Feasibility Study of Stochastic Streaming with 4K UHD Video Traces

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Introduction

- Cisco Visual Networking Index (VNI) says
  - The summation of all possible forms of video contents will constitute 80% to 90% of global data traffic by 2017, and the traffic from mobile and wireless portable devices will exceed the traffic from wired devices by 2016.
  
  → Efficient wireless video streaming algorithms are of the highest importance

- Based on this importance, stochastic streaming algorithms have been investigated
  - Aiming at the time-average quality maximization subject to video queue stability.
Introduction

- Related Work in Stochastic Video Streaming
  - [TON-2015]
    - Stochastic video streaming algorithms for device-to-device distributed computing systems are proposed.
    - Device-to-device stochastic video streaming with two types of schedulers (centralized vs. distributed) is discussed.
  - [TCOMM-2015]
    - Stochastic video streaming in small cell networks is proposed.

Introduction

• Related Work in Stochastic Video Streaming (Cont’d)
  • In the two research directions, they discuss about stochastic network optimization applications to adaptive video streaming (i.e., stochastic streaming) which maximizes time-average video streaming quality subject to queue/buffer stability.
    • If we transmit maximum quality video streams all the time, the streaming quality will be maximized whereas the queue/buffer within the transmitter will be overflowed.
    • On the other hand, if we transmit minimum quality video streams all the time, the queue/buffer will be stable whereas the streaming quality will be minimized.
    • Therefore, the proposed stochastic streaming adapts the quality of each video stream depending on current queue-backlog length.
Introduction

• Motivation and Novelty
  • In [TON-2015] and [TCOMM-2015], the used video traces are MPEG test sequences, however the test sequences are not used in current consumer electronics applications.
  
  • Therefore, this work evaluates the stochastic streaming algorithms with up-to-date 4K ultra-high-definition (UHD) video test sequences.
  
  • After observing the performance evaluation results with 4K UHD video traces, we can numerically identify how much the novel stochastic streaming algorithm is better than queue-independent non-adaptive video streaming algorithms.
Proposed Stochastic Video Streaming
Proposed Stochastic Video Streaming

Streaming Arrival Process: Placement of Streams

Streaming Departure Process: Transmission of Bits

Streaming Time Clock ($K=5$)

Transmission Time Clock

$t_s$

$t$

Video Streams

Stream 1  Stream 2  Stream 3  ......

Storage
Proposed Stochastic Video Streaming

Controlling the Arrival Process of TX Queue using Drift-Plus-Penalty (DPP) Algorithms

In each time slot, choose quality mode \( q \)

\[
\begin{align*}
\max & \quad \lim_{t \to \infty} \frac{1}{t} \sum_{t_s=0}^{t-1} \mathbb{E} \left[ \mathbb{P}(q(t_s), t_s) \right] \\
\text{subject to} & \quad \lim_{t \to \infty} \frac{1}{t} \sum_{t_s=0}^{t-1} \mathbb{E} \left[ Q(q(t_s), t_s) \right] < \infty
\end{align*}
\]

Where

\[
\Phi(q(t_s), t_s) \triangleq \mathbb{P}(q(t_s), t_s) - V \cdot \mathbb{B}(q(t_s), t_s) \cdot Q(t)
\]

PSNR of current chunk with quality mode \( q \)  
Bitrate of current chunk with quality mode \( q \)
### Feasibility Study – Text Sequence Generation

<table>
<thead>
<tr>
<th>Category</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>3840-by-2048 (for 4K UHD video)</td>
</tr>
<tr>
<td>Frame rate</td>
<td>30 fps (30 frames per second)</td>
</tr>
<tr>
<td>Bit depth</td>
<td>8 bits</td>
</tr>
<tr>
<td>Test sequence name</td>
<td>Traffic (for video standard testing)</td>
</tr>
<tr>
<td>Profile name</td>
<td>Main</td>
</tr>
<tr>
<td>Intra period</td>
<td>32</td>
</tr>
<tr>
<td>GOP size</td>
<td>8</td>
</tr>
<tr>
<td>Four different video qualities with QP</td>
<td>22, 27, 32, 37</td>
</tr>
<tr>
<td>(quantization Parameters)</td>
<td></td>
</tr>
<tr>
<td>Encoder</td>
<td>HM ver. 15.0 (HEVC standard reference codes)</td>
</tr>
<tr>
<td>PC</td>
<td>Intel i7 CPU, Windows7 64bit OS</td>
</tr>
</tbody>
</table>
Feasibility Study – 4K UHD Video Traces

QP: 22

QP: 27

QP: 22

QP: 37
Feasibility Study – Simulation Results with Various K

Tight Streaming Time Clock (K=1)

Loose Streaming Time Clock (K=10)
Feasibility Study – Simulation Results

Stochastic Streaming with
• Higher Quality (PSNR)
• More Queue-Backlog

Stochastic Streaming with
• Lower Quality (PSNR)
• Less Queue-Backlog

Highest Quality (PSNR)

Lowest Quality (PSNR)
Conclusions

• Feasibility study results of stochastic streaming algorithms with 4K ultra-high-definition (UHD) video traces.

• The performance improvements with the stochastic video streaming algorithms were verified with traditional MPEG test sequences in previous work; however there were no research results with up-to-date 4K UHD video traces.

• Thus, this work
  • Verifies the performance of the stochastic streaming algorithms with 4K UHD video traces
  • Shows that the stochastic algorithms perform better than queue-independent algorithms.
Q&A