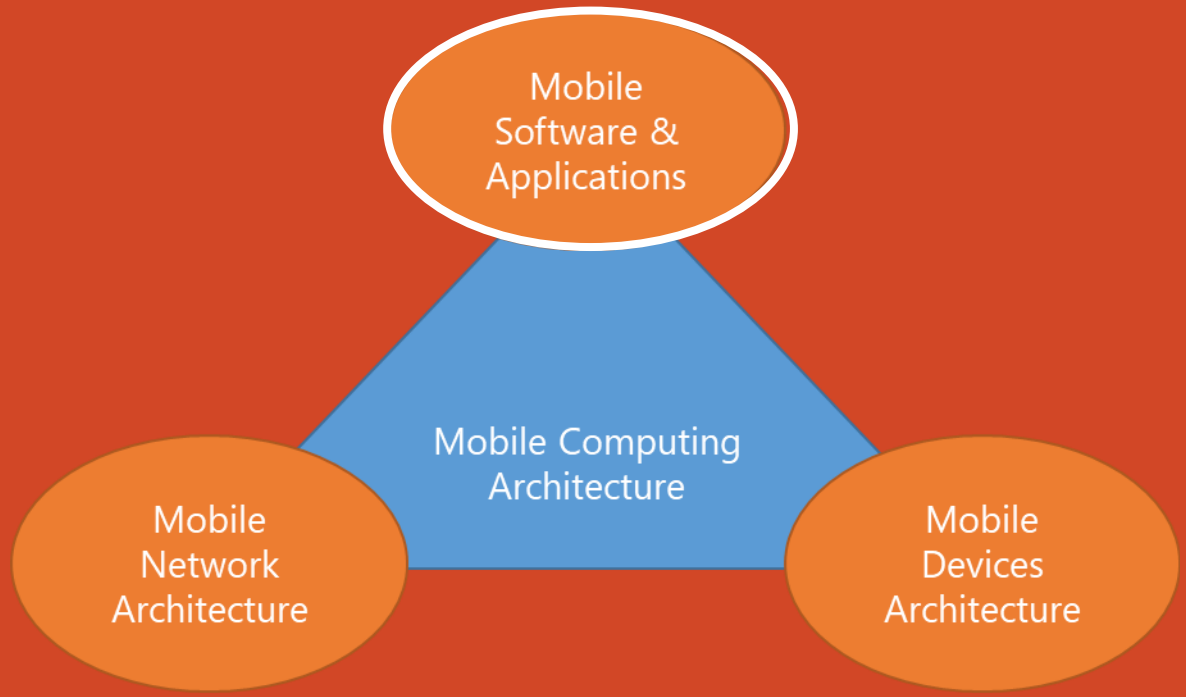
Mobile Computing Architecture

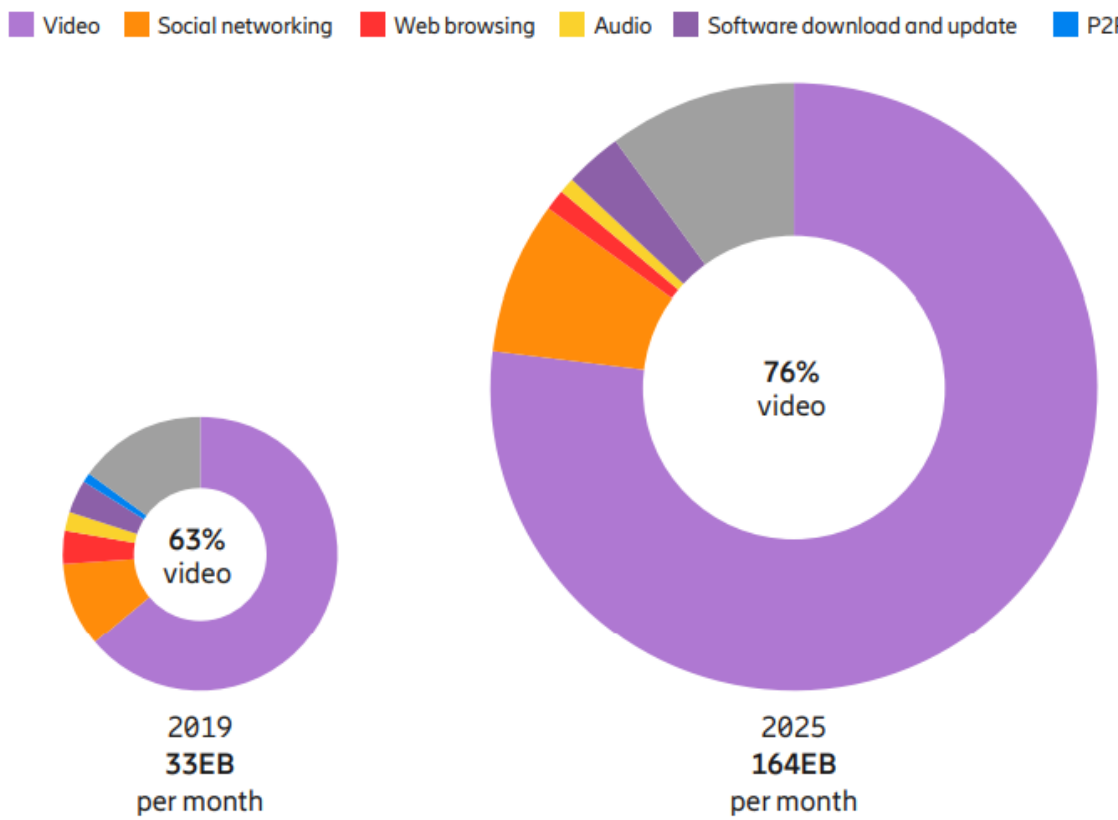
UW Bothell, WA

Over The Top Video (OTT Video)



Mobile Traffic – June 2020 Ericsson Mobility Report

Video traffic in mobile networks is forecast to grow by around 30 percent annually up to 2025. It will account for nearly three-quarters of mobile data traffic, which is up from just over 60 percent in 2019. Mobile video traffic growth is driven by the increase of embedded video in many online applications, growth of video-on-demand (VoD) streaming services in terms of both subscribers and viewing time per subscriber, and the evolution towards higher screen resolutions on smart devices. All of these factors are influenced by the increasing penetration of video-capable smart devices. Social network traffic is also expected to rise by around 20 percent annually over the next 6 years. However, its relative share of traffic will decline from 10 percent in 2019 to around 8 percent in 2025, because of the stronger growth of video.[1]

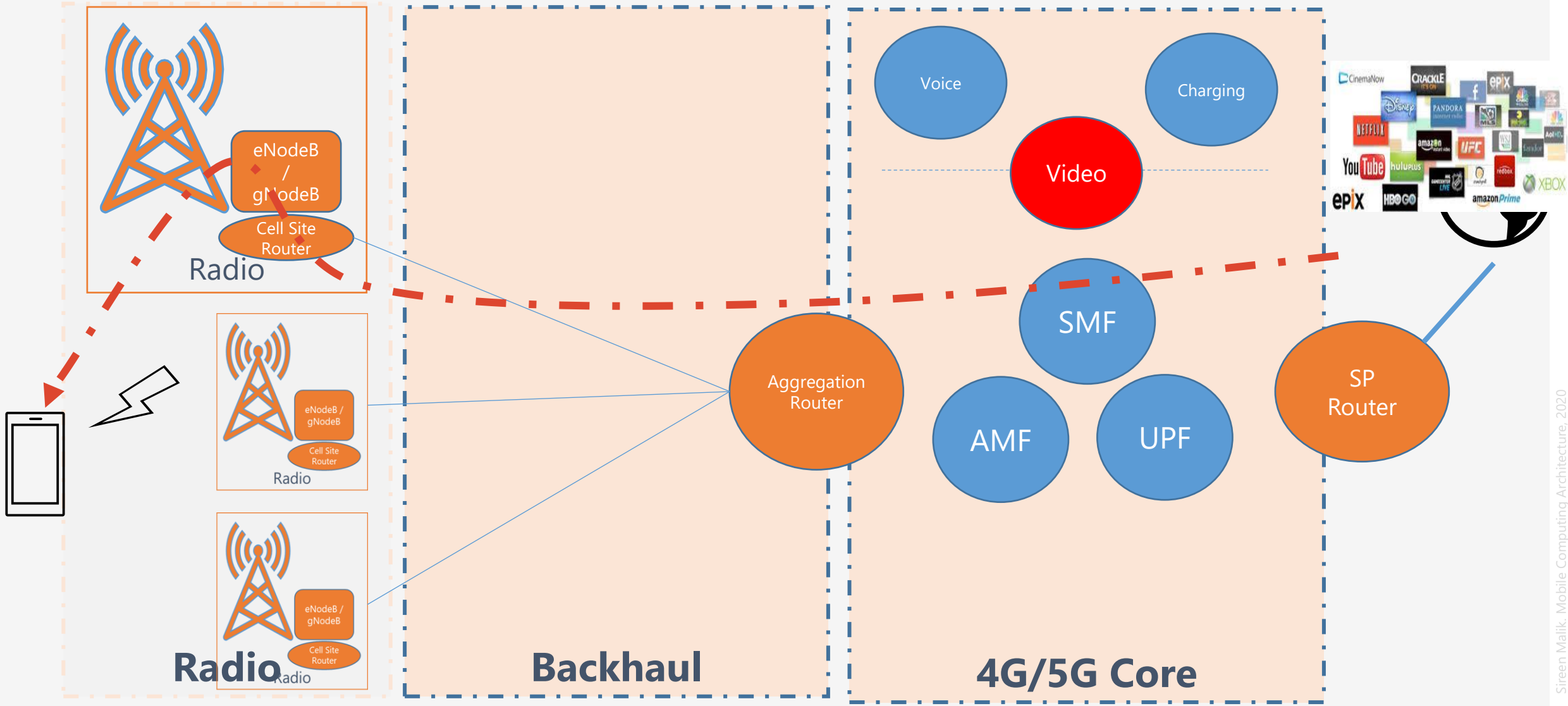


Main drivers for video traffic growth

- Video is part of most online content (news, ads, social media, etc.)
- Video sharing services
- Video streaming services
- Changing user behavior – video being consumed anywhere, any time
- Increased segment penetration, not just early adopters
- Evolving devices with larger screens and higher resolutions
- Increased network performance through evolved 4G deployments
- Emerging immersive media formats and applications (HD/UHD, 360-degree video, AR, VR)

[1] Traffic from embedded video in web browsing and social media is included in the application category "Video"

OTT Video over 5G Mobile Network

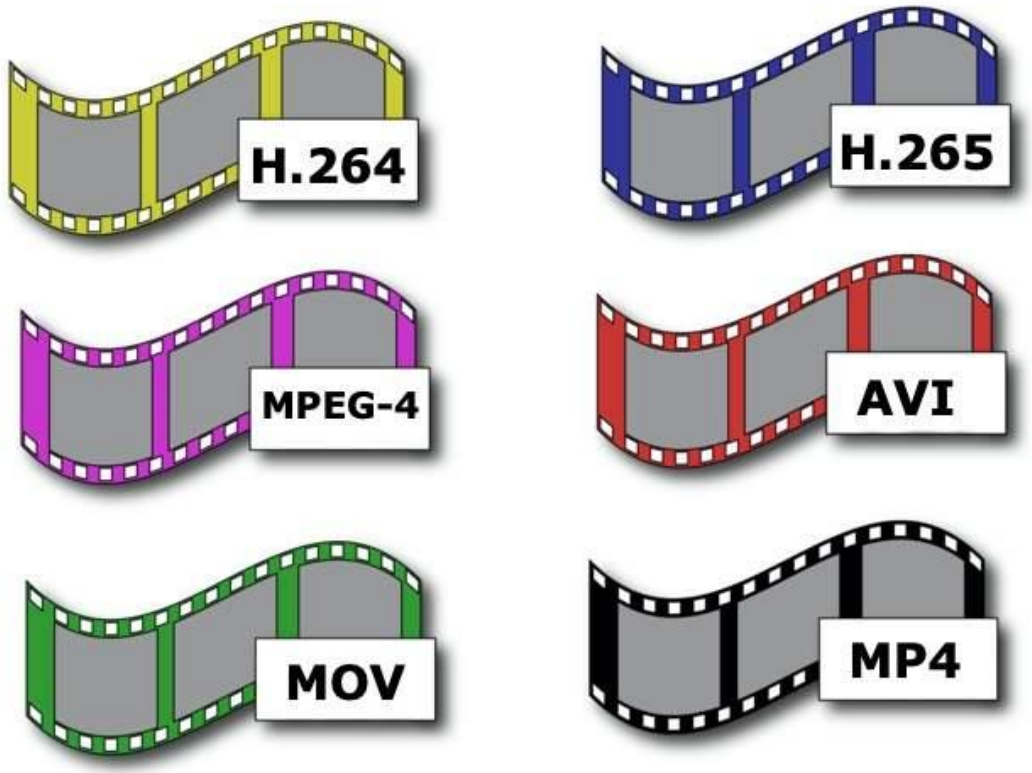


Common Video Codecs - I

The term codec is short for “coder/decoder”. It describes exactly how video or audio is converted from its raw, uncompressed form into something of a more palatable size.

Lossy Vs Lossless Formats

- For a given image resolution, there’s a ton of information. A single frame of 4K video is equal to a 3840×2160 photo! Compression technology uses various fancy mathematical ways to reduce the amount of information you need to reconstruct an image on screen
- Most of these compression techniques are “lossy”. Which is to say that they throw away some visual information to reduce the size of the video data. However, the loss is usually very minor and well worth the massive reduction in size. Any streaming video, DVD or BluRay content you watch uses lossy compression.
- Lossless compression for video is usually only found in the master digital recordings for big-budget film projects or in film archives.

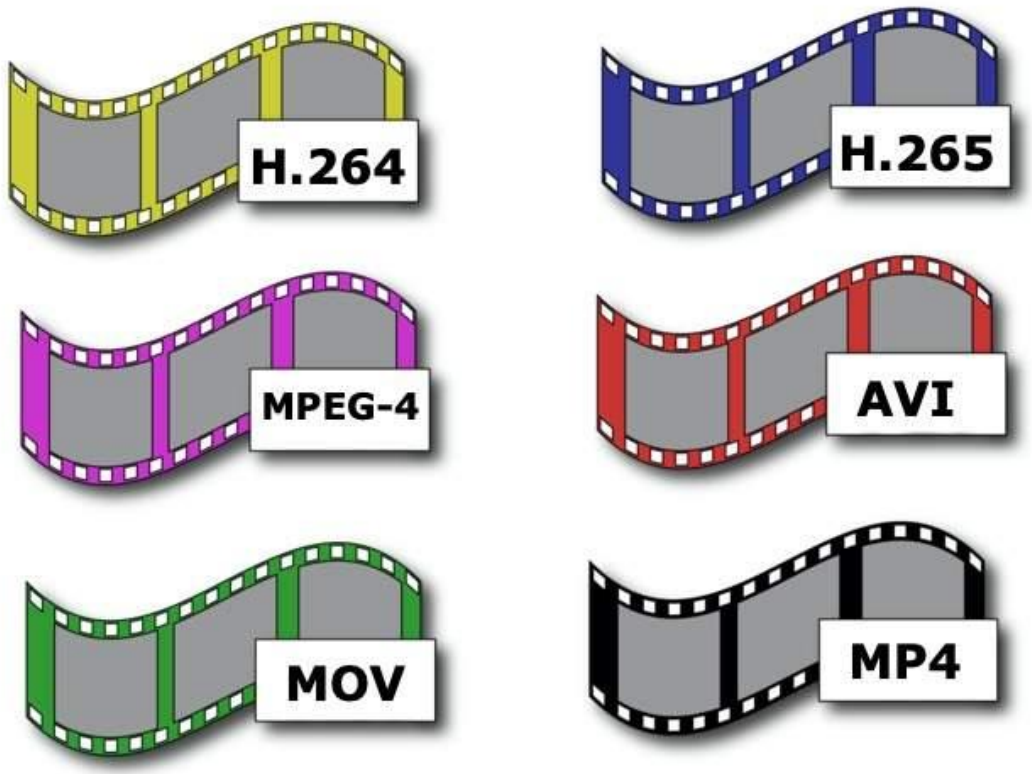


Common Video Codecs - II

The term codec is short for “coder/decoder”. It describes exactly how video or audio is converted from its raw, uncompressed form into something of a more palatable size.

- **H.264 Codec** is by far the most popular video codec. 80-%90% of all video offered in this common video format. Because H.264 is so popular, most devices (such as smartphones and smart TVs) have special hardware built in to decode H.264 video without putting any strain on the device’s main processor. Which is why even bottom-end smartphones can play HD video without breaking a sweat

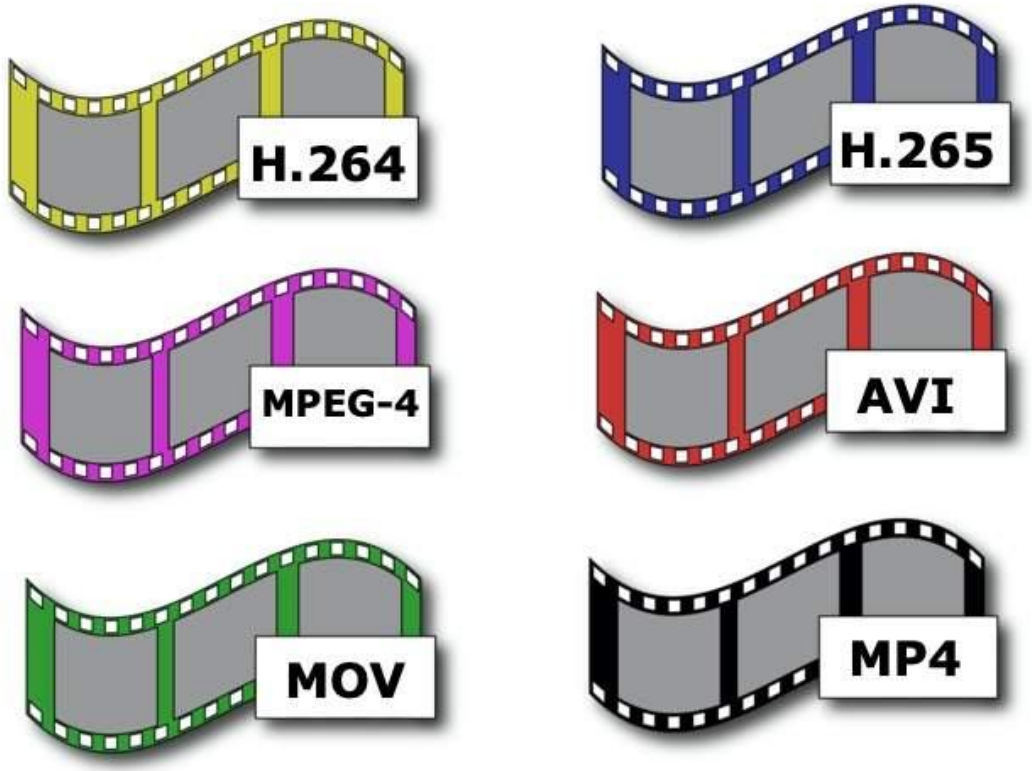
- **H.265** – The High Efficiency Video Coding (HEVC) format of video compression has revolutionized video streaming, since it can significantly reduce how much bandwidth you need. It’s designed to be the successor to H.264 and in general uses 25% to 50% less bandwidth to provide the same quality or better quality at the same bandwidth levels.



Common Video Codecs - III

The term codec is short for “coder/decoder”. It describes exactly how video or audio is converted from its raw, uncompressed form into something of a more palatable size.

- **MPEG-4** is also a very common video codec, but MPEG 4 Part 10 is actually the same as H.264. Early versions of MPEG-4 (e.g. Part 2) use older algorithms that are much less efficient in terms of space for the same level of quality. H.264 has essentially replaced MPEG-4 with a new naming convention
- **MP4** container format is supported by just about every device. It can contain any MPEG-4 format version and H.264. YouTube videos are usually in this common video format
- **AVI** is one of the oldest video containers and it isn’t used very often anymore, but it’s still widely supported, and a lot of existing content is in AVI. The number of codecs that can be used in the AVI container is large
- **MOV** container is associated with the Apple QuickTime Player and is its in-house format. Inside a MOV file you are most likely to find MPEG-4 video data. Which is why, in most cases, you can rename a MOV file to an MP4 file and it will work just the same.



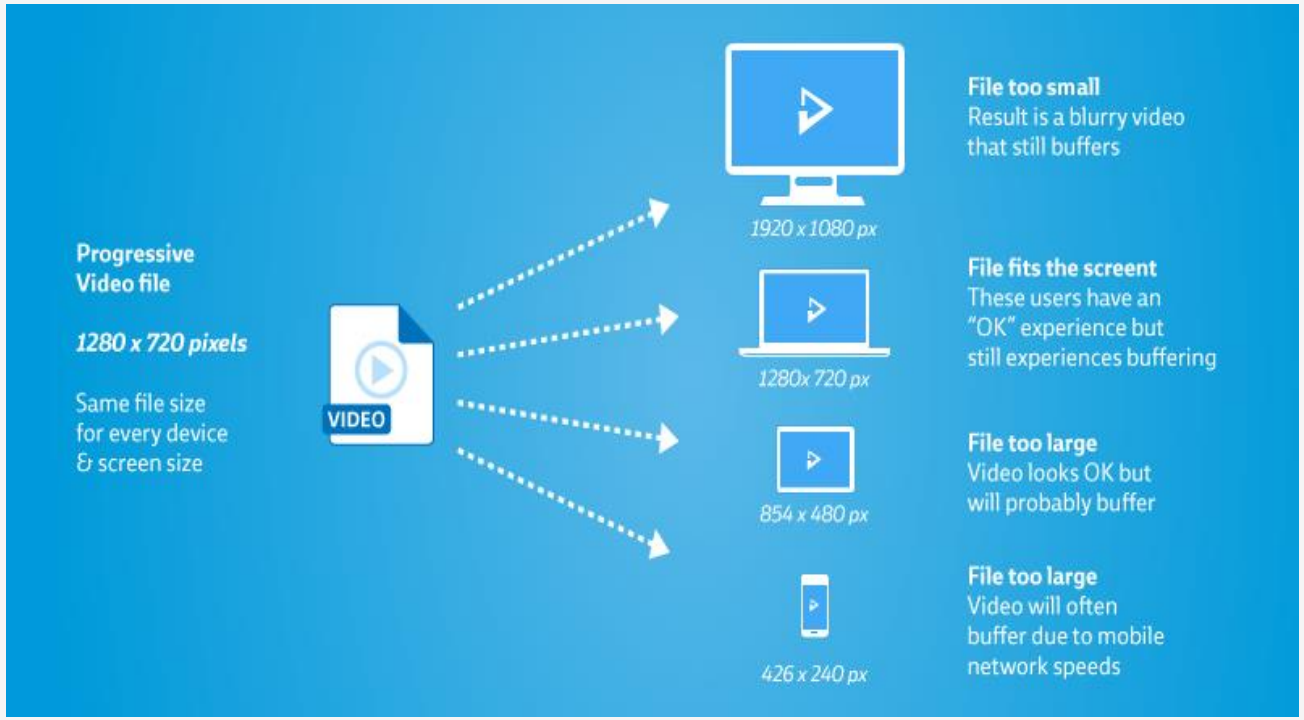
Adaptive Bit Rate (ABR) - I

Adaptive bitrate streaming provides the *best video quality and viewer experience p*ossible — no matter the connection, software, or device. Called ABR for short, the majority of these streams are delivered via HTTP-based technologies such as MPEG DASH and Apple's HLS.

- Adaptive streaming is designed to deliver video to the user in the most efficient way possible and in the highest usable quality for each specific user.

What is progressive video streaming?

- A progressive video stream is simply one single video file being streamed over the internet. This type of file is often an .mp4 but can of course be in many different formats. The progressive video can be stretched and squashed to fit different screen sizes, but regardless of the device playing it, the video file will always be the same. Issues:
  - (-) ideo that is only 1280 x 720 will never play at correct quality levels on a screen that is 1920 x 1080px
  - (-) The second is buffering. If the users has a poor-quality internet connection, and cannot download the video stream quickly enough, then the video will need to pause, wait for more data, and then start again. This makes watching a video horrible for the user.



https://bitmovin.com/adaptive-streaming/

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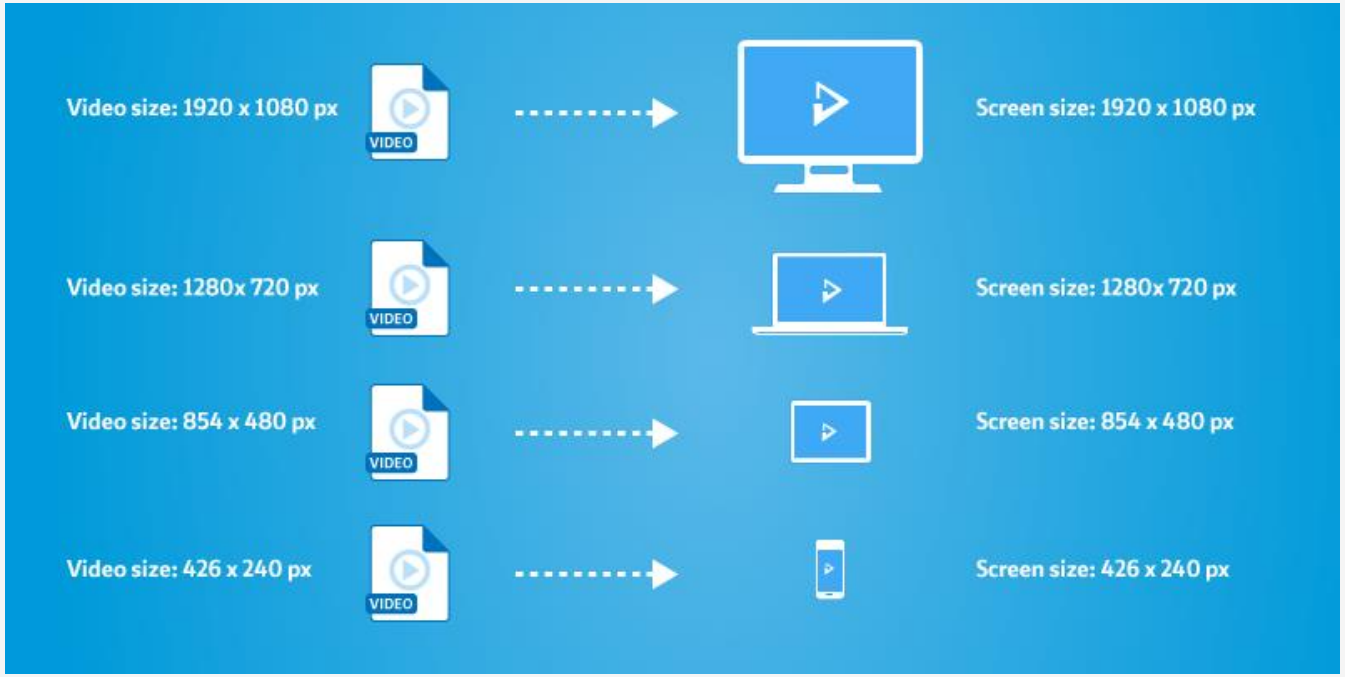
- Adaptive streaming allows the video provider to create a different video for each of the screen sizes (or devices) that he or she wishes to target. Stream a specific video file to fit specific screen sizes, ensuring that the viewer always receives a video that will look good

- If a user has a slow internet connection, and adaptive video stream will switch to a smaller video files size to keep the video playing.



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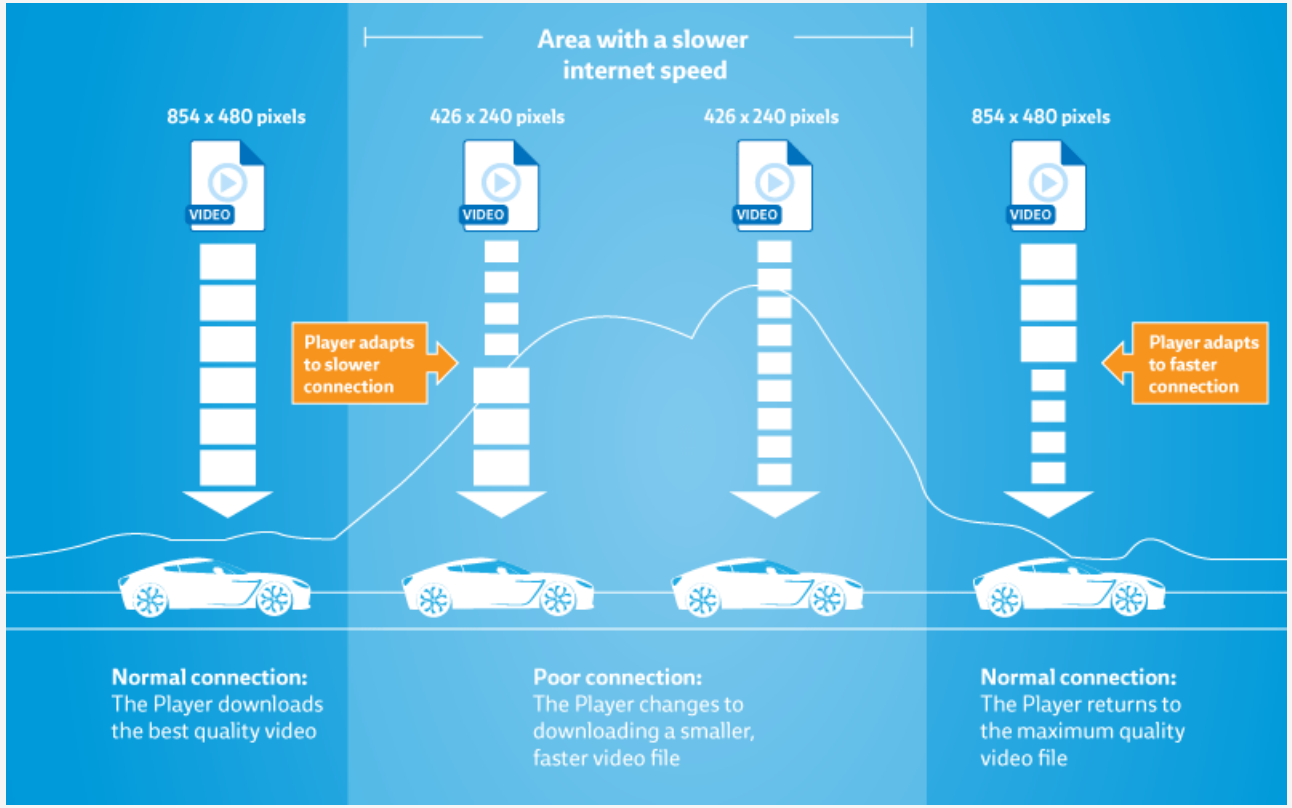
- The settings, and decisions about which video is best for each specific user can be changed from second to second
- As internet connection changes, the adaptive stream will switch back and forth between video qualities
- Segments are used for adaptive streaming. When a video file is encoded to adaptive format, it is broken up into segments. These are short snippets of video, often set to 4 seconds long
- At the end of each 4 second segment, the Player can switch to a different video file if necessary



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Netflix OTT Video

Below are the internet download speed recommendations per stream for playing TV shows and movies through Netflix.

- 0.5 Megabits per second - Required broadband connection speed
- 1.5 Megabits per second - Recommended broadband connection speed
- 3.0 Megabits per second - Recommended for SD quality
- 5.0 Megabits per second - Recommended for HD quality
- 25 Megabits per second - Recommended for Ultra HD quality

23.976 fps

Resolution	Streaming Bitrate	Hourly Conversion
480p (720×480)	1750 kbps	~792 MB per hour
720p (1280×720)	3000 kbps	~1.3 GB per hour
1080p (1920×1080)	4300-5800 kbps	~1.9 GB to ~2.55 GB per hour
1440p (2560×1440)	6350 kbps	~2.8 GB per hour
4K (3840×2160)	8000-16000 kbps	~3.5 GB to ~7 GB per hour

Most videos you play on Netflix should be 23.976 frames per second, so the above table should apply for most of what you play. However, Netflix also offers tests for 59.940 fps, so we ran those numbers as well. (Unfortunately, there's no way to tell if a show or movie plays at 23.976 or 59.940 frames per second.)

59.940 fps

Resolution	Streaming Bitrate	Hourly Conversion
720p (1280×720)	3600 kbps	~1.6 GB per hour
1080p (1920×1080)	6960 kbps	~3.1 GB per hour
4K (3840×2160)	16000 kbps	~7 GB per hour

YouTube OTT Video – Screen Size and Bitrates

Video Quality	Resolution (pixels)	Framrate (FPS)	Bitrate (average)	Data used per minute	Data used per 60 minutes
144p	256x144	30	80-100 Kbps	0.5-1.5 MB	30-90 MB
240p	426x240	30	300-700 Kbps	3-4.5 MB	180-250 MB
360p	640x360	30	400-1,000 Kbps	5-7.5 MB	300-450 MB
480p	854x480	30	500-2,000 Kbps	8-11 MB	480-660 MB
720p (HD)	1280x720	30-60	1.5-6.0 Mbps	20-45 MB	1.2-2.7 GB
1080p (FHD)	1920x1080	30-60	3.0-9.0 Mbps	50-68 MB	2.5-4.1 GB
1440p (QHD)	2560x1440	30-60	6.0-18.0 Mbps	45-135 MB	2.7-8.1 GB
2160p (4k) (UHD)	3840x2160	30-60	13.0-51.0 Mbps	95-385 MB	5.5-23.0 GB
4320p (8k) (FUHD)	7680x4320	30-60	20-50 Mbps (estimated @30FPS)	150-375 MB (estimated at 30FPS)	9.0-22.5 GB (estimated @30FPS)

Apple Devices

16:9 aspect ratio	H.264/AVC	Frame rate
416 x 234	145	≤ 30 fps
640 x 360	365	≤ 30 fps
768 x 432	730	≤ 30 fps
768 x 432	1100	≤ 30 fps
960 x 540	2000	same as source
1280 x 720	3000	same as source
1280 x 720	4500	same as source
1920 x 1080	6000	same as source
1920 x 1080	7800	same as source

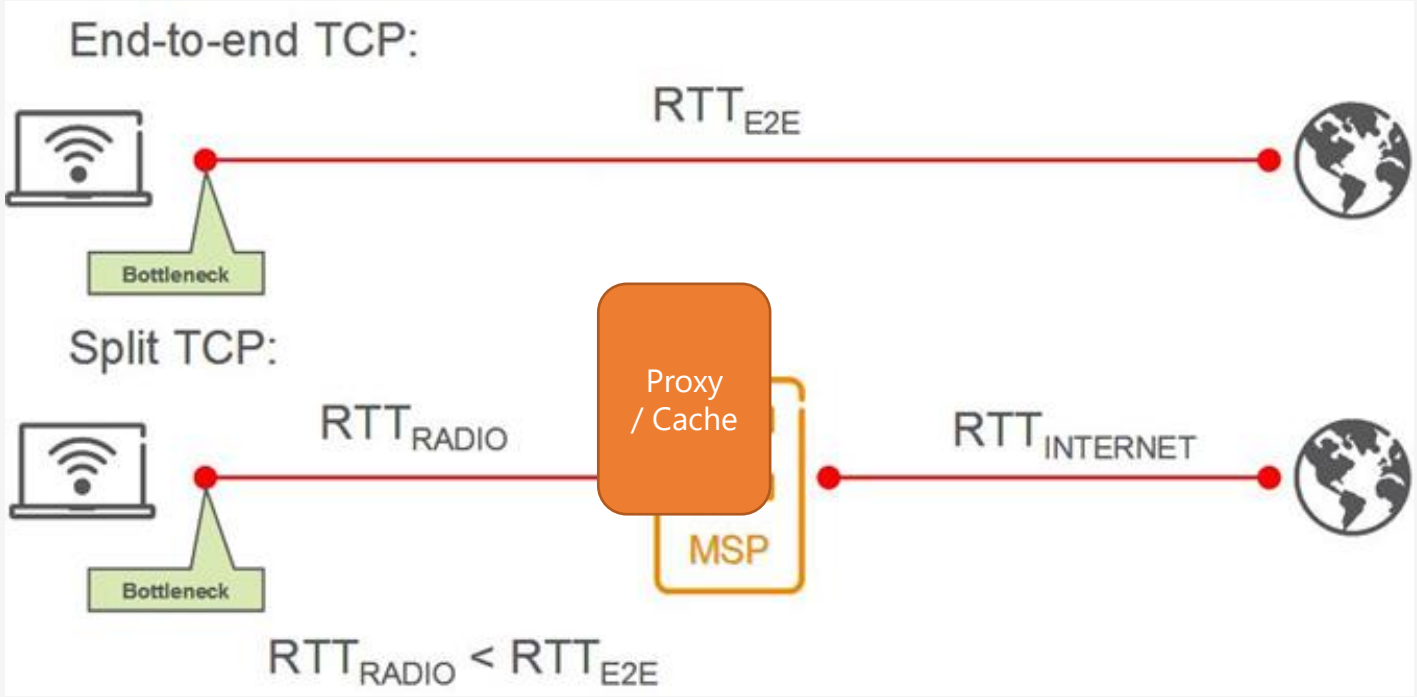
16:9 aspect ratio	HEVC/H.265 30 fps	HDR (HEVC) 30 fps	Frame rate
640 x 360	145	160	≤ 30 fps
768 x 432	300	360	≤ 30 fps
960 x 540	600	730	≤ 30 fps
960 x 540	900	1090	≤ 30 fps
960 x 540	1600	1930	same as source
1280 x 720	2400	2900	same as source
1280 x 720	3400	4080	same as source
1920 x 1080	4500	5400	same as source
1920 x 1080	5800	7000	same as source
2560 x 1440	8100	9700	same as source
3840 x 2160	11600	13900	same as source
3840 x 2160	16800	20000	same as source

Android Devices

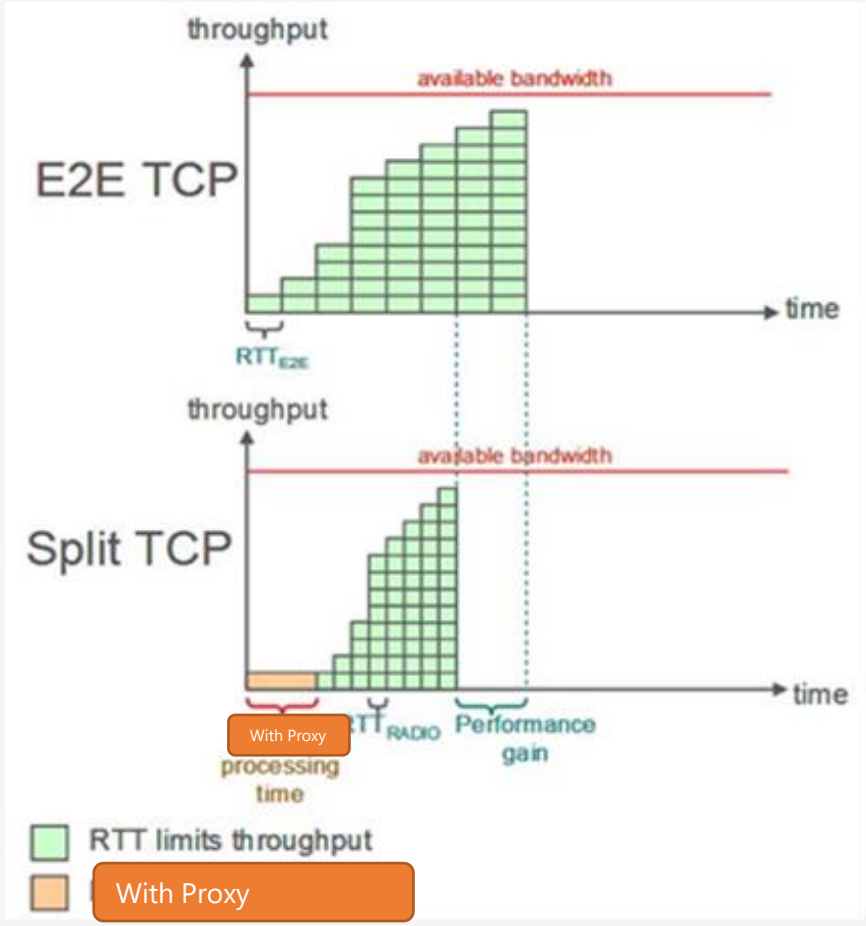
Format / Codec	Encoder	Decoder	Details	Supported File Type(s) / Container Formats
H.263	•	•	Support for H.263 is optional in Android 7.0+	• 3GPP (.3gp) • MPEG-4 (.mp4) • Matroska (.mkv)
H.264 AVC Baseline Profile (BP)	• (Android 3.0+)	•		• 3GPP (.3gp) • MPEG-4 (.mp4) • MPEG-TS (.ts, AAC audio only, not seekable, Android 3.0+) • Matroska (.mkv)
H.264 AVC Main Profile (MP)	• (Android 6.0+)	•	The decoder is required, the encoder is recommended.	
H.265 HEVC		• (Android 5.0+)	Main Profile Level 3 for mobile devices and Main Profile Level 4.1 for Android TV	• MPEG-4 (.mp4) • Matroska (.mkv)
MPEG-4 SP		•		3GPP (.3gp)
VP8	• (Android 4.3+)	• (Android 2.3.3+)	Streamable only in Android 4.0 and above	• WebM (.webm) • Matroska (.mkv, Android 4.0+)
VP9		• (Android 4.4+)		• WebM (.webm) • Matroska (.mkv)
AV1		• (Android 10+)	The decoder is optional.	• MPEG-4 (.mp4) • Matroska (.mkv)

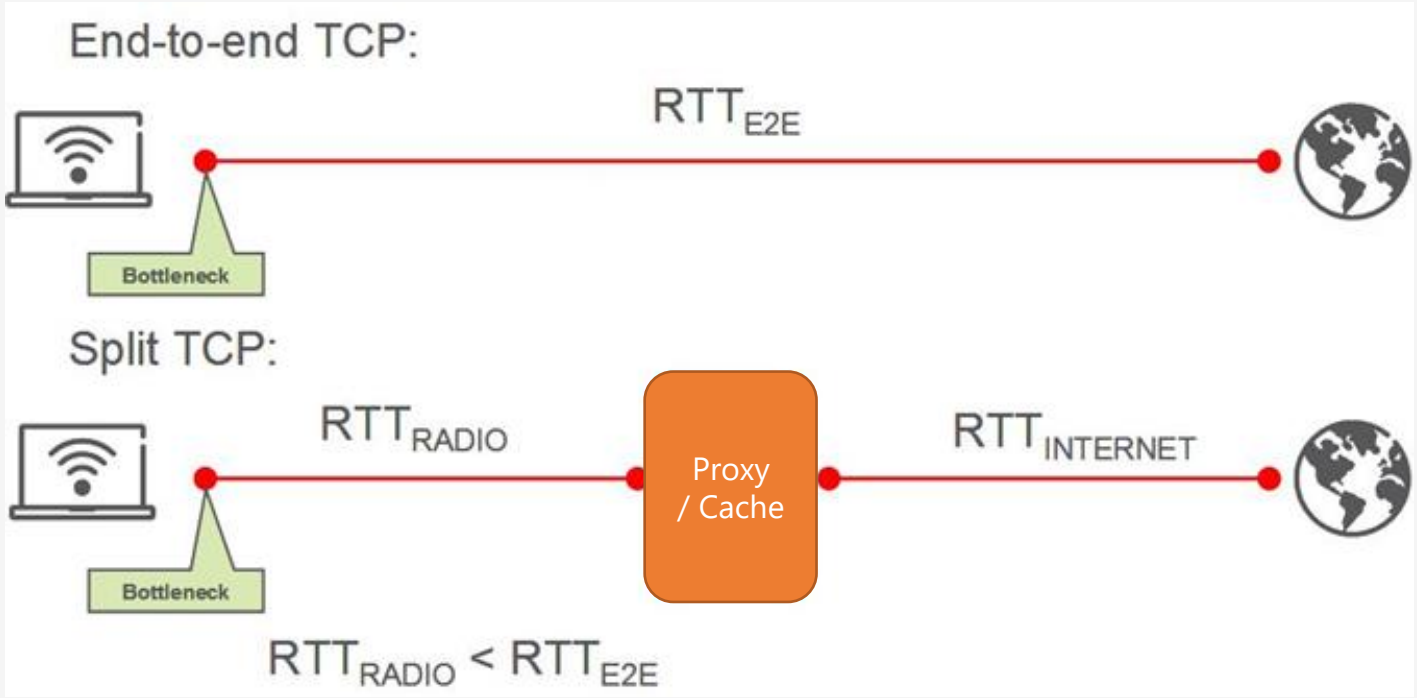
Mobile Network Proxy/Cache – I

- Faster delivery of Video content
- Content Providers push the most popular content to Cache installed at Service Providers
- Higher Quality (ABR) removing chances of Internet connection
- Higher Quality (ABR) as reducing RTT (recall TCP Throughput) increases Bitrates for video



Mobile Network Proxy/Cache – II
TCP Performance

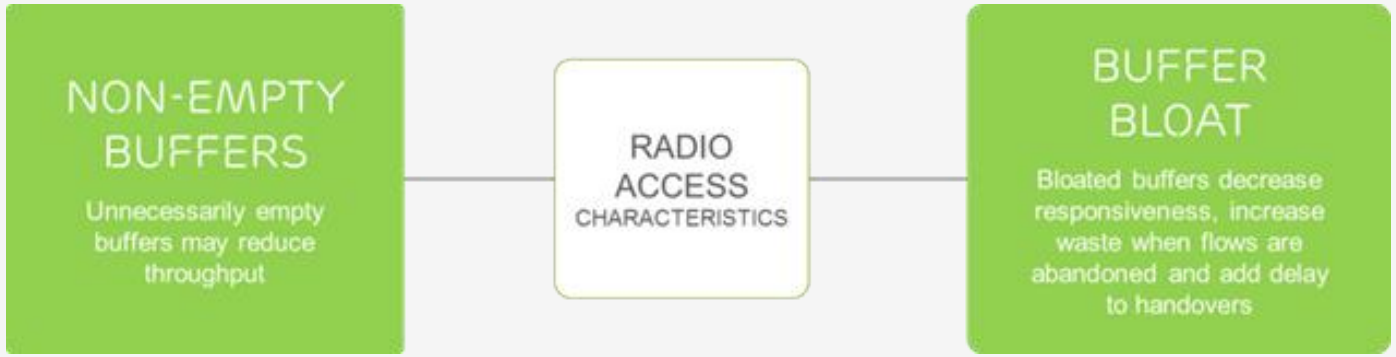




Mobile Network Proxy/Cache – III
RADIO Network Optimized TCP Variants

A major vendor TCP implantation:

- detects congestion and reduced signal strength based on both latency and packet loss
- It detects an increasing congestion manifested as an increased delay before packet loss occurs.
- The increased delay is also an indication of the queue buildup in the network.
- When the latency increases, the protocol progressively reduces the send rate. It can also give higher priority to specific content types, protocols or subscriber categories.



Mobile Network Proxy/Cache – IV
Improving Cost of Ownership

- **Do we need very high Bitrate for mobile watching videos on mobile phones?**

=> Activity: what would be the good bitrate for SD quality for your phone? Compare it with the bitrate for 4K quality.

- Service providers often Rate-Limit the video connections for saving:
  - Expensive Radio spectrum
  - Expensive Backhaul and Transport capacity
  - Expensive security and traffic inspection