Empowering the Creative User:
Personalized HTTP-based
Adaptive Streaming of Multi-path Nonlinear Video

Vengatanathan Krishnamoorthi[1], Patrik Bergström[1], Niklas Carlsson[1], Derek Eager[2], Anirban Mahanti[3], Nahid Shahmehri[1]

[1] Linköping university, Sweden
[2] University of Saskatchewan, Canada
[3] NICTA, Australia

LiU EXPANDING REALITY

Most of us have seen Tom & Jerry movies, what if they could create their own versions of these movies??

For a minute...think that you are Tom

For a minute...think that you are Tom
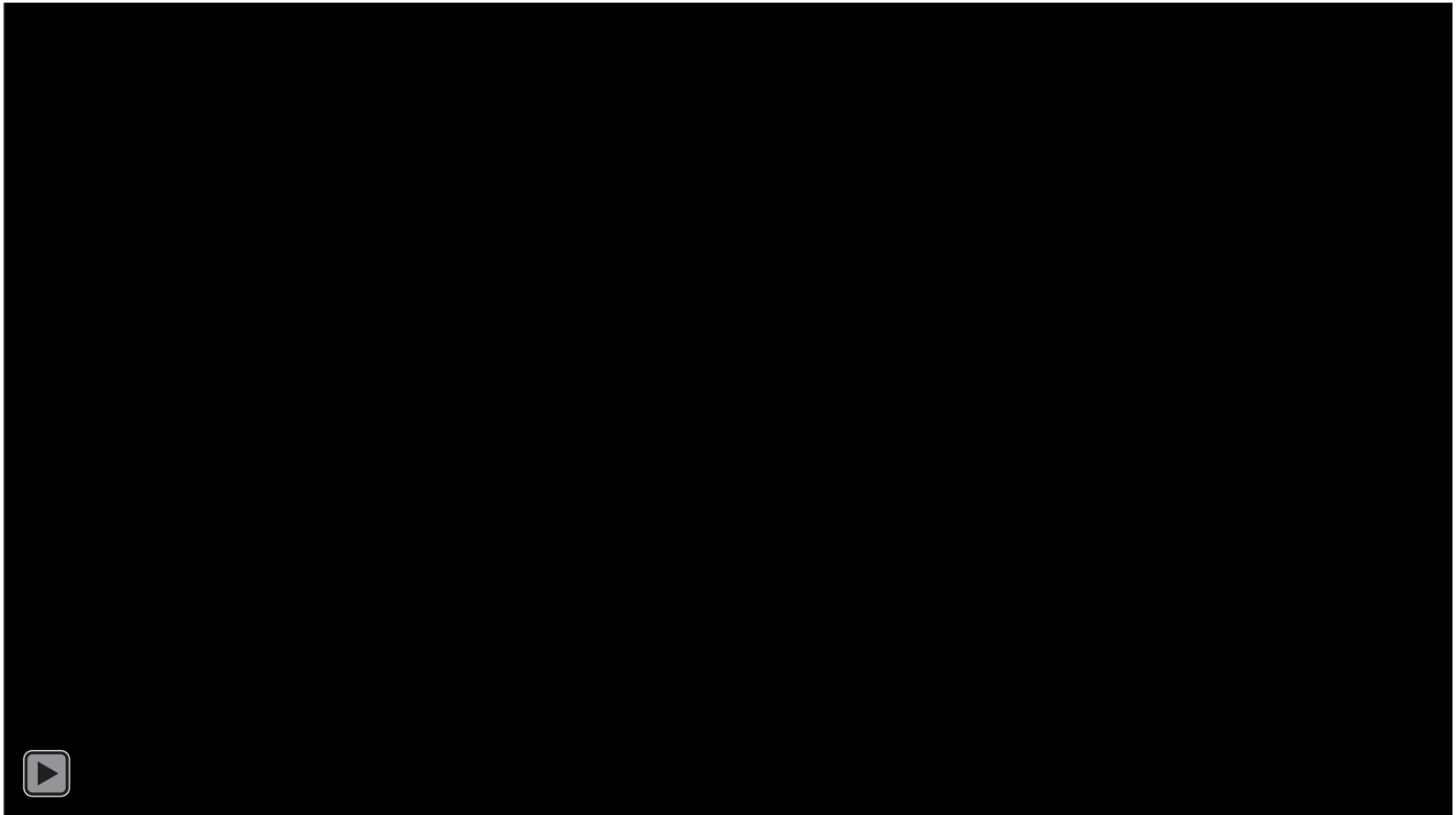
Likes:

For a minute...think that you are Tom

Likes:

For a minute...think that you are Tom

Dislikes:

Tom's video

ACROBAT READER IS REQUIRED TO PLAY THE VIDEO, NOT COMPATIBLE WITH OTHER PDF VIEWERS
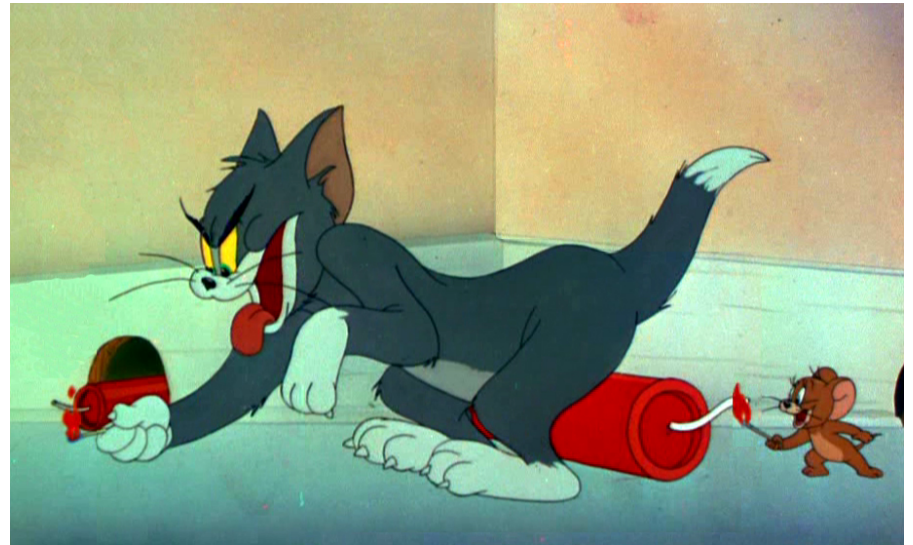
LiU EXPANDING REALITY

Now, lets look at his opponent Jerry

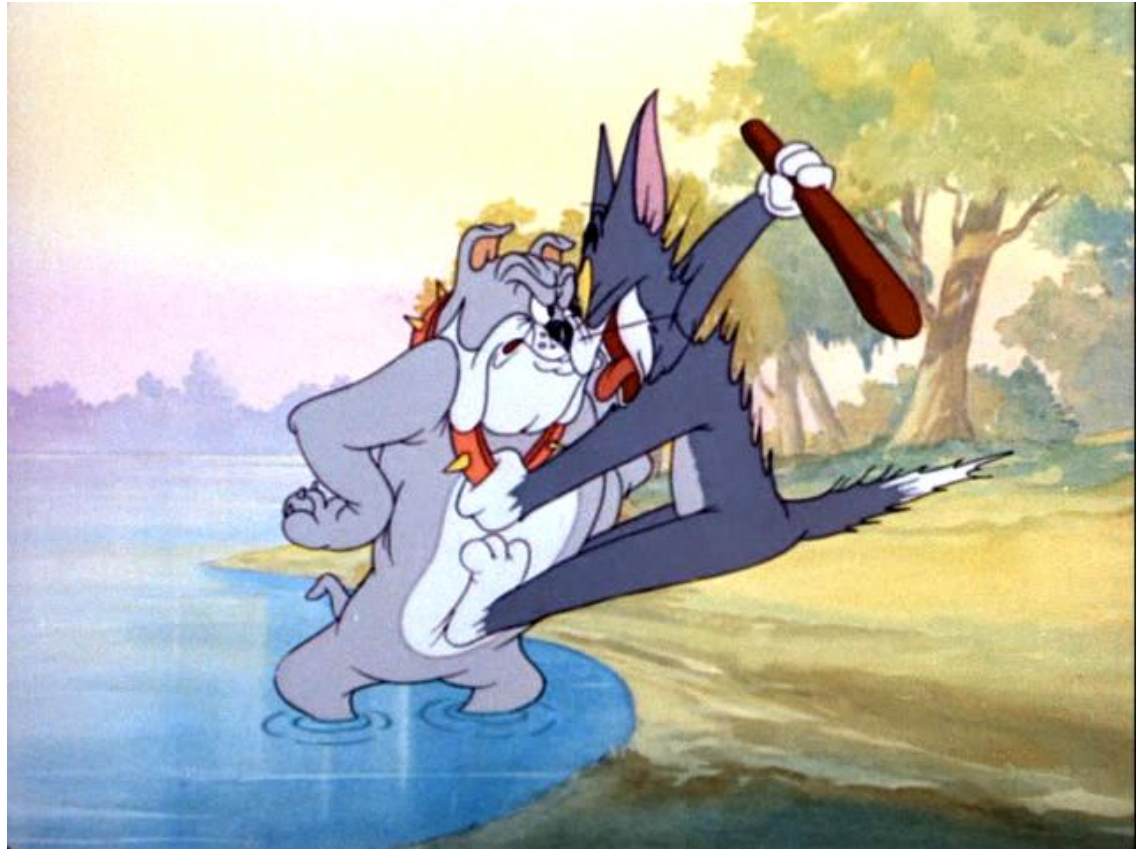# Now, lets look at his opponent Jerry
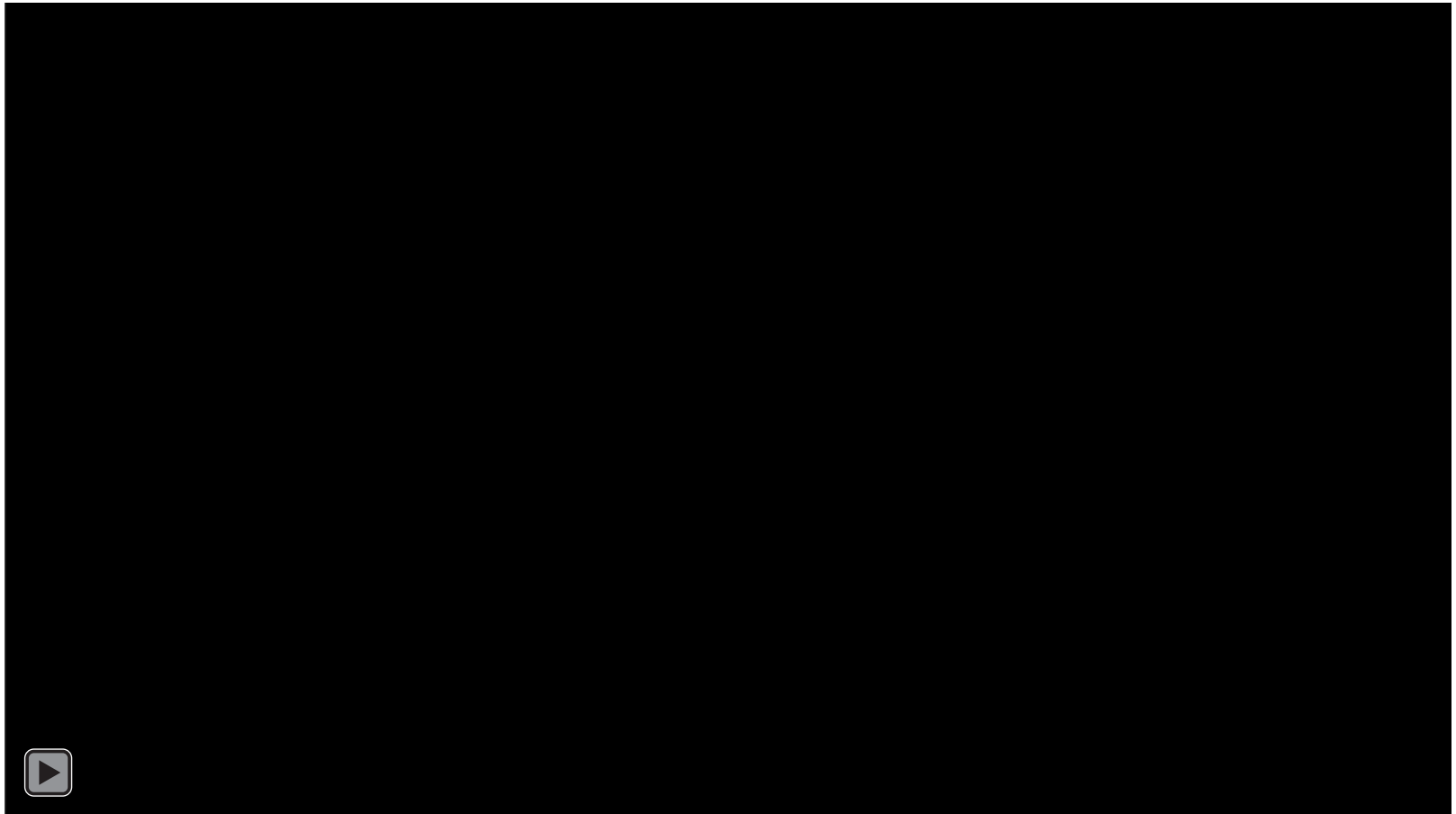

Likes:

Now, lets look at his opponent Jerry

Likes:

Now, lets look at his opponent Jerry

Dislikes:

LiU EXPANDING REALITY

Jerry's video

ACROBAT READER IS REQUIRED TO PLAY THE VIDEO, NOT COMPATIBLE WITH OTHER PDF VIEWERS

LiU EXPANDING REALITY

Contributions

- Framework that allows the creator to easily create customized playback experiences for the viewer

  - Combines ideas of personalized multi-path video and HTTP-based adaptive streaming (HAS)

- Creator can use a light-weight personalized metafile to define any arbitrary set of paths and path choices through some original video (or file that concatenate multiple linear video clips)

- Allows viewer to traverse through the video by interacting with the player and choosing among multiple path options

- Seamless video playback using rate-adaptive prefetching and buffer management based on current network conditions
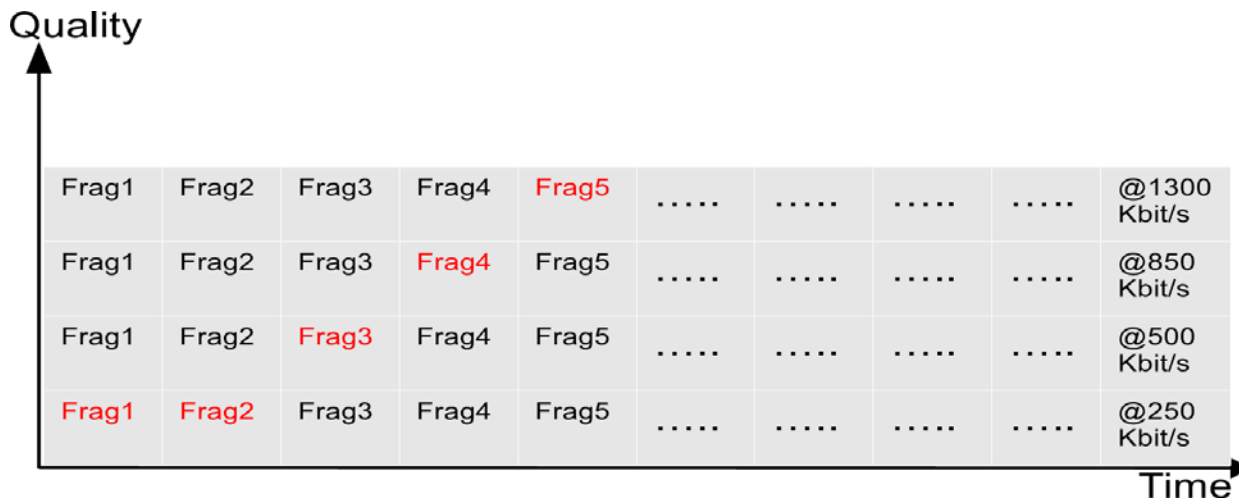
LiU EXPANDING REALITY

HTTP-based streaming

Frag1	Frag2	Frag3	Frag4	Frag5	.....	.....	.....	.....	Frag20

Time →
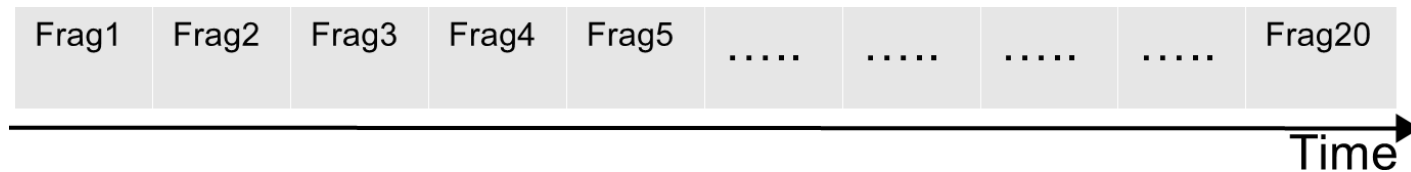
- HTTP-based streaming

  - Split into fragments

  - Use of HTTP allows: Easy caching, get through NATs/firewalls, etc.

  - Some support for interactive VoD

HTTP-based adaptive streaming (HAS)

- HTTP-based adaptive streaming
  - Multiple encodings of each fragment (defined in manifest file)
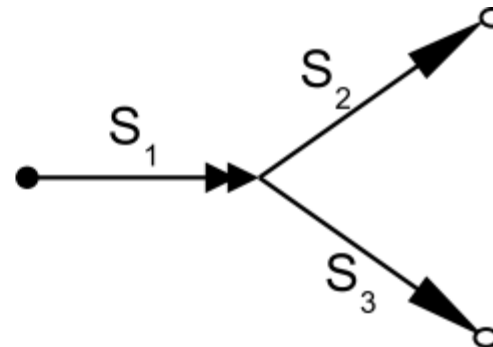 - Clients adapt quality encoding based on (buffer and network) conditions
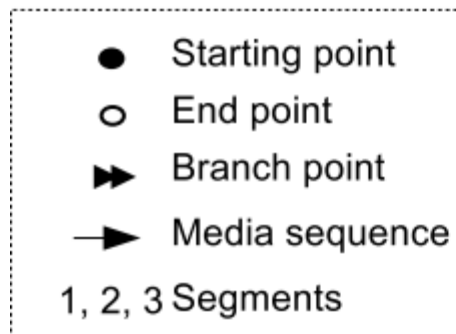
Nonlinear multi-path video

- **Nonlinear segments:** non-contiguous fragments of video can be stitched together to form what we term nonlinear video segments

Fragments 1-5	Fragments 11-15	Fragments 7-9

Segment S_1

- **Multi-path and branch points:** The video can include branch points at which there are multiple choices of which segment to play back next

- ● Starting point
- ○ End point
- ►► Branch point
- → Media sequence
- 1, 2, 3 Segments
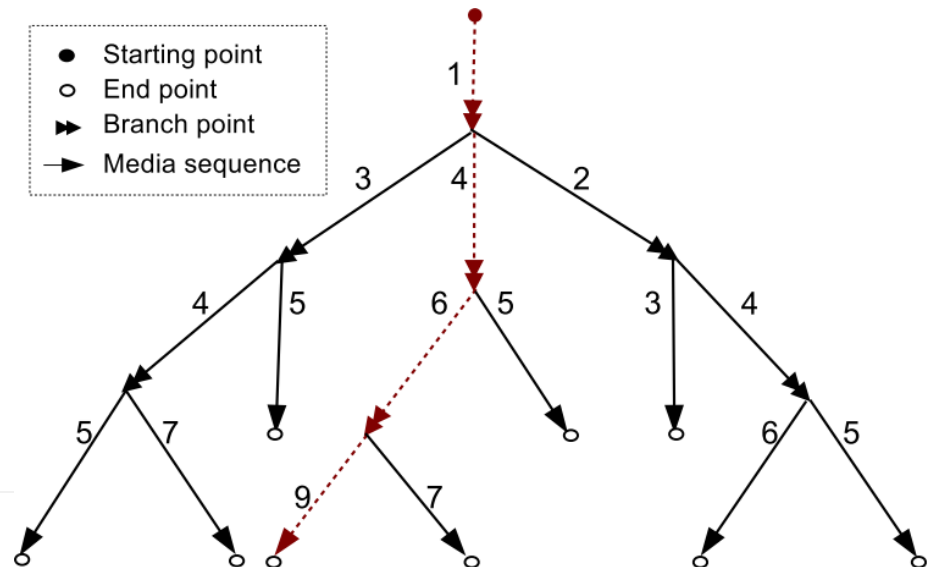
LiU EXPANDING REALITY

A separate flexible and personalizable metafile

- In addition to regular manifest file, we use a separate metafile

- Allows the creator to define any arbitrary set of paths and path choices through some original video (or a file that is the concatenation of multiple linear video clips, for example)

  - Nonlinear segments and branch points

- Longest path matching

  - Maintain history of player path

  - Break ties when multiple contenders

LiU EXPANDING REALITY

A separate flexible and personalizable metafile

- In addition to regular manifest file, we use a separate metafile

- Allows the creator to define any arbitrary set of paths and path choices through some original video (or a file that is the concatenation of multiple linear video clips, for example)

  - Nonlinear segments and branch points

- Longest path matching

  - Maintain history of player path

  - Break ties when multiple contenders

A separate flexible and personalizable metafile

- In addition to regular manifest file, we use a separate metafile

- Allows the creator to define any arbitrary set of paths and path choices through some original video (or a file that is the concatenation of multiple linear video clips, for example)

  - Nonlinear segments and branch points

- Longest path matching

  - Maintain history of player path

  - Break ties when multiple contenders

length: 4 3 2 2 3 2 2 2 2 2
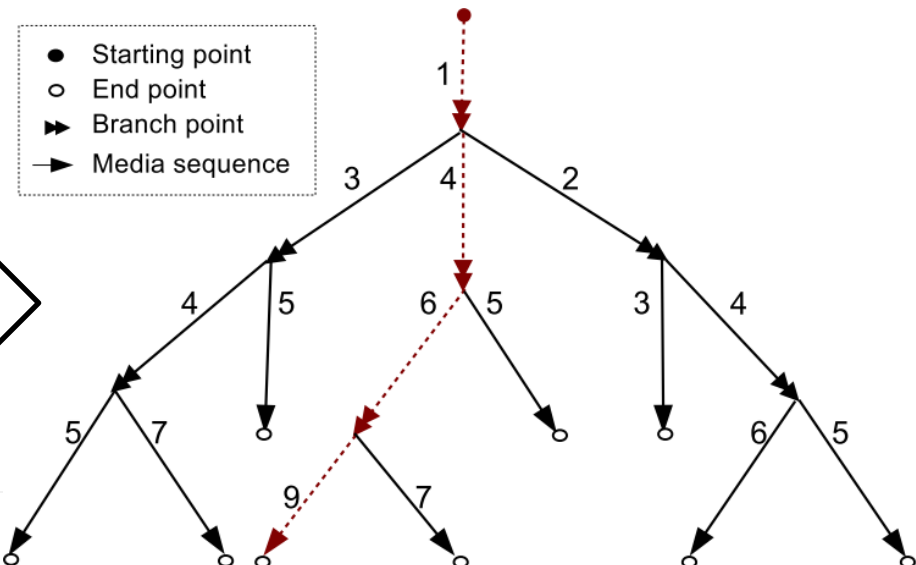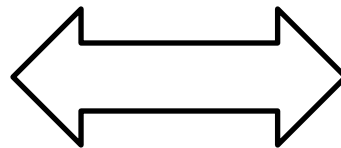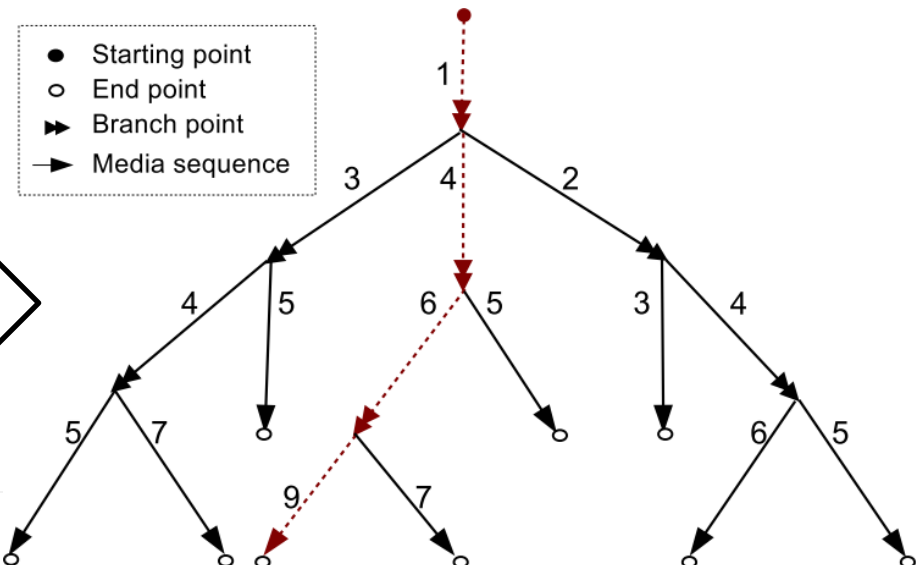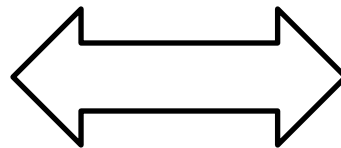
begin 1(2,3,4)

12(3,4)

24(5,6)

13(4,5)

34(5,7)

14(5,6)

146(7,9) end

A separate flexible and personalizable metafile

- In addition to regular manifest file, we use a separate metafile

- Allows the creator to define any arbitrary set of paths and path choices through some original video (or a file that is the concatenation of multiple linear video clips, for example)

  - Nonlinear segments and branch points

- Longest path matching

  - Maintain history of player path

  - Break ties when multiple contenders

A separate flexible and personalizable metafile

- In addition to regular manifest file, we use a separate metafile

- Allows the creator to define any arbitrary set of paths and path choices through some original video (or a file that is the concatenation of multiple linear video clips, for example)

  - Nonlinear segments and branch points

- Longest path matching

  - Maintain history of player path

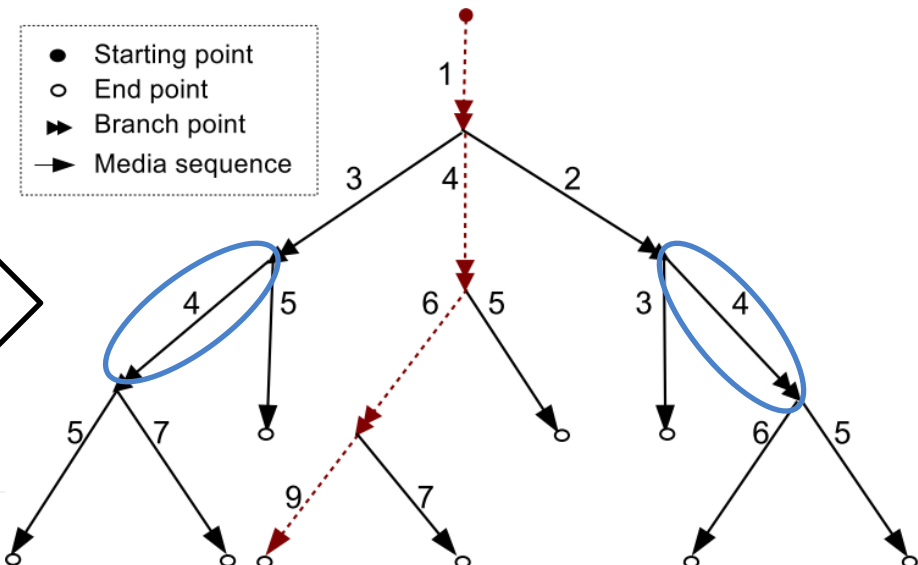 - Break ties when multiple contenders

length: 4 3 2 2 3 2 2 2 2 2
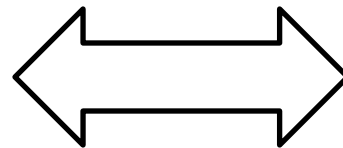
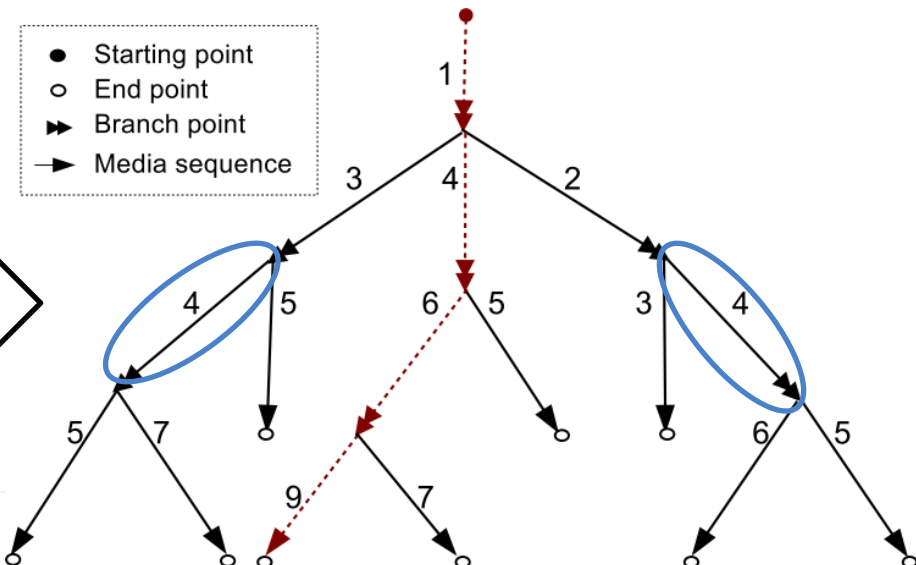begin 1(2,3,4)
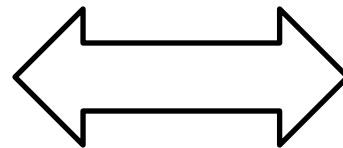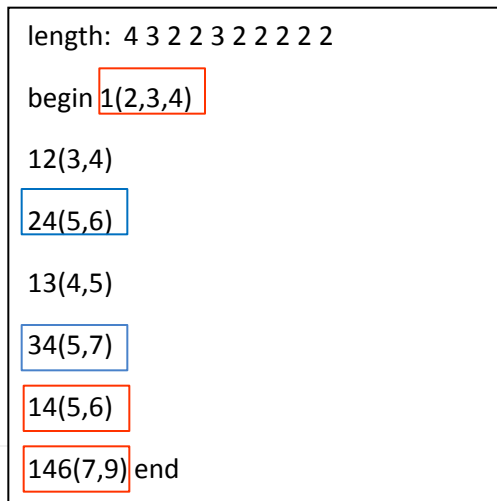
12(3,4)

24(5,6)

13(4,5)

34(5,7)

14(5,6)

146(7,9) end

A separate flexible and personalizable metafile

- In addition to regular manifest file, we use a separate metafile

- Allows the creator to define any arbitrary set of paths and path choices through some original video (or a file that is the concatenation of multiple linear video clips, for example)

  - Nonlinear segments and branch points

- Longest path matching

  - Maintain history of player path

  - Break ties when multiple contenders

The player

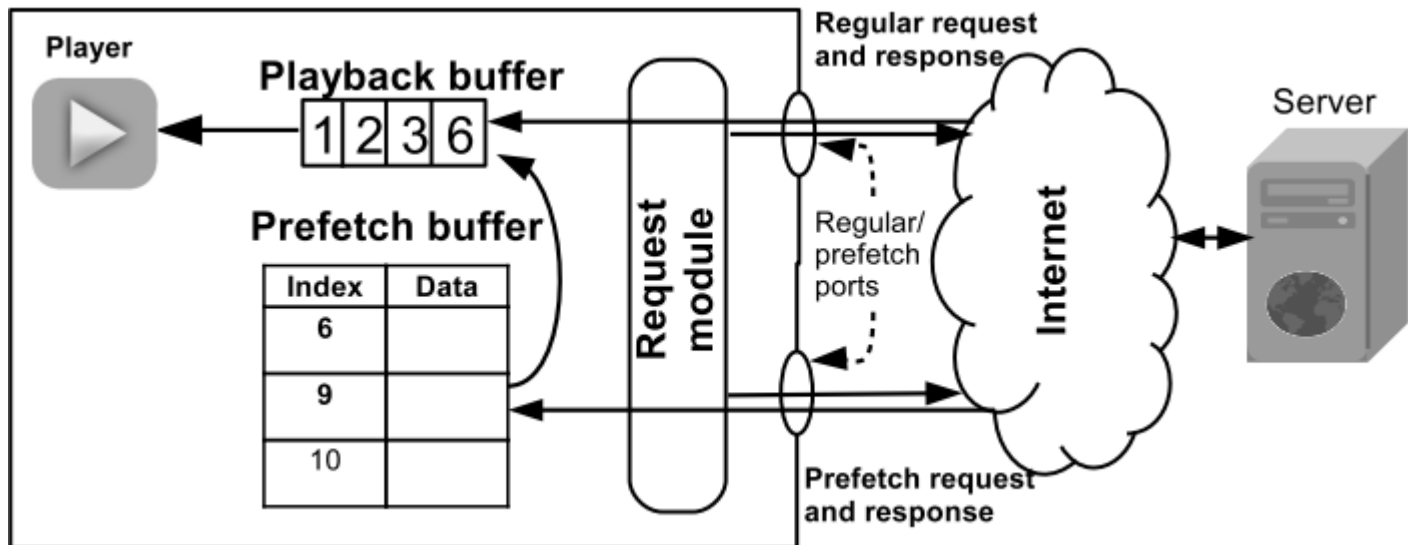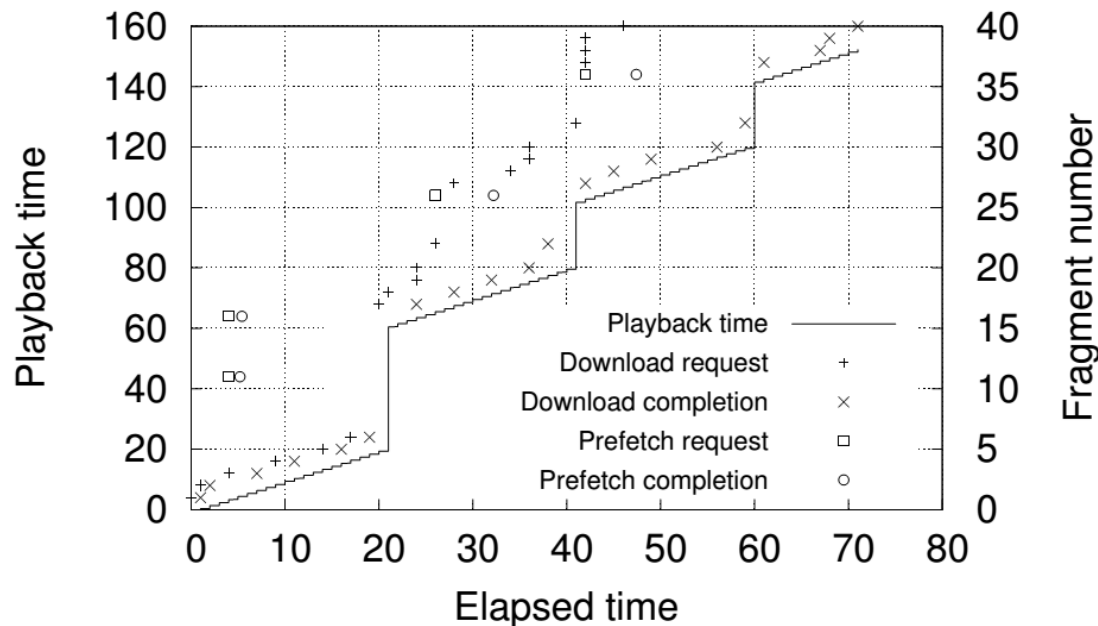# Prefetching and rate adaptation

- Adapt prefetch quality requests based on branch points and buffer/network conditions

- Player modifications include

  - Internal prefetch buffer

  - Prefetch module for requests

  - Buffer managament for branch points

Proof-of-concept evaluation

- Setup
  - Server (Adobe media server 5.0); Client (Firefox)
  - Available bandwidth (dummynet: 1, 2, 3 Mbps)

- Prefetch ahead of branch points

- No stall events (late data)

- Adapt prefetch quality to current conditions

Proof-of-concept evaluation

- Setup
  - Server (Adobe media server 5.0); Client (Firefox)
  - Available bandwidth (dummynet: 1, 2, 3 Mbps)
- Prefetch ahead of branch points
- No stall events (late data)
- Adapt prefetch quality to current conditions
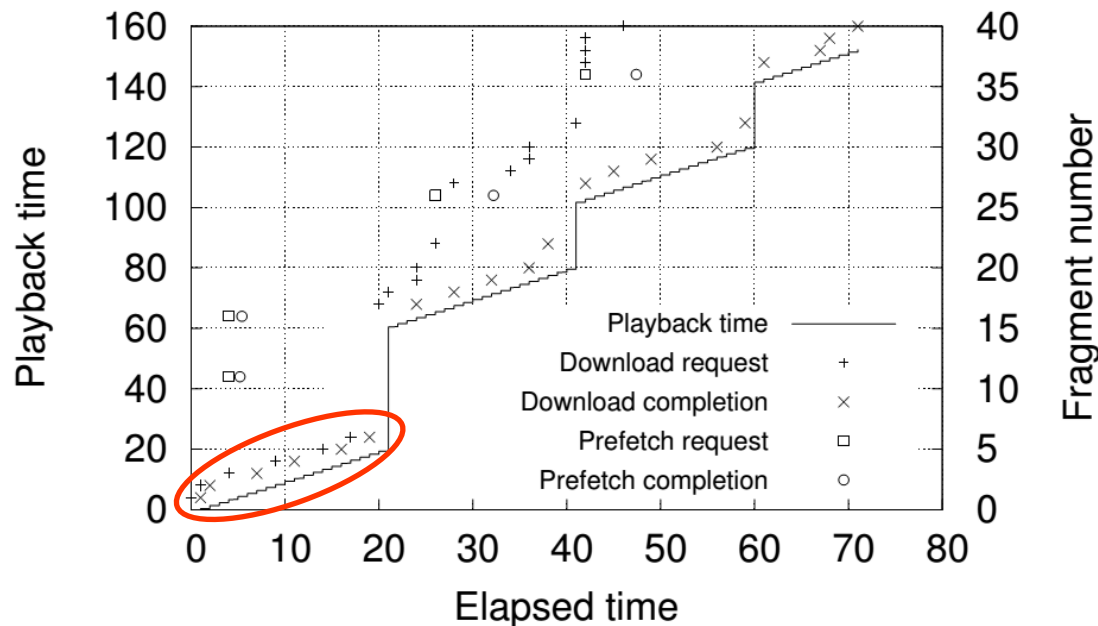
Proof-of-concept evaluation

- Setup
  - Server (Adobe media server 5.0); Client (Firefox)
  - Available bandwidth (dummynet: 1, 2, 3 Mbps)
- Prefetch ahead of branch points
- No stall events (late data)
- Adapt prefetch quality to current conditions
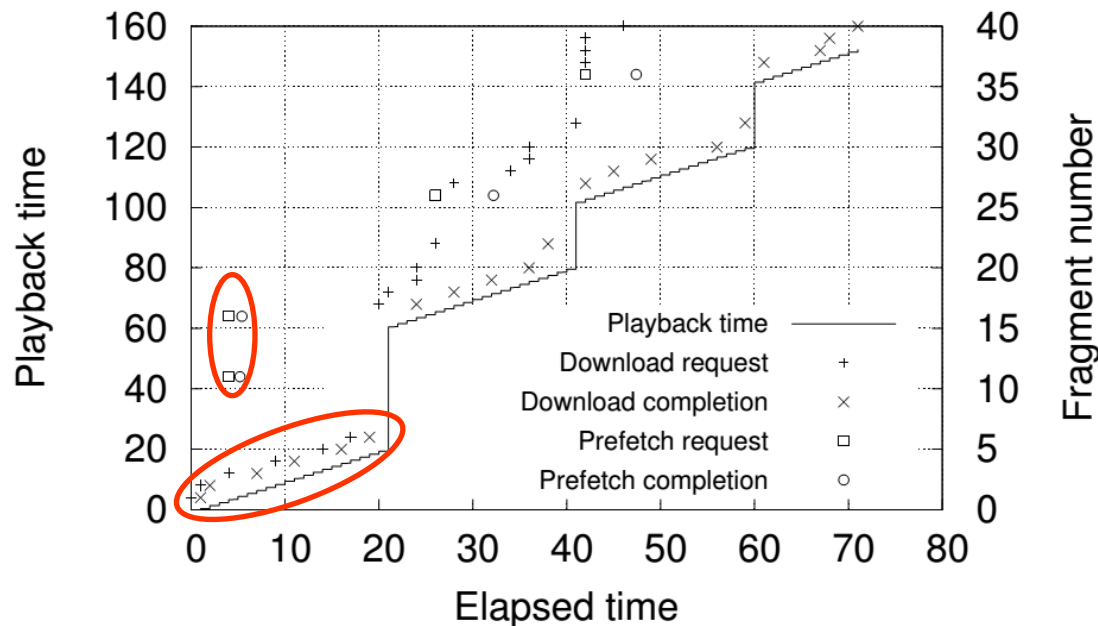
Proof-of-concept evaluation

- Setup
  - Server (Adobe media server 5.0); Client (Firefox)
  - Available bandwidth (dummynet: 1, 2, 3 Mbps)
- Prefetch ahead of branch points
- No stall events (late data)
- Adapt prefetch quality to current conditions
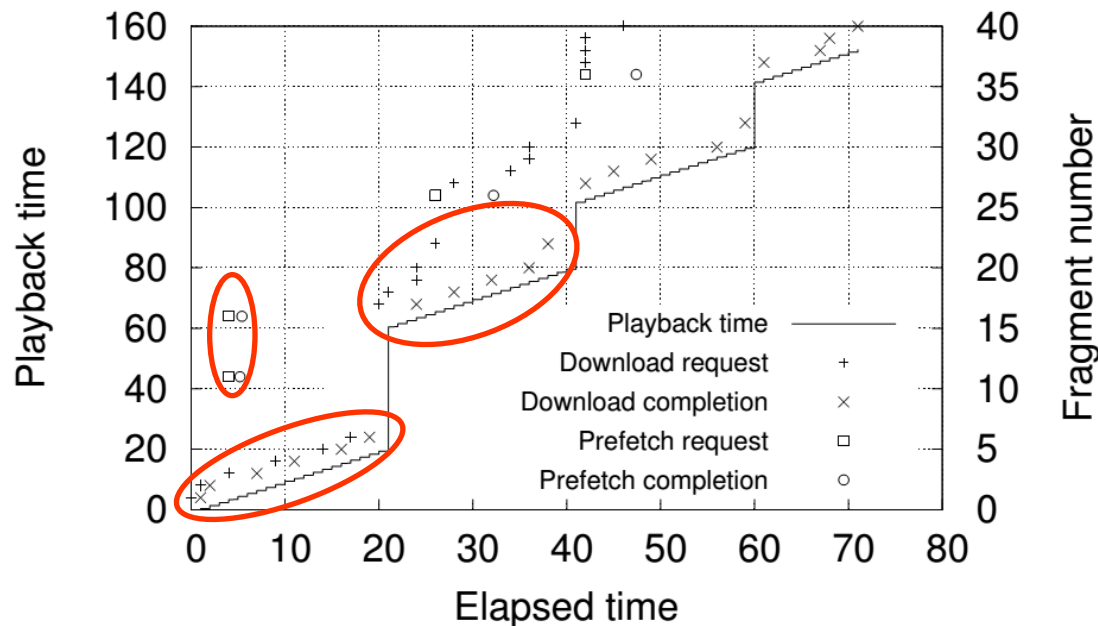
Proof-of-concept evaluation

- Setup
  - Server (Adobe media server 5.0); Client (Firefox)
  - Available bandwidth (dummynet: 1, 2, 3 Mbps)
- Prefetch ahead of branch points
- No stall events (late data)
- Adapt prefetch quality to current conditions

| Scenario	Policy	Late data (stall events)	Branch time (seconds)
3Mb/s	No prefetching	100%	3.39 (0.94)
	Adaptive prefetch	0%	0.49 (0.10)
2Mb/s	No prefetching	100%	4.96 (1.08)
	Adaptive prefetch	0%	0.64 (0.19)
1Mb/s	No prefetching	100%	4.14 (1.10)
	Adaptive prefetch	0%	0.68 (0.17)

Proof-of-concept evaluation

- Setup
  - Server (Adobe media server 5.0); Client (Firefox)
  - Available bandwidth (dummynet: 1, 2, 3 Mbps)
- Prefetch ahead of branch points
- No stall events (late data)
- Adapt prefetch quality to current conditions
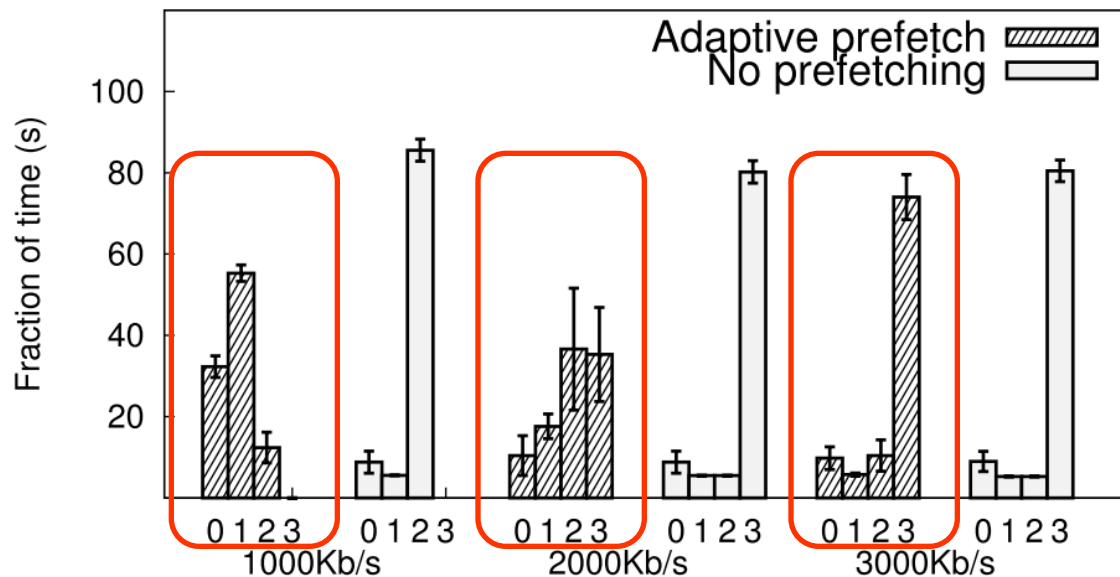
Conclusions and future work

- ## Conclusions

  - We have designed and developed an interactive multi-path nonlinear media player; leveraging fragment-based nature and differentiated quality levels of HTTP-based adaptive streaming

  - Endless personalization of content using a simple metafile

  - Seamless playback achieved by careful prefetching and buffer management policies
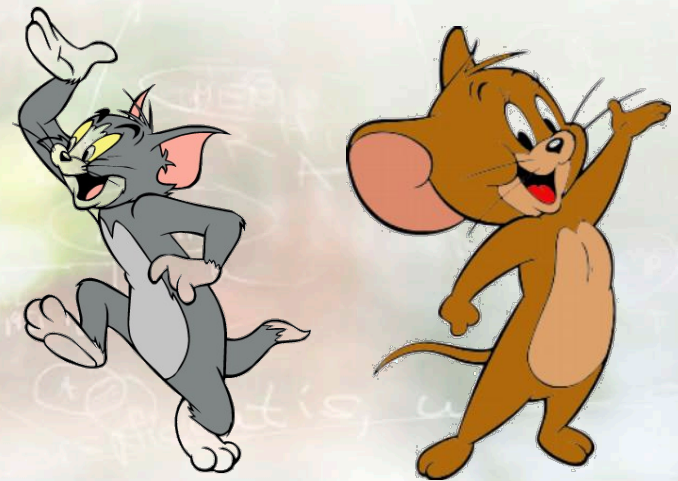
- ## Future work

  - Design and evaluation of improved prefetching and buffer management policies

  - Detailed player evaluation under a wider range of scenarios

LiU EXPANDING REALITY

Empowering the Creative User:
Personalized HTTP-based Adaptive
Streaming of Multi-path Nonlinear Video

Linköping University
expanding reality

Contact: **Vengatanathan (Vengat) Krishnamoorthi**

vengatanathan.krishnamoorthi@liu.se

www.liu.se