User Experience Modeling for DASH Video

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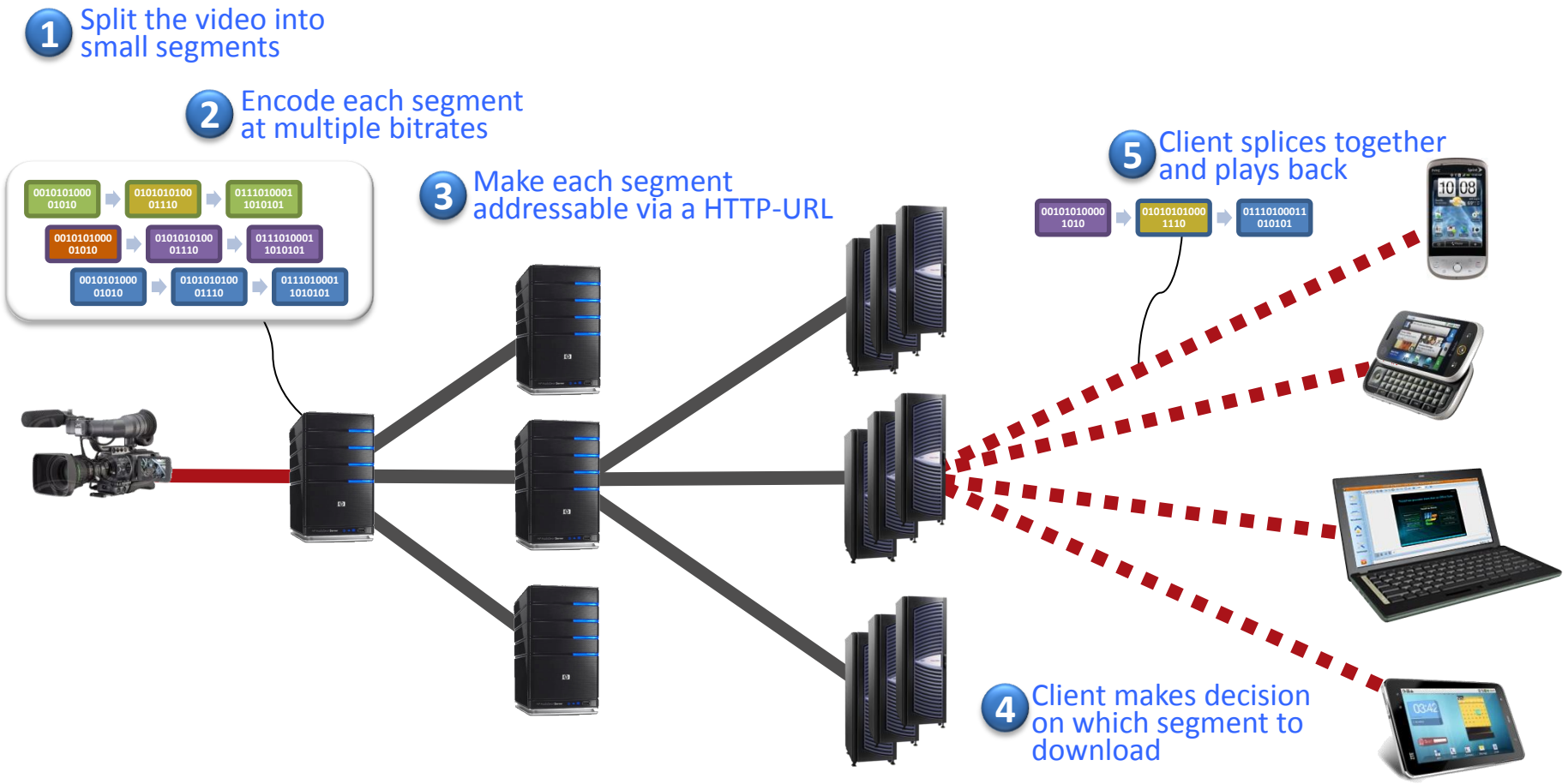
Dec 12, 2013

Introduction of DASH video

- DASH (dynamic adaptive streaming over HTTP) is a new standard for streaming media using standard web servers.
- The video bit rate/quality is adapted according to the network condition.



Introduction of DASH video (2)

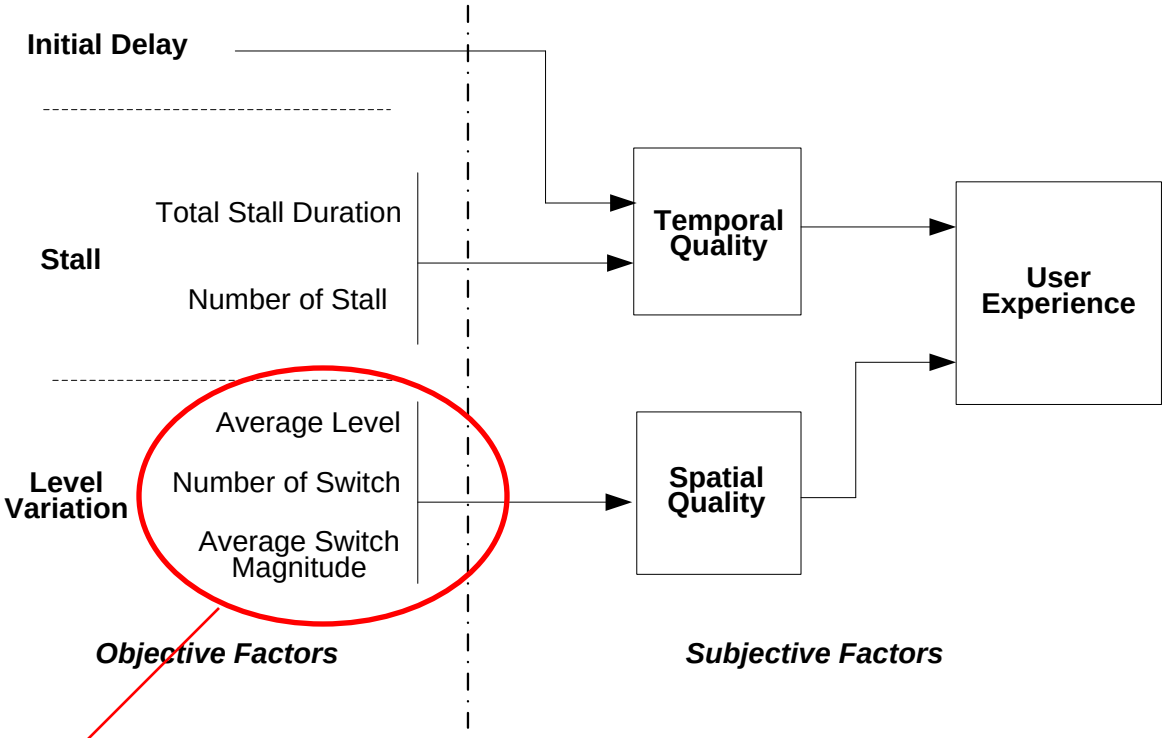
DASH video source are pre-encoded into several levels, splitted into short segments, and stored in Web sever.

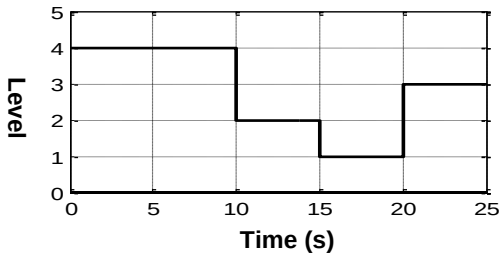
Level	Bit Rate (kbps)	Resolution	Frame Rate
1	400	312 x176	15
2	600	400 x 224	15
3	900	512 x 288	15
4	950	544 x 304	15
5	1250	640 x 360	25
6	1600	736 x 416	25
7	1950	848 x 480	25
8	3450	1280x720	30

Encoding settings for streaming Vancouver Olympics

How to quantitatively measure the user experience of DASH video streaming, without accessing the video source ?

Factors affecting User Experience for DASH video streaming





Average Level = (4+4+2+1+3)/5= 2.8

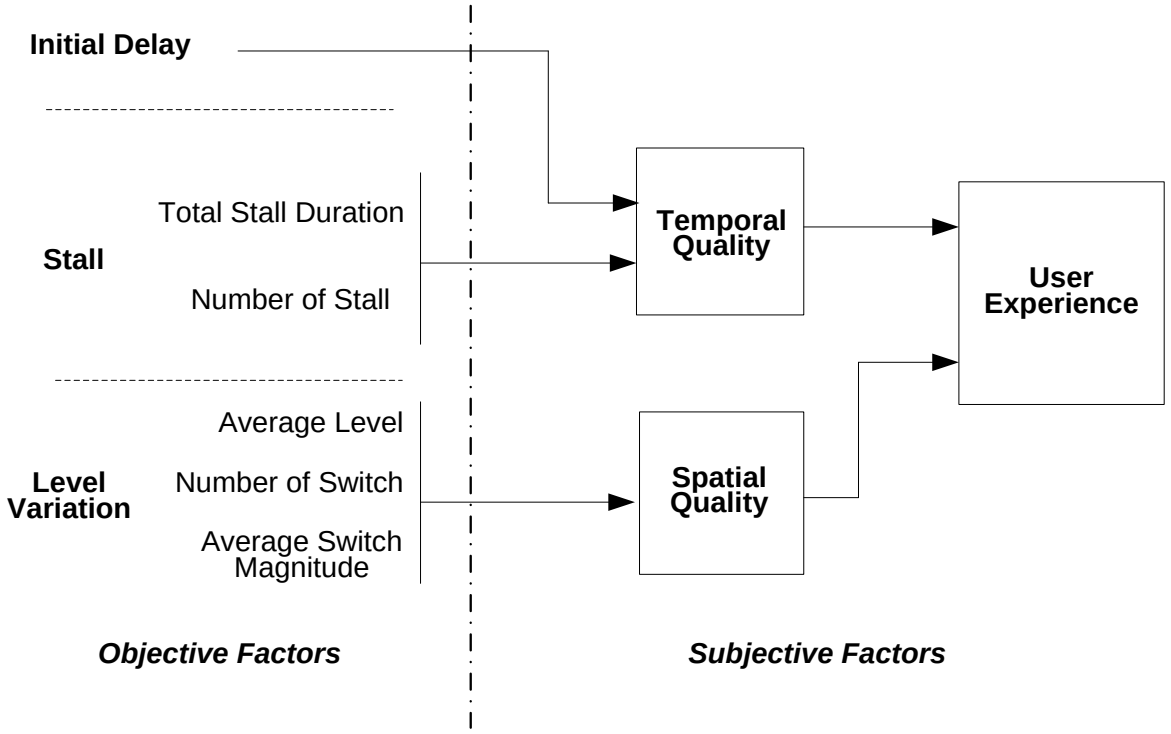
Number of Switch = 3

Average Switch Magnitude = [(4-2)+(2-1)+(3-1)]/3= 1.67

- Up to now, there is no publication which consider these factors simultaneously.

- We will conduct subjective experiments to derive impairment function for each of these factors

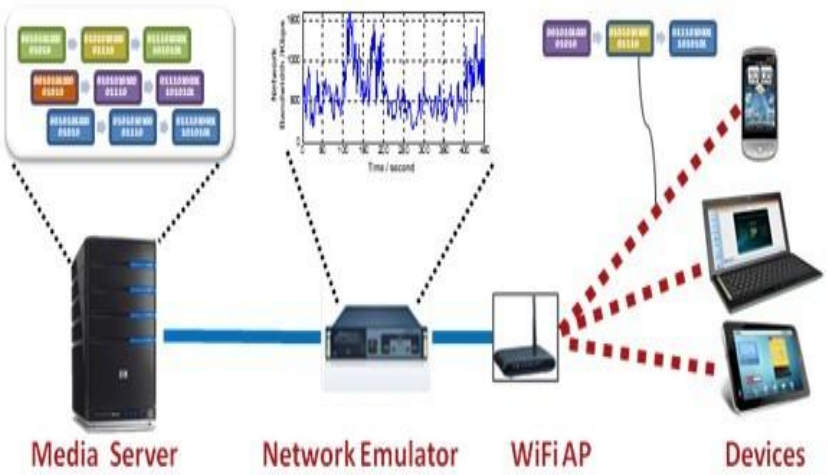
Factors affecting User Experience(2)



- There are also other factors that affect UE: such as video length, amount of motion in video. However, in this study, we focus on medium motion, short video (about several minutes long).

DASH Video Streaming Characterization Experiment (1)

Before doing subjective test, we conduct a set of characterization experiment (streaming DASH video under various mobile network conditions), to understand and characterize how DASH adaptation algorithm will behave.

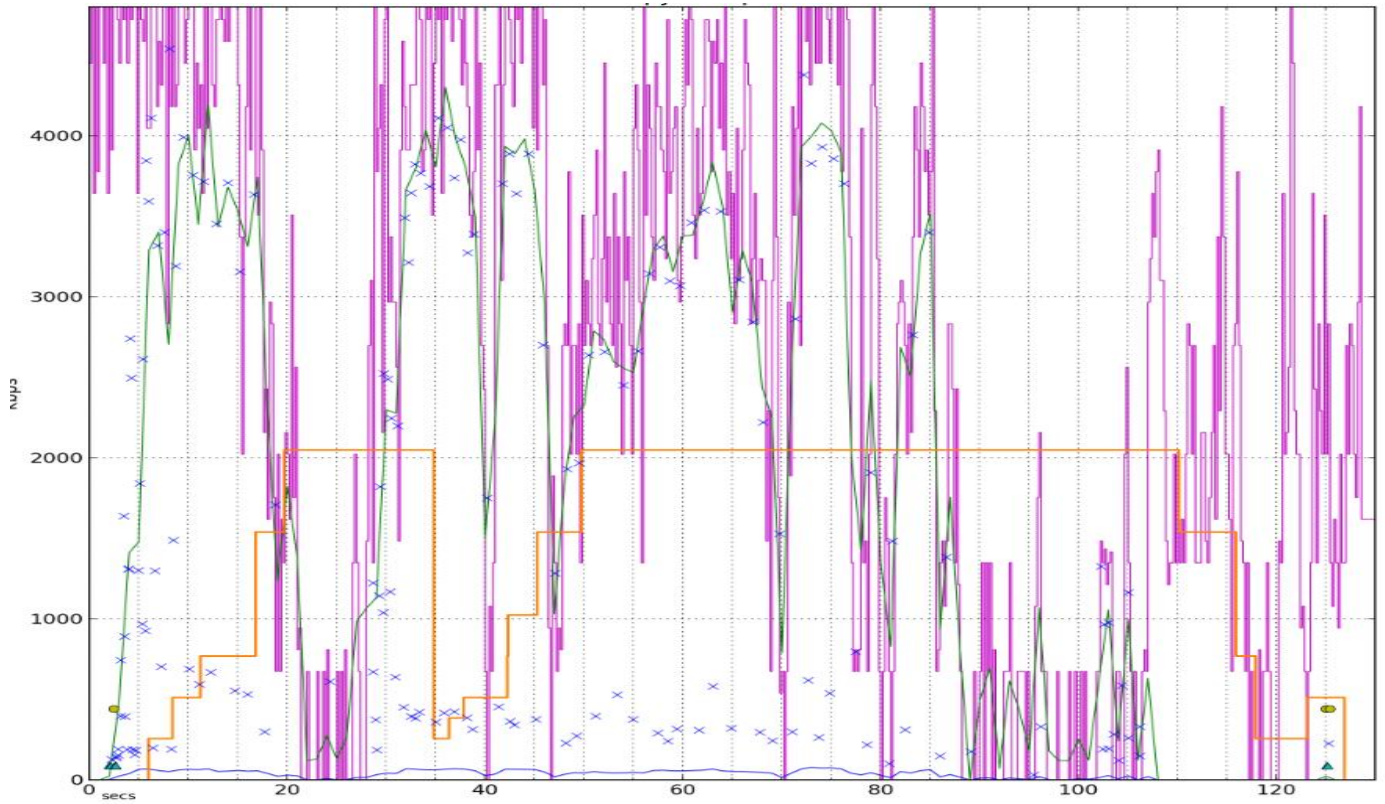


Testbed of DASH video streaming characterization experiment.

- We have tested under 20 Cellular network traces. The video length we choose is 2 minutes.
- Among the 20 traces, average bandwidth ~ [750, 1850] kbps, network latency ~ [0, 100] ms, packet loss rate ~ [0%, 1%].

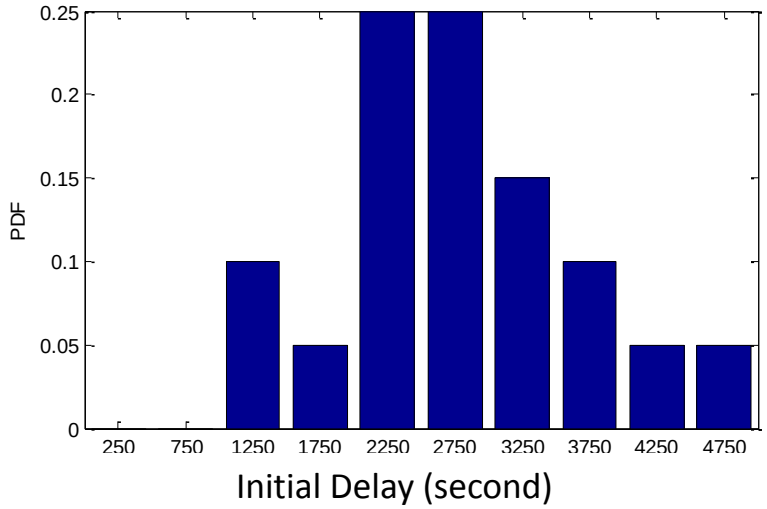
DASH Video Streaming Characterization Experiment (2)

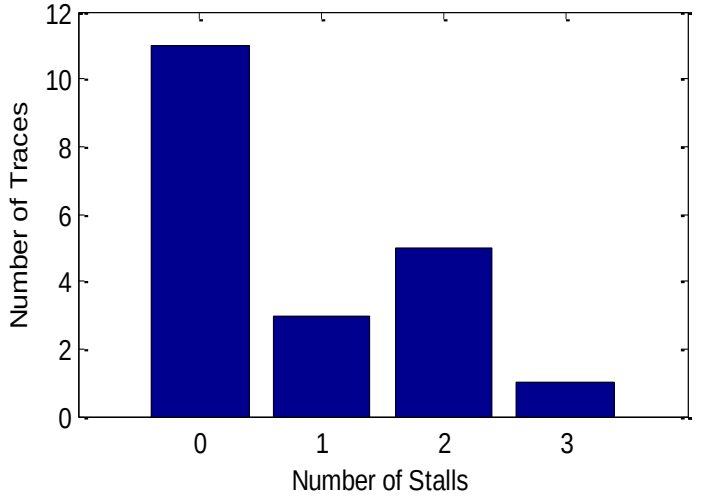
Sample plot of experiment result

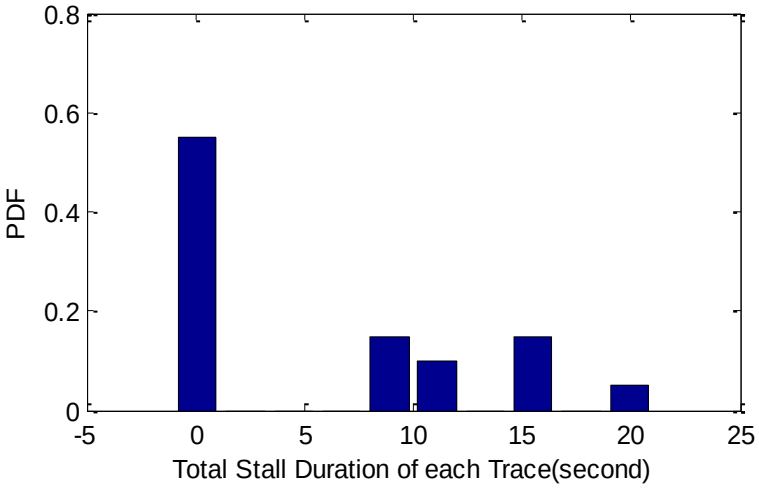


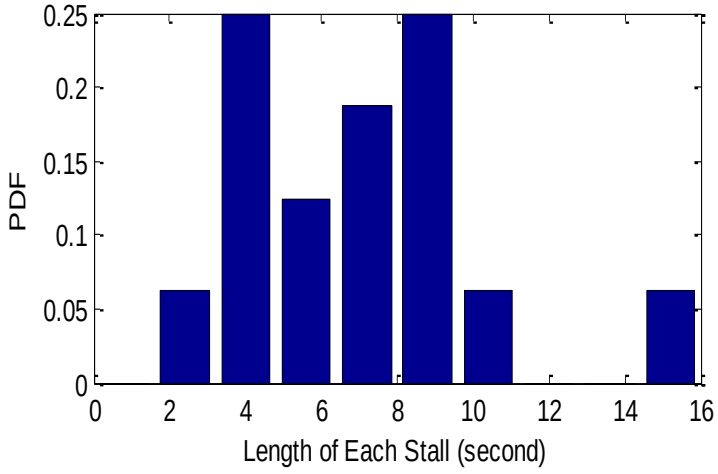
(1) purple curve: network bandwidth; (2) green curve: segments download bit rate; (3) orange curve: video bit rate.

Distribution of factors: initial delay and stall

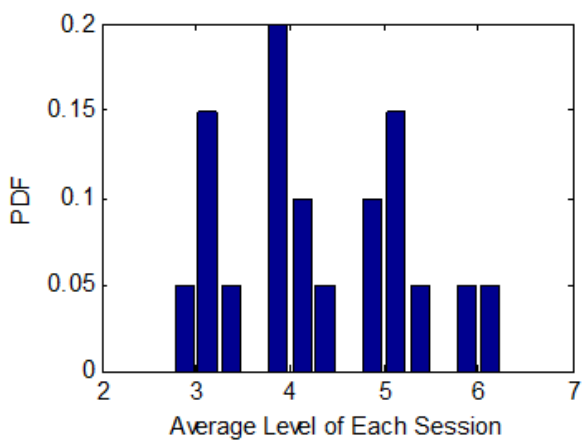


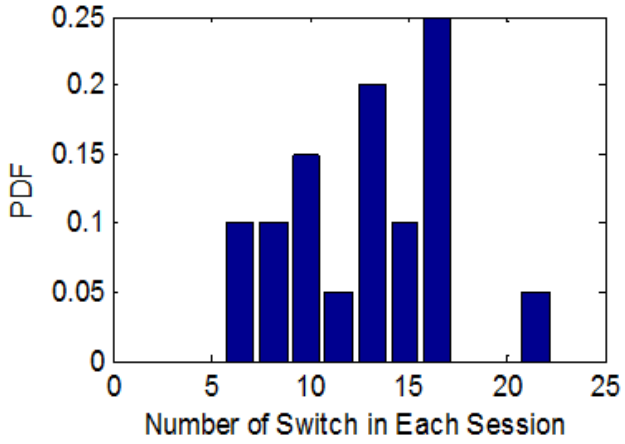


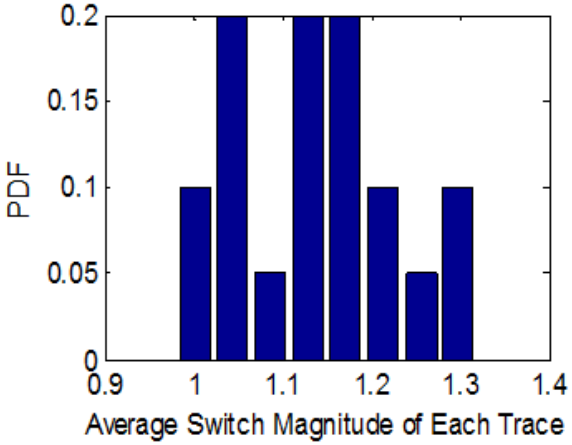




Distribution of factors: level variation







Distribution of level variation: (a) left, average level; (b) middle, number of switch; (c) right, average switch magnitude.

- We will develop test videos for subjective experiments according to the distribution of the factors.

- However, we will also include test videos whose characteristics are outside of what was observed in the DASH characterization tests, to ensure we also cover more extreme cases.

Test Videos for Subjective Experiment

- In subjective experiment, we aim at deriving impairment function for each factor (initial delay, stall and level variation), therefore we generate test video including impairment caused by these factors.
- In each test case, we only vary one factor, and keep the other two factors at their best values.

Video source we used for subjective experiment.

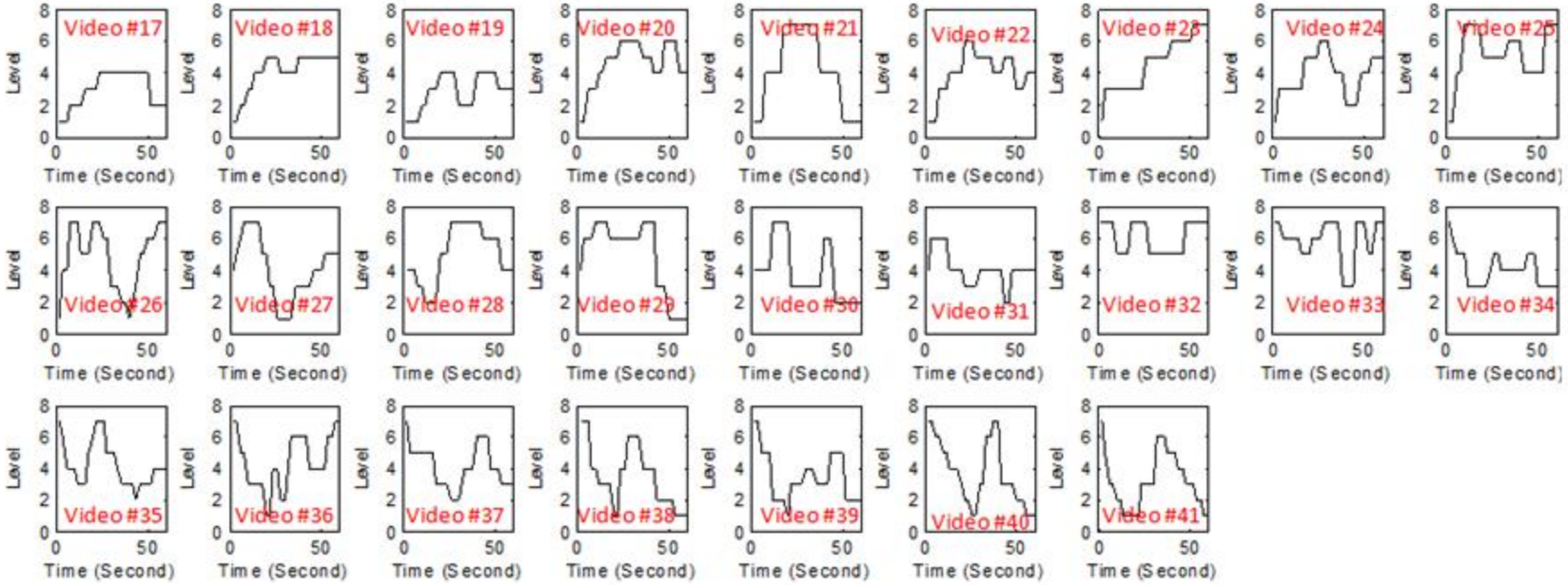
Video ID	1	2	3	4	5
Initial Delay Value (s)	2	4	6	10	15

TEST CASES FOR INITIAL DELAY

Video ID	6	7	8	9	10	11	12	13	14	15	16
Stall Duration	4 sec			8 sec				12 sec			4 sec
Stall Number	1	2	4	1	2	3	8	1	3	12	1

TEST VIDEOS FOR STALL

Test Videos for Subjective Experiment (2)



Test Videos of for Level Variation, including 25 different level variation patterns.

Subjective Experiment

- 30 subjects from UCSD, with age ranges from 18 to 28, were selected for the study.

- They will watch the designed DASH test videos (with impairment caused by the 3 factors) in a lab environment, and gives individual evaluation about the perceived video quality with a 100 point quality scale.

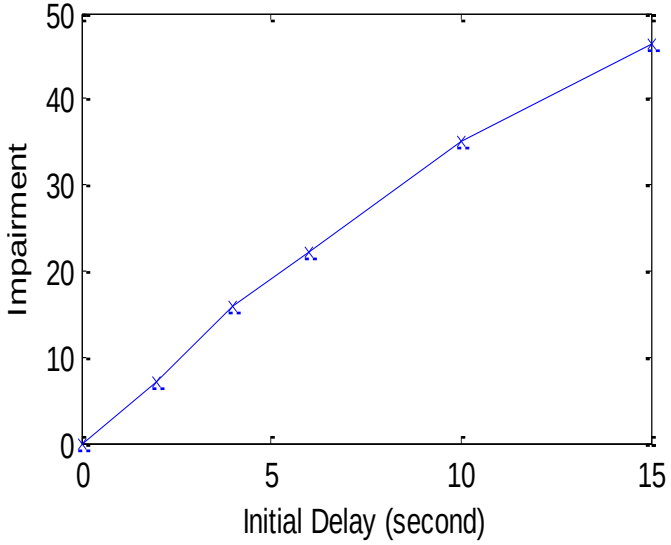
- A Qualcomm MSM8960 tablet with 1280x768 display resolution is used to watch the test videos.

RATING CRETERIA FOR VIDEO QUALITY

Quality Evaluation	Description
100	Excellent experience, no impairment at all
80-100	Minor impairment, will not quit
60-80	Noticeable impairment, might quit
40-60	Clearly impairment, usually quit
0-40	Annoying experience, definitely quit.

Results of Impairment Function I_{ID}

Initial delay



$$I_{ID} = \min\{3.2 * L_{ID}, 100\}$$

L_{ID}: Length of Initial Delay (second)

Results of Impairment Function I_{ST}

Stall

Video ID	6	7	8	9	10	11	12	13	14	15
Stall Duration	4 sec			8 sec				12 sec		
Stall Number	1	2	4	1	2	3	8	1	3	12
Impairment Value	16.5	21.8	31.3	31.1	27.3	33.3	47.5	40.8	37.5	58.5

$$I_{ST} = a * D_{ST} + b * N_{ST} - c * \sqrt{D_{ST} * N_{ST}}$$

$D_{ST:}$ Total Duration of Stall

N_{ST}: Number of Stall

a	b	c
3.8	4.2	2.6

Results of Impairment Function I_{LV}

Level Variation

Different service providers may encode/prepare DASH video using different settings. In order to ensure that I_{LV} is generally applicable, instead of using '*Level*', we use VQM_i to indicate the visual quality of a encoded DASH segment *i*.

Impairment caused by low bit rate itself

Impairment caused by bit rate change

$$I_{LV} = \frac{1}{N}[B_1 * \sum_{i=1}^{N} VQM_i * e^{k*T_i} + B_2 * \sum_{i=1}^{N-1} \left| VQM_i - VQM_{i+1} \right|^2 * sign(VQM_i - VQM_{i+1})$$

VQM_i: VQM (objective video frame quality) for segment i

k	B_1	B_2
0.02	75.6	48.2

Summary

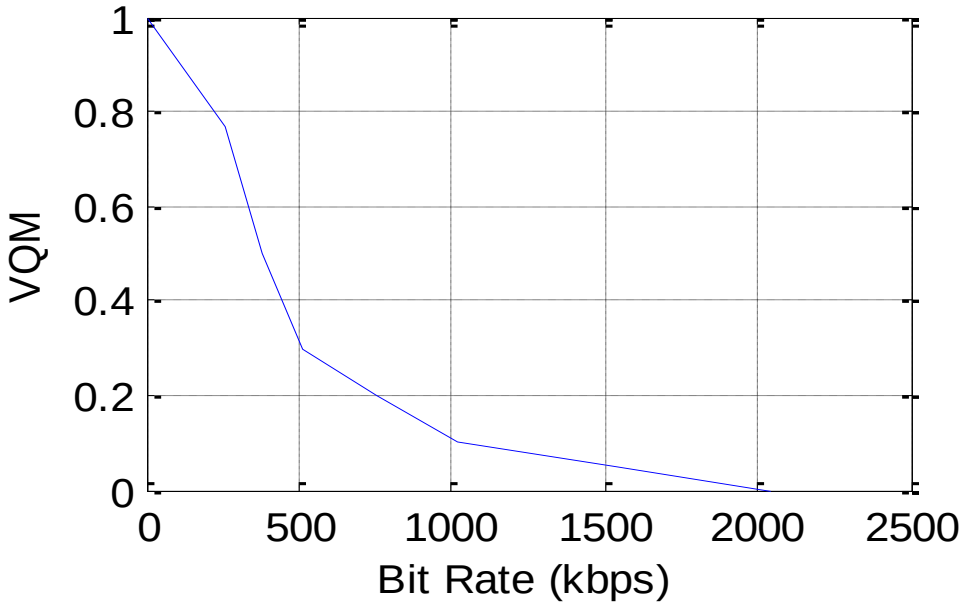
- Identify 3 factors that affect DASH video streaming user experience
- Conduct DASH video streaming characterization experiment to obtain the range and distributions of these 3 factors
- Conduct subjective quality assessment experiment to derive impairment functions for these 3 factors
- In the future, we will conduct another round of subjective experiment to combine the 3 impairment functions together to form an overall user experience model.

Questions

Thanks !

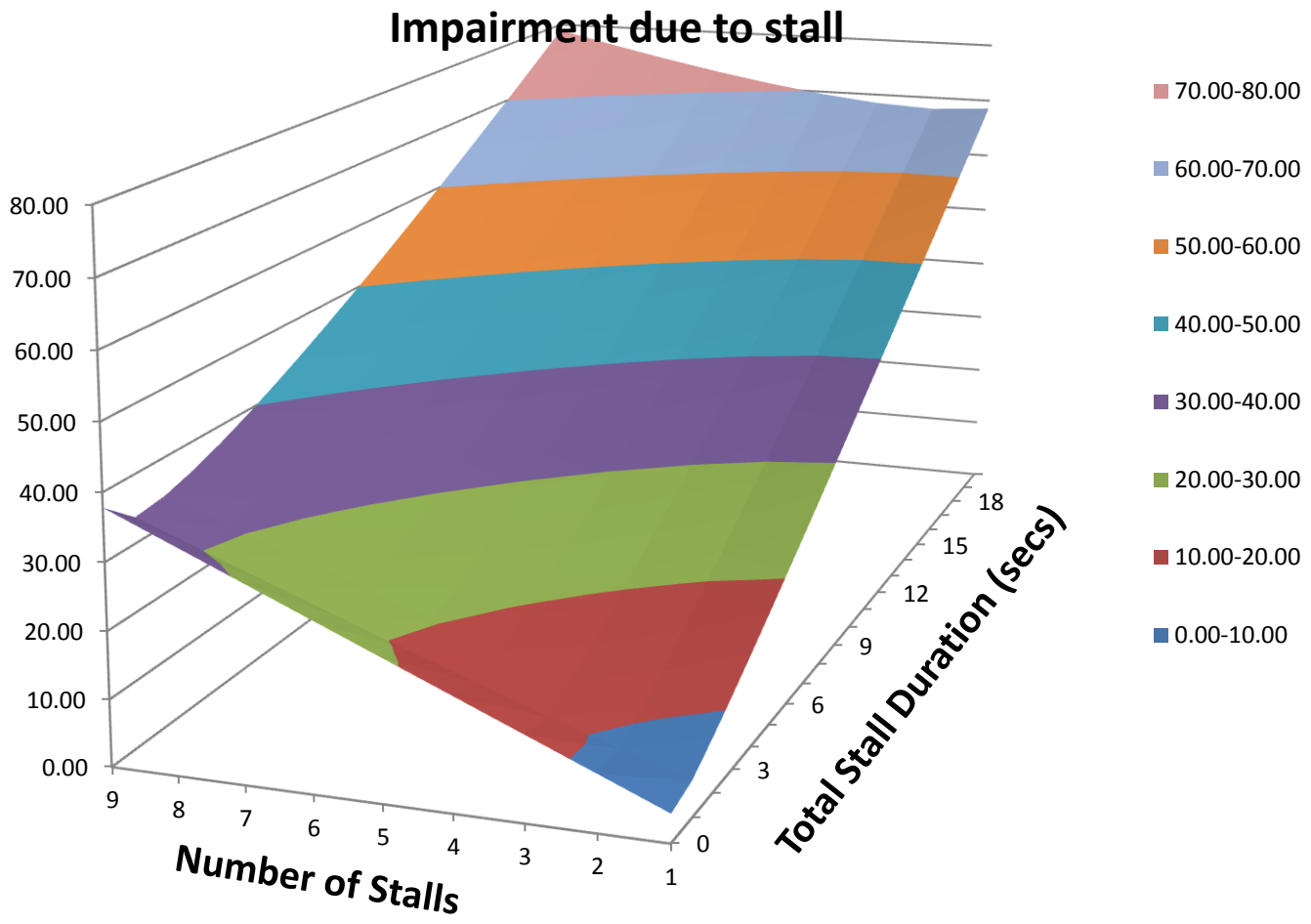
Backup

VQM is a widely accepted video quality metric. It take value between [0, 1]. High VQM stands for lower quality.
It cannot be directly applied to DASH video because it doesn't include quality variation.



Relationship between VQM value and bit rate

Backup


Impairment due to stall
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
9
8
7
6
5
4
3
2
1
Number of Stalls
0
3
6
9
12
15
18
Total Stall Duration (secs)
70.00-80.00
60.00-70.00
50.00-60.00
40.00-50.00
30.00-40.00
20.00-30.00
10.00-20.00
0.00-10.00