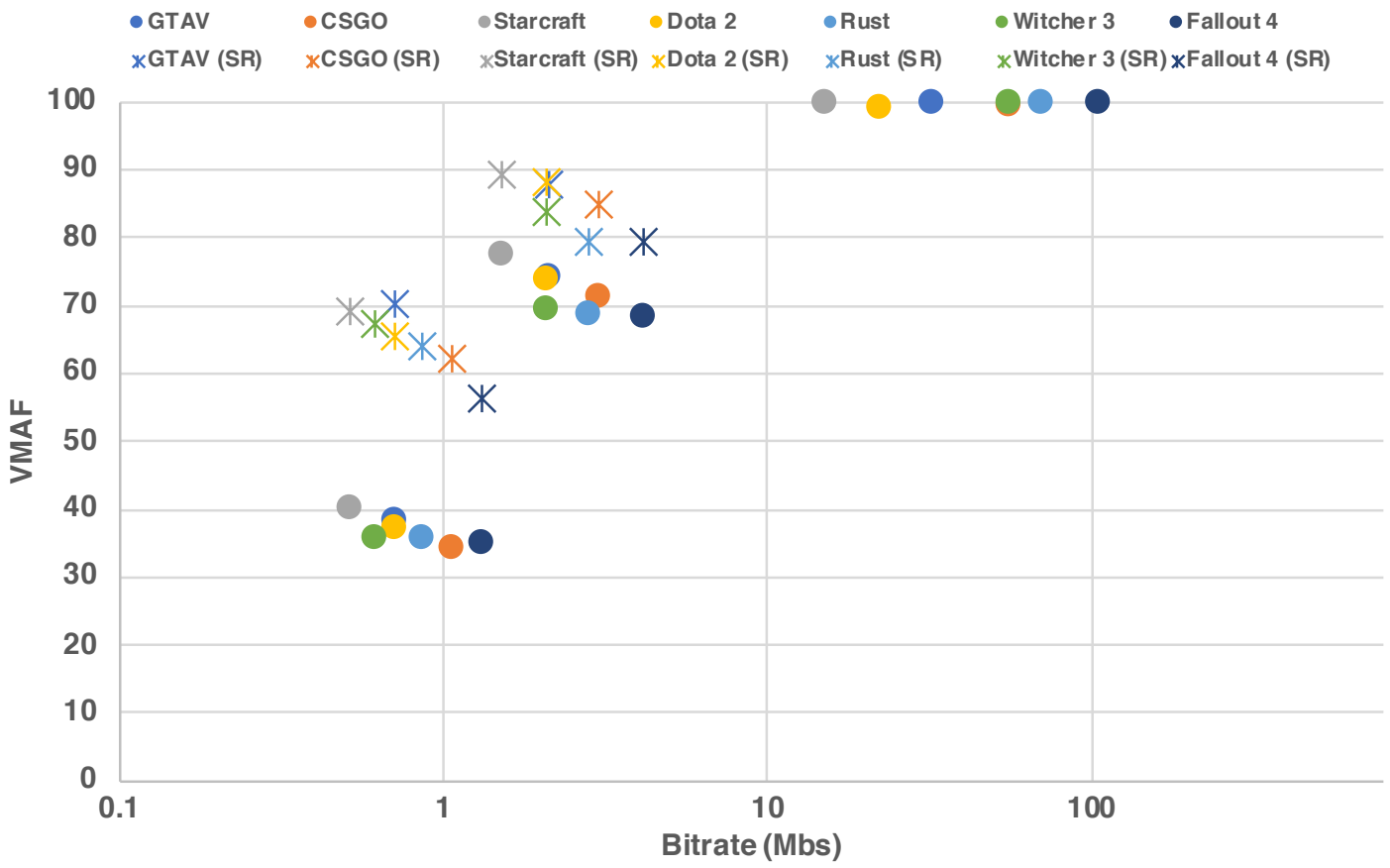


LevelUp, 480x270



Quality vs. Bitrate



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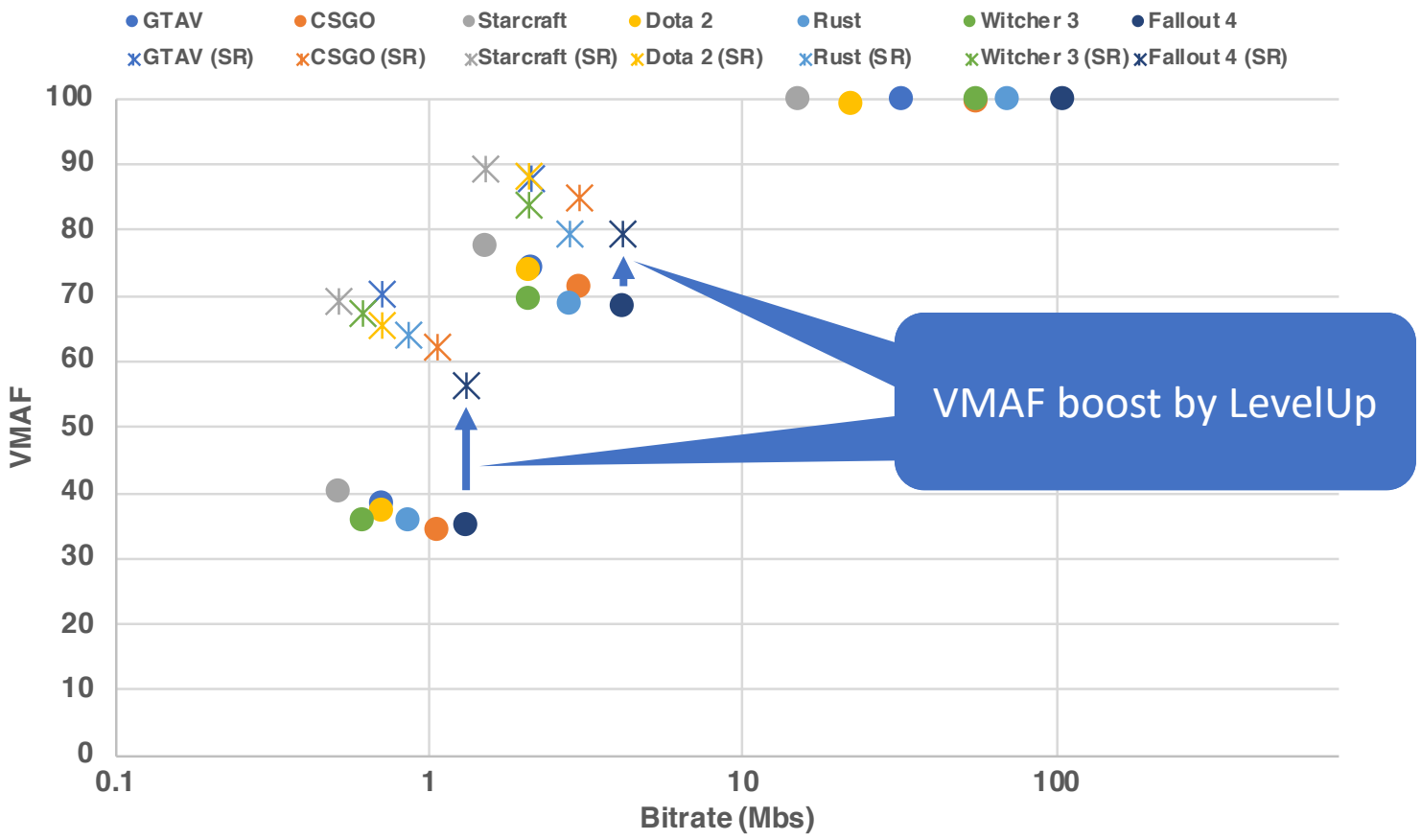

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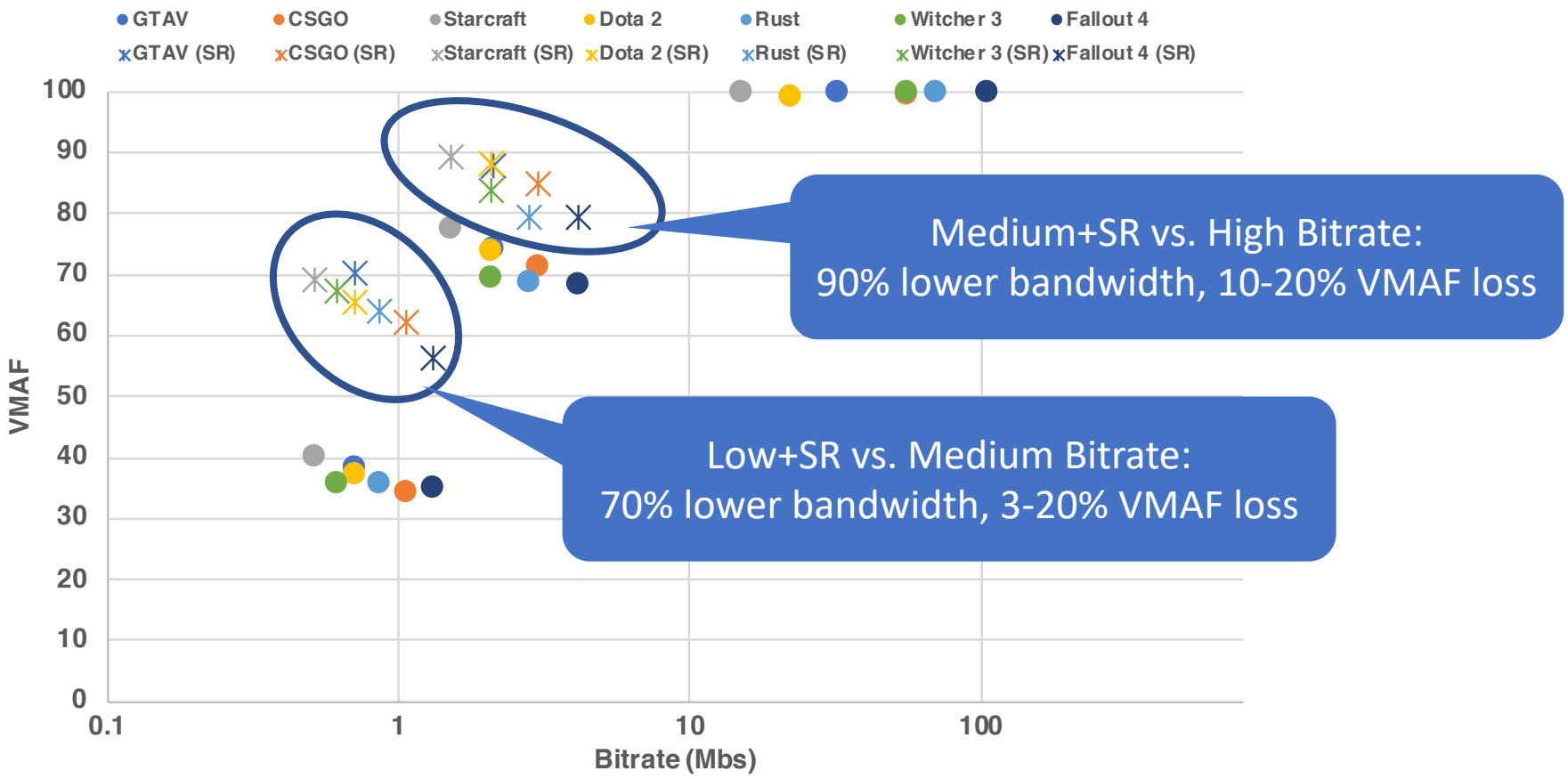


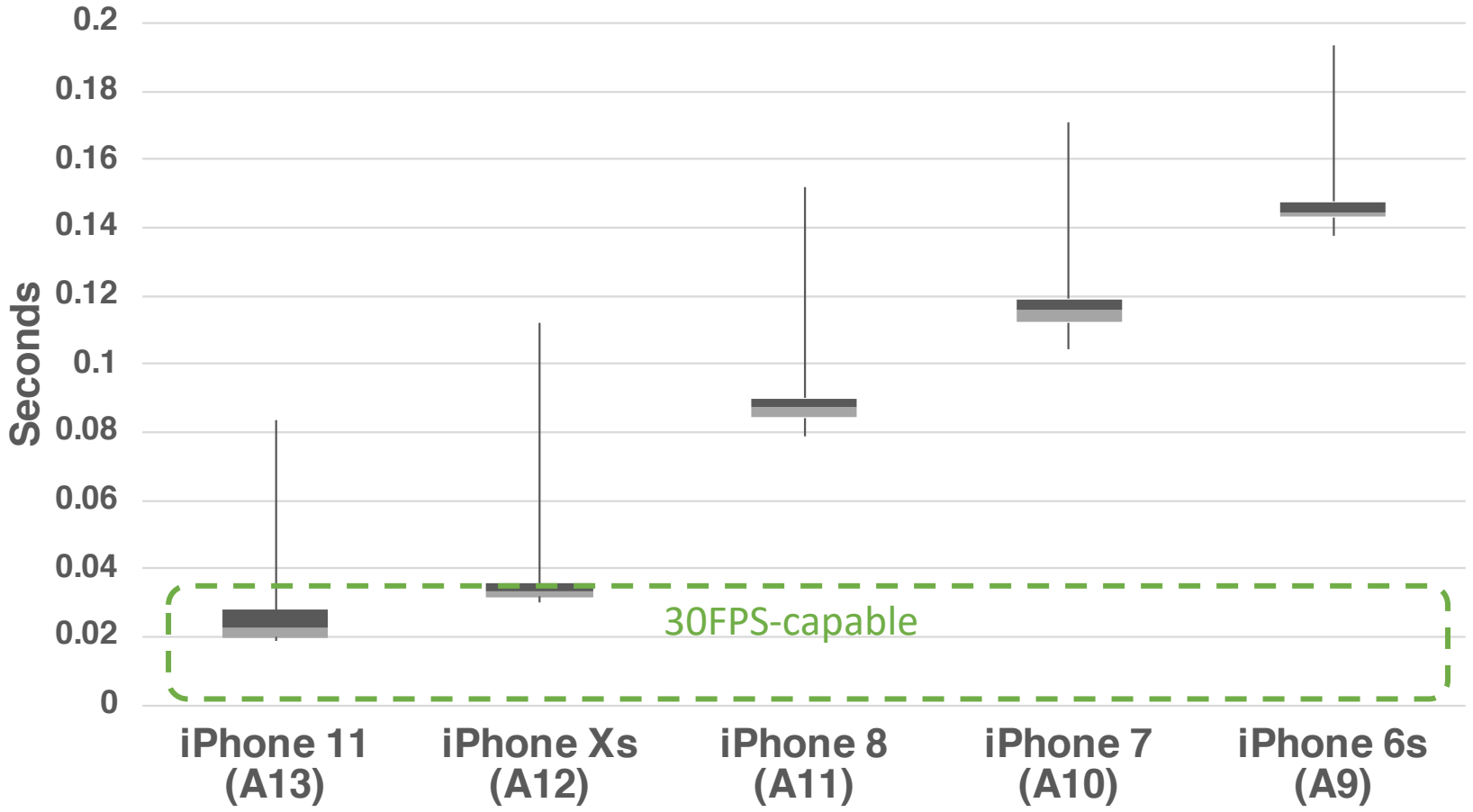
Super-resolution can greatly improve game stream quality w/o extra bandwidth consumption

Can broadcaster encode multi-bitrate streams?

- Encode 3 2-second segments (1080p, 480p, 270p) at the same time
- Test on iPhone 11 Pro, the iPhone Xs, iPhone 8, iPhone 7, and iPhone 6s
- All devices can encode in realtime

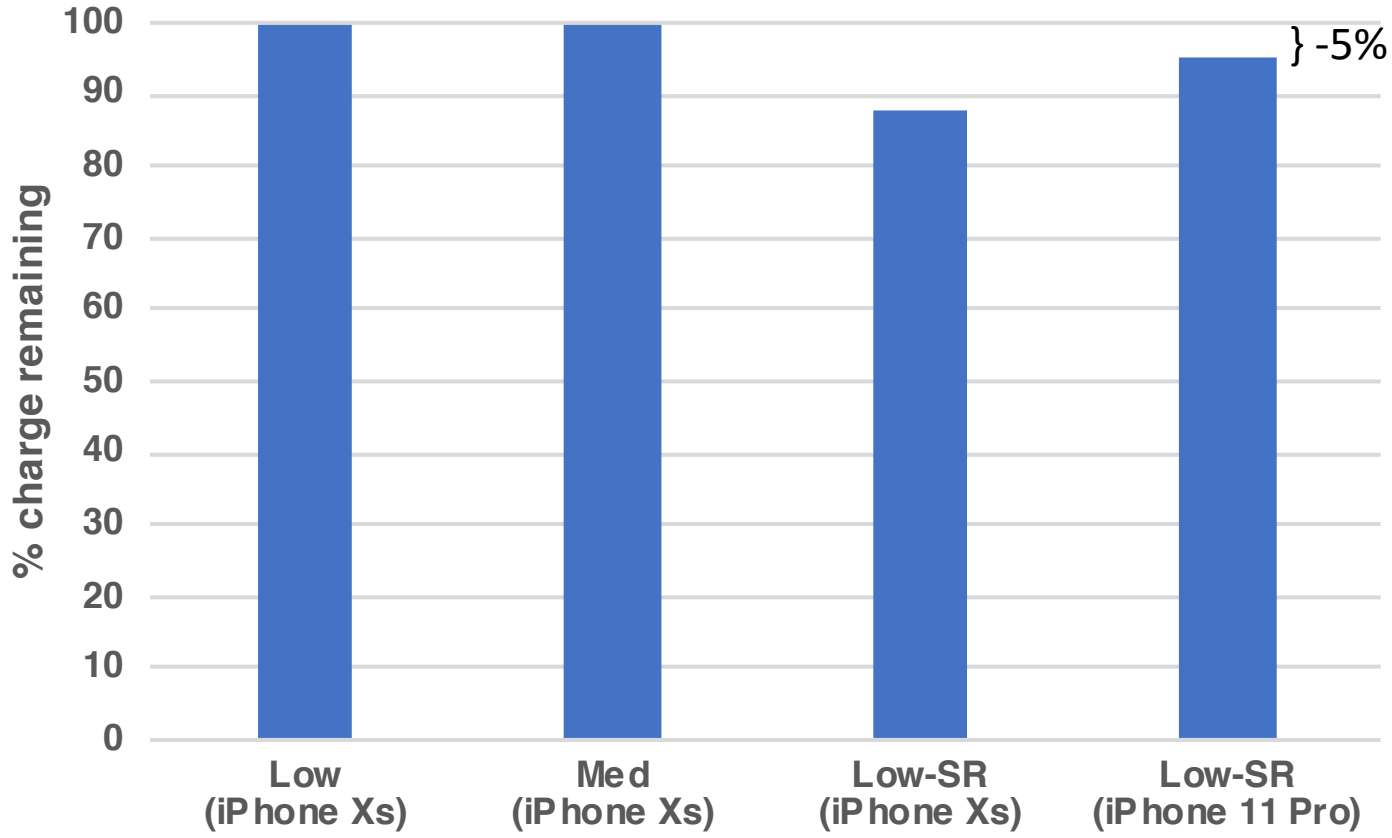
- Multi-bitrate encoding is feasible on modern smartphones

Can viewers super-resolve video?



Recent smartphones equipped with ML accelerators can super-resolve gaming streams in realtime.

Energy overhead



} -5% after 30 min streaming

LevelUp has small energy overheads even with super-resolution enabled.

Conclusion

- Game livestreaming is expensive due to realtime transcoding
- LevelUp can greatly reduces game livestreaming costs by leveraging smartphones for transcoding
- LevelUp uses super-resolution to boost quality for reduced-resolution videos by up to 88%
- LevelUp can transcode and super-resolve game streams in realtime using recent smartphone hardware accelerators

Thank you!
Q & A

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