Behind the Streams

The Technology That Powers Netflix, iPlayer and the Others

Dr **Paul Stallard**, Principal Software Architect
Science at Fishbourne, 18 August 2025

Most Popular

View all

Match of the Day

Call the Midwife

Casualty

Towards Zero

Gladiators

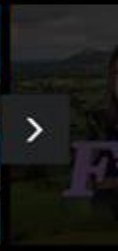
Recommended for you

The Apprentice

Virdee

Towards Zero

Would I Lie to You?



Funboys

Amazing Transformations

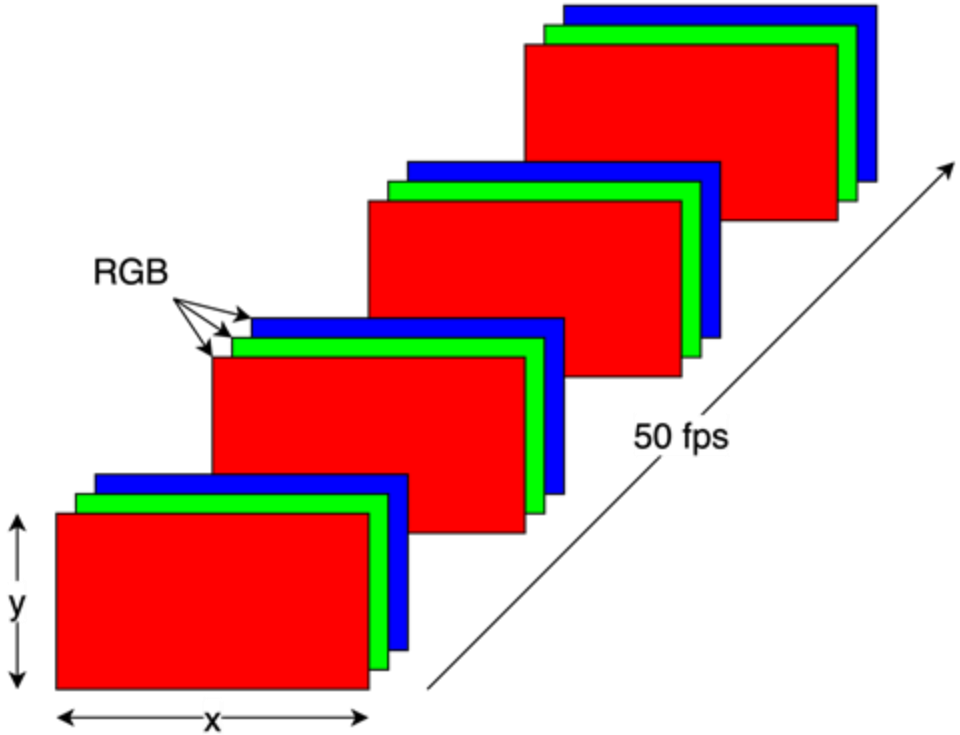
View all

10 Gbps

Raw Ultra HD (4K) video bitrate

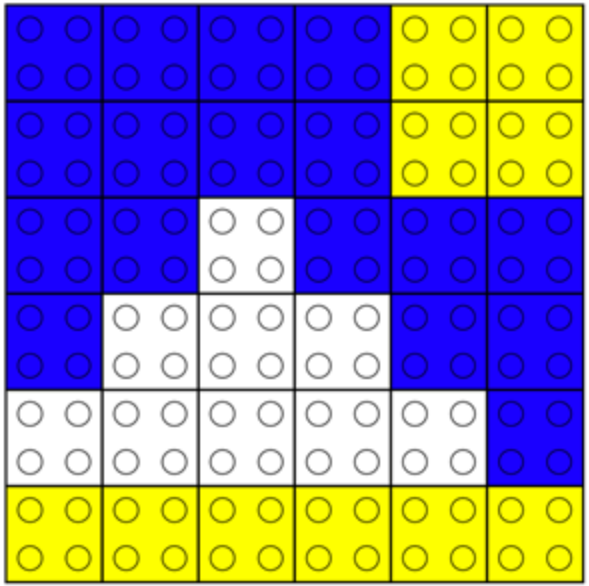
Video Data Rates

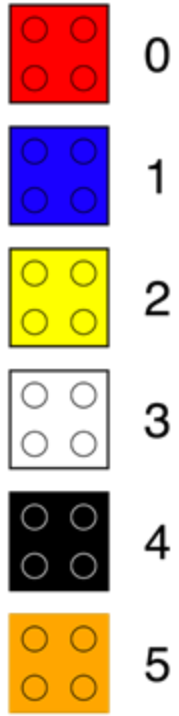
- **High Definition**
  - 1920 x 1080 x 24 x 50 (1)
  - 2,488,320,000 bits per second (~ 2,500 Mbps or 2.5 Gbps)
- **Ultra High Definition (4K)**
  - 3840 v 2160 x 24 x 50
  - 9,953,280,000 bits per second (~ 10,000 Mbps or 10 Gbps)
- **Standard Definition (4:3)**
  - 720 x 576 x 24 x 25 (interlaced)
  - 248,832,000 bits per second (~250 Mbps)



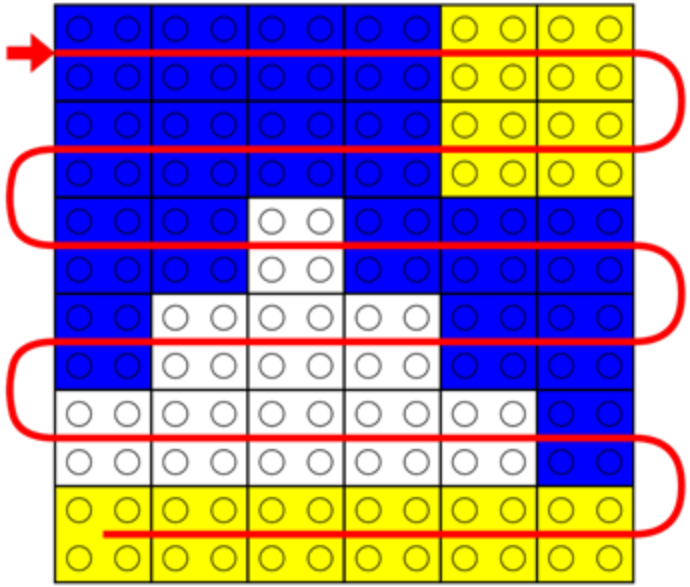
(1) Assuming 24 bits per pixel and 50 frames per second

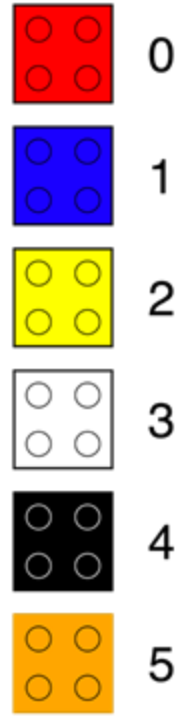
Reducing the bitrate

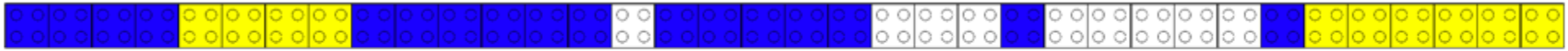




Transform to a string of numbers

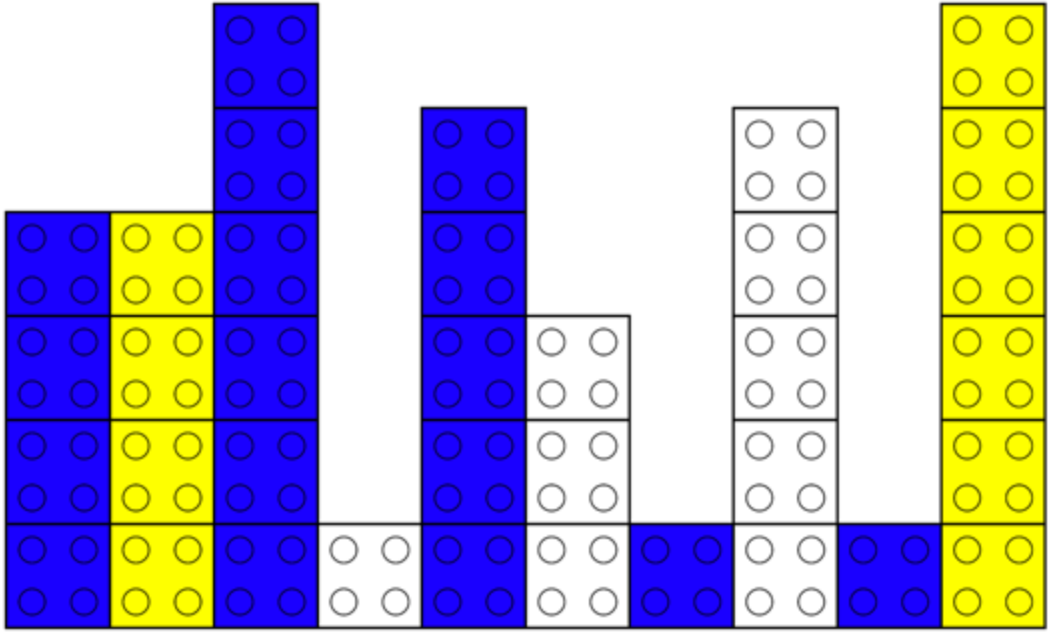


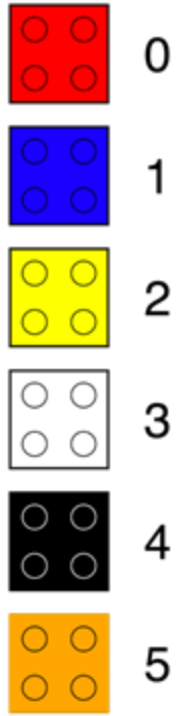




1 1 1 1 2 2 2 2 1 1 1 1 1 1 3 1 1 1 1 1 3 3 3 1 3 3 3 3 3 1 2 2 2 2 2 2

Compress the image (run-length encoding)



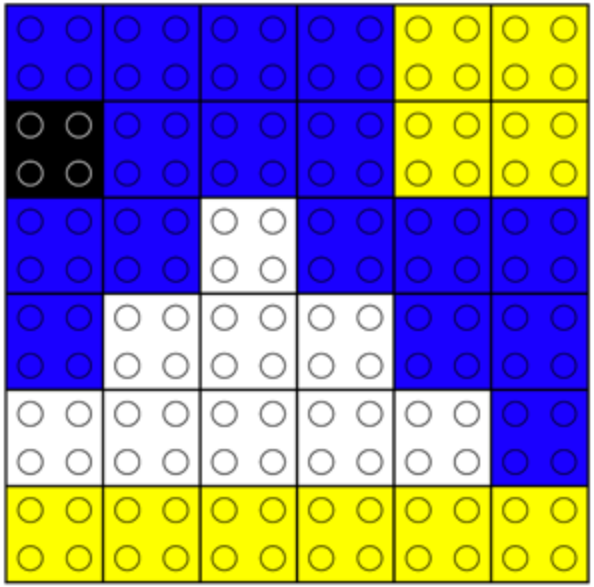


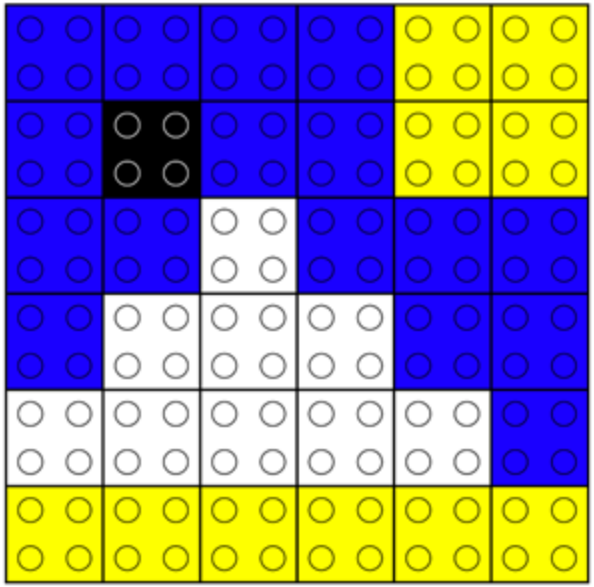
Was: **36**

Now: **20**

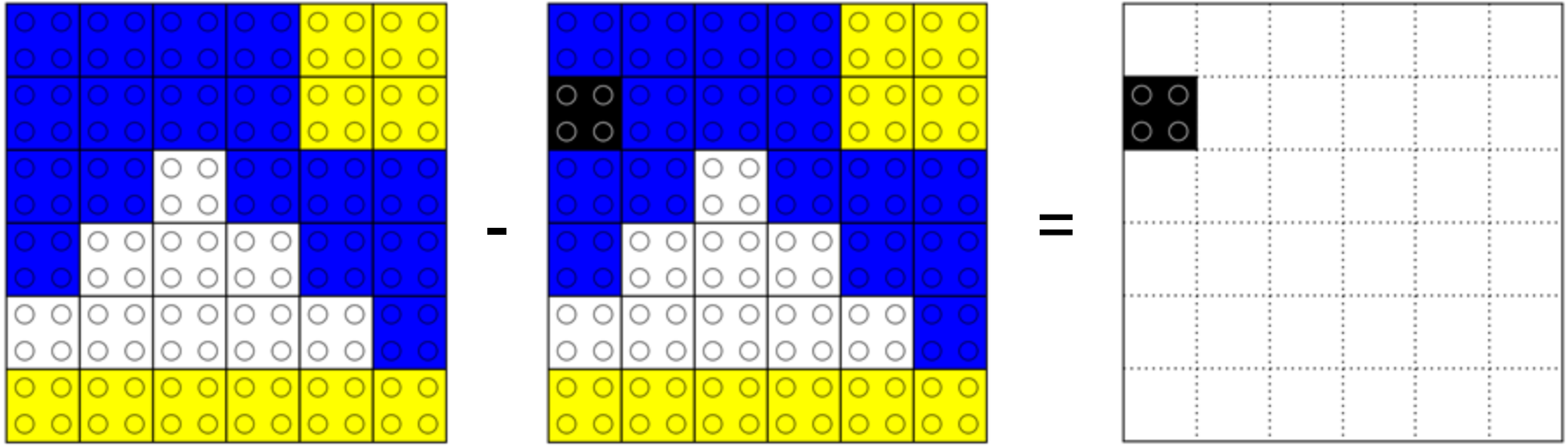
55% of the original size

Next frames in the sequence…



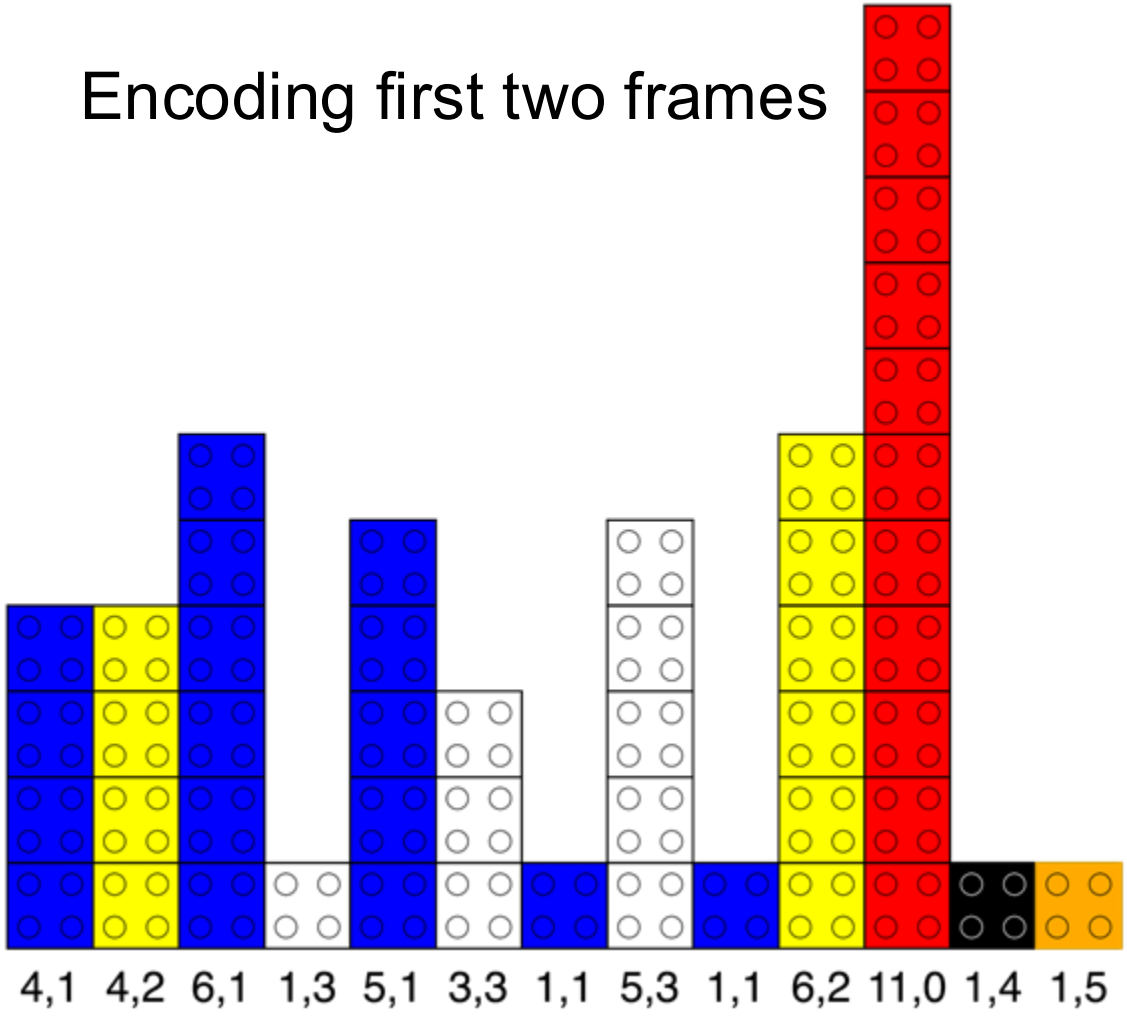


Difference between the first two frames



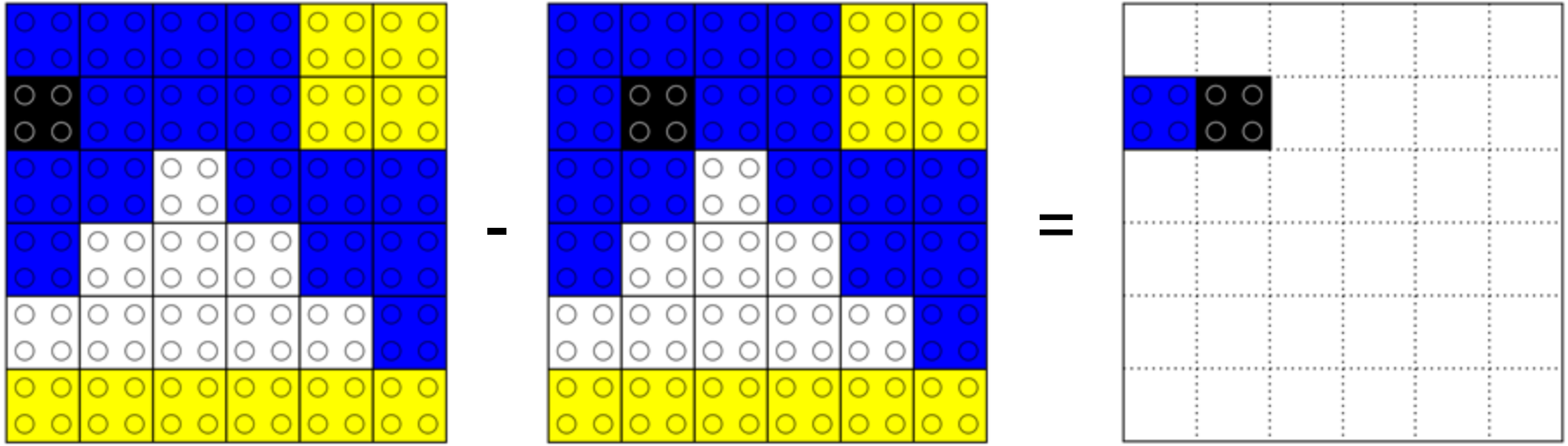
Let's use  to mean "no change", and  to mean "end"

Encoding first two frames



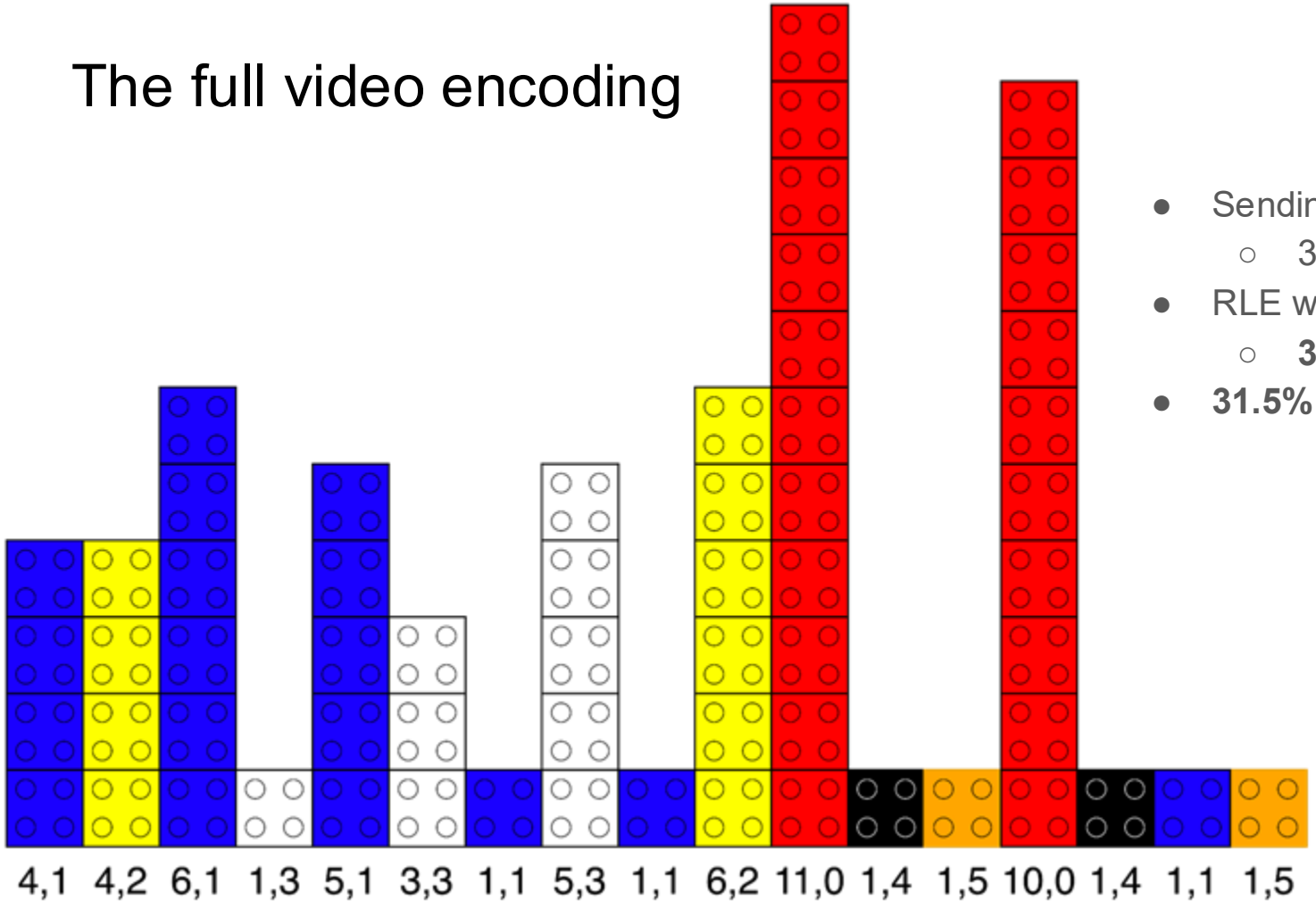
- Sending each pixel:
  - 36 x 2 = **72**
- RLE with difference frames
  - **26**
- **36.1%** of original size

Difference between the second and third frames



Let's use  to mean "no change", and  to mean "end"

The full video encoding

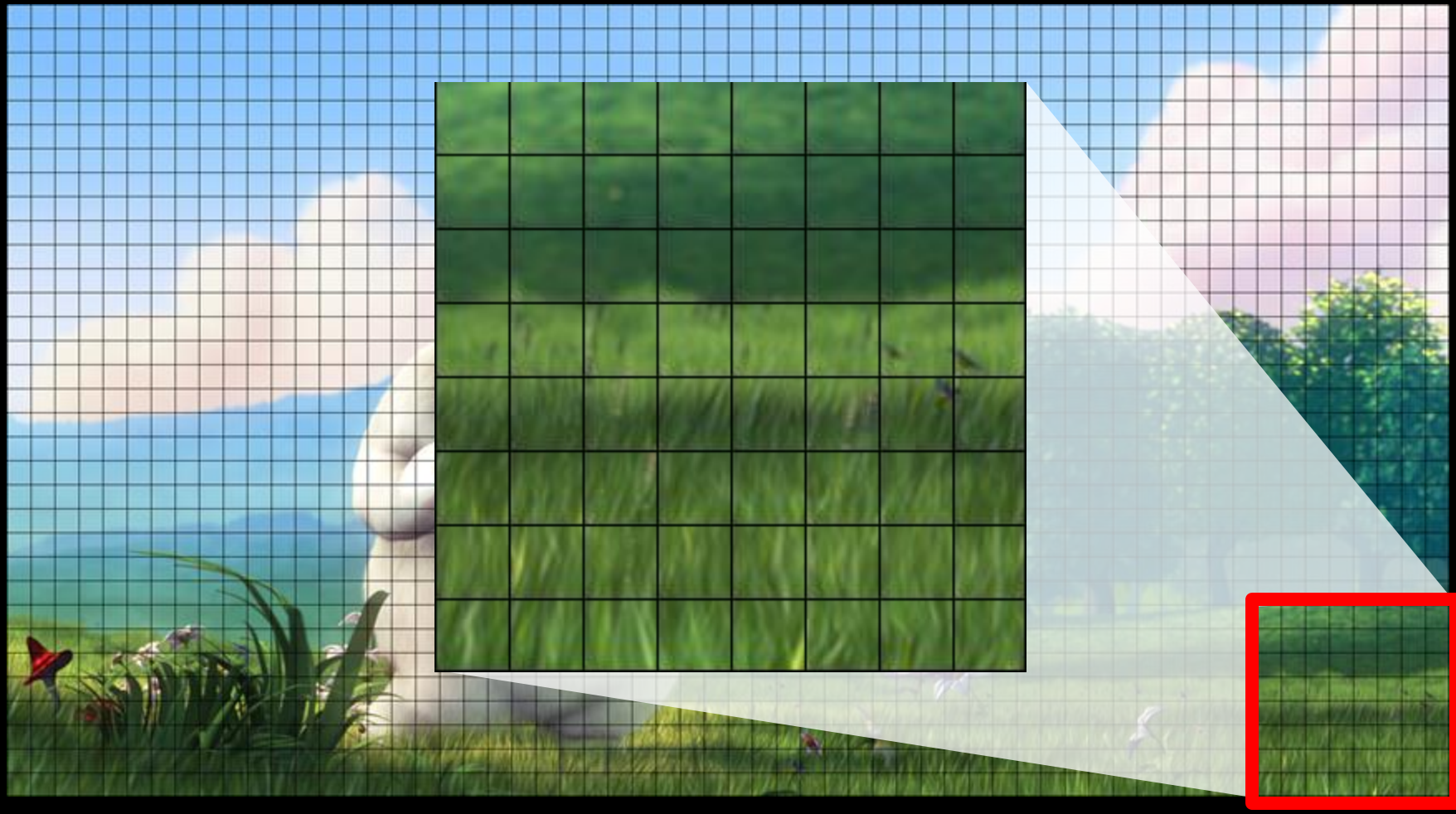


- Sending each pixel:
  - 36 x 3 = **108**
- RLE with difference frames
  - **34**
- **31.5%** of original size

Original

Difference

https://youtu.be/qw78nxcV3XU




0:50
$1 MILLION
$250,000
$100,000
$30,000
$20,000
$7,000
$5,000
$3,000
$2,000
$1,000
$500
STEVE'S BANK
$7,000
WNEP

120

Compressed versions of each movie

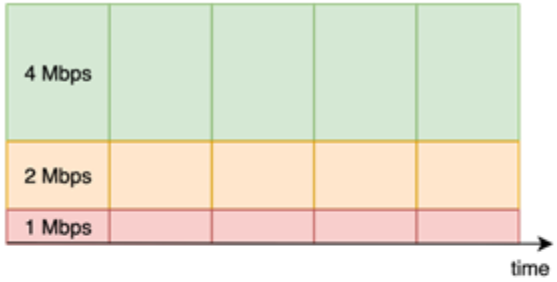
Why so many versions?

- Lots of devices, with different screen resolutions, aspect ratios etc.
  - Resolution and aspect ratio differs across devices
    - No point sending a UHD stream to a device with a high-definition display
    - TV aspect ratio (16:9), Apple iPhone 16 (19.5:9), Google Pixel 9 (20:9)
- Internet speeds vary
  - Provider, location, fibre vs mobile, etc
  - Over time (busy periods of the day, tunnels, …)

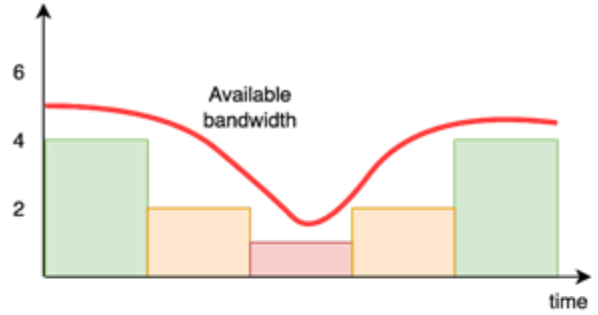
Solution:

- Divide streams up into chunks (~10s long)
  - Infinite stream → files (Internet is optimised for moving files)
- Create multiple versions of each chunk

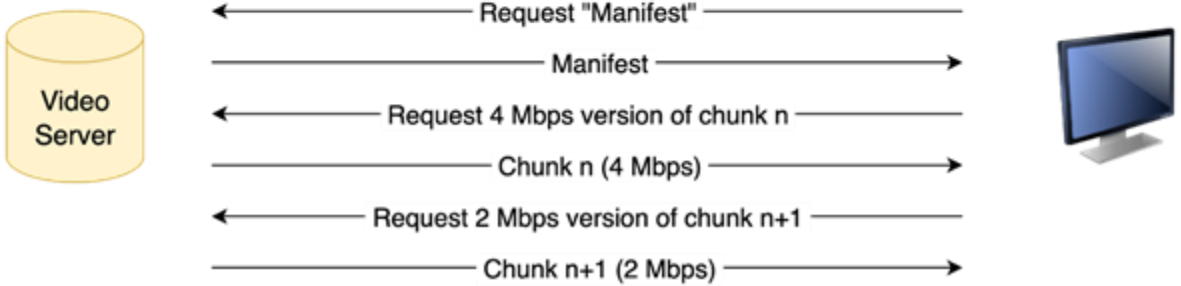
Coping with Network Variability



Server



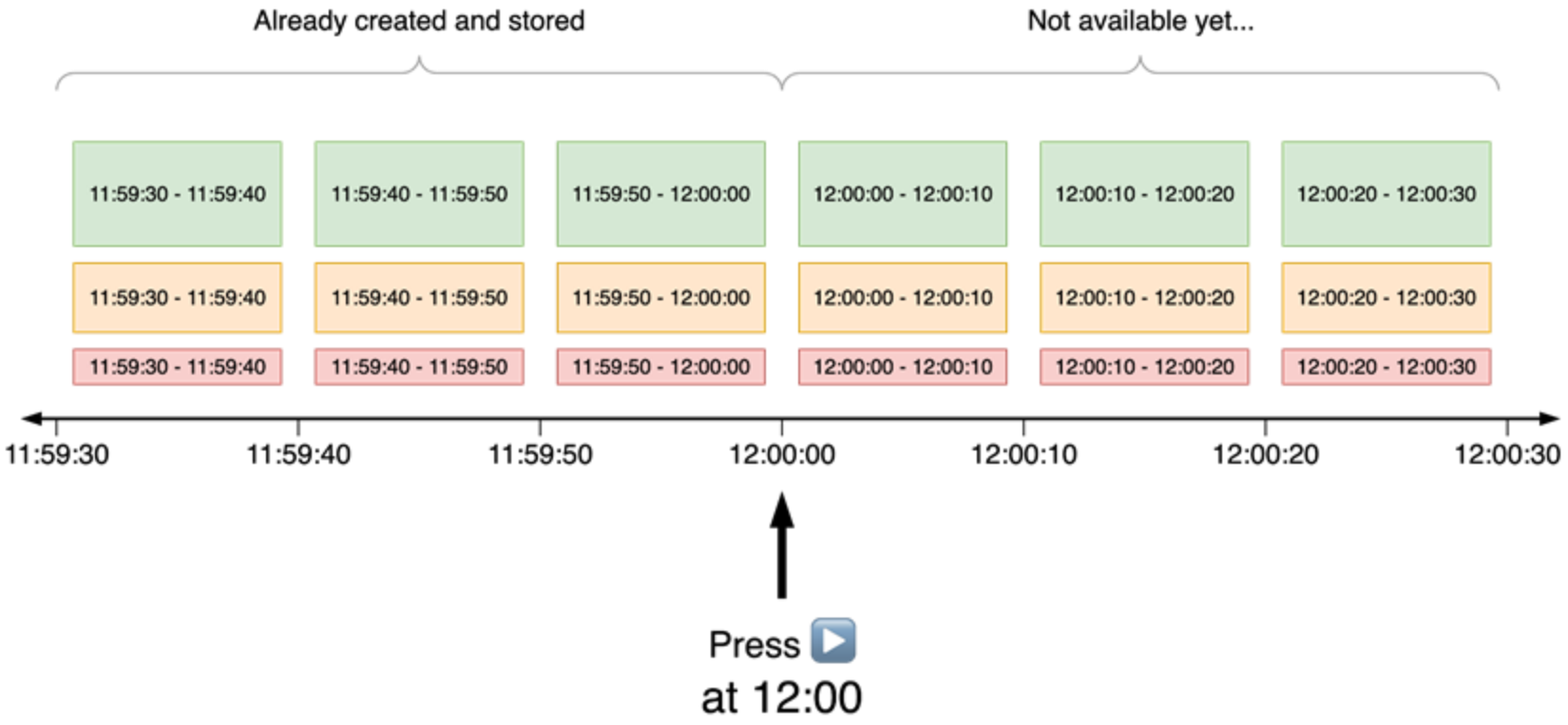
Client
(phone, smart TV, tablet, etc)



30

Typical streaming latency (seconds)

Joining a live stream

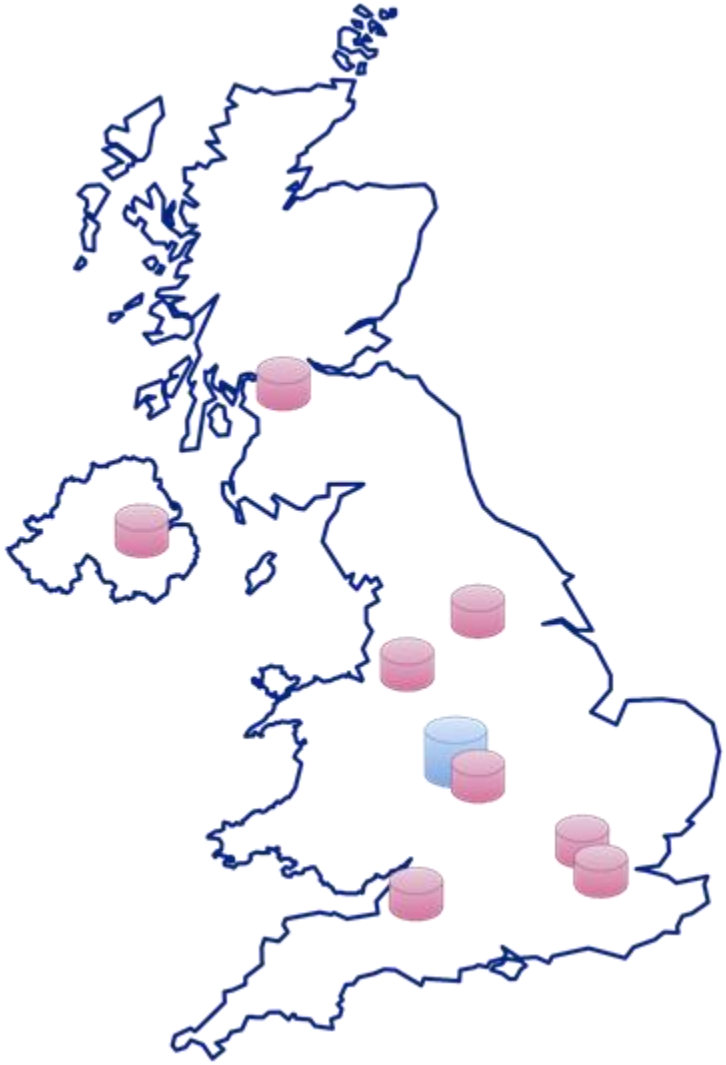


65 million

Highest published number of concurrent streams

Content Delivery Networks

Content Delivery Networks



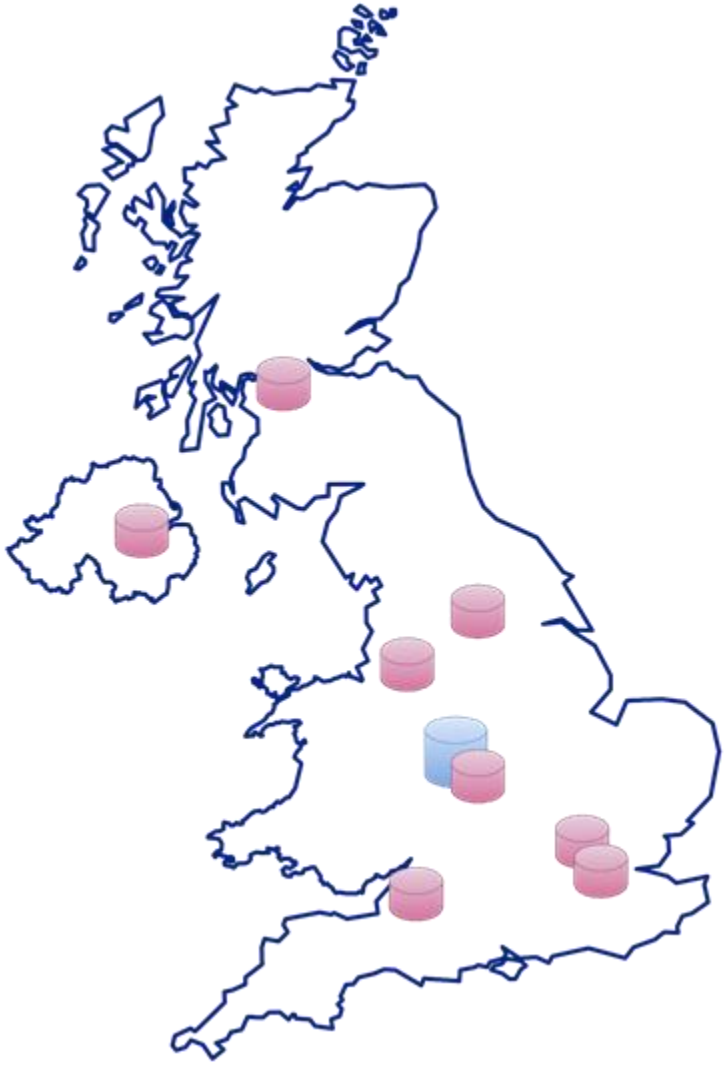
Content Delivery Networks

Akamai

CLOUDFLARE

amazon cloudfront

fastly



Cloud Computing

aws

Microsoft Azure

Google Cloud

99.999%

Availability requirement

Availability

- Redundancy (within and across data centres/regions)
- Health Checks
- Automatic Failover
- Test, test, test
  - Test automation, blue/green deployments
  - Chaos Engineering — yes, that really is a thing!

Can get very expensive… Not all failures have the same impact

500 billion

~500 billion events and ~1.3 PB *per day*
~8 million events and ~24 GB *per second* during peak times

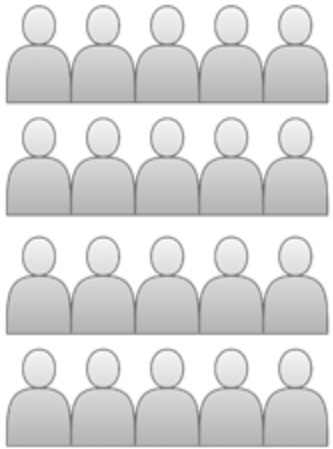
What data is collected? (pretty much everything…)

- General
  - Your IP address and location
  - Device type, browser, software versions, network connection (wifi / mobile), battery level
- Browsing
  - Every rail and tile you look at
  - Every detail page you viewed
  - How long you spend on each screen
  - Every click/press you made
- Viewing
  - What you watched
  - How long you watched it for - did you finish it, or stop after 5 minutes?
  - Did you pause, rewind, fast forward?

Why collect it?

- Business reporting
- Monitoring (fault detection and diagnostics)
- App Personalisation
  - Continue watching, series reminders, etc
  - Rail ordering, tile ordering, poster images
  - Recommendations
- Marketing
  - To you, and people “like” you
  - Promote to target “groups” (sports lovers, comedy watchers, true crime fans, …)
- Targeted Ads
- Content performance
- A/B Testing

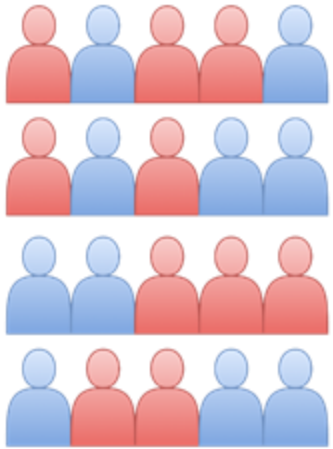
A/B Testing



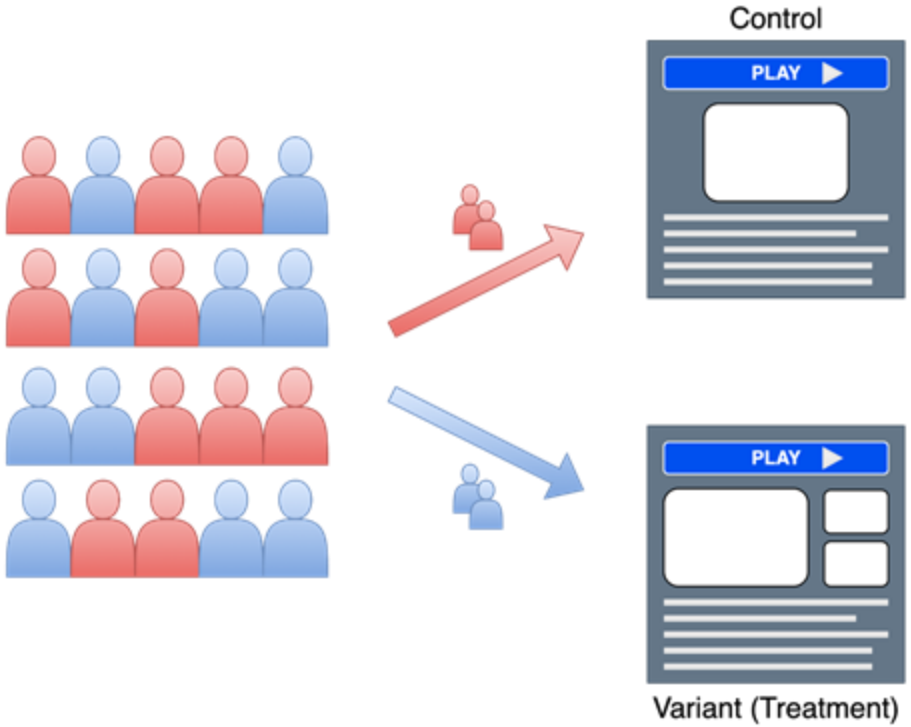
Control

Variant (Treatment)

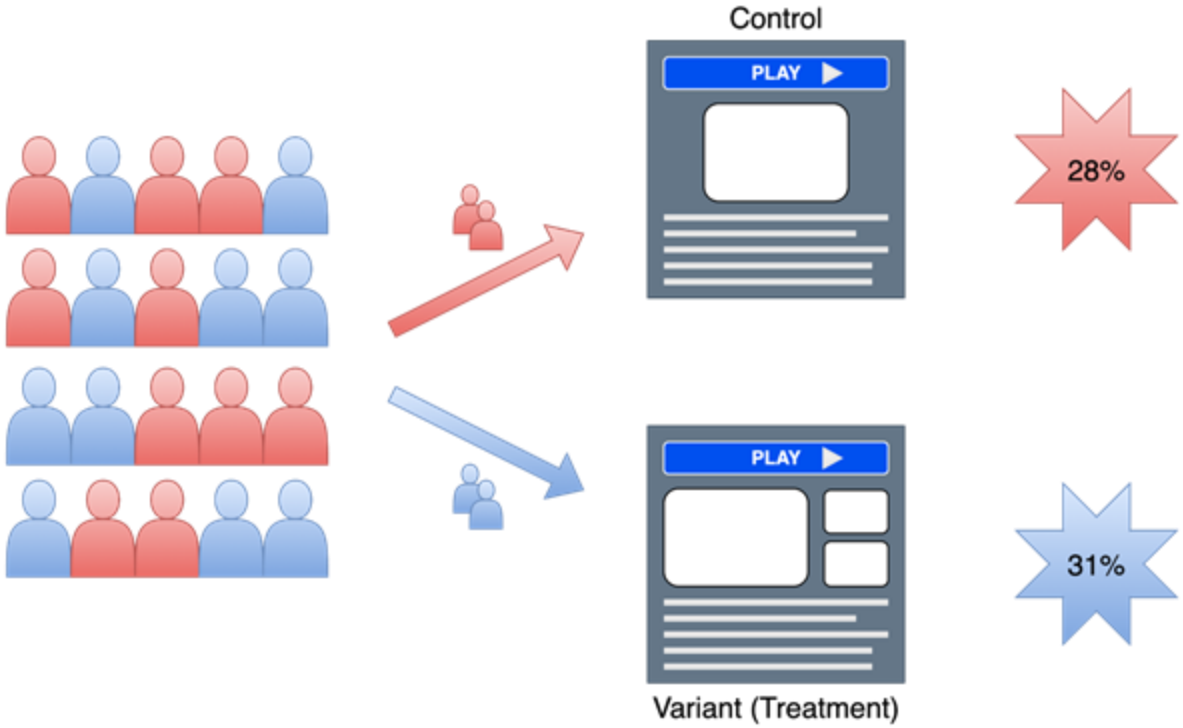
A/B Testing

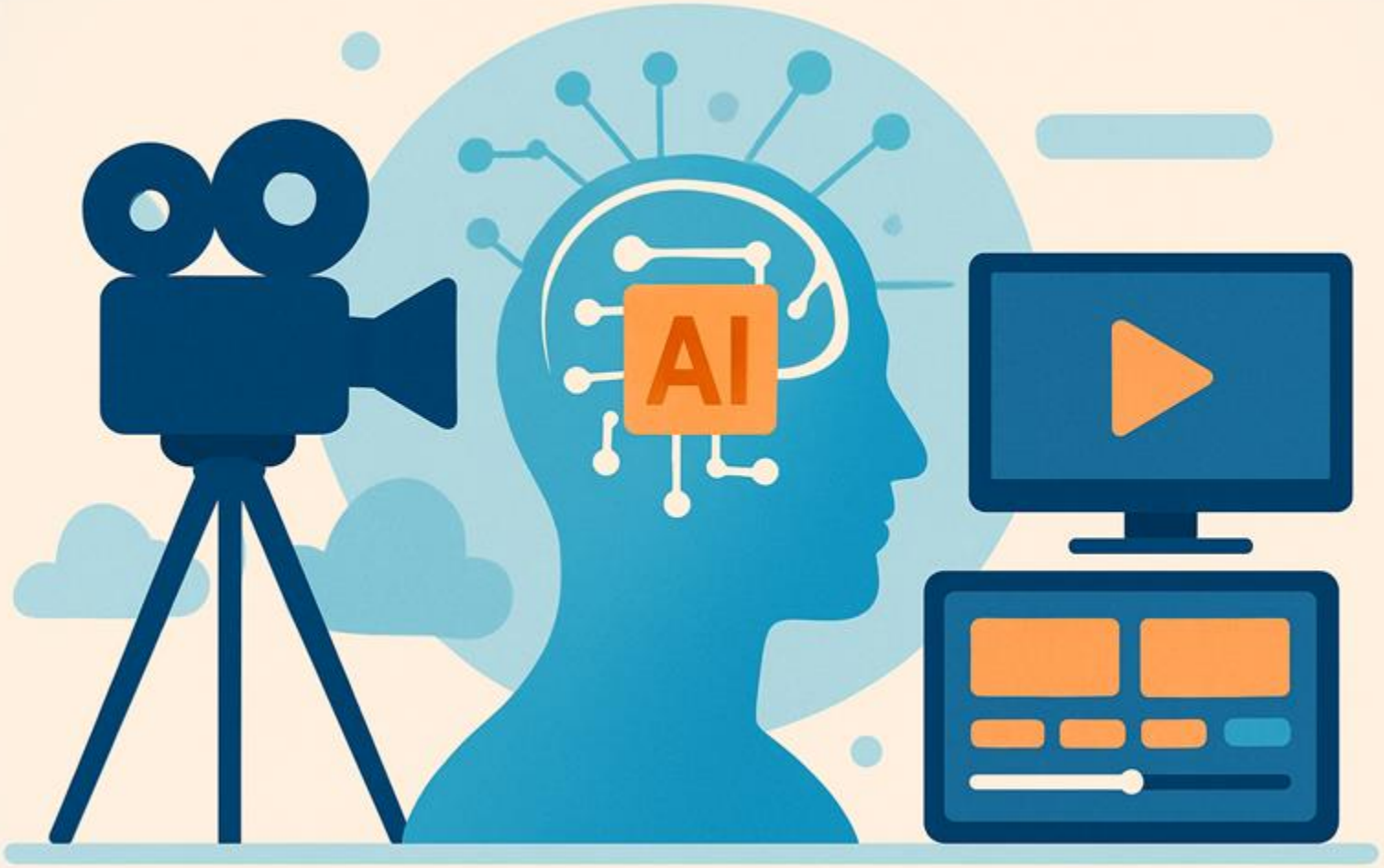


A/B Testing



A/B Testing




AI

What’s next…

Sports content

- Interactivity
- Multiple camera angles
- “Sit” where you want in the stadium
- Automatic video highlights creation

Post production

- Subtitling
- Dubbing & lip syncing
- Actor replacement

Personalisation

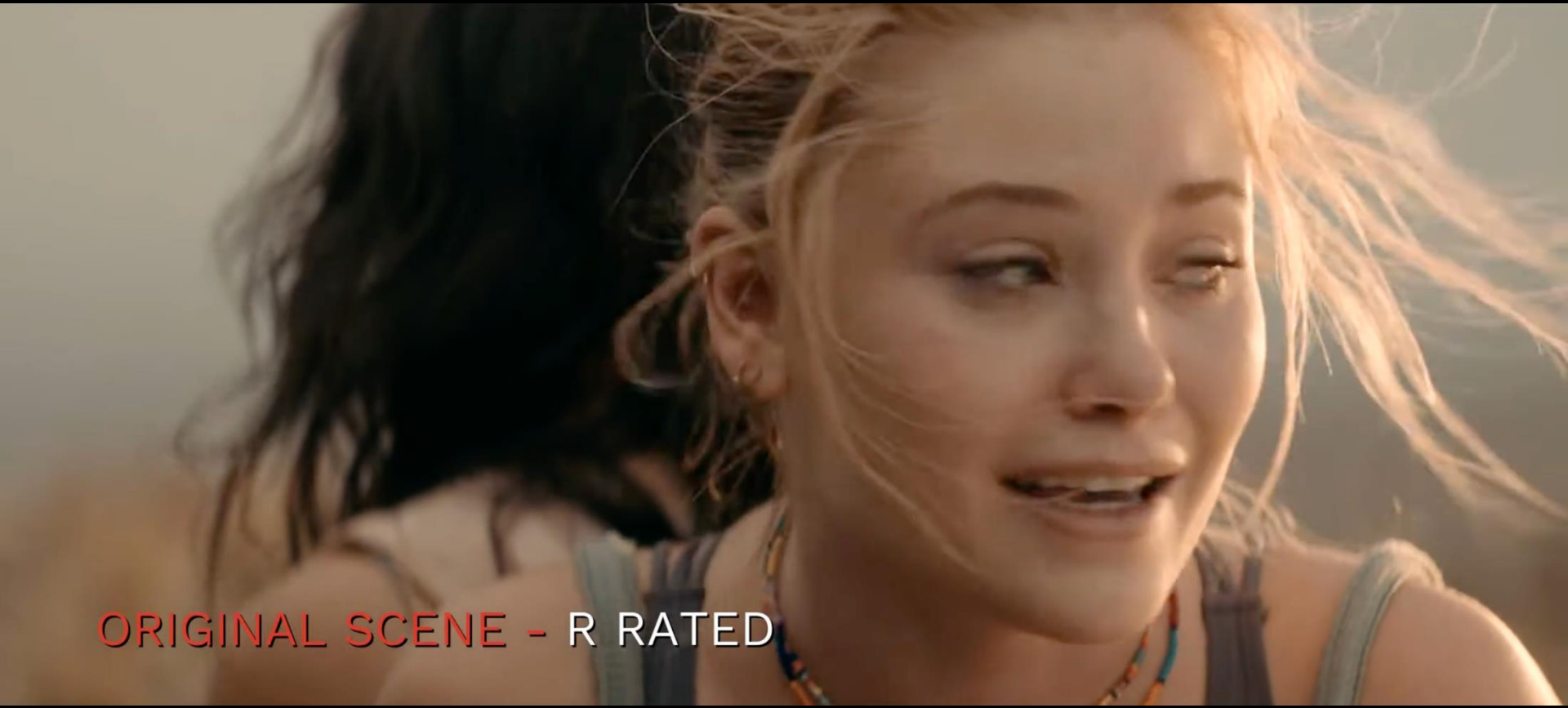
- Ads with you wearing / using the product?
- Would you pay more for a movie with you as the lead?

Writing

- Plot development
- Writing assistants
- Entire scripts

Video and audio generation

- News broadcaster
- Special effects
- Entire programmes / films, maybe…?



https://youtu.be/iQ1OPpj8gPA

Questions?