# Towards Understanding User Tolerance to Network Latency in Zoomable Video Streaming

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## Goal

We conducted a user study with 35 participants to understand:

- User tolerance to network latency when interacting with zoomable video streams
- How the choice of concealment schemes affects user tolerance to delay

## Importance of Delay Tolerance Study

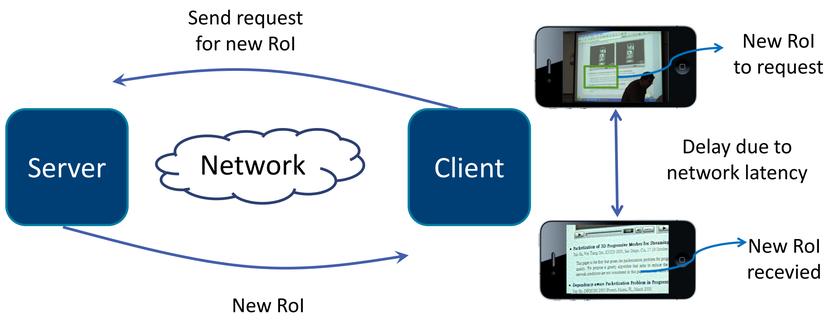
Knowing tolerance levels can help in designing a system

- Decide whether prefetching or caching is necessary for a streaming system of zoomable videos.
- Build better peer-to-peer streaming protocol for requesting or disseminating data of RoIs among the peers in peer-to-peer streaming system.

## Zoomable Video Streaming

Zoomable video allows users to zoom and pan around a video to watch a region-of-interest (RoI) at a higher resolution.

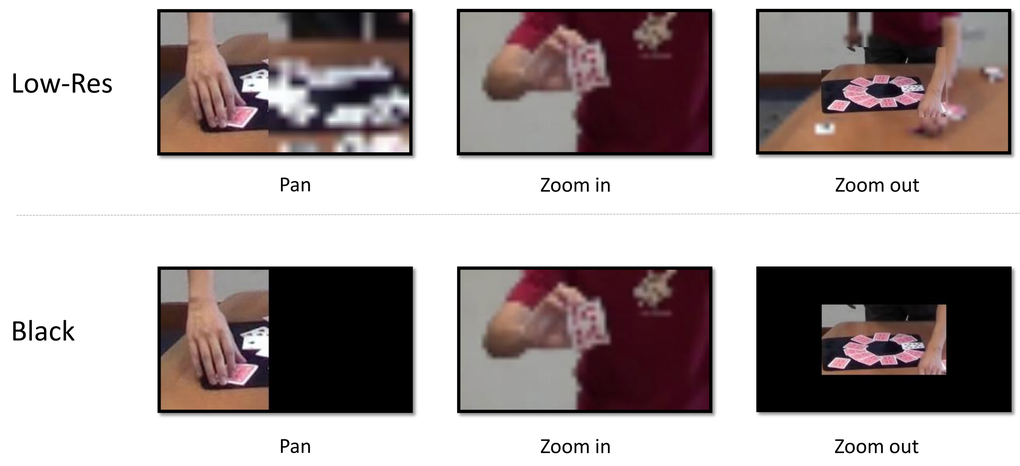

We are interested in supporting zooming and panning in the streaming context, where video sources are available at the server side.




## Concealment Schemes

Concealment schemes attempt to quickly respond to a change in RoI, by displaying parts of new RoI with data already available. Two concealment schemes, *Low-Res* and *Black*, differ in how they *conceal unavailable parts* of new RoI.

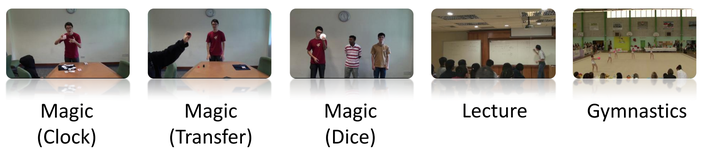
- Black scheme renders newly revealed part as region of black pixels.
- Low-Res scheme covers any unfilled part of new RoI with pixels up-scaled from the corresponding region of thumbnail video.




## User Study

### Experiment Parameters

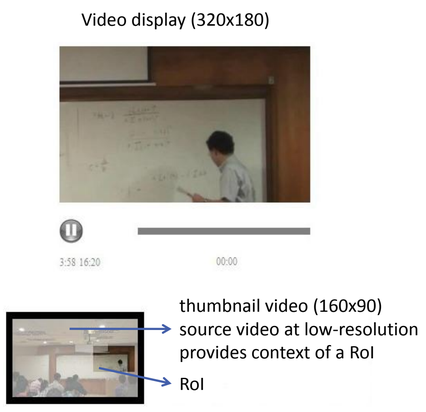
- Video Clips: 5 video clips captured by a HD camera




- Pilot Study: a pilot study with 8 users to find out the proper range of delay values
- Delay values (second): 1, 2, 3, 4, 5
- Five delay values were randomly assigned with different videos to form five configurations.
  - avoiding the same video content to be watched multiple times in a session
  - avoiding fixed coupling between a delay and a video
- Five configurations were tested in each concealment schemes. So, we had 10 test cases.

### Experiments

- 35 participants (22 male, 13 female) were in the experiment.
- A demo & practice session was provided. No network latency was introduced in this session.
- Participants were not told about the presence of delay and delay values.
- Test cases were presented in a random order to avoid:
  - preference to any delay value or concealment scheme
  - users' adaptation to gradual change of delay (by not using *method of limits)*
- For each test case, a participant was asked to watch, interact (zoom/pan) with a video, and evaluate the *responsiveness* of zooming and panning.
  - *Do you find the responsiveness when zooming and panning acceptable?*




Support 6 zoom levels (0 – 5)
Highest video resolution 1920x1080

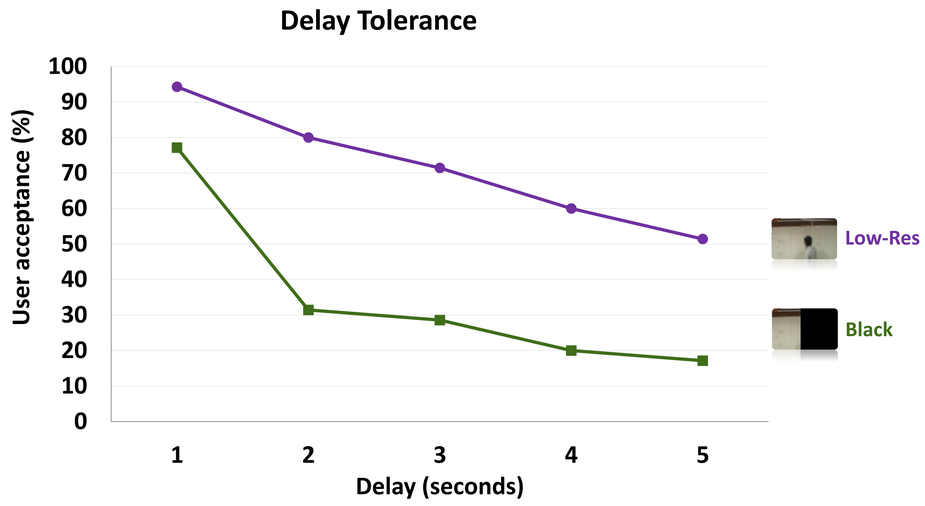
Zoom level 0: lowest level of details, equivalent to watching video of 1920x1080 resolution at the display size 320x180

Higher zoom level means watching a smaller RoI at the display size, with more details

Effects of network latency when users change RoI were simulated in the video player

## Results and Finding

We measure *user acceptance,* the percentage of participants who rated a delay value as acceptable.




## Finding

- More users were tolerable to delays in Low-Res scheme than Black scheme.
- Tolerable delay value in viewing zoomable video streams is higher than thresholds found in some high interactive multimedia applications.
- User tolerance starts degrading beyond 1 second: prefetching or caching is necessary.
- More time to request or forward data through multi-hops to reach a requesting peers.

## Conclusions

Our user study presented findings on:

- how much network latency users can tolerate in interaction with zoomable videos
- how their tolerance degrades in the presence of network latency
- how the choice of concealment scheme helps improve delay tolerance levels of users

Our findings can be incorporated into designing a system for streaming of zoomable video that provide both good Quality of Experience and Quality of Service.