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.

[TON-2015] J. Kim, G. Caire, and A.F. Molisch, "**Quality-Aware Streaming and Scheduling for Device-to-Device Video Delivery**," *IEEE/ACM Trans. on Networking*, [Published Online: July 2015].
[TCOMM-2015] D. Bethanabhotla, G. Caire, and M.J. Neely, "**Adaptive Video Streaming for Wireless Networks With Multiple Users and Helpers**," *IEEE Trans. on Communications*, 63(1):268-285, January 2015.

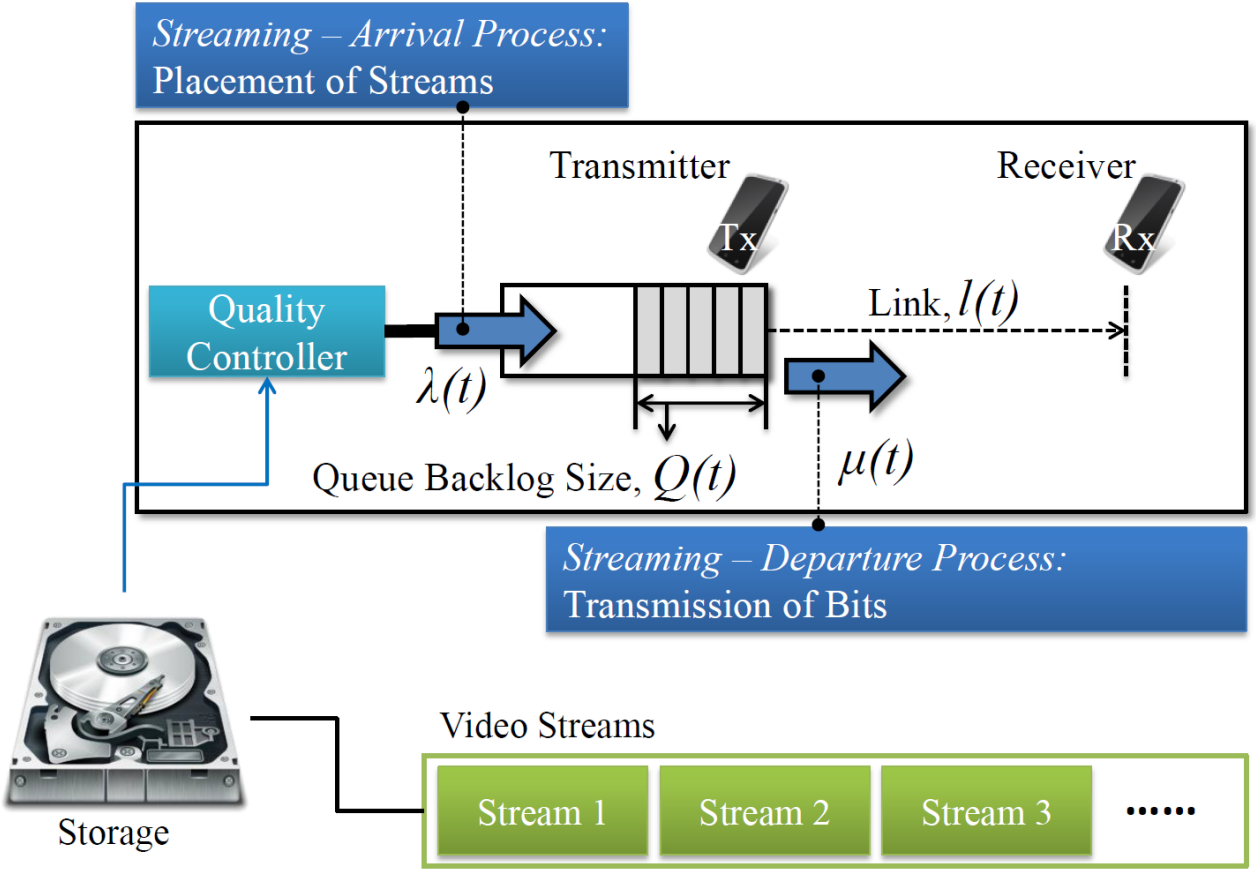
Introduction

- **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.**

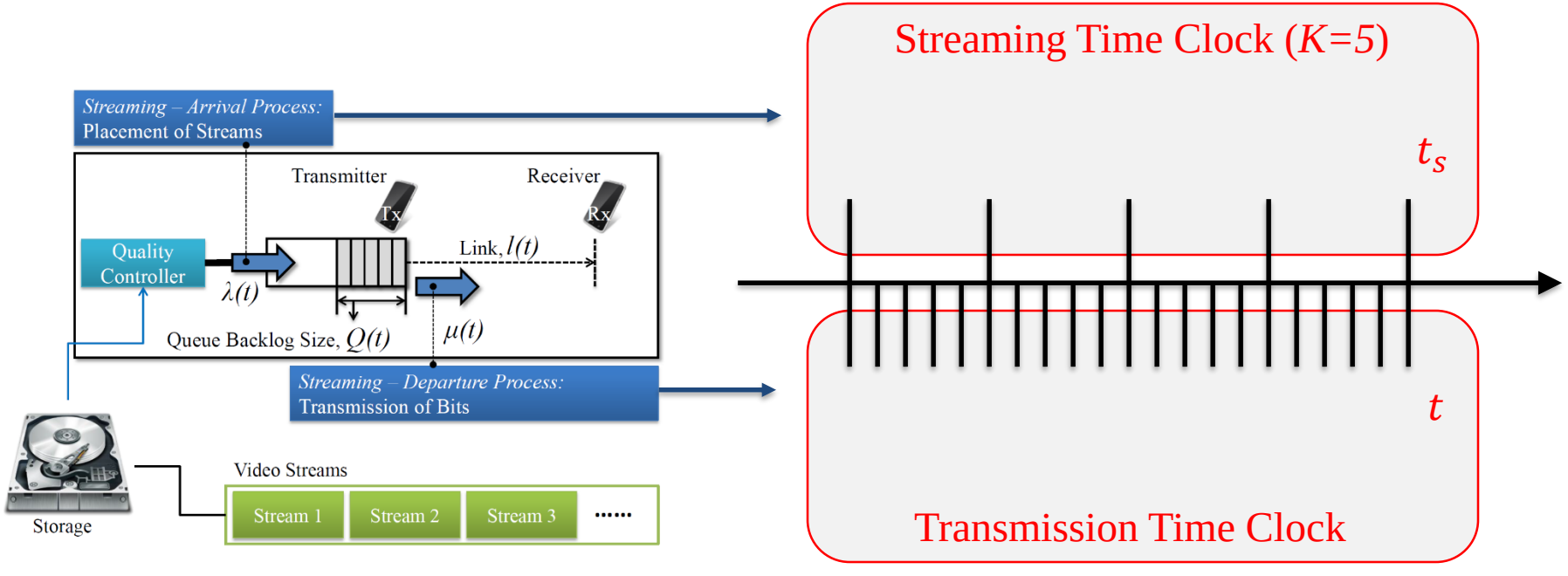
Introduction

- **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



Proposed Stochastic Video Streaming

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

$$\max \quad \lim_{t\to\infty} \frac{1}{t} \sum_{t_s=0}^{t-1} \mathbb{E}\left[\mathbb{P}\left(q\left(t_s\right), t_s\right)\right]$$

$$\text{subject to} \quad \lim_{t\to\infty} \frac{1}{t} \sum_{t_s=0}^{t-1} \mathbb{E}\left[Q\left(q\left(t_s\right), t_s\right)\right] < \infty$$

Stochastic Optimization

In each time slot, **choose quality mode *q***

$$q^*\left(t_s\right) \leftarrow \arg \max_{q(t_s)\in M} \Phi\left(q\left(t_s\right), t_s\right)$$

where

$$\Phi\left(q\left(t_s\right), t_s\right) \triangleq \mathbb{P}\left(q\left(t_s\right), t_s\right) - V \cdot \mathbb{B}\left(q\left(t_s\right), t_s\right) \cdot Q(t)$$

PSNR of current chunk with **quality mode *q***

Bitrate of current chunk with **quality mode *q***

Feasibility Study – Text Sequence Generation

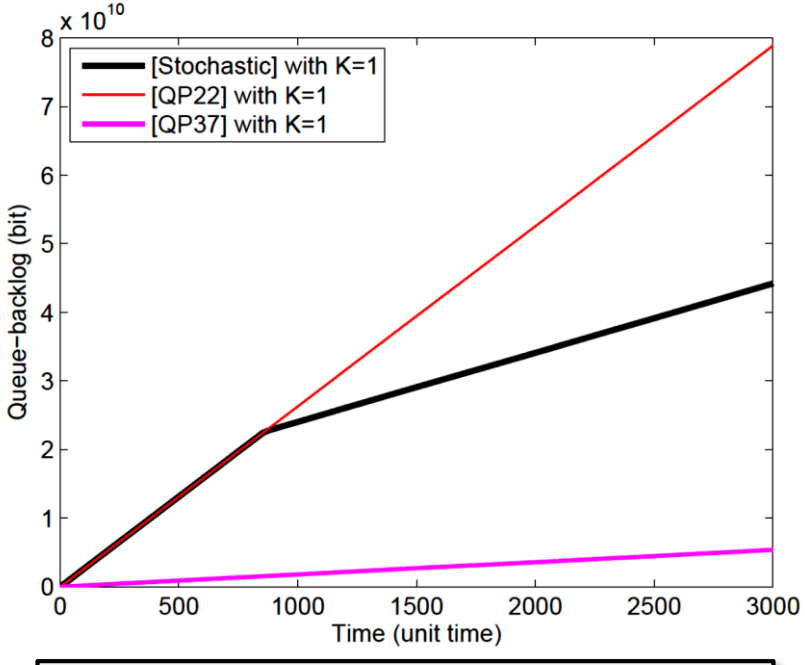
Category	Values
Resolution	3840-by-2048 (for 4K UHD video)
Frame rate	30 fps (30 frames per second)
Bit depth	8 bits
Test sequence name	Traffic (for video standard testing)
Profile name	Main
Intra period	32
GOP size	8
Four different video qualities with QP (quantization Parameters)	22, 27, 32, 37
Encoder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

Feasibility Study – 4K UHD Video Traces

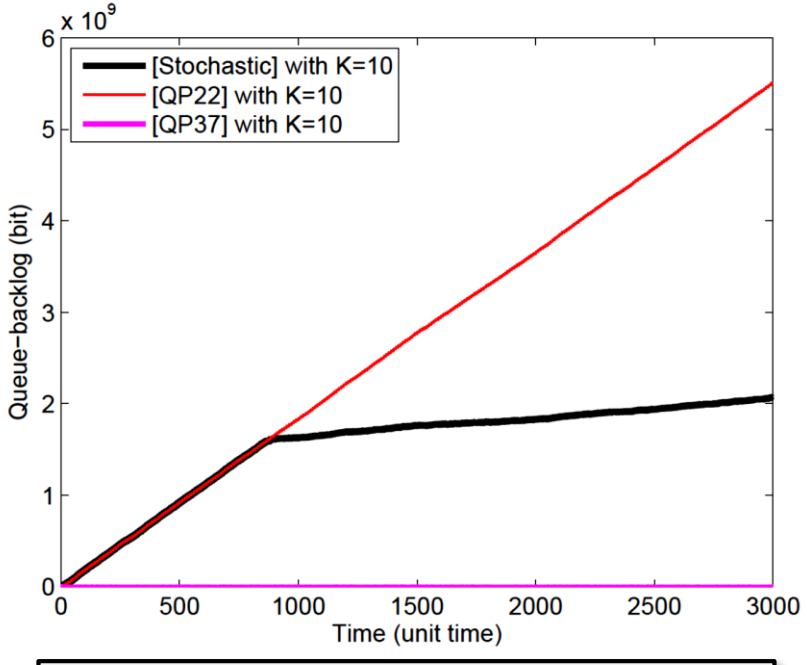
Feasibility Study – 4K UHD Video Traces

QP: 22	QP: 27	QP: 22	QP: 37

Feasibility Study – Simulation Results with Various K

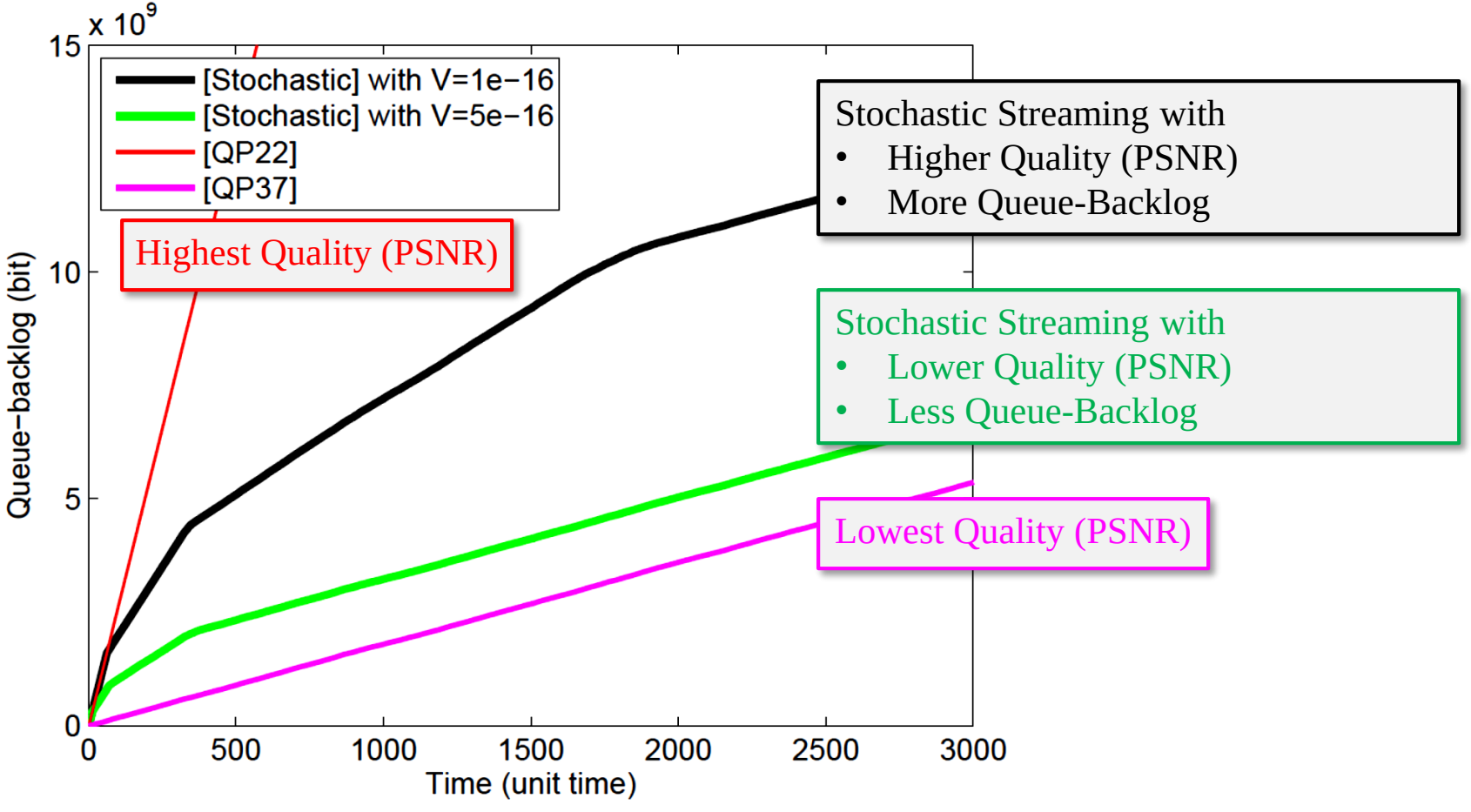


Tight Streaming Time Clock (*K=1*)



Loose Streaming Time Clock (*K=10*)

Feasibility Study – Simulation Results



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