Optimized Scalable Video Delivery for Streaming, Downloading, and Hybrid Access Models

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Scalable Video Delivery Policies

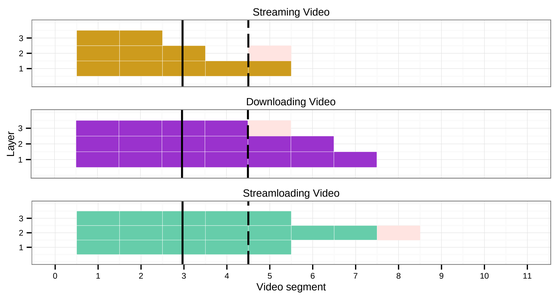
Adaptive video delivery policies have been well studied. However, we have not seen any research which considers how these policies are affected by an access model mandated by a content provider.

In this work, we find optimal delivery policies for scalable video under different access constraints:

- streaming,
- downloading,
- and a hybrid access model called *streamloading*.

Internet Video Access Models

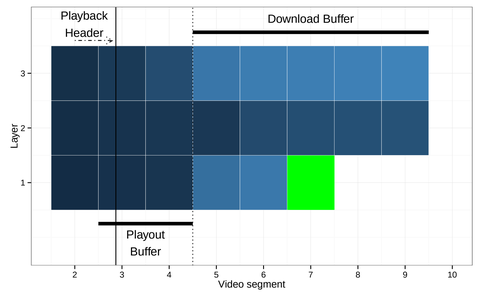
The *access model* contrains how much content may be stored in a buffer on the user's device.



- **Streaming.** Data may only be downloaded just in time to be decoded and played back.
- **Downloading.** Video data may be retrieved indefinitely far ahead and stored on the user's device until it is played back.
- **Streamloading.** Hybrid access model, where the base layer is streamed and enhancement layers may be prefetched [1].

Semi-Markov Decision Process Formulation

State. The state of the process includes the channel quality, the occupancy of the playout buffer and download buffer, and the playback position.



Actions. The action is expressed as a layer index (0,1, or 2) of a future segment to download next. Depending on the state and the access rules only a subset of these actions may be allowed.

Channel Model. The channel is a stochastic process based on empirical channel measurements of a cellular data network in a dense urban area in downtown Brooklyn.

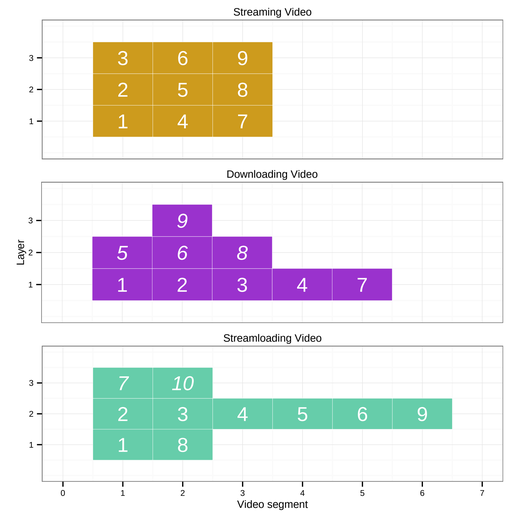
Reward. The reward function for the SMDP is:

$$r_{a,s} = \sum_{t=1}^{t_{s,a}} \log\left(\sum_{k=1}^{u_t} l_k\right) \quad (1)$$

where $t_{s,a}$ is the duration of action a, u_t is the number of layers for a segment to be played in timestamp t, and l_k is the size of the k^{th} layer of the video being played in one time slot.

Solution. We use the value iteration method [2] to solve the SMDP.

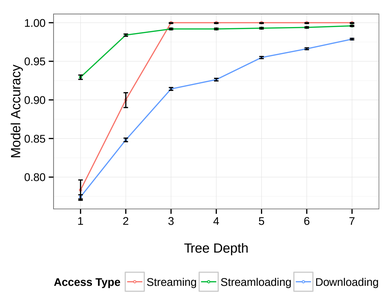
Policies



Policy Approximation

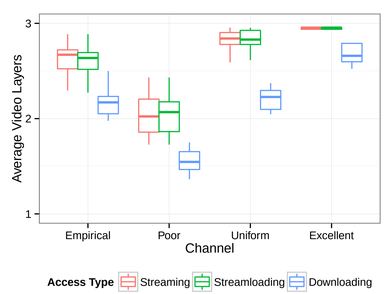
The SMDP policy is essentially a classifier, which takes as its input a 7-dimensional state, and outputs one of a set of actions. To approximate the SMDP policy, we use a decision tree [3] to develop a simplified set of rules for selecting the next download.

Approximate Policies



A tree-based policy of depth 3 chooses the same action as the SMDP in > 90% of states, for all access models under consideration.

External Validity



The policy gives reasonable results under conditions different from the empirical channel process with which the policy was derived.

Demonstration

http://goo.gl/ZK4zKP

References

[1] A. Rath, S. Goyal, and S. Panwar, "Streamloading: low cost high quality video streaming for mobile users," in *Proceedings of the 5th Workshop on Mobile Video (MoVid '13)*. New York, NY, USA: ACM, 2013, pp. 1–6.

[2] P. J. Schweitzer, "Iterative solution of the functional equations of undiscounted markov renewal programming," *Journal of Mathematical Analysis and Applications*, vol. 34, no. 3, pp. 495–501, 1971.

[3] T. Hothorn, K. Hornik, and A. Zeileis, "Unbiased recursive partitioning: A conditional inference framework," *Journal of Computational and Graphical Statistics*, vol. 15, no. 3, pp. 651–674, 2006.