# Motion Picture Engineering

Video Streaming

# 1968

NETFLIX

Watch Instantly

Just for

Recently Watched

My List

See All

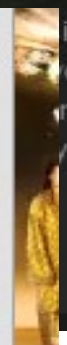
hulu TV MOVIES ORIGINALS KIDS LATINO MORE

*Watch the Latest Episode*

**Parks and Recreation**

**Farmers Market**

Leslie battles a lewd chard vendor at the Pawnee Farmers Market.



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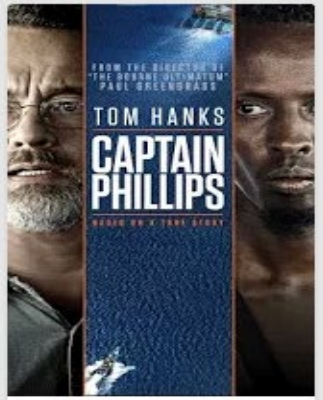
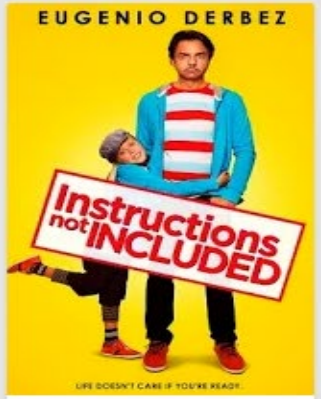
New Releases

## New Movie Releases

Our Recommended Picks




Captain Phillips
Action & Adventure
★★★★½ $3.99




Instructions Not Inc
Drama
★★★★½ $3.99


All Is Lost
Drama
★★★★☆ $3.99

## 2014 Oscars

And the nominees are ...



70%
internet is
video

1 Billion
hours on
YouTube

40%
of the world
owns a
smartphone

# And then the pandemic hit in 2020

- Real time video communications is one of the technologies which allowed the world economy to survive
  - PEOPLE WERE ABLE TO WORK AND STUDY FROM HOME
- Video Streaming sites enabled entertainment (SEE THIS)
  - STREAMING VIEWERSHIP UP 30% AT PEAK OF 1ST LOCKDOWN IN AUG 2020
- The pressure on bandwidth was so large that Governments appealed to Netflix to reduce their streaming resolutions.

# The challenges of video streaming

- The available bandwidth is generally not enough to receive the video data generated at the source.
- That bandwidth changes every second.
- There are thousands of different realisations of devices/hardware for generation and display of media
- Devices can generate and display different resolutions and aspect ratios. They can be rotated in the middle of playback so your aspect ratio can change suddenly.
- The artistic intent of a director in terms of picture quality needs to be reproduced on every possible display device.

# The challenges of video streaming

| Challenge | Solution |
| --- | --- |
| The bandwidth is not enough | Video Compression/Transcoding/Transrating |
| Bandwidth is time varying | Adaptive Bitrate (ABR) Compression, HLS+DASH |
| 1000’s of different devices | Adaptive Multiplexing and ABR |
| Reproducing Artistic Intent | Perceptual Quality Measurement |
| | |

# Back of the envelope calculation

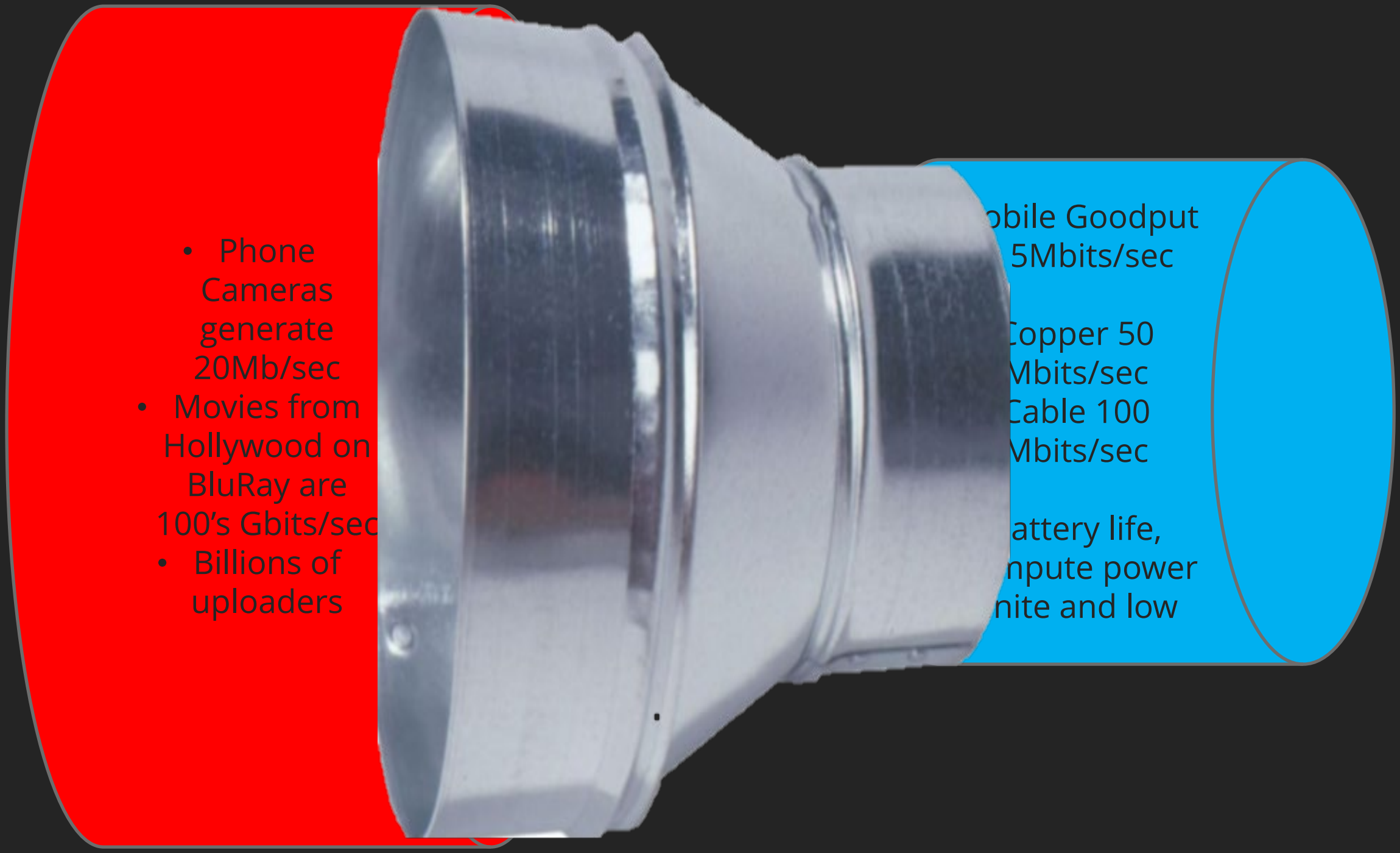
| Video Generated | Raw Data Bitrate |
| --- | --- |
| 1080p from iphone, at 25fps, YUV420 sampling | Bits/Pixel $\times$ Pixels/frame $\times$ fps $= 8 \times 1920 \times 1080 \times 1.5 \times 25 = 593\text{Mbps}$ |
| 4k from Red “Helium” Cinema Camera at 60fps RGB444 sampling, 16 bit channel | $= 16 \times 3840 \times 2160 \times 3 \times 60 = 22.8\ \text{Gbps}$ |

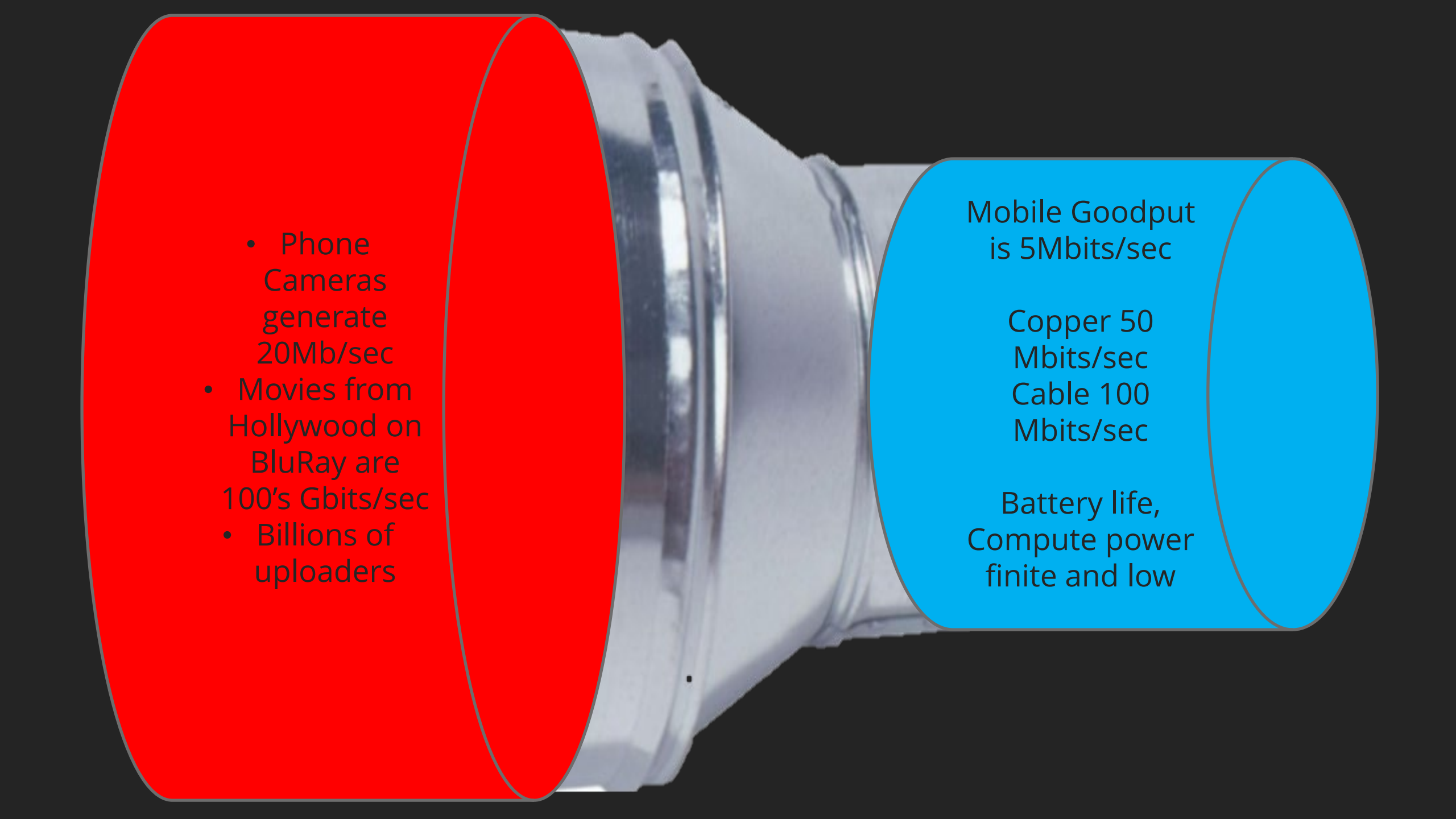
Your average phone bitrate is 8Mbps, Home Fibre probably 50Mbps
But that is only you. There are maybe 1B people looking at video in every instant of every day. Each pixel has got to get to all of them. So the bandwidth available is less.

**Thankfully Video Compression Algorithms have improved and Quality has changed for the better**

320 Kbps

160 Kbps


• Phone Cameras generate 20Mb/sec
• Movies from Hollywood on BluRay are 100’s Gbits/sec
• Billions of uploaders
obile Goodput 5Mbits/sec
Copper 50 Mbits/sec
Cable 100 Mbits/sec
attery life, mpute power nite and low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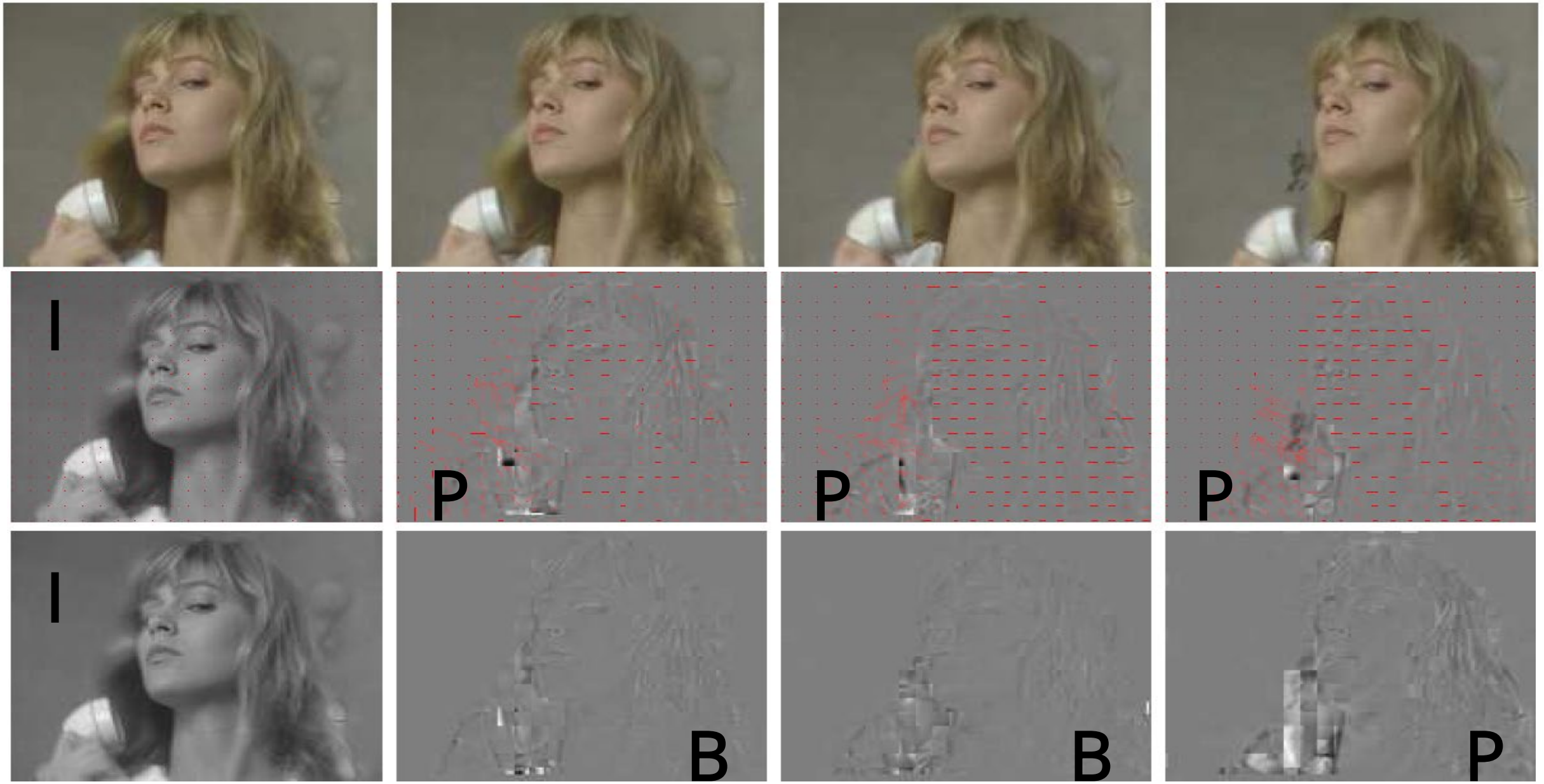
Mobile Goodput is 5Mbits/sec
Copper 50 Mbits/sec
Cable 100 Mbits/sec
Battery life, Compute power finite and low

# RATE/QUALITY TRADEOFF

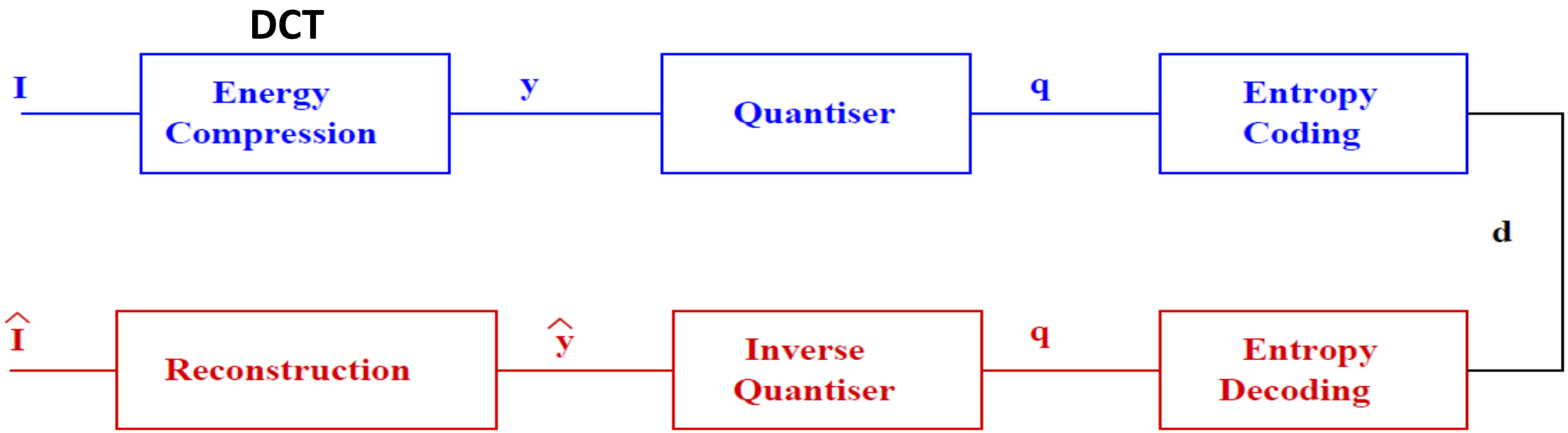
Low bitrate but poor quality

High quality but high bitrate

# Video Compression Basics (very)



# Basic DSP Elements of Media Compression



1 November 1992

# Video compression using lapped transforms for motion estimation/compensation and coding

*Robert W. Young; Nick G. Kingsbury*

original image

DCT

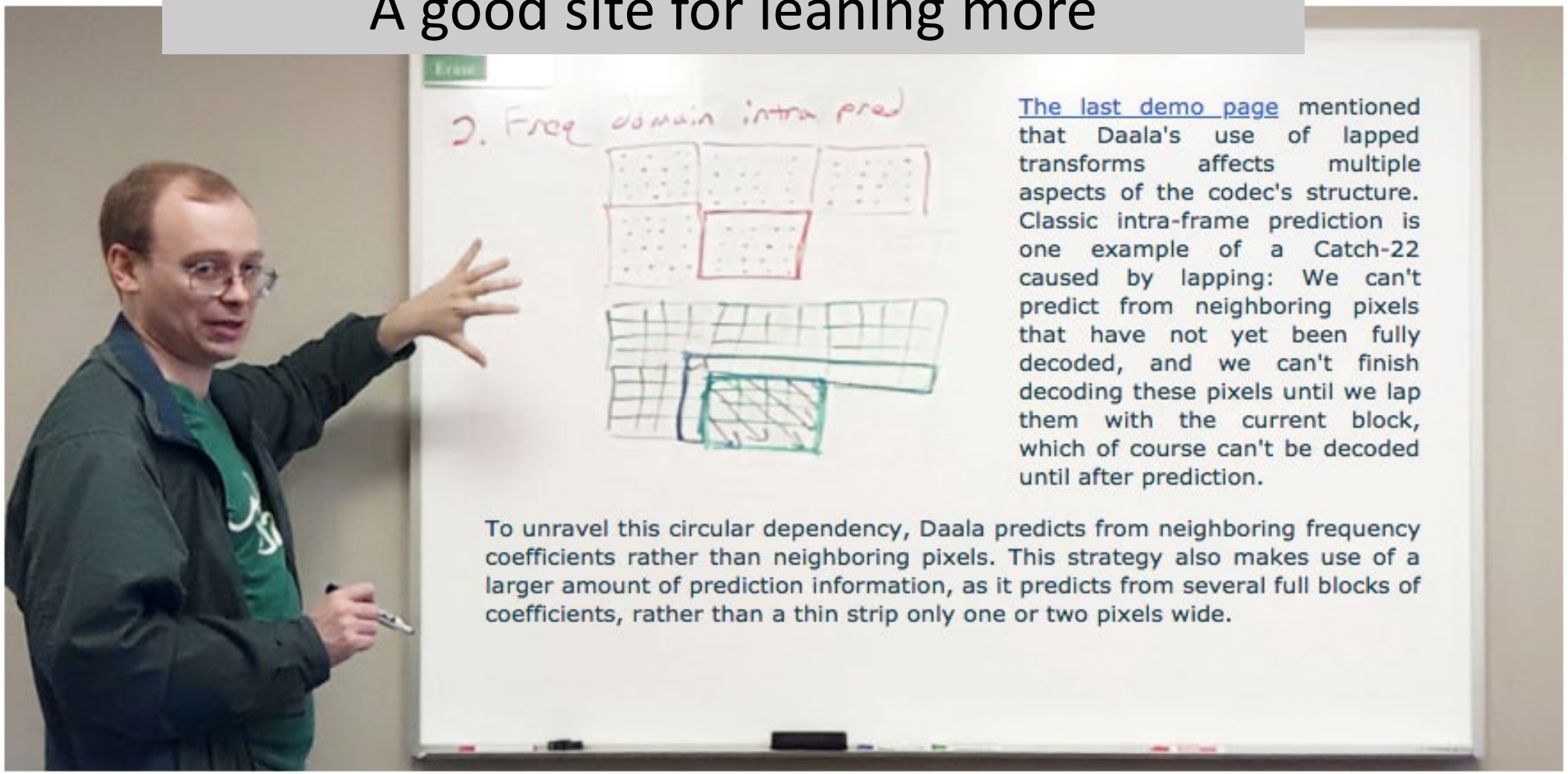
lapped transform

xiph.org

# Introducing Daala part 2: Frequency Domain Intra Prediction

(...up to the main demo page)

## A good site for leaning more




*Above: Dr. Timothy Terriberry of Mozilla and Xiph.Org gives an informal presentation on Daala's intra prediction at Mozilla headquarters on June 1, 2013.*

## Reference Material

### Background on Digital Media
http://xiph.org/video/vid1.shtml http://xiph.org/video/vid2.shtml

Excellent Overview of Media Compression at http://people.xiph.org/~tterribe/pubs/lca2012/auckland/intro_to_video1.pdf ; https://www.xiph.org/daala/

VP9 Presentation at Google IO 2013 : http://www.youtube.com/watch?v=K6JshvblIcM

HEVC Information http://hevc.hhi.fraunhofer.de/
http://www.atlanta-smpte.org/HEVC-Tutorial.pdf

H.264 Information http://www.itu.int/rec/T-REC-H.264

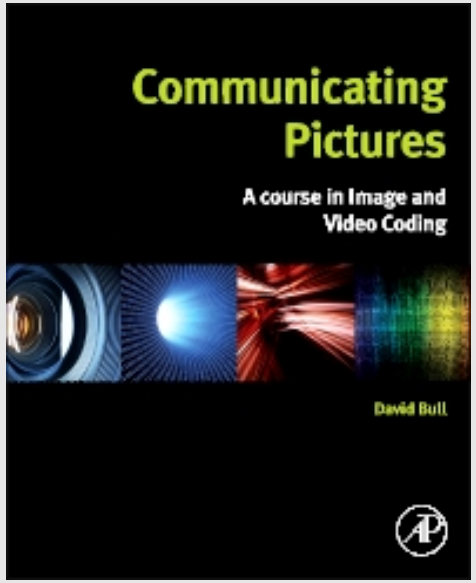
Tools : www.ffmpeg.org http://www.videolan.org/

Rate Control in H.264 : http://www.pixeltools.com/rate_control_paper.html

Communicating Pictures

A Course in Image and Video Coding

1st Edition - June 20, 2014



When did we start getting this right?

TELEVISION BROADCAST LEADS

OTT Leads Picture Quality

SORTING OUT INFRASTRUCTURE

2000

Sky Turns off Analoge

6 Mb/sec, 720x576

2005

YouTube

H.264

2007

Vimeo starts streaming HD

6 Mb/sec, 1920 x 1080p

2010

Netflix dominates evening streaming

2013

YouTube launches Denoiser, VP9

2014

4K 16 Mb/sec

HFR

HDR

360 Video

2016

8K

3D 360

2000 MPEG2

H.263

Theora, VC1, Dirac

2005 H.264

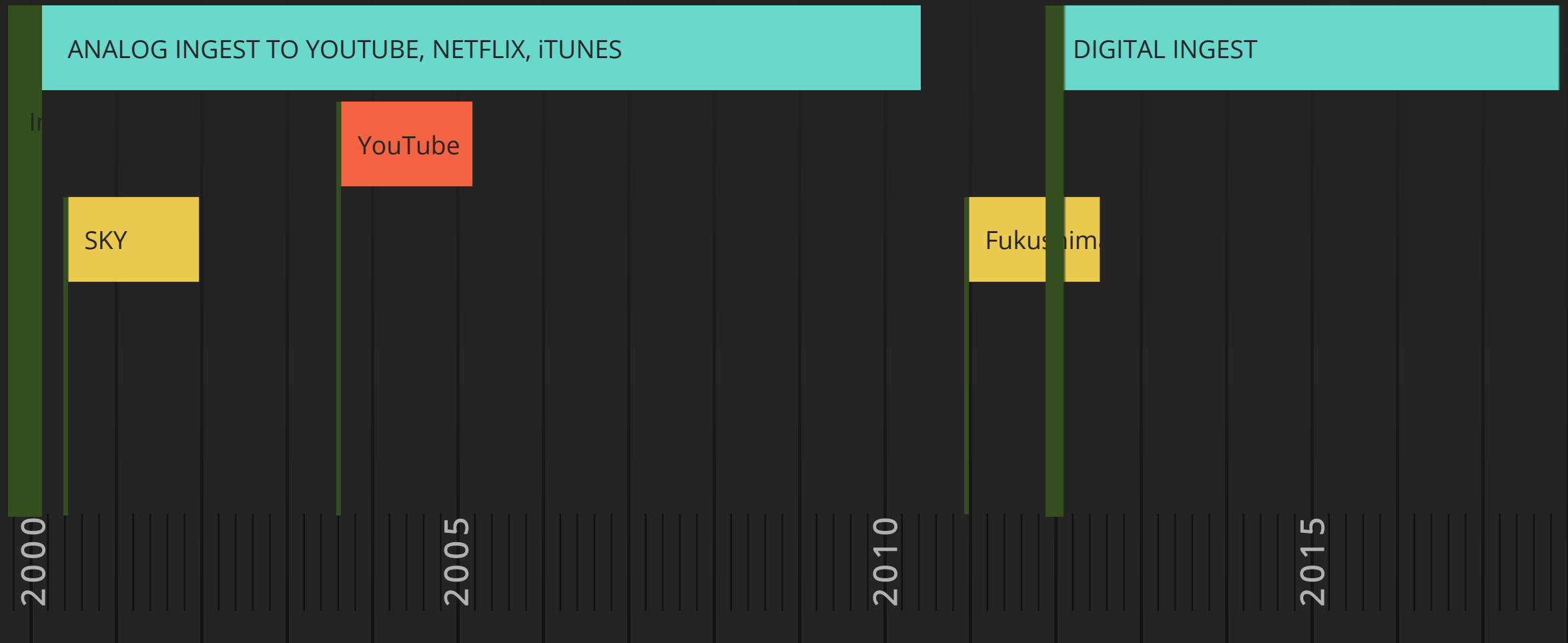
2010

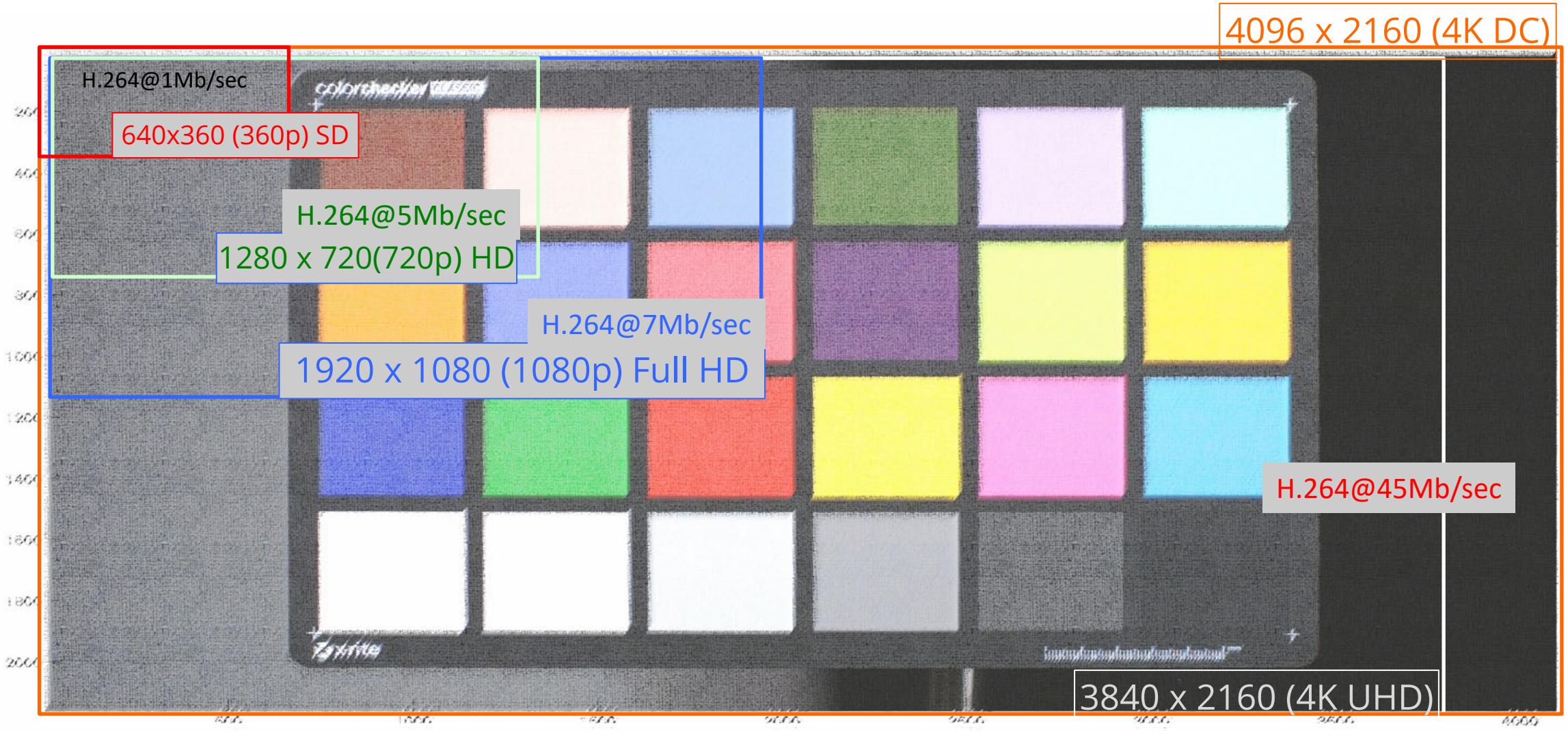
H.265, VP9, Daala

2015

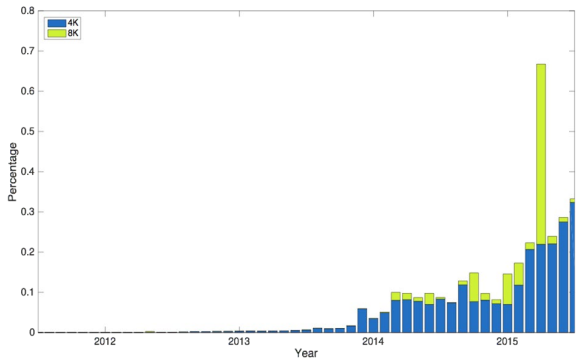
H.266, AV1

# Fukushima increased importance of ffmpeg and video over the internet

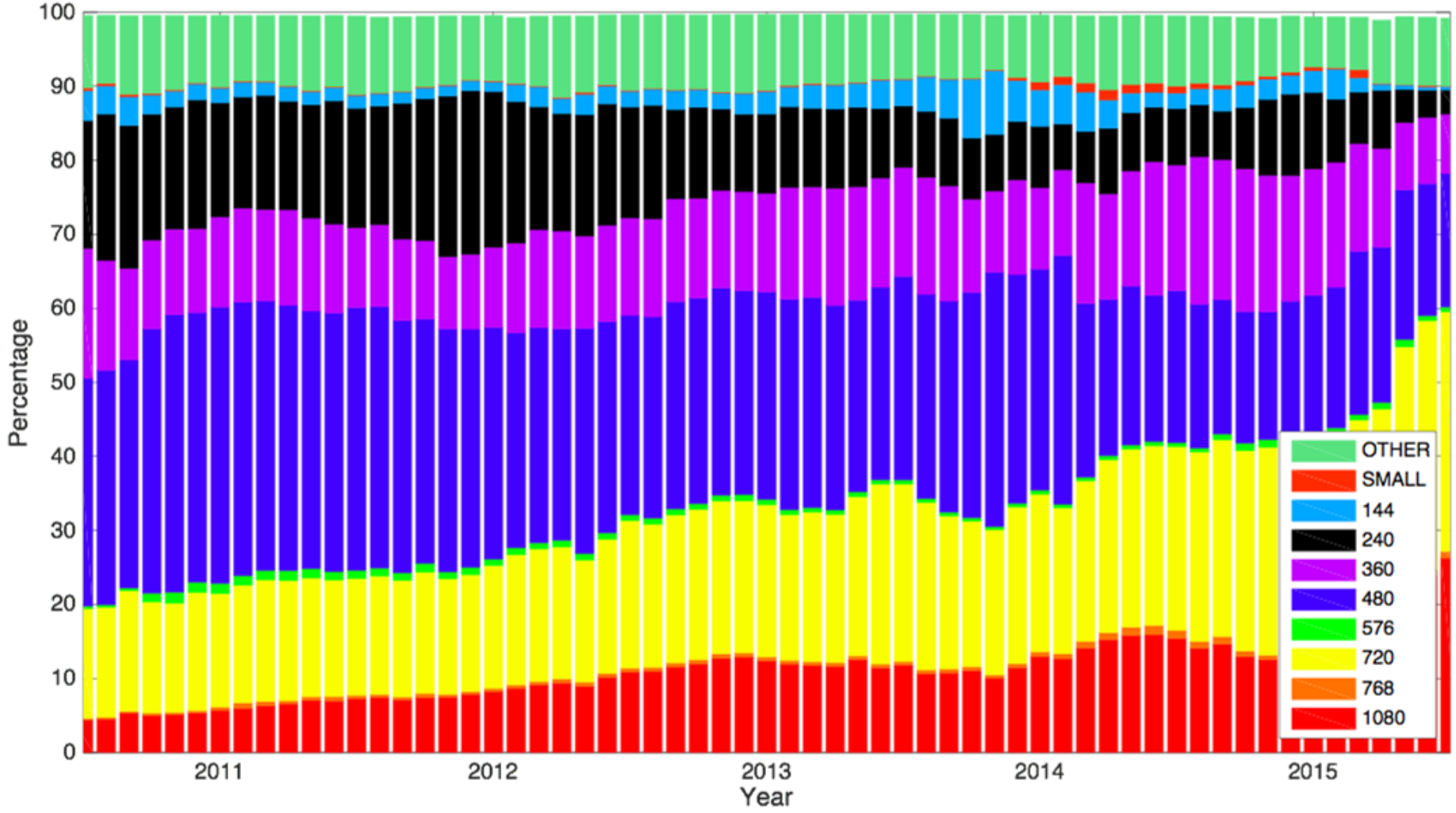



4096 x 2160 (4K DC)
H.264@1Mb/sec
640x360 (360p) SD
H.264@5Mb/sec
1280 x 720(720p) HD
H.264@7Mb/sec
1920 x 1080 (1080p) Full HD
H.264@45Mb/sec
3840 x 2160 (4K UHD)

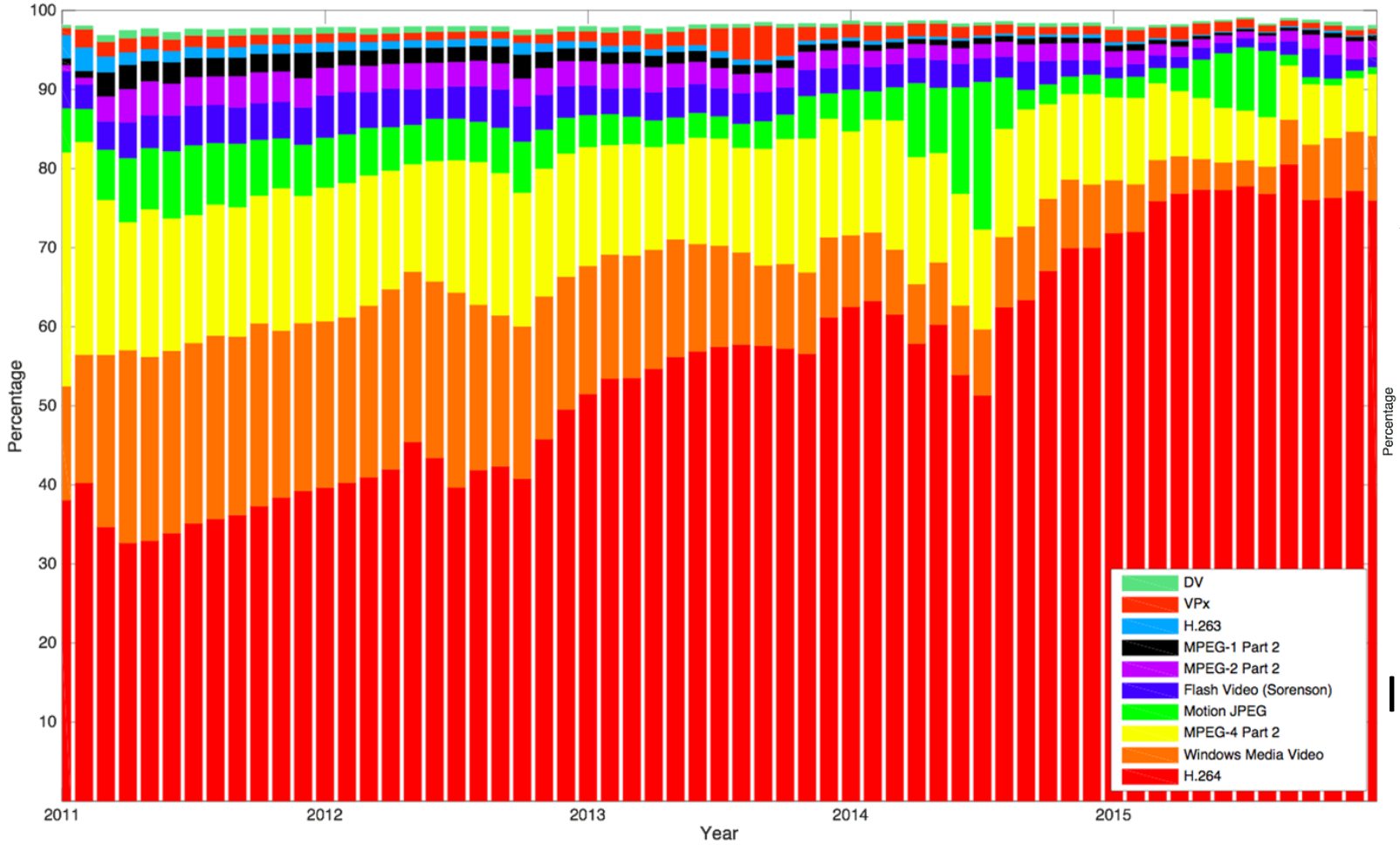
# Some Trends (from YT): Resolutions

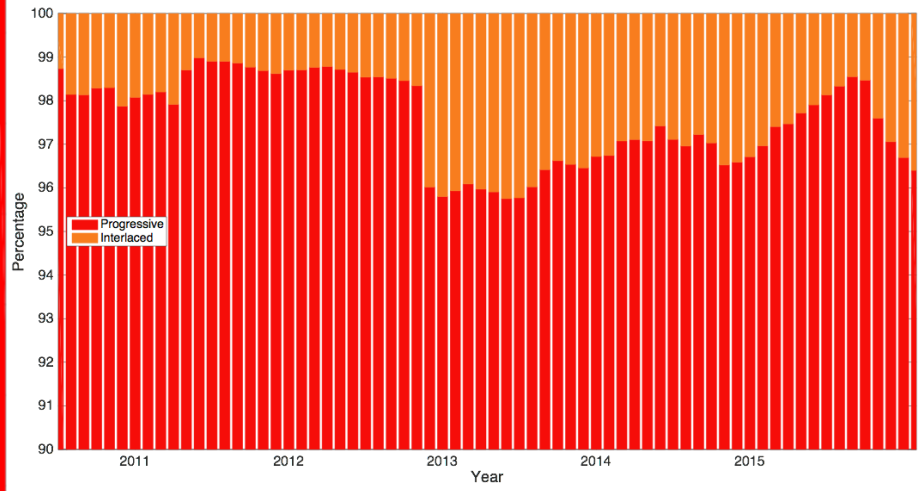



4k and 8k



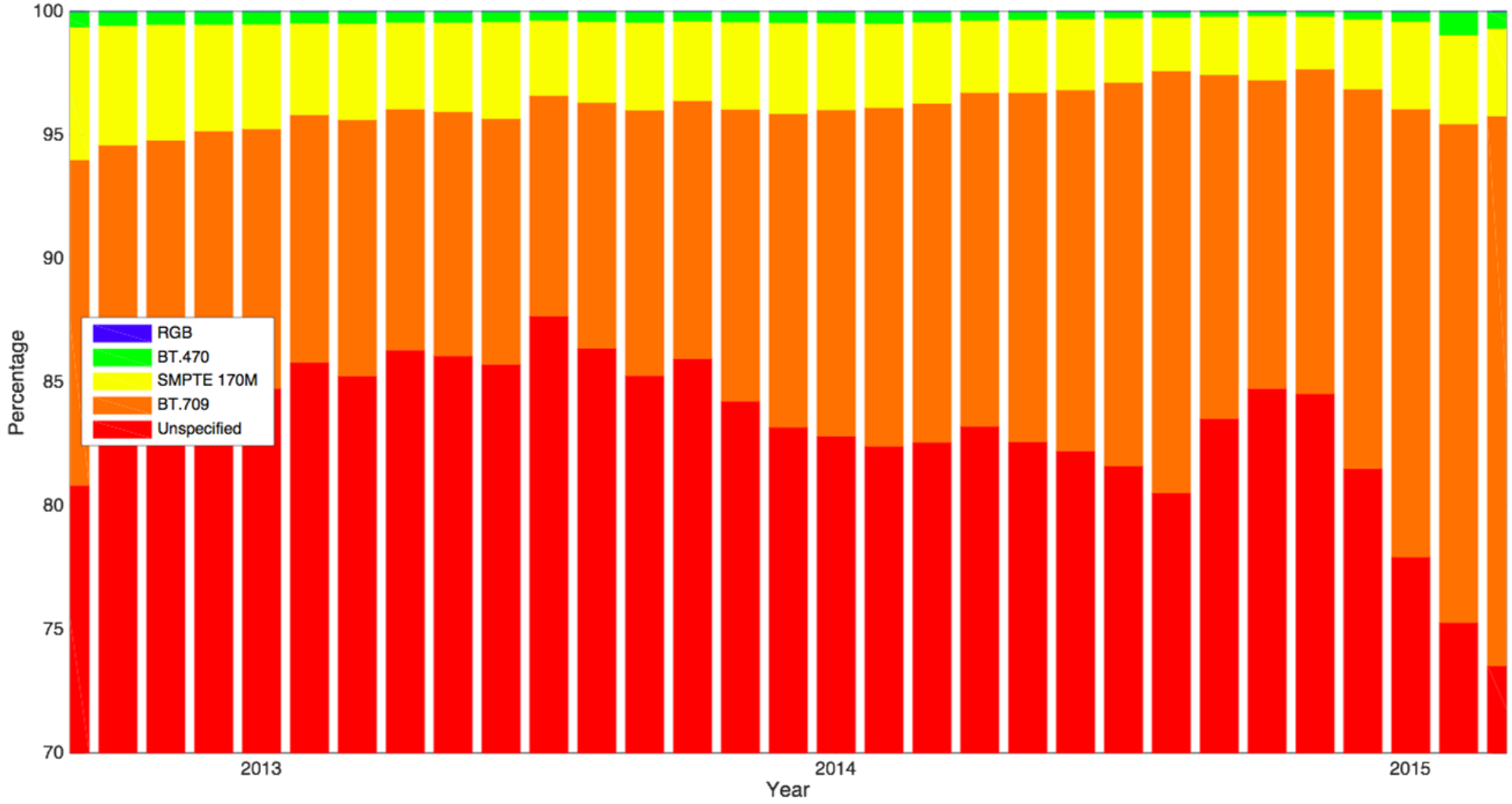
# Some Trends (from YT): Video



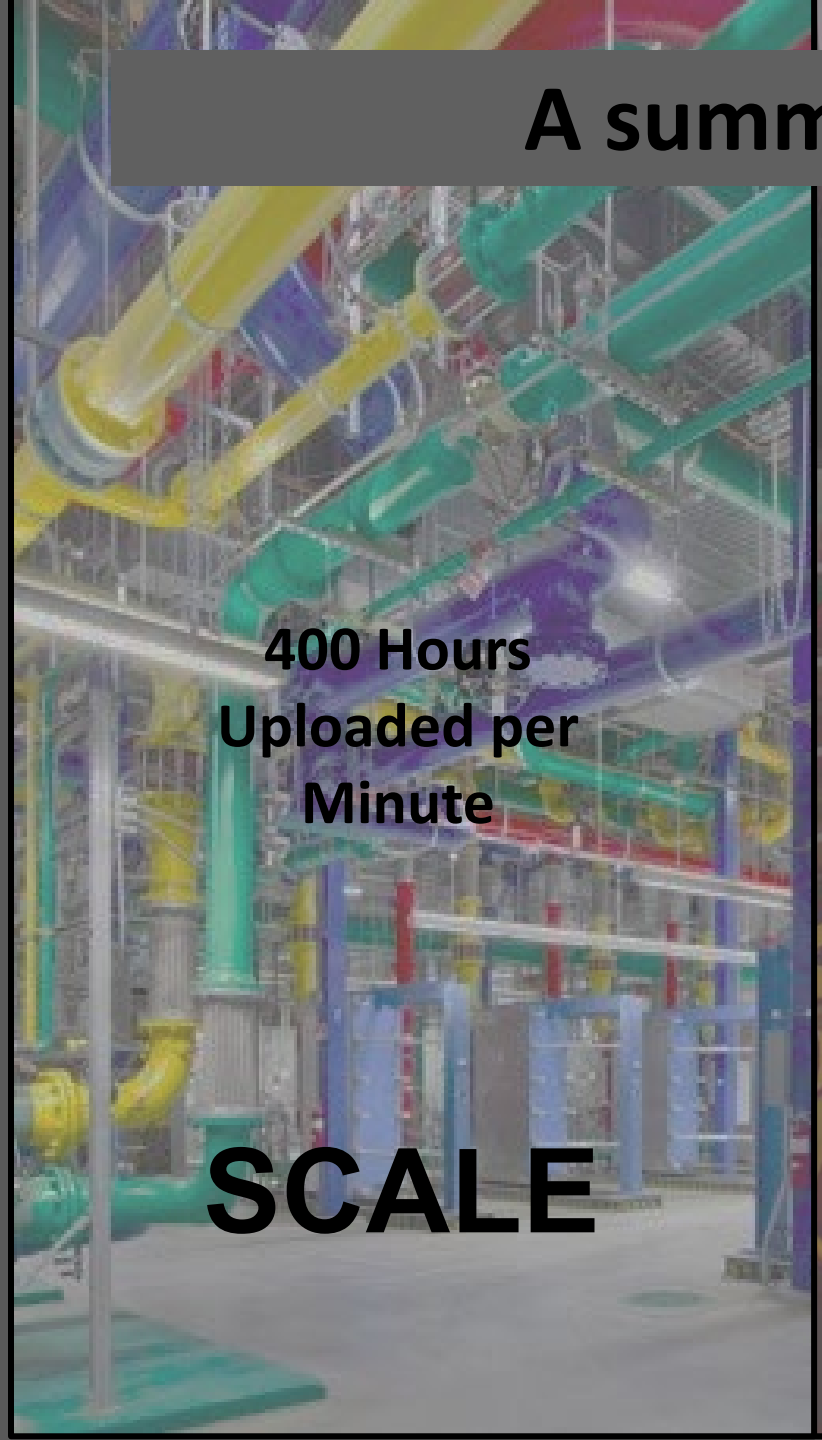




Interlaced media never goes away

# Some Trends: Colorspaces

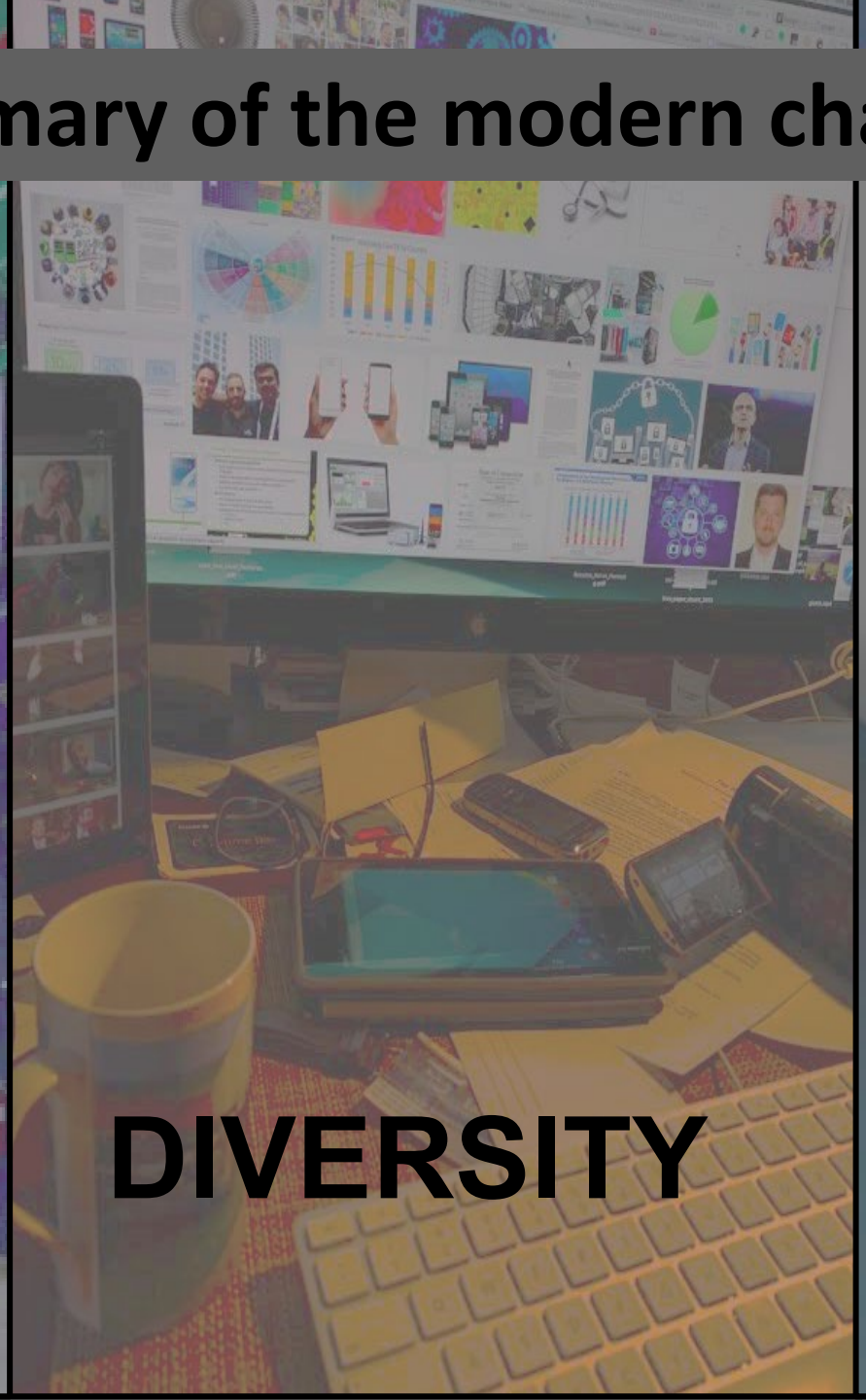


# A summary of the modern challenges



400 Hours Uploaded per Minute

SCALE

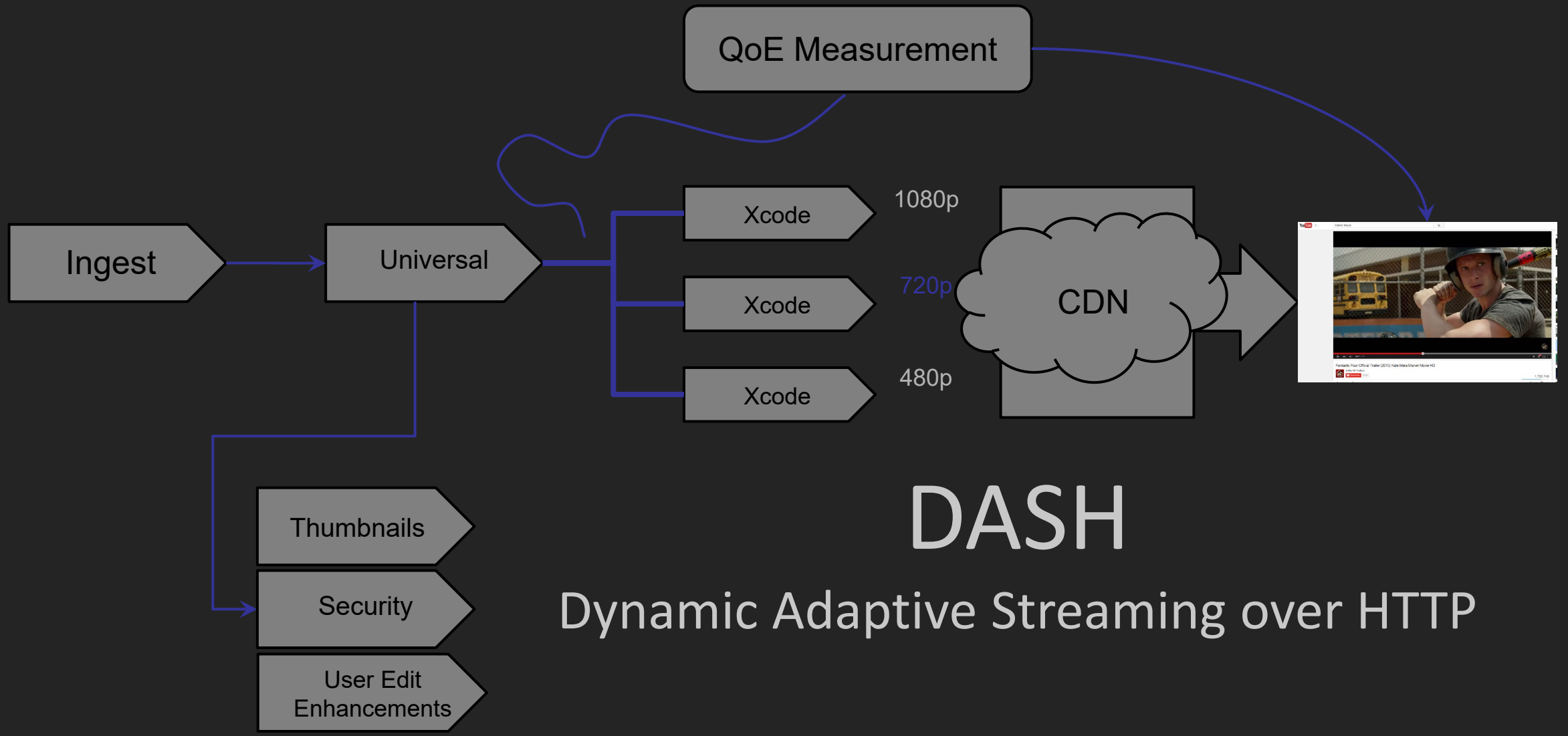


DIVERSITY

Available bandwidth varies enormously

BANDWIDTH

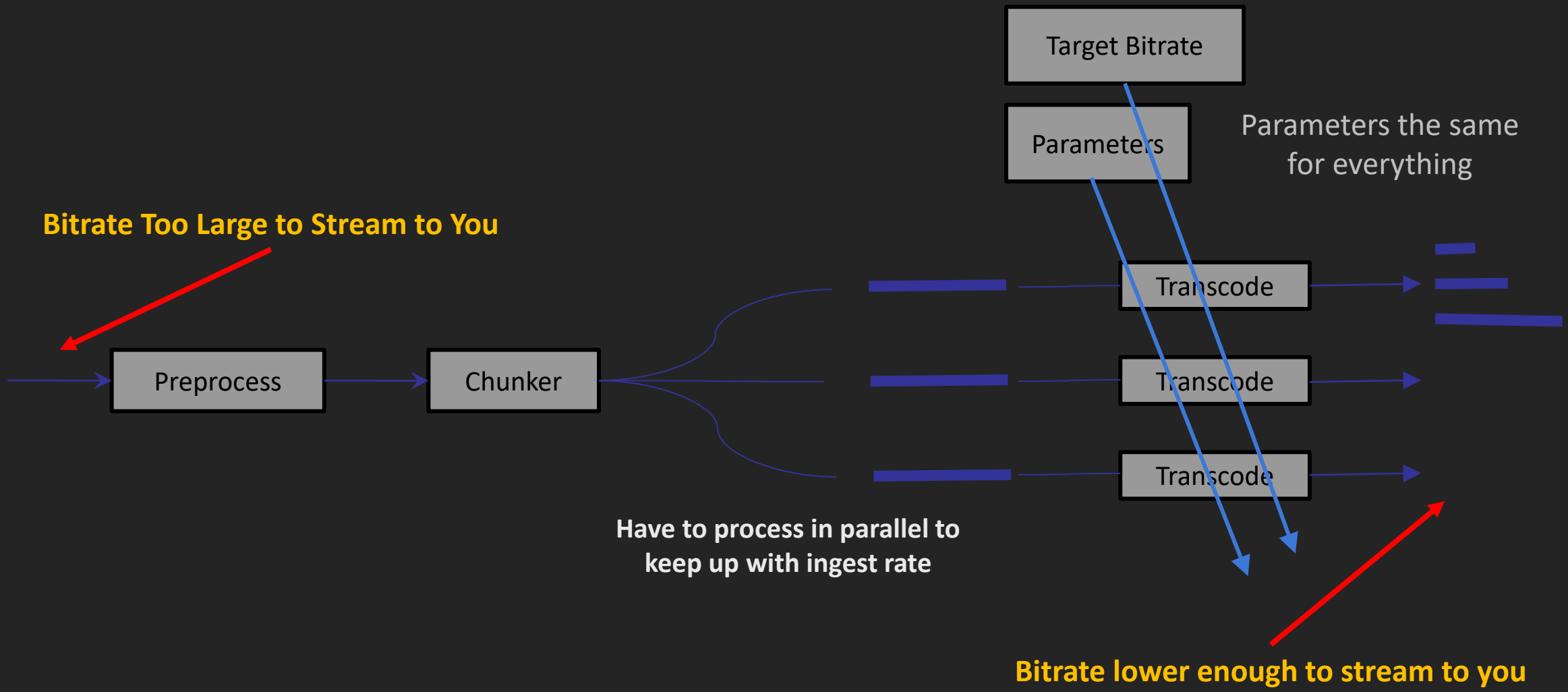
# Addressing scale, diversity and varying bandwidth

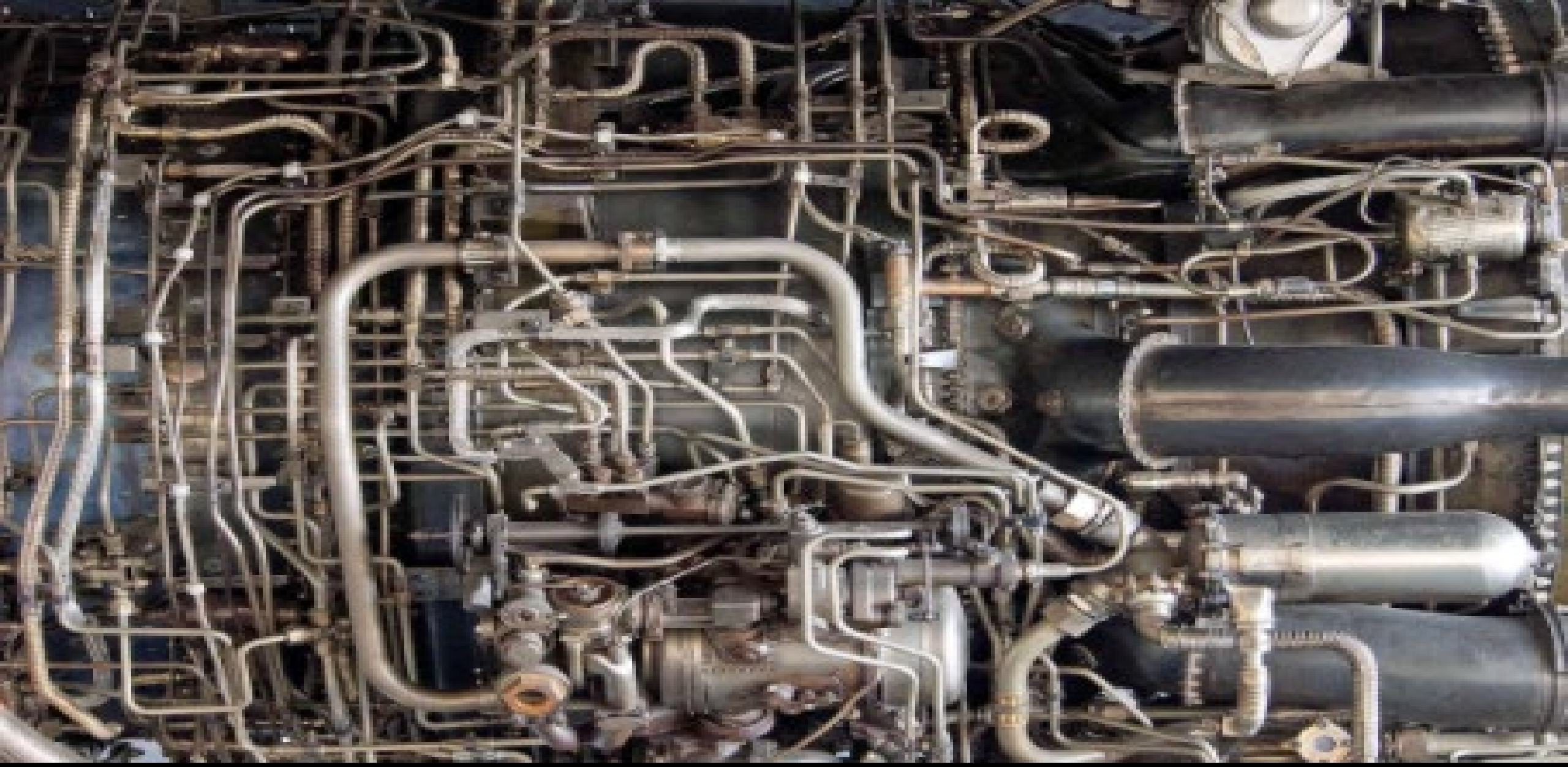



## DASH

Dynamic Adaptive Streaming over HTTP

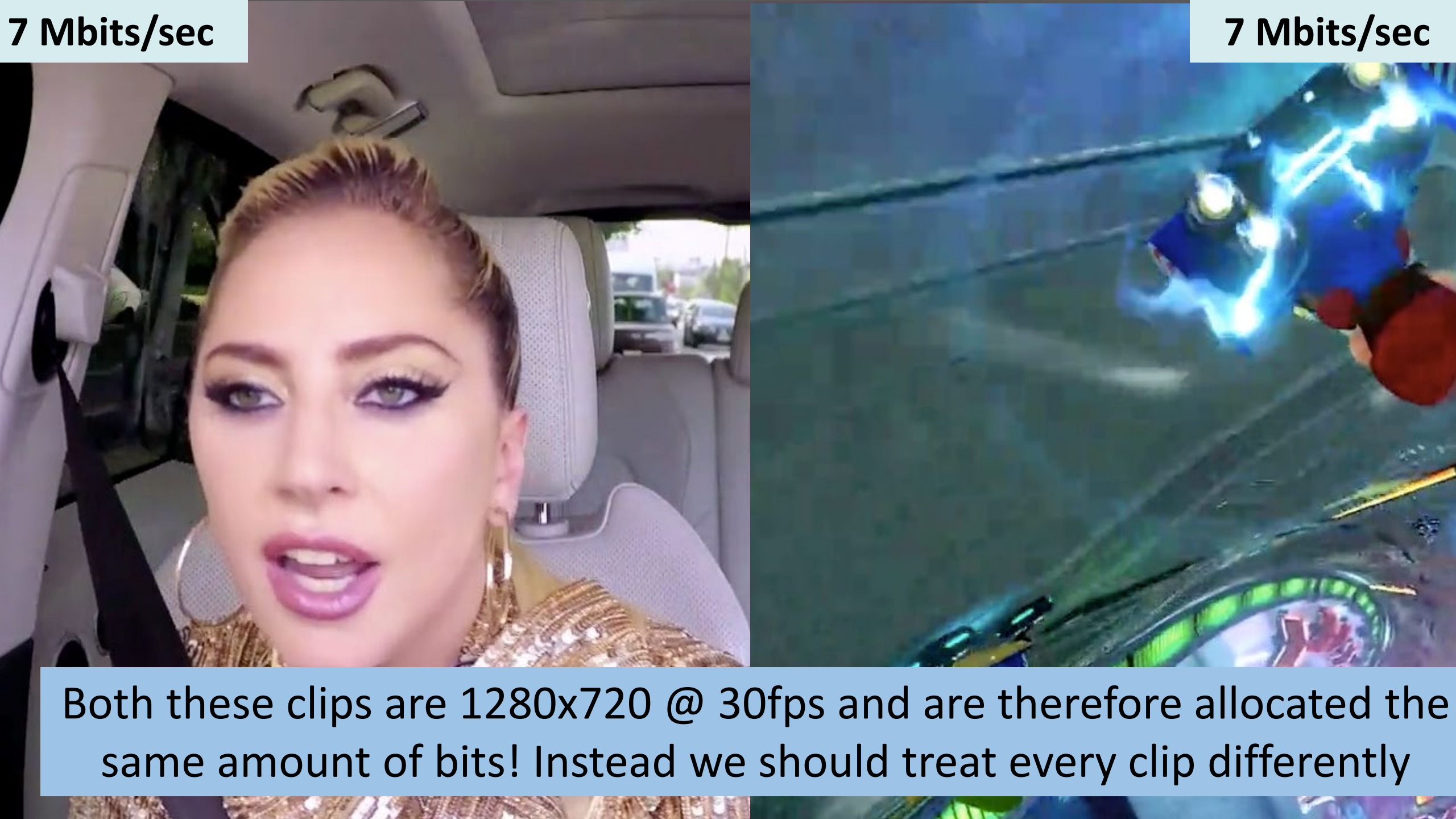
# The Core Cloud Video Engine





**TRANSCODERS ARE COMPLICATED**

**LOADS MORE PARAMETERS THAN ANYONE FIDDLES WITH**

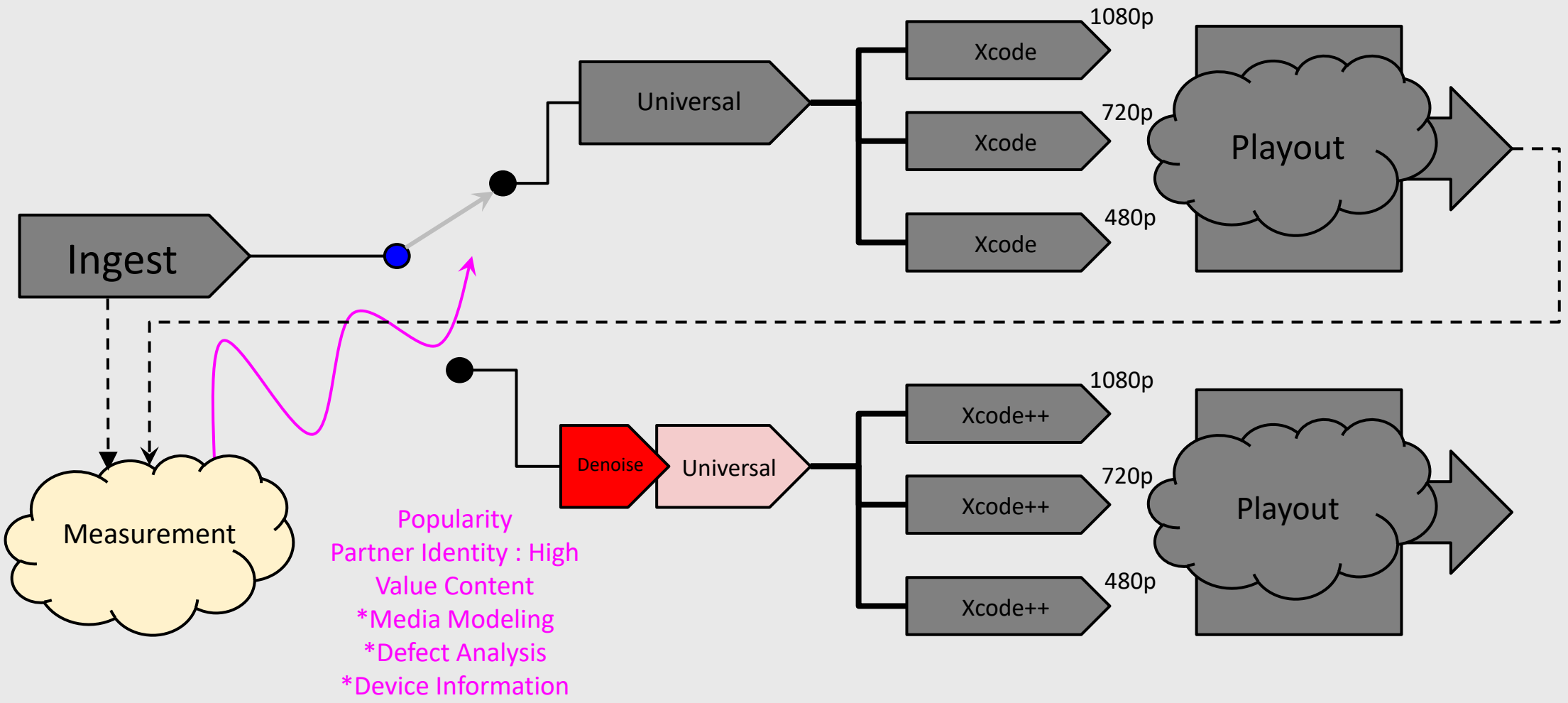



Both these clips are 1280x720 @ 30fps and are therefore allocated the same amount of bits! Instead we should treat every clip differently

WOULD BE GREAT IF WE COULD WATCH EVERYTHING AND MEASURE PICTURE QUALITY : But we can’t. So we develop algorithms to measure quality.



With a quality measurement we can do this kind of thing : Adaptive Quality Control Pipeline



THIS IS WHAT WE ARE GOING TO DO

| Challenge | Topic | Assessment |
|---|---|---|
| The bandwidth is not enough | Review of Video Compression Standards | |
| Diversity | Transcoding | Lab on Transcoding (15%) |
| Diversity, Bandwidth | Adaptive Bitrate (ABR) Compression, ABR Standards | Assignment on ABR (20%) (Creating a bitrate ladder) |
| Reproducing Artistic Intent | High Dynamic Range Video and Modern Colour Standards | |

AND Quiz worth 10%

FIN