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# Multi-Profile Ultra High Definition (UHD) AVC and HEVC 4K DASH Datasets

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## ABSTRACT

In this paper we present a Multi-Profile Ultra High Definition (*UHD*) DASH dataset composed of both AVC (*H.264*) and HEVC (*H.265*) video content, generated from three well known open-source 4K video clips. The representation rates and resolutions of our dataset range from 40Mbps in 4K down to 235kbps in 320x240, and are comparable to rates utilised by on demand services such as Netflix, Youtube and Amazon Prime. We provide our dataset for both real-time testbed evaluation and trace-based simulation. The real-time testbed content provides a means of evaluating DASH adaptation techniques on physical hardware, while our trace-based content offers simulation over frameworks such as ns-2 and ns-3. We also provide the original pre-DASH MP4 files and our associated DASH generation scripts, so as to provide researchers with a mechanism to create their own DASH profile content locally. Which improves the reproducibility of results and remove re-buffering issues caused by delay/jitter/losses in the Internet.

The primary goal of our dataset is to provide the wide range of video content required for validating DASH Quality of Experience (*QoE*) delivery over networks, ranging from constrained cellular and satellite systems to future high speed architectures such as the proposed 5G mmwave technology.

## CCS CONCEPTS

• **Information systems** → **Multimedia streaming**; • **Networks** → Public Internet;

## KEYWORDS

Dataset, 4K, Ultra High Definition, UHD, AVC, H.264, HEVC, H.265, Dynamic Adaptive Streaming over HTTP, DASH

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## 1 INTRODUCTION

The last number of years have seen a monumental shift in how and where video content is viewed, placing never before seen stain on the underlying online delivery networks due to insufficient network resources [2]. To limit the impact of varying throughput in these delivery networks, on demand services such as Netflix and Amazon Prime have adjusted to the quality needs of the heterogeneity of devices streaming their content, by implementing adaptive video delivery [1]. One of the most prominent and leading techniques for adaptive video delivery is the standardised Dynamic Adaptive Streaming over HTTP (*DASH*) [15]. DASH is a progressive download or adaptive HTTP streaming technique, which utilises existing HTTP web-servers and associated infrastructure to overcome issues such as firewalls and degradation in video quality due to losses within the network. The potential of adaptive video promised by DASH is understandably constrained by: i) variations in delivery delay within the backhaul network, ii) inherent variations in channel condition of last hop wireless technologies such as WIFI and LTE (*4G*) and iii) the increased delivery bitrate of content expected by the emergence of 4K UHD smart TVs, dedicated online streaming hardware such as the Apple TV 4K, and the delivery of 4K content from on demand services such as Netflix and Amazon Prime. Providing the research community with a sufficiently large range of DASH content can assist in simulated/emulated evaluation and help understand these inherent delivery issues, especially as we see new technologies such as 4K and 5G being deployed.

While a large range of commercial [1] and academic datasets (see Section 2) are available, they are predominately HD or Full HD quality, with one underlying video encoder, and with a limited number of representation rates and underlying DASH profiles. Mostly they focus on a single use-case and support online access only. Allowing support for local access facilitates controlled experimentation. Which highlights the need for, and the benefits provided by, our large Ultra High Definition (*UHD*) dataset. Our dataset is composed of both AVC (*H.264*) and HEVC (*H.265*) encoded video content, across a range of representation rates (235kbps to 40Mbps) and resolutions (320x180 to 3840x2160). Which provides a means of evaluating numerous use-cases for both existing constrained delivery networks and future high speed architectures such as the proposed 5G mmwave technology.

The remainder of the paper is organised as follows. Section 2 details existing DASH datasets in the literature. Section 3 presents an overview of encoding decision and content structures of our presented dataset, while Section 4 illustrates results from evaluating our DASH dataset over ns-3 modules for LTE and 5G mmwave. Section 5 describes future work in this area and the paper concludes in Section 6.

## 2 BACKGROUND AND RELATED DATASETS

While the availability of video datasets for the evaluation of streaming content has grown in recent times, the recent standardisation of DASH has focused research on the analysis of underlying adaptive algorithms. While DASH does not specify how stream quality adaptation should occur, it does provide options for various design features inherent in the DASH standard. These include the video

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2018. ACM ISBN 978-1-4503-0000-0…$15.00
https://doi.org/10.1145/0000

[1] https://bitmovin.com/mpeg-dash-hls-examples-sample-streams/

**Table 1: DASH Dataset Comparison**

| | H.264 | H.265 | HD | UHD | # clips | max_clip_lgt | # rates | max_rate | # profiles | # seg_dur |
|---|---|---|---|---|---|---|---|---|---|---|
| [11] | ✓ | | ✓ | | 6 | ~97min | 20 | 8 Mbps | 1 | 5 |
| [12] | ✓ | | ✓ | | 1 | ~97min | 17 | 6 Mbps | 1 | 5 |
| [10] | | ✓ | ✓ | ✓ | 1 | ~2.5min | 13 | 18 Mbps | 4 | 5 |
| [9] | ✓ | | ✓ | | 12 | ~15min | 12 | 10.4 Mbps | 1 | 1 |
| [7] | ✓ | ✓ | ✓ | | 23 | 16min | 10 | 4.3 Mbps | 1 | 5 |
| This paper | ✓ | ✓ | ✓ | ✓ | 3 | ~15min | 13 | 40 Mbps | 6 | 5 |

encoder, resolution values, the quantity and bitrate level for each representation rate, the number of frames per segment duration (# seg_dur), which is typically in a range from 1 to 15 seconds.

The first of the DASH datasets "Dynamic Adaptive Streaming over HTTP Dataset" [11] was released in 2012, and provides a procedure of evaluating DASH adaptive algorithms with a common set of content. The dataset consists of six video clips which are encoded with H.264 [17], MPEG-4 Part 10 Advanced Video Coding (MPEG-4 *AVC*) with representation rates and resolutions from 50kbps @ 320x240 to 8Mbps @ 1920x1080 (Full HD) across five segment durations. One additional component released with this dataset was an open source DASH content encoder called "DASHencoder". This dataset is the default standard for all future DASH datasets and was followed in 2013 with the "Distributed DASH dataset" [12], which implements the design parameters of [11] but only one of the dataset clips, namely the RedBull Playstreet sequence. The goal of this dataset is to provide adaptive clients with a means of accessing the same content which is mirrored across the globe, and evaluating/implementing the decision making process by which these clients dynamically switch between servers, which is typical of the content delivery networks (*CDNs*) of on-demand content providers.

The "Ultra High Definition dataset" [10] (2014) utilises a second encoder, namely H.265 [16], also known as High Efficiency Video Coding (*HEVC*). HEVC, with respect to AVC, provides for improved compression, increases resolution sizes up to 4K and overall reduced bandwidth required. One clip of two minutes and twenty two seconds is generated with a two-second GOP in three resolutions, from 1280x720 (*HD*) to 3840x2160 (*4K*), across thirteen bitrates ranging from 1.8Mbps to 18Mbps, two frame rates and four DASH profiles: live, live with bitstream switching, on demand, and main. The two-second GOP is replicated in five segment durations (2, 4, 6, 10 and 20 seconds). Overall this dataset provides a means of investigating adaptation with respect to higher bitrates. The first Scalable Video Coding (*SVC*) DASH dataset [9] was released in 2015, and provides a toolchain for reproducibility of their dataset and generation of new SVC DASH datasets. Four long and eight short duration clips are encoded with AVC, across three resolutions (640x360, HD, Full HD), twelve representation rates over the base and enhancement layers (from 600kbps to 10.4Mbps) and across four different variants of spatial and temporal scalability. PSNR and SIMM values are also provided by the authors. Similar to the "Distributed DASH dataset", the content of the SVC dataset provides the option of multi-access from different CDNs, but can be further extended to investigate caching and routing strategies, e.g., prioritising the base layer(s).

In 2016, an AVC/HEVC Full HD DASH dataset [7] was published, the first to offer a comparison of content across both encoders. The configuration of this dataset consisted of twenty three clips, across a range of genres, providing resolutions ranging from 320x240 to Full HD, encoding rates of 235kbps to 4.3Mbps respectively (comparable to on demand services such as Netflix) and clip durations spanning ten to sixteen minutes. All content is provided across five segment durations (2, 4, 6, 8, and 10 seconds) and one DASH profile (full). This dataset can be used for both trace-based (segment distribution over ns-3) simulation and real-time testbed evaluation of DASH. One additional option available with this dataset is the rebuilding of the entire dataset locally, from only the header information per clip, thus permitting reproducibility of evaluation results by removing transmission issues which may occur over the Internet.

As can be seen from the datasets outlined, each one corresponded to a demand within the research community at that point in time, with each evolving beyond the datasets that came before. With the emergence of high speed architectures such as the proposed 5G mmwave technology, there is now a need for a UHD DASH dataset which can be utilised to evaluate these emulated and simulated high speed architectures, and to begin to understand how various existing profiles within the DASH standard will evolve as these technologies are deployed. Table 1 presents a comprehensive comparison of the dataset previously described and the Multi-Profile Ultra High Definition DASH dataset presented in this paper.

## 3 DATASET OVERVIEW

In this paper, we expand on the UHD dataset of [10], and the design configuration of the AVC/HEVC full HD dataset of [7] to provide a Multi-Profile Ultra High Definition (*UHD*) Dynamic Adaptive Streaming over HTTP (*DASH*) dataset composed of both AVC (*H.264*) and HEVC (*H.265*) video content. Our dataset is composed of six distinct DASH profiles, across three well-known open-source 4K video clips, each with a duration in excess of ten minutes. The primary goal of our dataset is to provide the wide range of video content required for validating DASH QoE delivery over networks, ranging from constrained cellular and satellite systems to future high speed architectures such as the proposed 5G mmwave technology. We begin by presenting the structure of the clips chosen for our UHD dataset:

### 3.1 Original Clip Content

All of the native source material is encoded in a UHD 4K format, such that our DASH dataset could be generated without the need for upsampling or modifications to the quality levels of the original clip content. Our DASH content is generated from three open-source

**Table 2: Average Encoding Rate versus per Clip Resolution**

| | 40Mbps | 25Mbps | 15Mbps | 4.3Mbps | 3.85Mbps | 3Mbps | 2.35Mbps | 1.75Mbps | 1.05Mbps | 750Kbps | 560Kbps | 375Kbps | 235Kbps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BBB | 3840x2160 | 3840x2160 | 3840x2160 | 1920x1080 | 1920x1080 | 1280x720 | 1280x720 | 720x480 | 640x480 | 512x384 | 512x384 | 384x288 | 320x240 |
| Sintel | 3840x1744 | 3840x1744 | 3840x1744 | 1920x872 | 1920x872 | 1280x582 | 1280x582 | 720x328 | 640x292 | 512x234 | 512x234 | 384x174 | 320x146 |
| TSOS | 3840x1714 | 3840x1714 | 3840x1714 | 1920x858 | 1920x858 | 1280x572 | 1280x572 | 720x322 | 640x286 | 512x228 | 512x228 | 384x172 | 320x142 |
| 16:9 | 3840x2160 | 3840x2160 | 3840x2160 | 1920x1080 | 1920x1080 | 1280x720 | 1280x720 | 736x414 | 640x360 | 512x288 | 512x288 | 384x216 | 320x180 |

video clips, ranging from simple animation to ground-breaking visual effects. All sequences are licensed under Creative Commons Attribution 3.0 license, so they are free to share and modify, but with some rights reserved. The three clips utilised are:

(1) Big Buck Bunny (*BBB*) [4] (2008): is a simple animation short clip of 10 minutes and 34 seconds duration and is the result of the Peach open movie project. The original content is composed of animated characters with a non intricate background, initially encoded with a 4K resolution of 3840x2160, at 60fps in the Matroska (*MKV*) open standard video file format. Copyright information can be found here: [2].
(2) Sintel [5] (2010): is an elaborate animation short clip of 14 minutes and 48 seconds duration and is the result of the Durian open movie project. The original content is composed of complex animated characters and scenery, initially encoded with a 4K resolution of 3840x1744, at 24fps in the Apple developed *MOV* format. Copyright information can be found here: [3].
(3) Tears of Steel (*TOS*) [6] (2012): is a short visual effects-based film of 12 minutes and 14 seconds duration and is the result of the Mango open movie project. The original content is composed of real actors and super imposed digital effects, initially encoded with a 4K resolution of 3840x1714, at 24fps in an MOV format. Copyright information can be found here: [4].

As the source content for each of the clips was encoded in a different 4K resolution, this mandated that each of the subsequent lower resolutions in our dataset, would be spatially downsampled at a different rate for each of the respective clips. Table 2 illustrates the underlying resolutions and average encoding rates for each of the clips. As can be seen, there are three bitrates at 4K, two bitrates at Full HD, two bitrates at HD, and six bitrates at lower resolutions, which provides a sufficiently large range of representation bitrate to accommodate DASH content for use-cases ranging from 5G delivery to low powered devices. Downsampling at a different rate for each of the respective clips lead to an issue during the creation of the DASH profiles (encoding steps are explain in the next section). Due to the difference in the aspect ratios of the varying resolutions, MP4Box created a number of DASH AdaptationSets per Period, which lead to switching issues between AdaptationSets across the entire range of representation rates during playback. To provide consistency across all clips a resolution aspect ratio of *16:9* is defined, and the finalised resolutions for all clips are illustrated in Table 2 under the reference 16:9.

[2]https://media.xiph.org/BBB/bbb3d/
[3]https://media.xiph.org/sintel/
[4]https://media.xiph.org/tearsofsteel/

## 3.2 Encoding Decisions

Next we define the decisions made prior to encoding the dataset. In our dataset, representation rates for all resolutions up to and including Full HD follow those provided in [7], while the chosen encoding rates of 40Mbps, 25Mbps and 15Mbps for 4K are based on the following: 40Mbps is selected as the highest 4K encoding rate as the original MOV/MKV files were encoded in a similar rate. Netflix recommendations an Internet download rate of 25 Mbps [5], while Amazon Prime requires an Internet connection of at least 15Mbps [6] for their respective UHD 4K content.

The MPEG DASH standard defines a number of formats for delivery of Media Presentation Description (*MPD*) files and for segments, which can be defined as *Profiles*. These profiles inform the DASH clients as to the requirements of the underlying video stream. Examples of the DASH profile identifiers include: "urn:mpeg:dash :profile:isoff-on-demand:2011" and "urn:mpeg:dash:profile:main :2011". The "on-demand" profile provides the best compatibility among DASH clients, while "main" is typically seen as a fall back profile when "on-demand" restrictions are not met. To increase the usage of our dataset, we chose six of the most prominent profile formats and encoded our dataset with these. The six DASH profiles chosen were Full, Full Byte Range, Live, Main, Main Byte Range, and onDemand Byte Range. The byte-range profiles can benefit clients who value the knowledge of the oscillation of segment byte sizes prior to segment selection during video stream adaptation decisions. For each of the six Profiles created, we further extend the dataset by providing five distinct segment durations, namely 2-second, 4-second, 6-second, 8-second and 10-second. It is important to note that the size of each of the segment durations equates to the underlying MP4 GOP values: thus reducing the number of I-frames per clip as the segment size increases, and mandating that the original MP4 file for each segment duration is different.

## 3.3 Dataset Generation

As illustrated in Figure 1, creation of the DASH content from the source MKV/MOV file formats utilises well-known open-source software, namely:

(1) Converting the original MKV/MOV content to a non compressed lossless YUV format, highlighted in green in Figure 1, requires "ffmpeg", version N-87774. Over 1.3TB of raw YUV files are created for all three clips, across all resolutions. Audio was removed in this step, and was not re-added in step 3, as streaming video delivery over the network is the focus of our research.

[5]https://help.netflix.com/en/node/306
[6]https://www.amazon.com/gp/help/customer/display.html?nodeId=201648150

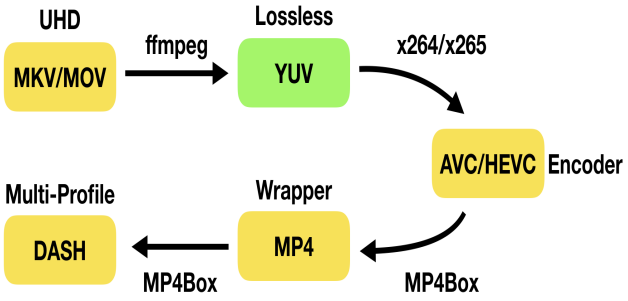



**Figure 1: The MKV/MOV to DASH profile content generation process.**

(2) Encoding of the YUV content requires "x264", version 0.152.x, and "x265", version 2.5+27, both sourced from VideoLAN: makers of the free and open source cross-platform multimedia player "VLC" [7]. Approximately 278GB of content is created during the encoding step, with a similar GB size generated during the next MP4 wrapper stage.
(3) Packaging the encoded content in an MP4 wrapper and generating the MPD profiles and associated DASH content uses the multimedia packager "MP4BOX" [8], version 0.7.2, which is part of the open source multimedia framework GPAC, developed at Telecom ParisTech. In excess of 1.7TB of DASH content is generated across all six profiles in this final stage. Each of the generated 180 MPD files, (two encoders * five segment durations * three clips * six profiles) passed the DASH validation tool test available at [9].

A VirtualBox VM of a clean install of Ubuntu 16.04.03, complete with "VirtualBox Guest Additions" is provided that includes all source code and associated encoding and playback software, outlined above, to stream our UHD 4K dataset [10]. For viewing the DASH content, the software required includes: openHEVC [11] (software to decode HEVC content), and MP4Client (a multi functional media player provided by GPAC). Generation of our Dataset took approximately 60 days from downloading the MKV/MOV files to complete dataset creation. Across all segment durations, and representation rates, each of the AVC clips took circa 3 days from YUV to MP4, while the HEVC content took on average 16 days per clip for the same conversion. The remaining time was consumed by the change from MKV/MOV to YUV and the segmentisation of the MP4 to the DASH profiles.

## 3.4 Dataset Usage

We provide three means of using our UHD DASH dataset, of which a summary of the features and settings are presented in Table 3:

(1) *Real-Time Testbed Dataset*: Our first dataset provides network infrastructure designers and video streaming clients, a means to implement and explore how real-time streaming of UHD content impacts on the control loops within the network (tcp, throttling, slicing) and adaptation logic at the clients (buffer-, throughput-/rate-, hybrid-based). Having real 4K content streaming over a physical infrastructure can begin to provide the insights needed for those scenarios in which video streaming dominates the available bandwidth, such as last hop technologies WIFI, LTE and future technologies such as 5G.
(2) *Trace-based Dataset Content*: Our second dataset benefits trace-based frameworks such as ns-2 and ns-3, in which different transmission network topologies can be evaluated: typically for headless DASH clients where no content is required to be decoded and viewed. For this dataset we extract the segment distribution of our non-byte range DASH profile content, as well as provide the original AVC/HEVC MP4 PSNR files for all DASH profiles. Similar to the byte-range MPD, the segment distribution files provide the per segment transmission cost information, which can benefit clients whose adaptive algorithms utilise future segment sizes when determining the optimal segment/representation rate to select, such as the buffer-based approach in BBA-2 [3] and the rate-based method in ARBITER [18]. These adaptive algorithms have proven to reduce steam switching and re-buffering issues, such as stalls, when channel conditions are stable. With the AVC/HEVC MP4 PSNR values provided per frame we present a means to determine a single quantitive evaluation value per streamed clip, by summation of the PSNR per segment at the appropriate representation rate. As an example of the oscillation in segment sizes, Figure 2 illustrates the AVC segment distribution for the 4K 40Mbps representation rate for Tears of Steel (*TSOS*) with a 4-second segment duration, while Figure 3 presents the same clip distribution but with the HEVC encoder (note: 40,000 bits * 4 seconds % 8 = 20,000 bytes, i.e., average segment size shown in Figures 2 and 3).
(3) *Dataset Modification and Adaptation*: Our third and final dataset contains all of the pre-DASH MP4 files and provides researchers with a mechanism to recreate all or a subset of our multi-profile UHD DASH locally. Thus removing inherent issues when streaming content over the Internet, such

**Table 3: Summary of Dataset Features**

| Dataset | Feature | Settings |
|---|---|---|
| (1) | Real-Time | Decodable Content<br>Adaptive Algorithm Agnostic<br>Evaluation over Physical Devices |
| (2) | Simulation | ns-2/ns-3 trace-based evaluation<br>Extracted segment distribution<br>PSNR values per frame |
| (3) | Creation | Original non-DASH MP4 files<br>Multi-profile DASH creation script:<br>onDemand Byte Range, Live, Main, Full,<br>Main Byte Range, Full Byte Range |

[7] http://www.videolan.org/index.html
[8] https://gpac.wp.imt.fr/mp4box/
[9] http://dashif.org/conformance.html
[10] http://www.cs.ucc.ie/misl/research/datasets/ivid_uhd_dataset/
[11] https://github.com/OpenHEVC/openHEVC/blob/hevc_rext/README.md

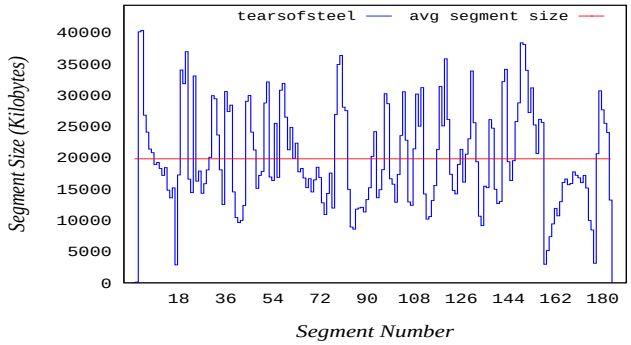



**Figure 2: AVC segment distribution for the 4K 40Mbps representation rate for TSOS with a 4-second segment duration.**

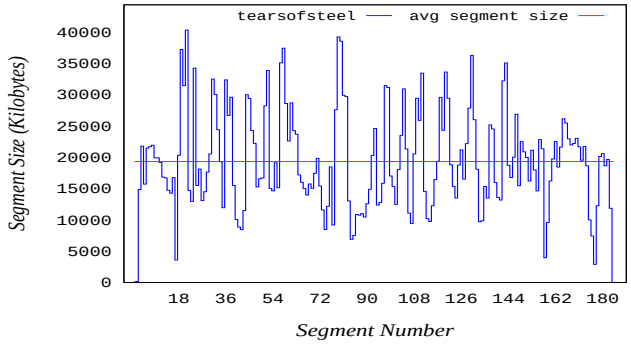



**Figure 3: HEVC segment distribution for the 4K 40Mbps representation rate for TSOS with a 4-second segment duration.**

as reproducibility of results and re-buffering caused by delay/jitter/losses in the Internet. As stated the entire MP4 content is approximately 278GB and once expanded will create in excess of 1.7TB of DASH content. The MP4 content is segregated based on segment-size/encoder/clip-name, thus permitting a portion of the dataset to be downloaded based on underlying requirements.

We provide a bash script for generating the DASH files from the MP4 content, with easy modification to permit a subset of the six DASH profiles to be created, or the generation of additional/new DASH profiles as required. The DASH generation script and the datasets can be obtained/browsed from [12], and from the Zenodo research data repository [13]

## 4 USE CASE EXAMPLE

In this section we present a sample use-case for our UHD dataset, where content was evaluated over a modified version of our *D-LiTE* [8] video streaming platform testbed. D-LiTE encompasses all of the components required to realistically evaluate the performance of Dynamic Adaptive Streaming over HTTP (*DASH*) over a real-time ns-3 simulated LTE/4G network via the ns-3 LENA module [14]. We utilise Raspberry Pi hardware, as our physical clients

[12] http://www.cs.ucc.ie/misl/research/datasets/ivid_uhd_dataset/
[13] https://doi.org/10.5281/zenodo.1219788

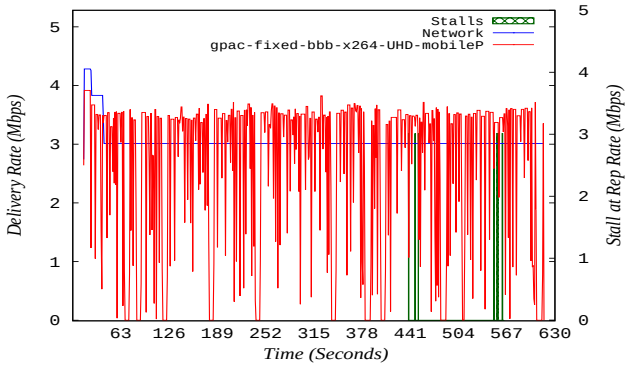



**Figure 4: Example of switching and achievable representation rate for UHD 4K streaming over simulated 4G LENA.**

and HTTP apache2 server, running Ubuntu Mate 16.04, a derivative of the official Linux distribution. We extended our D-LiTE platform to encompass the 5G mmwave module for ns-3 [13], to provide a means of evaluating real-time 4K content streaming in a high speed dynamic wireless network.

We implemented a simplified network of two clients, located 150m from the cell tower and evaluated 4K content streaming over both 4G and 5G, using the GPAC DASH player MP4Client version 0.7. For ns-3 4G LENA, we implemented the *proportional fair* pf scheduler, with a *mobile pedestrian* fading model. While for ns-3 5G mmwave we utilised a comparative *transmission time interval* tti proportional fair scheduler, *3GPP propogation* pathloss model over a *3GPP* channel. As MP4Client implements a default adaptational algorithm, which defines the chosen representation rate based on observed throughput, per client average achievable rates of 3.5Mbps were obtained for 4G, while average rates of 15Mbps were achieved for 5G. Figures 4 and 5 illustrate one example of the switching and achievable representation rate for both 4G and 5G respectively. While not shown, both clients per wireless architecture achieved comparative results.

As can be seen in Figure 4, simulated LTE with an average throughput of 3.5Mbps using a mobile pedestrian model (network variation shown in red), using the default GPAC adaptation algorithm mandates huge variations in achievable quality (blue line) and a number of stalls (outlined in green, with the height of the line denoting the representation rate at which the stall occurred). While streaming over simulated 5G Figure 5, at an average throughput of 12Mbps, with peaks of 23Mbps, removes the issue of stalls, and illustrates a number of switches between the Full HD and 4K content.

In this example, 5G clients received varying levels of 4K content, while 4G clients attained HD rates only. Demonstrating how 4K content, such as our UHD 4K dataset, is better suited to evaluate future high speed wireless architectures such as 5G, as Full HD/HD representation rates at 5G delivery rates do not show any delivery or re-buffering issues due to such high delivery rates (depending on number of users per cell).

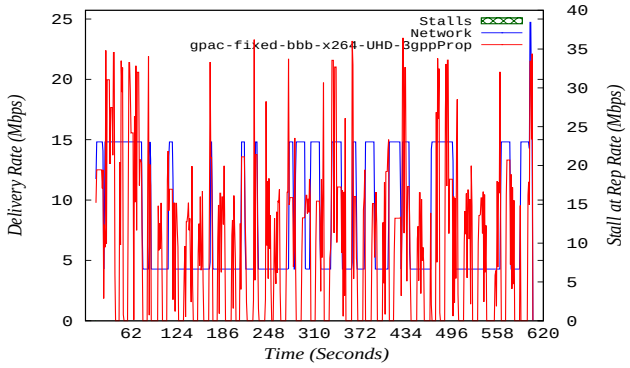



**Figure 5: Example of switching and achievable representation rate for UHD 4K streaming over simulated 5G mmwave.**

## 5 FUTURE WORK

Future work will consider using the toolchain in [9] to create Scalable extensions to our Multi-Profile UHD dataset for AVC (*SVC*) and HEVC (*SHVC*). We shall also consider modification to existing, and/or proposals for future, MPD configurations required for streaming high resolution content, such as 4/8/16K over high speed infrastructures such as 5G, which is anticipated for applications such as Virtual and Augmented reality, and 360 degree video. Finally, we shall continue to evaluate DASH delivery over mmwave, to determine delivery issues with high bitrate 4K streams, large 5G peaks in throughput, as well as the increased numbers of adaptive heterogenous clients that 5G can accommodate.

## 6 CONCLUSION

In this paper, we present a novel Multi-Profile Ultra High Definition (*UHD*) DASH dataset composed of both AVC (*H.264*) and HEVC (*H.265*) video content, generated from three well known open-source 4K video clips. The dataset is available for both trace-based simulation and real-time evaluation, with a wide range of features. We also make available the pre-DASH MP4 files for all clips, to provide a mechanism to reproduce the entire dataset locally to improve usability.

As we have seen in the example use-case, the evaluation of 4K content is currently constrained in simulated LTE networks. While 4K content provides the ideal catalyst for the evaluation of 5G mmwave technologies, with respect to the number of users per cell and associated delivery rates required to assess real-time DASH streaming.

The goal of this work is to provide DASH dataset content to evaluate adaptive clients over both constrained and high speed networks, and to assist in answering such questions as "How will throughput- and buffer-based adaptive clients react with a combination of 4K content and wireless 5G?", "How will content adaptation adjust as clients handover between the widely varying delivery rates of 4G and 5G technologies?" and "How will existing DASH profiles customise to suit these new technologies?".

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