QUALCOMM

UWS UNIVERSITY OF THE WEST of SCOTLAND

EPSRC
Engineering and Physical Sciences Research Council

Enabler for Next-Generation Mobile Video Applications

Dr. Qi Wang

In collaboration with **Dr. James Nightingale** & **Prof. Christos Grecos**, Audio-visual Communications & Networks Centre (AVCN), UWS

Dr. Sergio Goma, Multimedia R&D, Qualcomm, USA

High Efficiency Video Coding (HEVC)

- Latest video coding standard
  - ITU-T H.265/ ISO/IEC 23008-2 (2013)
  - MPEG-H Part 2 (2013)
- Requires up to 50% less bandwidth than current H.264/AVC (MPEG 4) standard without any loss of video quality
- H.265/HEVC video networking is in very early R&D stage

QUALCOMM

UWS UNIVERSITY OF THE WEST of SCOTLAND

EPSRC Engineering and Physical Sciences Research Council

Project Aims

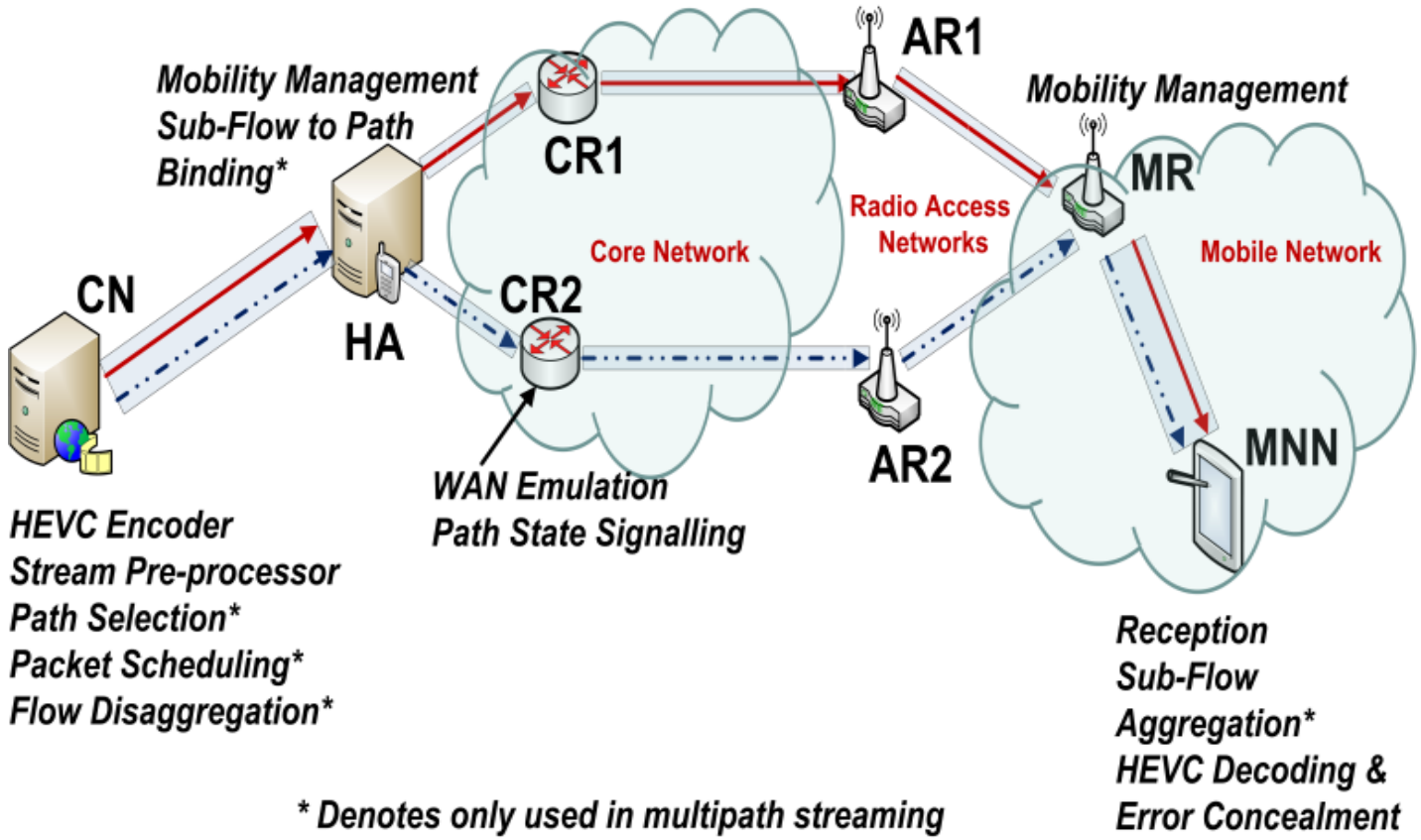
- Investigate enabling techniques for H.265/HEVC applications in challenging mobile environments.
  - Concurrent multipath streaming
  - Scalable HEVC streaming
  - Quality of experience (QoE) driven HEVC streaming

WP1. HEVStream

- Tool to aid HEVC video network research on physical test beds
  - Facilitates study of HEVC streaming in impaired networks

- Features:
  - Trace driven, Linux, C++ and Python
  - Encapsulation, scheduling and transmission
  - Single path or concurrent multipath streaming
  - Analysis tools (network/QoS and video)

HEVStream

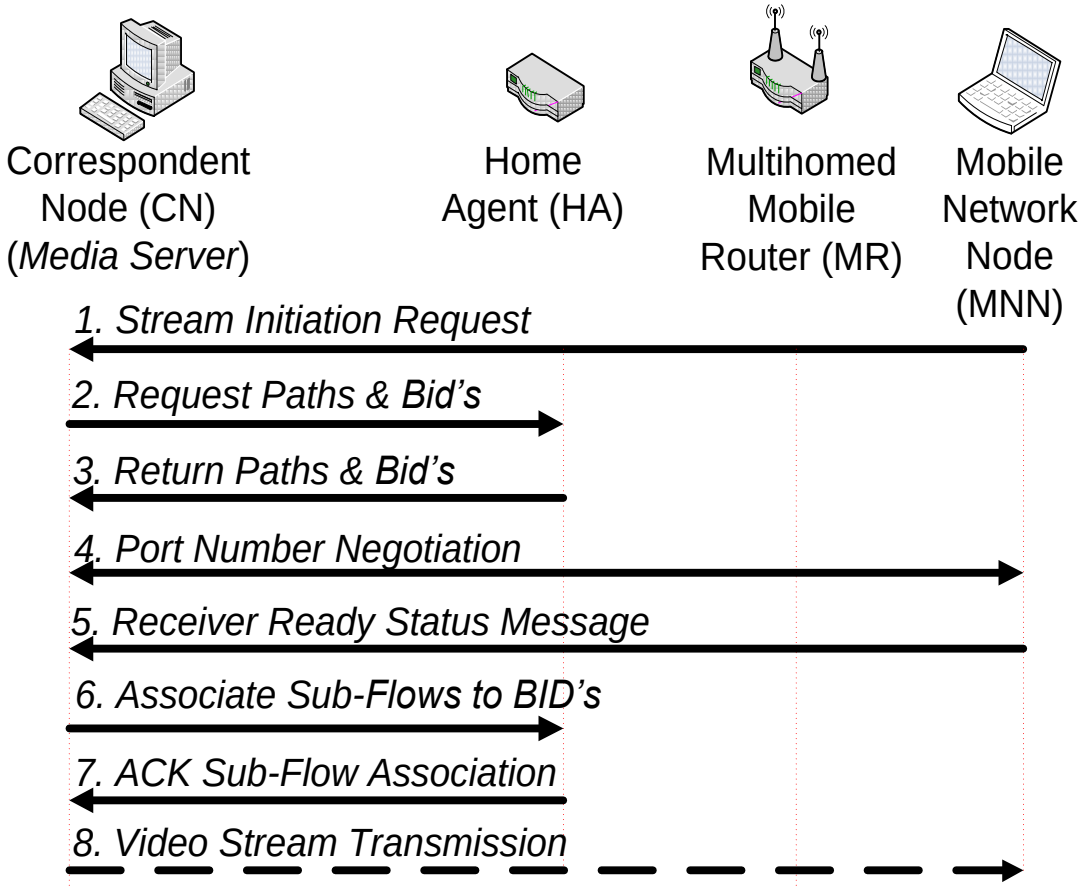

Mobility Management
Sub-Flow to Path
Binding*
CR1
AR1
Mobility Management
MR
Radio Access
Networks
Core Network
Mobile Network
CN
CR2
HA
AR2
MNN
WAN Emulation
Path State Signalling
HEVC Encoder
Stream Pre-processor
Path Selection*
Packet Scheduling*
Flow Disaggregation*
Reception
Sub-Flow
Aggregation*
HEVC Decoding &
Error Concealment
* Denotes only used in multipath streaming

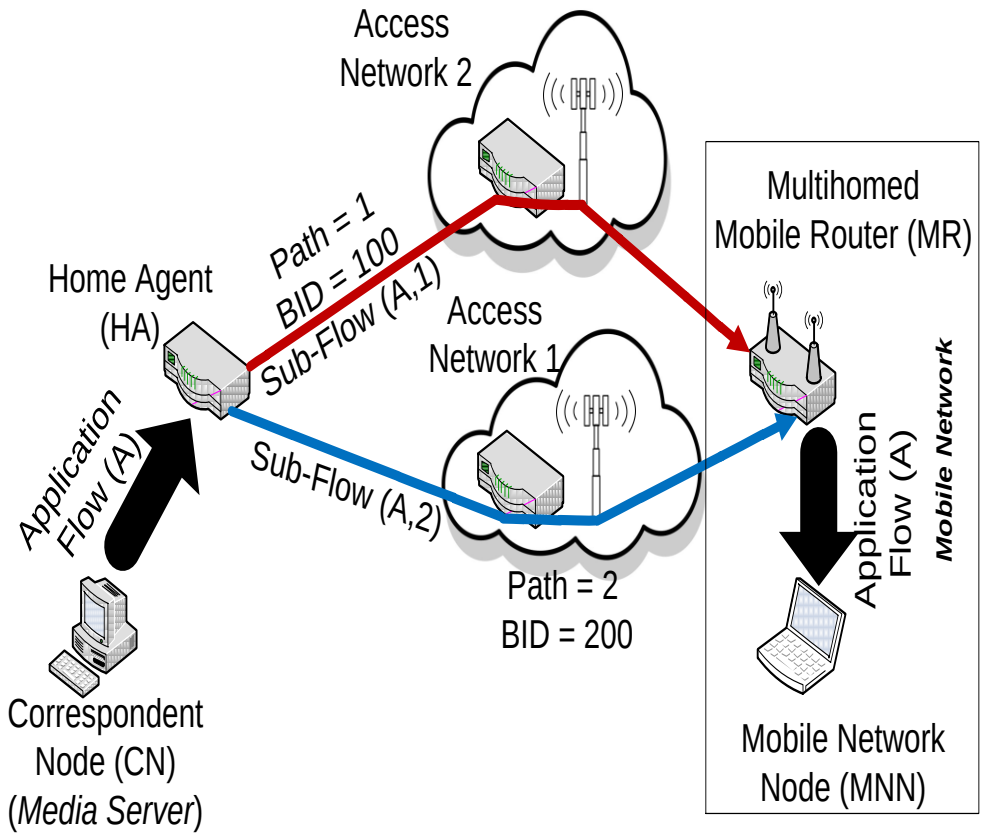
HEVStream

- **Sender**
- Modified HEVC Encoder
  - Generates trace files
  - Interfaces with modules for calculation of NAL unit priorities (*Option*)
- Custom bitstream extraction tool (select NAL units from list)
  - Sort encoded bitstream by priority (selectable window size) (*Option*)
- RTP packetiser (uses proposed IETF payload format)
- Scheduling agent
  - Select path(s) based on current network conditions
  - Distribute application flow over multiple paths
  - Drop non-viable packets

- **Receiver**
  - Trace file generation
  - Sub-flow aggregator (multi-path transmission)
  - Out of sequence buffer management
  - NAL unit loss and delay analyser
- Modified HEVC Decoder
  - Reference picture set reconstruction (in presence of loss)
  - Basic (Frame copy or block copy) error concealment
  - Trace file generation

HEVStream (Concurrent Multipath)

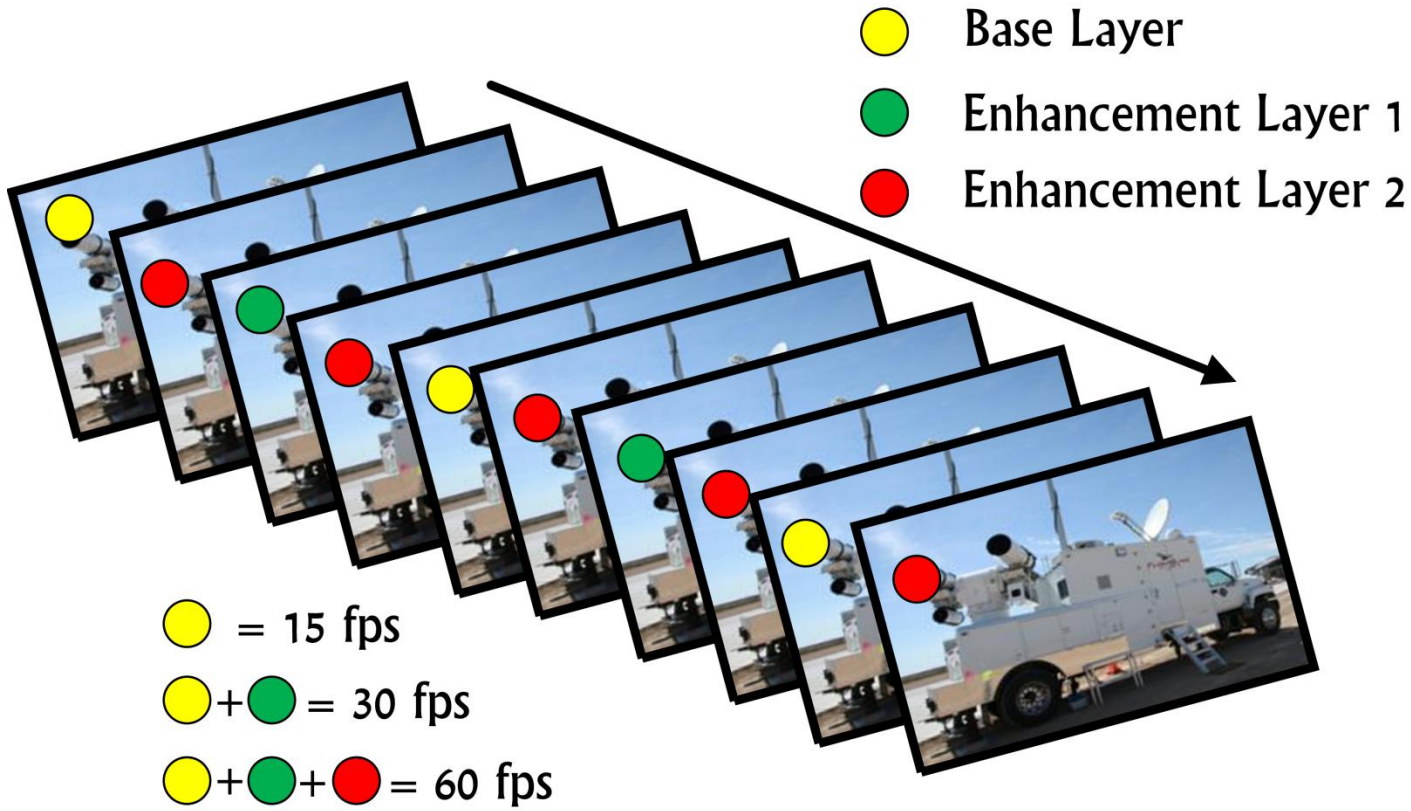




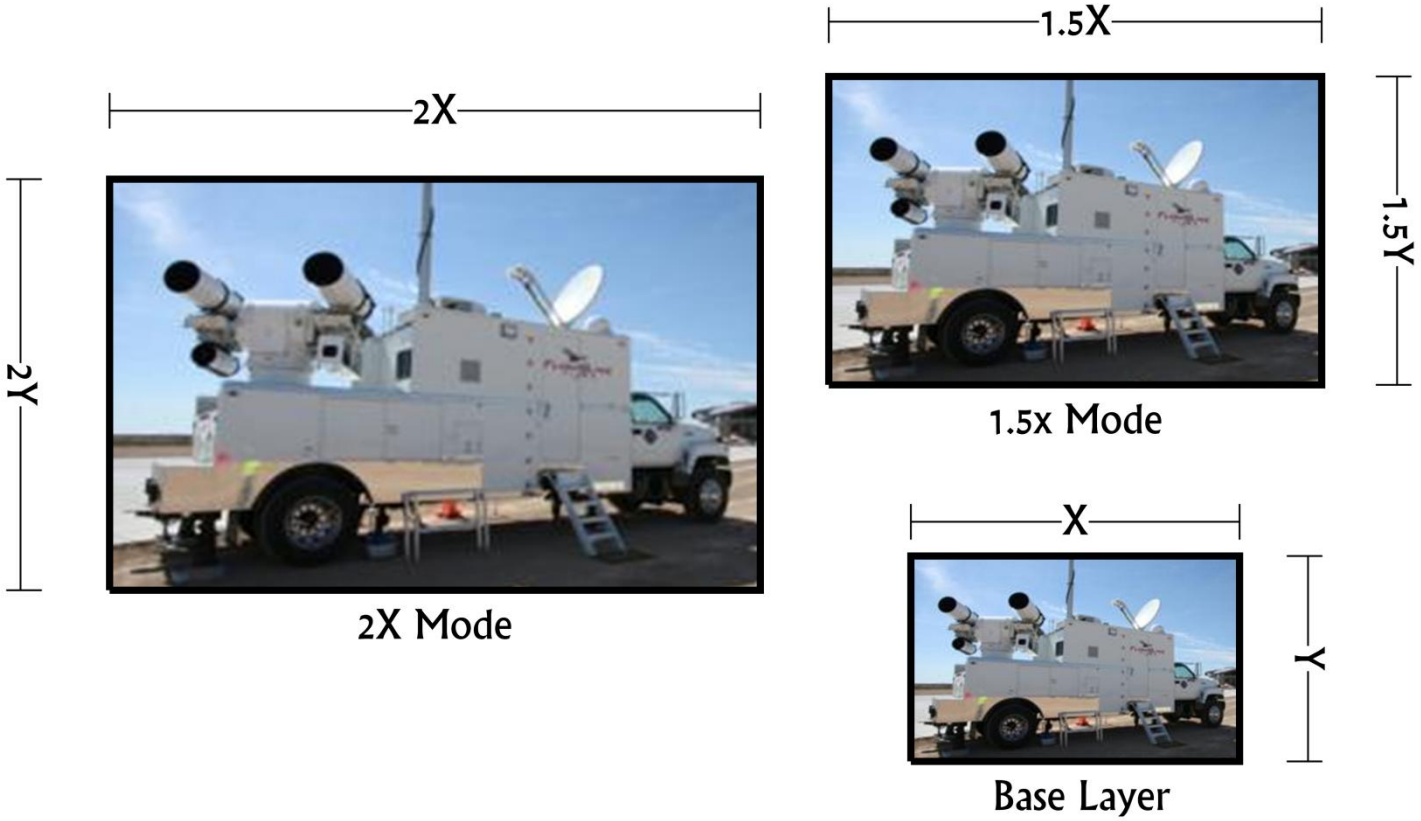
WP2. Scalable HEVC (SHVC)

- Scalable extension to HEVC (still under development)
  - HEVC already has TEMPORAL scalability built-in
  - SHVC adds SPATIAL and QUALITY scalable dimensions
  - Provides ability to adapt streams to device constraints and prevailing network conditions

Temporal Scaling in SHVC



Spatial Scaling in SHVC



Quality Scaling in SHVC

Base Layer
QP =37

Enhancement
Layer 1
QP =32

Enhancement
Layer 2
QP =27

Scalable HEVC (SHVC)

- HEVStream updated to include SHVC
  - Priority weight module to use scalable layer ID)
  - SHVC scheduler
  - SHVC dependency checker

- ‘As displayed’ video quality comparison in dynamic spatial adaptation

Comparing SHVC to HEVC and H.264/SVC

- Quality based SHVC adaptation can reduce bandwidth by 27% for a PSNR loss of only 0.5dB
- SHVC adaptation gives better results than packet prioritising HEVC scheme by up to 6dB of PSNR
- SHVC better than H.264/SVC by up to 18dB in aggressive adaptation scenarios.

WP3. Subjective Evaluation of HEVC

- Significantly higher compression ratio than previous codecs
- Each network packet carries larger portion of picture
- Will the loss of a packet have a greater impact ?
- Subjective evaluation– indicator of QoE

Subjective Evaluation of HEVC Video

- 16 subjects (small sample as initial pilot study)
- Age 22 – 50, both sexes
- PhD students & University employees (admin staff)
- Double stimulus impairment scale (DSIS) method used
- Testing station followed BT.500 guidelines
- (larger, comprehensive study using 50 participants in February 2014)

Encoding

6 sequences - (*Racehorses, Flowervase, Blowingbubbles, Basketballpass, Basketballdrilltext, Keiba*)

2 spatial resolutions (*416*240 and 832*480*)

3 target bitrates (*500Kbps, 1400Kbps and 2200Kbps)*

HEVC reference software HM 8 used

QP chosen to match target bitrates (closest match)

Packet Loss

At WAN emulation router

Random packet loss

Packet loss ratios 0%, 1%, 3% and 5%

One NAL unit per RTP packet

NAL unit loss rate = RTP packet loss rate

Decoder

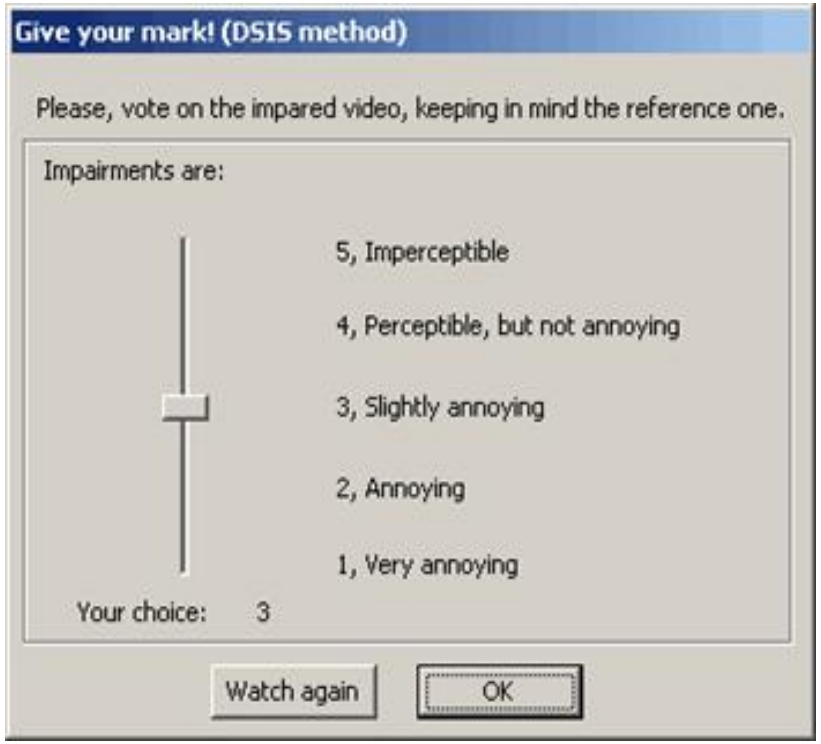
HM 8

Designed for conforming bitstreams

Some problems when random NAL unit loss encountered

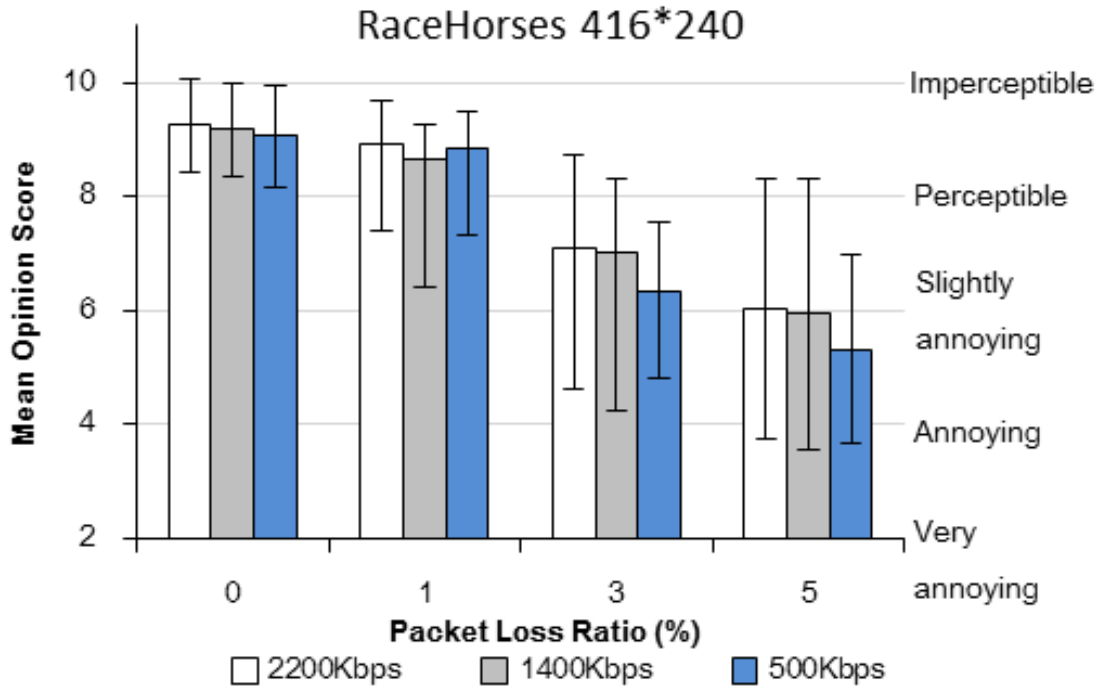
Basic error concealment –frame copy or co-located block copy

Subjective Evaluation of HEVC Video



Subjective Evaluation of HEVC Video

- Racehorse sequence at 416*240
- No packet loss – 9.17
- 8.86 at 1% dropping to 5.3 at 5%
- Variability increases with packet loss
- From 3% loss most found annoying



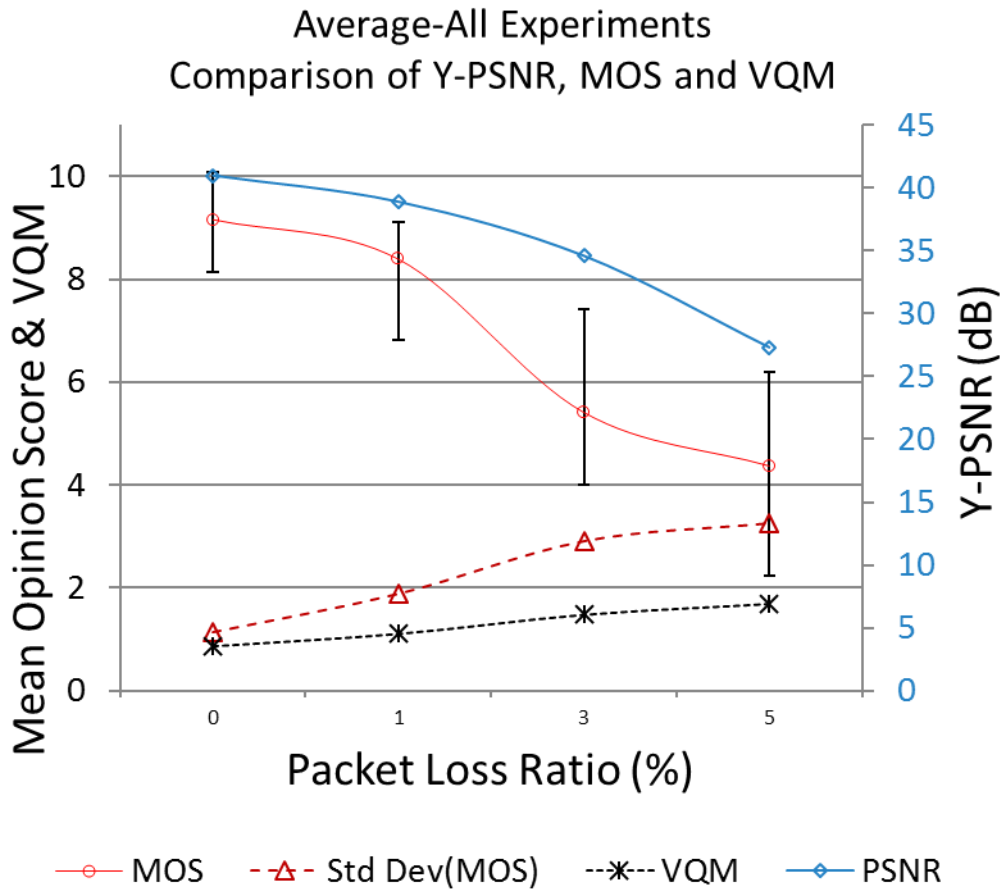
Subjective Evaluation of HEVC Video

Variability increases with loss

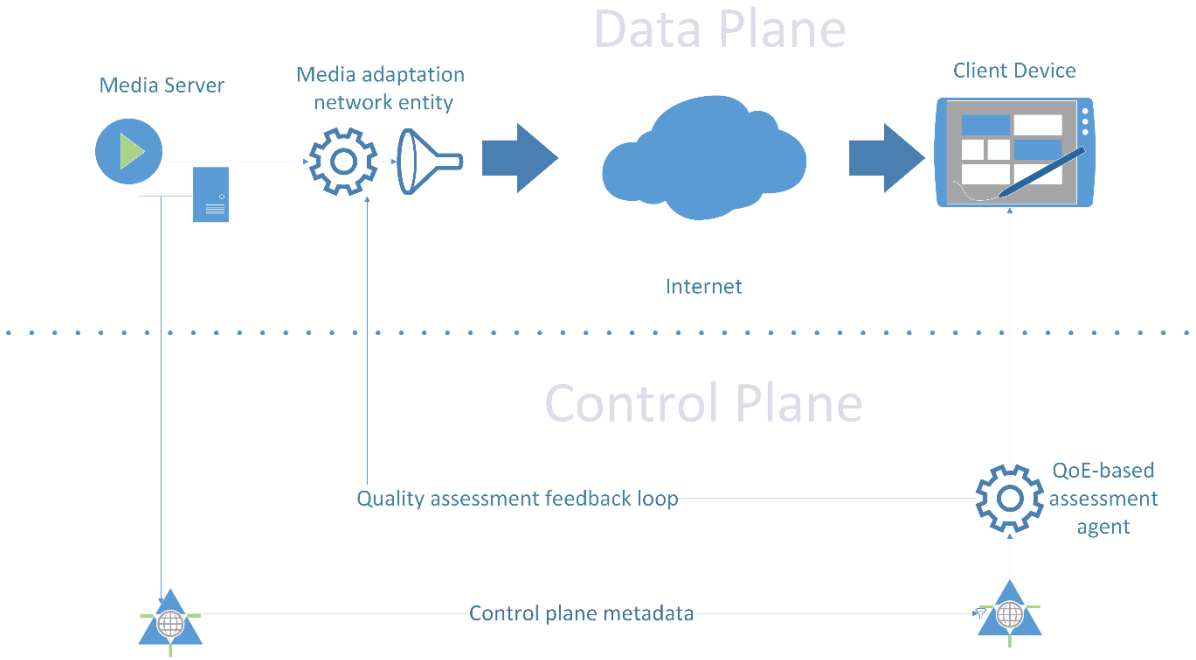
PSNR does not track MOS accurately

VQM trend slightly better than PSNR

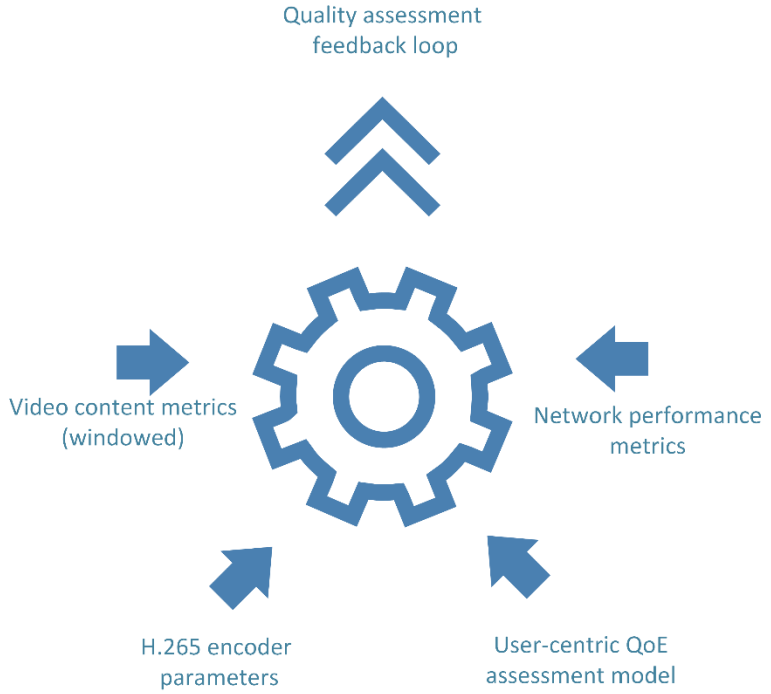
8.86 at 1% dropping to 5.3 at 5%



QoE-Driven HEVC Streaming



User-centric video stream adaptation scheme



Client side quality assessment engine

More Details in Publications

- Book chapters
  - "Mobile Video Cloud Networks", in Mobile Networks and Cloud Computing Convergence for Progressive Services and Applications (ISBN13: 9781466647817), IGI Global, USA, Nov. 2013.
- Journals
  - "HEVStream: A framework for streaming and evaluation of high efficiency video coding (HEVC) content in loss-prone networks," *IEEE Transactions on Consumer Electronics* , Vol. 58, No. 2, pp. 404-412, May 2012.
  - "Performance evaluation of concurrent multipath video streaming", *International Journal of Digital Multimedia Broadcasting (Hindawi),* Vol. 2013, 20 pages, July 2013.
- Conference papers
  - "Priority based methods for reducing the impact of packet loss on HEVC encoded video streams", *Proc. IS&T/SPIE Real Time Imaging 2013,* (Invited Paper), San Francisco, USA, Feb. 2013.
  - "Scalable HEVC (SHVC)- based video stream adaptation in wireless networks", *Proc. IEEE Personal Mobile and Indoor Radio Conference (PMIRC 2013)*, London, UK, Sept. 2013.
  - "Subjective evaluation of the effects of packet loss on HEVC encoded video streams", *Proc. IEEE International Conference on Consumer Electronics (ICCE-Berlin)*, Berlin, Germany, Sept. 2013.
  - "The impact of network impairment on quality of experience (QoE) in H.265/HEVC video streaming", *Proc. IET International Conference on Wireless, Mobile and Multimedia (ICWMMN 2013)*, Beijing, China, Nov. 2013.
  - "Evaluation of the emerging scalable high efficiency video coding (SHVC) standard for video stream adaptation in lossy mobile networks," *Proc. IS&T/SPIE Mobile Devices and Multimedia: Enabling Technologies, Algorithms, and Applications 2014,* San Francisco, USA, Feb. 2014.