BBC and BT
UHD Internet Distribution

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Proof-of-Concept

• OTT live distribution of World Cup (Brazil) & Commonwealth Games (Scotland) in UHD

• World Cup p60
  – satellite contribution

• CWG p50
  – end-to-end IP delivery
  – from camera to screen
Technologies Used

- **DASH**
  - Dynamic Adaptive Streaming over HTTP

- **HEVC**
  - High Efficiency Video Codec (H.265)
  - Reduce bitrate by 30-50% compared to H.264

- **p50/p60 Video**
  - No interlace
  - Impact on motion blur with sporting content
  - Need for p100/p120?

- **Main 10 profile (CWG only)**
  - Bitrate efficient
  - Better linearity
    - High dynamic range (future use)
Live video delivery via DASH

✓ No special infrastructure required
  ✓ Compatible with existing CDN architectures
✓ Client adaptation between video rates to mitigate network variability
✓ Flexible audio/video combinations (manifest)
✓ Pause/rewind are straightforward
  ❖ Introduces startup delay
World Cup Final - BT Tower Demonstration

- 5 superfast broadband lines to BT Tower
  - 3 set-top boxes
  - 1 reference board
  - 2 IDTVs LG & Samsung
  - 4K p60 @35Mbits/sec
Vixs
  • Xcode 6400 series SoC
  • libDash

Sagemcom
  • Broadcom
  • DASH-js

Humax
  • Broadcom
Commonwealth Games
Commonwealth Games Contribution Network
Distribution Architecture

- **Elemental Live encoder**
  - 12Gbits/sec input (4 3G SDI)
  - Parallel encodes
    - 35 Mbits/sec @ 3840x2160
    - 12Mbits/sec @ 1920x1080
  - DASH
  - 4 second segments
  - Manifest

- **Packager**

- **Origin server**

- **CDN**
  - Infinity lines

- **Hub**

- **TV/stb**
Distribution delays

- Encode
  - $T_e$ (Unknown)
  - $T_{ew}$ 15s allowed
- Repackage/upload
  - $T_u$ <1s
- Manifest availability
  - $T_c$ 404 TTL
- Download time
  - $T_d$, Typically $\frac{1}{2}$ to 1 times segment duration
- Client buffering
  - $T_b$ (Unknown, might be 3 times segment duration)
- Decode and render
  - $T_r$ (Unknown, likely to be fixed)

$T_m$ Manifest availability set to 10s after repackage/upload starts
Lessons Learnt

• HEVC encoding
  – Live HEVC encoding very new technology
    • Bitrates 40% higher than estimated from offline encoding tests
    • Consistent across a number of encoder implementations
  – Insufficient processing capability to encode multiple representations in real-time
  – Main 10 support is not ubiquitous in decoders

• Client adaptation to variable network throughput
  – Unable to test thoroughly with 2 representations
    • DASH implementations were very simple
    • Clients did not track network bandwidth

• End-to-end delay
  – Typically 45s late compared to UHD broadcast
  – Delay increased in some receivers as event progressed
  – Delay is inherent but a better implementation should achieve 20s

• Network/Client interaction
  – Numerous detail issues identified
    • Number of connections opened by a client

• Home Networking Throughput
UHD – just more pixels?

• Better Pixels
  – Benefits to all screen sizes
  – High frame rate
    • 25fps → 50fps → 100fps
  – High dynamic range
    • 10 bit path
  – More colours – BT2020
  – Interaction with HEVC encoding

• Better audio
Conclusions

• Delivering UHD via DASH is viable
  – 3 BBC Sites
  – BT Tower event

• BT CDN infrastructure worked as expected
  – UHD bitrates supported

• Distribution encoders
  – Currently typically support 1UHD+1HD stream

• Production architectures
  – 4 x 3G is very difficult to use
Conclusions