The Business of 4K
How to deliver on the growing consumer demand for 4K

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4K Market Growth

Worldwide 4K TV Sales


- 98.4M projected in 2018
- 8% worldwide penetration in 2017
- Supported by strong 4K media streamer sales (Roku, Amazon, Apple)
4K Market Growth

• 4K production equipment costs are falling
• Content availability growing steadily
  • E.g. 1000+ hours on Netflix
• 125 Live UHD channels worldwide (April 2018)¹
  • 26% growth in the prior 6 months

What are the barriers to 4K?

1. Contribution
2. Primary Distribution
3. Encoding Costs
4. Delivery Costs
5. Addressable market
Barriers to 4K adoption

• VOD services using >15 Mbps (e.g., Netflix @ 16Mbps)
• Live services require 25-35Mbps (e.g., BBC iPlayer @ 34 Mbps)
• So it doesn’t look too bad?

Average bandwidth (select countries)

Source: Worldwide broadband speed league 2018, M-Lab/Cable
Average speeds don’t tell the story

<Data not provided>  50% of the times users get less than this

I am an average

I am a peak connectivity

People giving up due to poor service not included in the analysis
OTT connectivity – Reality vs. Myth

Time spent watching different bitrates – UK Fixed connections 2017

<table>
<thead>
<tr>
<th>Bitrate</th>
<th>% of Viewing Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;500 Kbps</td>
<td>6%</td>
</tr>
<tr>
<td>0.5–1 Mbps</td>
<td>27%</td>
</tr>
<tr>
<td>1–2 Mbps</td>
<td>40%</td>
</tr>
<tr>
<td>2–3 Mbps</td>
<td>18%</td>
</tr>
<tr>
<td>&gt;3 Mbps</td>
<td>9%</td>
</tr>
</tbody>
</table>

Advertised bitrates! 4K requirements!

BAD  
SO SO  
SD/HD
PERSEUS Plus for 4K

4K Movies/TV @ 6Mbps

4K Live Sports @ 8Mbps
## Codec bitrate comparisons

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Live Full HD</td>
<td>15</td>
<td>7</td>
<td>5</td>
<td>2.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Live UHD</td>
<td>N/A</td>
<td>N/A</td>
<td>25</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>VOD Full HD</td>
<td>12</td>
<td>4</td>
<td>3</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>VOD UHD</td>
<td>N/A</td>
<td>N/A</td>
<td>16</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

### Processing overhead:
- MPEG-2 (1991): 0.3x
- AVC/h.264 (2003): 1x
- HEVC (2012): 2x
- PERSEUS Plus (2017): 0.7x
- AV1 (2018): >50x
### 4K encoding feasibility & costs

#### Indicative encoding costs based on AWS cloud

<table>
<thead>
<tr>
<th>Quality</th>
<th>H.264</th>
<th>HEVC @ 60%</th>
<th>VP9 @ 60%</th>
<th>VP9 @ 70%</th>
<th>H.264 @ 50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoding time</td>
<td>1x</td>
<td>~4x H.264</td>
<td>~2x H.264</td>
<td>1000+ xVP9</td>
<td>1x H.264</td>
</tr>
<tr>
<td>HD Cost per hour (approx. – single level)</td>
<td>$0.99</td>
<td>$4.00</td>
<td>$2.00</td>
<td>Not available</td>
<td>$0.60</td>
</tr>
<tr>
<td>4K Cost per hour (approx. – single level)</td>
<td>Not available</td>
<td>$16.00</td>
<td>Not available</td>
<td>Not available</td>
<td>$4.00</td>
</tr>
<tr>
<td>5 UHD channels per year (incl. typical 12-month commitment discounts)</td>
<td>Not available</td>
<td>$3,500,000</td>
<td>Not available</td>
<td>Not available</td>
<td>$875,000</td>
</tr>
</tbody>
</table>

**Note:** 5 channel annual estimates assume ABR profile with 5 output levels

Improving 4K distribution feasibility

How do things change if live 4K is 8 Mbps instead of 25 Mbps?

Figure 5: Distribution of average peak-time, 8-10pm, fixed broadband download speeds, by rurality: November 2016 and 2017

Reachable viewers will at least double!

Improving 4K distribution feasibility

• But it’s not just about the last mile!
  • Overall network and CDN capacity must be considered too
  • Very clear from recent World Cup streaming collapses!

• Better video compression is the primary solution to all of these barriers
Thank you

Visit us at 14.C36 to see our PERSEUS 4K distribution demos

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