THE BILLION DOLLAR QUESTION IN ONLINE VIDEOS: HOW VIDEO PERFORMANCE IMPACTS VIEWER BEHAVIOR?

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If a video that you want to watch…

Does not start quickly, would you abandon?

Freezes in middle, would you watch less?

Completely fails, would you come back?

Can science answer these questions *causally* and *quantitatively*?

WHY STUDY VIEWER BEHAVIOR?

(Besides scientific curiosity of course)

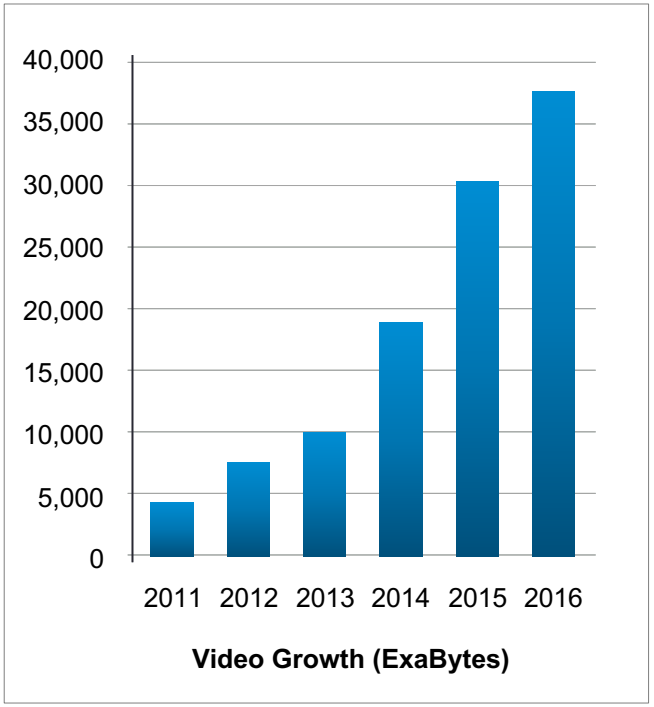
Online videos are the killer application of the Internet

Current:

- 86% of US Internet audience viewed online video
- Video over half of global consumer Internet traffic

Future (By 2016):

- Video-on-demand traffic will triple Video will be ~86 percent of global consumer traffic.

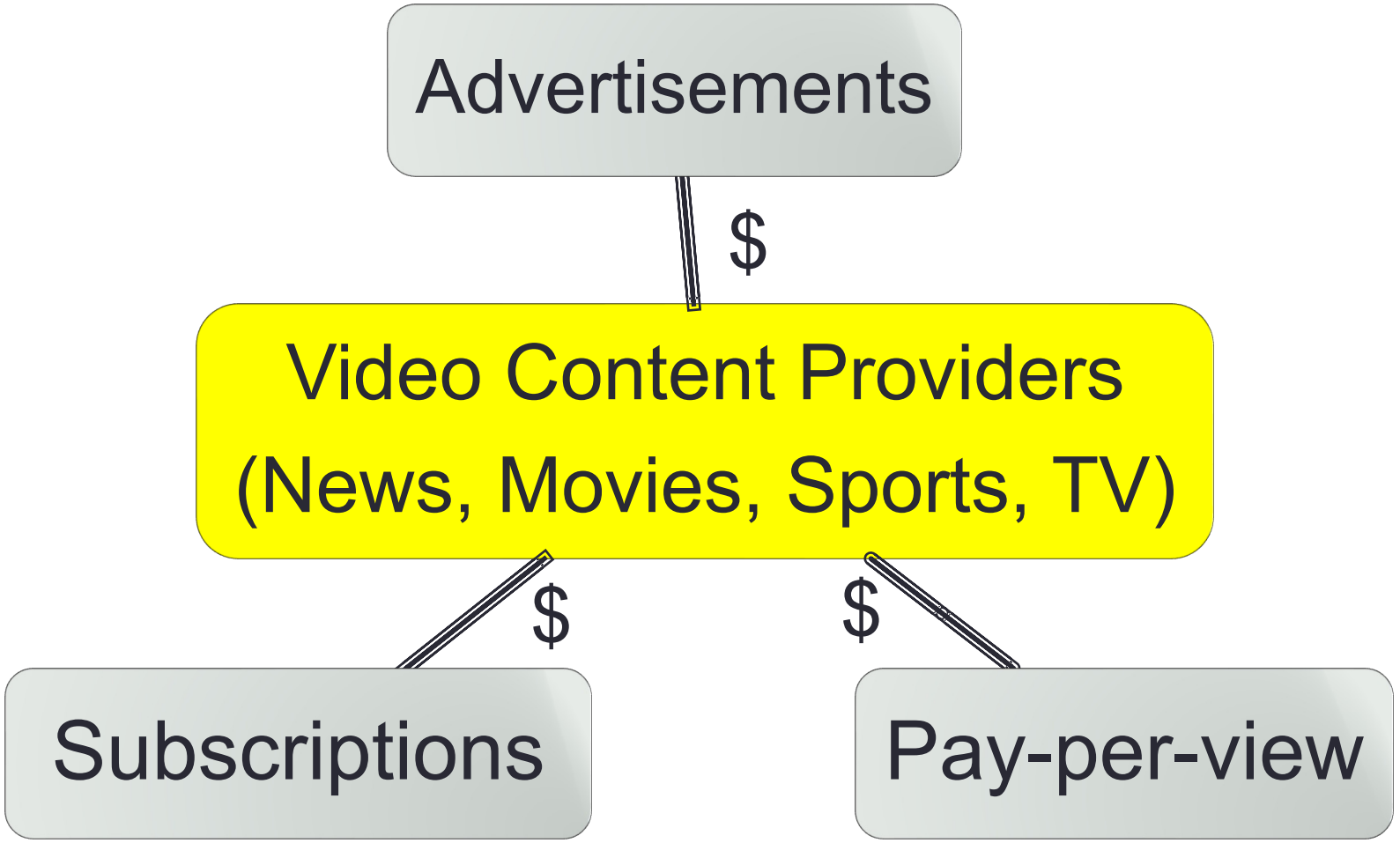


Sources: YouTube, ComScore, Cisco Visual Networking Index, 2011-2016,

THE MEGA QUESTION FOR VIDEO PROVIDERS

How to monetize videos?
Are videos even sustainable, leave alone profitable?

Ways of Monetization



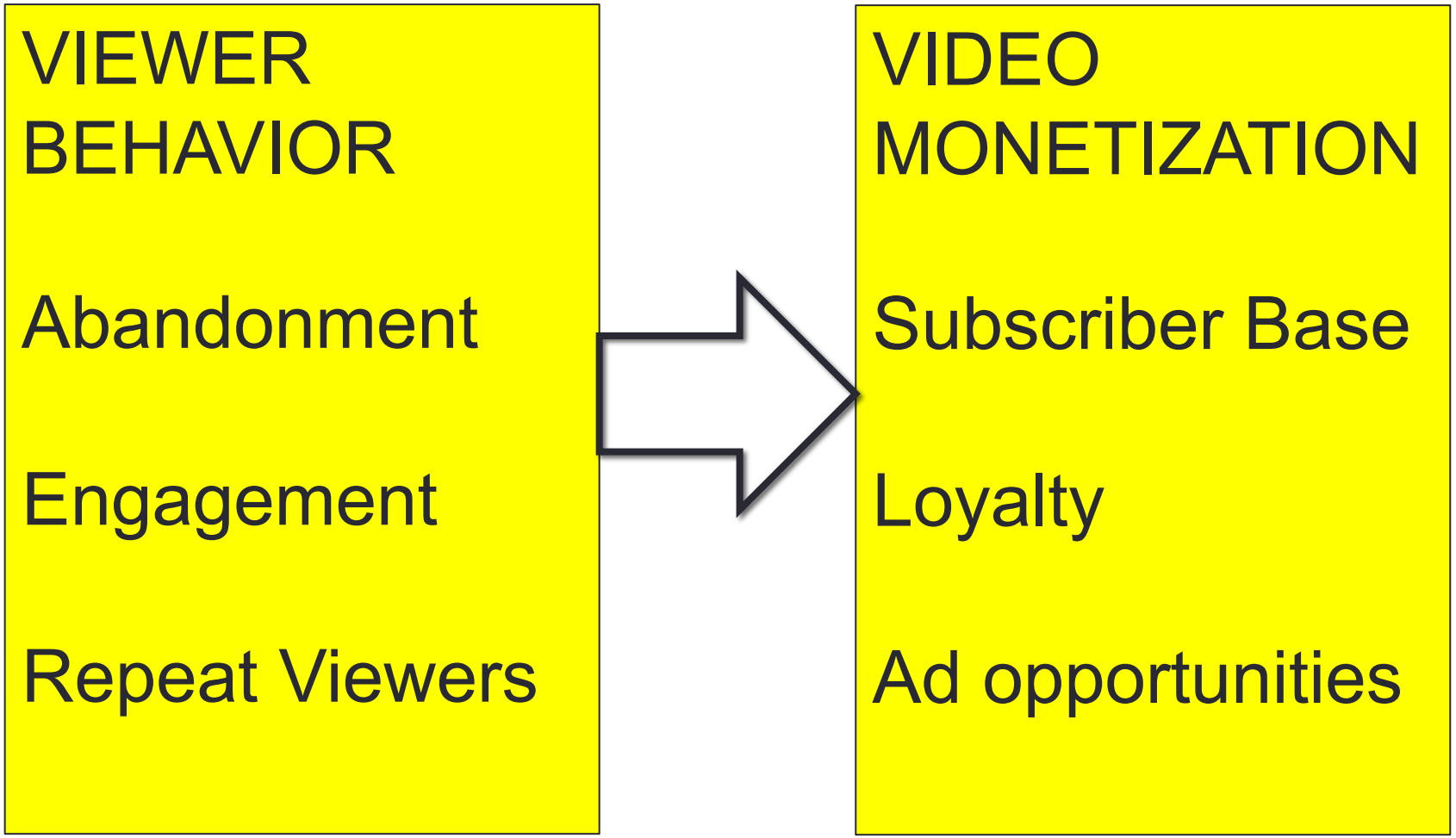
Online videos viable only if video providers figure out how to keep users watching!

Reduce abandonment: Not click away even before the video starts

Increase engagement: Watch longer once the video starts

Enhance repeat viewership: Keep coming back to site to watch more videos

Understanding viewer behavior holds the keys to video monetization



But what impacts viewer behavior?

VIDEO CONTENT

Story line

Picturization

Relevance, etc

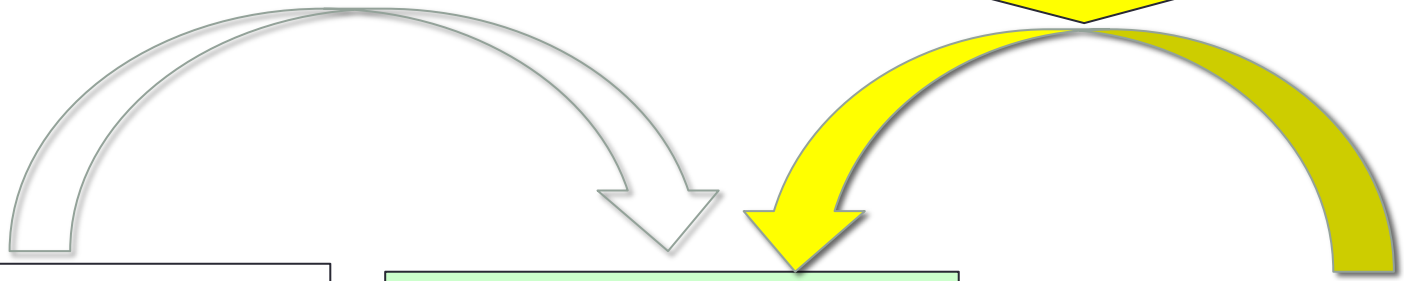
VIEWER BEHAVIOR

Abandonment

Engagement

Repeat Viewers

First large-scale scientific study to *causally* establish the significant impact of performance on viewers



VIDEO CONTENT

Storyline

Picturization

Relevance, etc

VIEWER BEHAVIOR

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Engagement

Repeat Viewers

VIDEO PERFORMANCE

Availability

Fast Startup

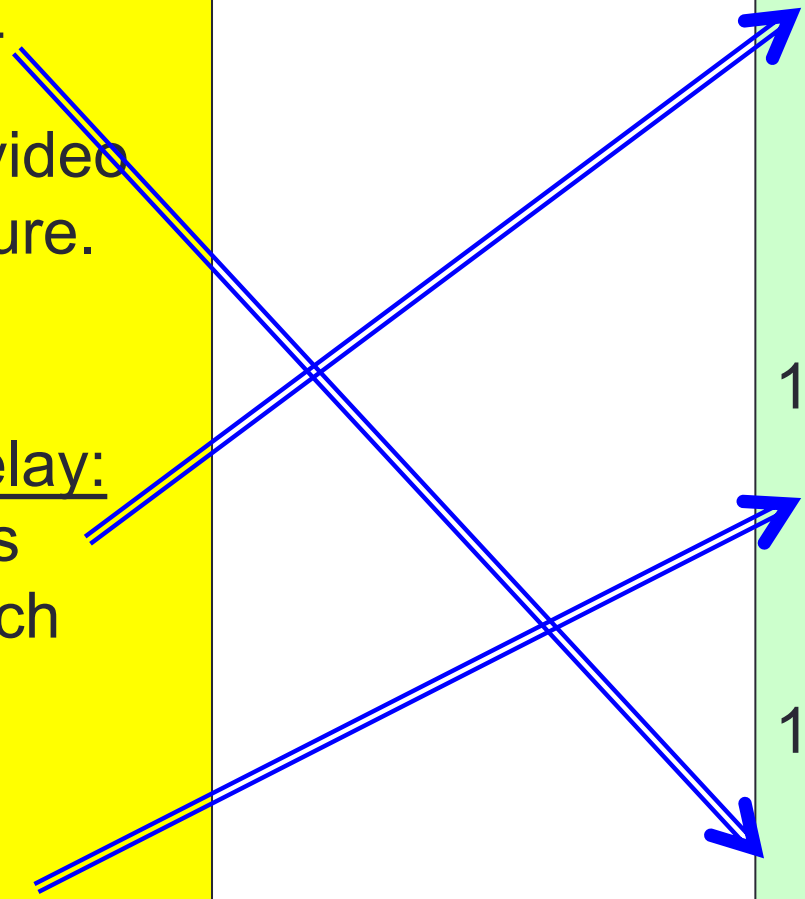
Less Rebuffers

VIDEO PERFORMANCE

1. Availability: Viewers download video without failure.

1. Startup Delay: Video starts without much delay.

1. Rebuffers: Video plays without freezes.



VIEWER BEHAVIOR

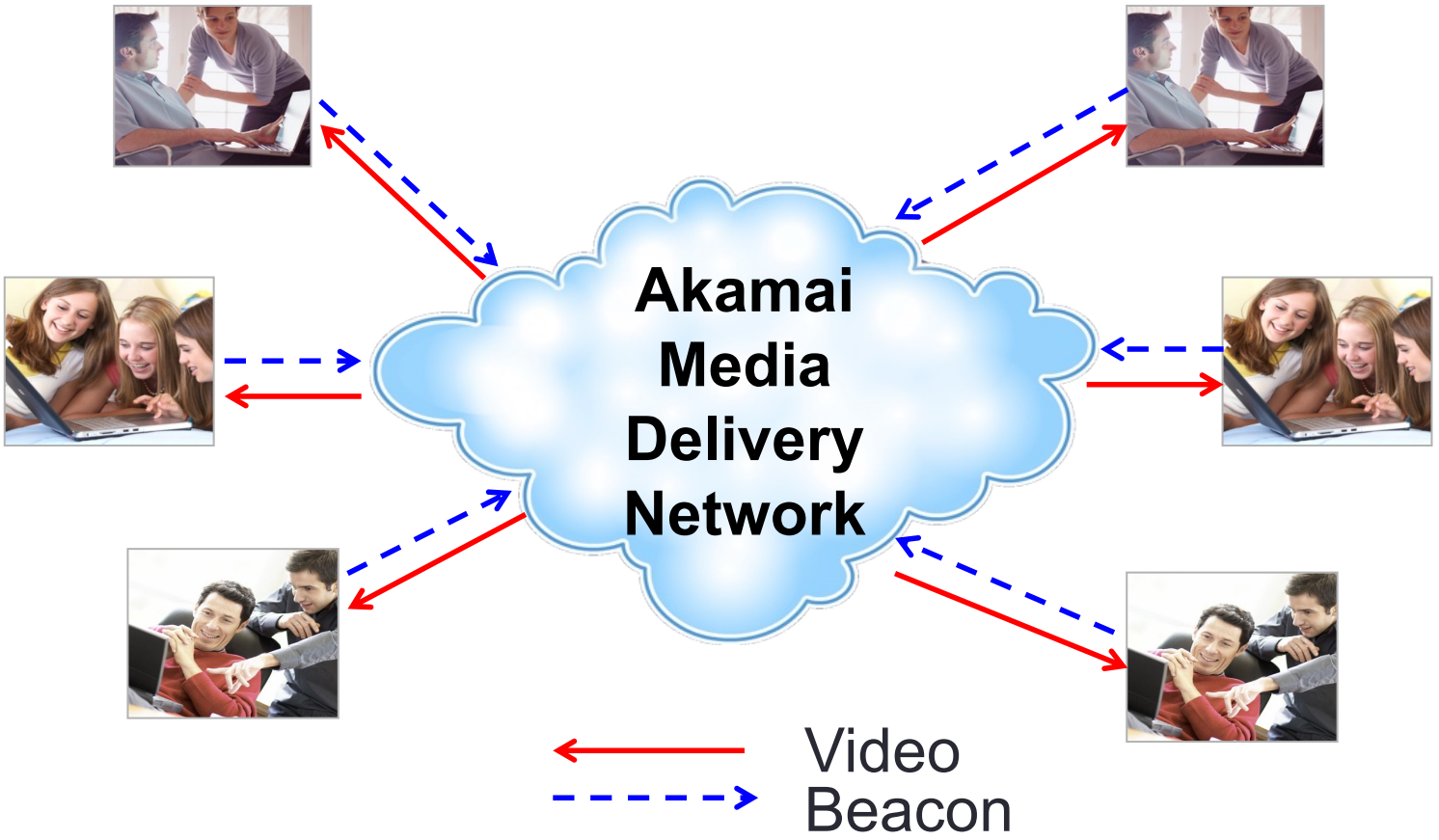
1. Abandonment: Reduce viewers who abandon without viewing the video.

1. Engagement: Viewers watch videos longer.

1. Repeat Viewership: Viewers keep coming back to site to watch more videos.

HOW TO STUDY VIEWER BEHAVIOR?
Needed: Big Data

DATA COLLECTION



Globally-deployed Akamai plugin that runs inside the media player and reports *anonymized* viewer actions and performance metrics via ``beacons'' from millions of actual end-users around the world.

Our Data Set

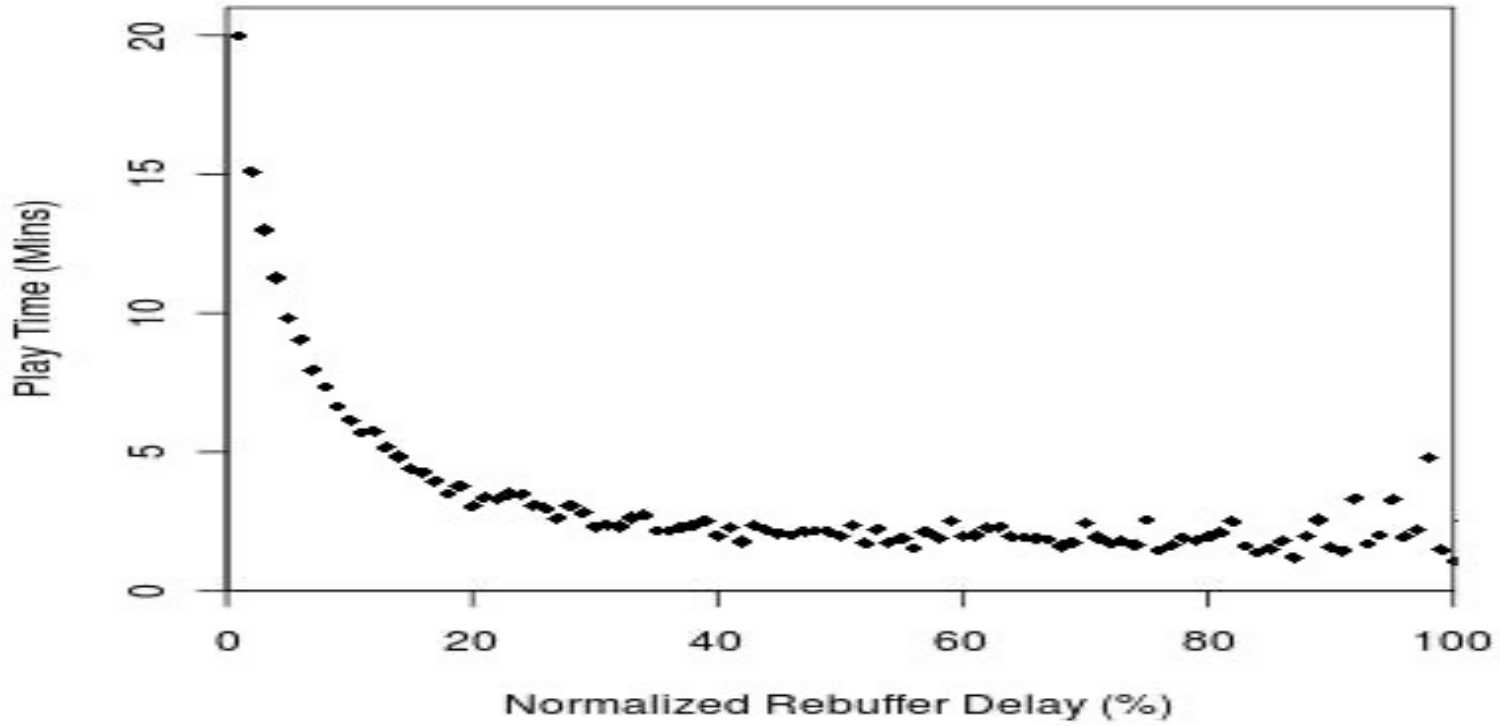
Extensive data set including major genres of online video such as news, entertainment, sports, movies, etc.

- 6.7 million unique viewers
- 23 million videos watched
- 216 million minutes of video played
- Viewers in three continents (NA, Europe, and Asia)

HOW TO STUDY VIEWER BEHAVIOR?

Needed: New analytic techniques

Basic Tool: *Correlate* Performance and Behaviour



Hypothesis: Video rebuffering causes viewers to watch less

Strong negative rank correlation. Kendall correlation = -0.421.

Correlation ≠ Causality

Correlation: A and B “move together”.

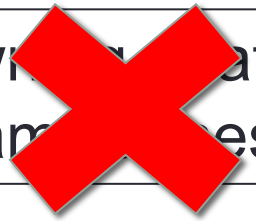
versus

Causality: A causes B to occur.

Threats to Causality: Confounding variables that could account for both A and B.

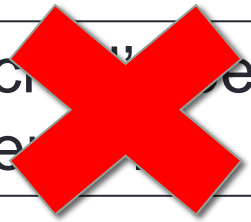
Lets play the causality game!
Are these causal?

Ice cream sales and drowning deaths are strongly correlated. Therefore, eating ice cream causes drowning.



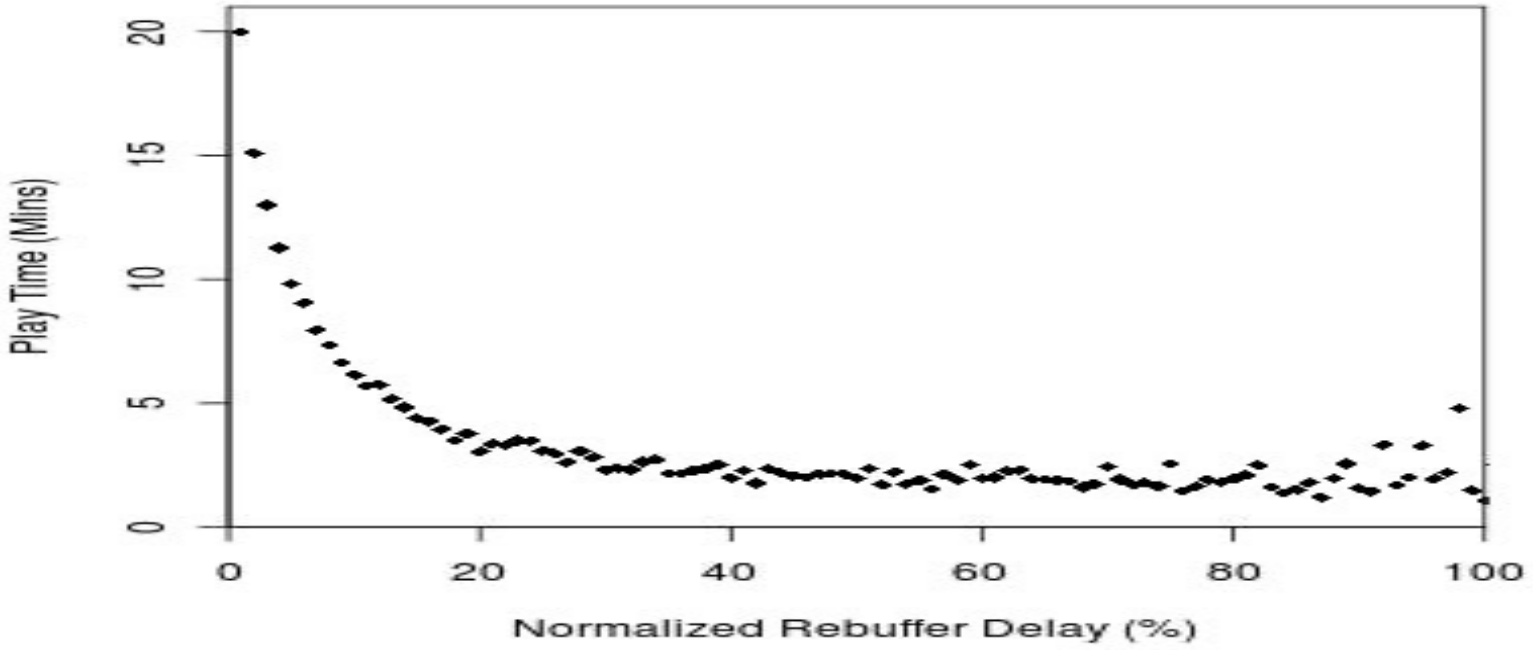
Possible Threat: Summer weather (confounding variable)

Leaving the lights on in a child's bedroom at night is strongly correlated with myopia later. So, lights causes myopia.



Possible Threat: Parent's own myopia (confounding variable)

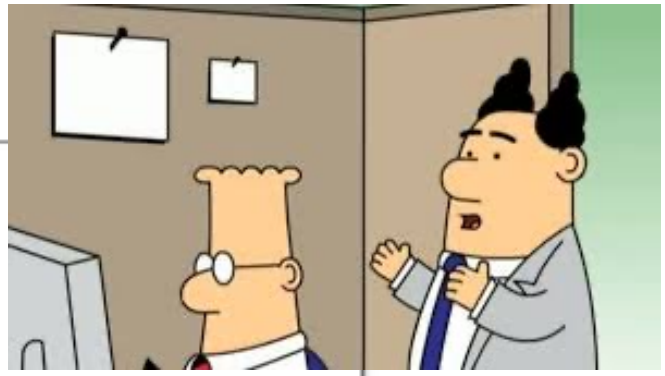
Threats to Causality

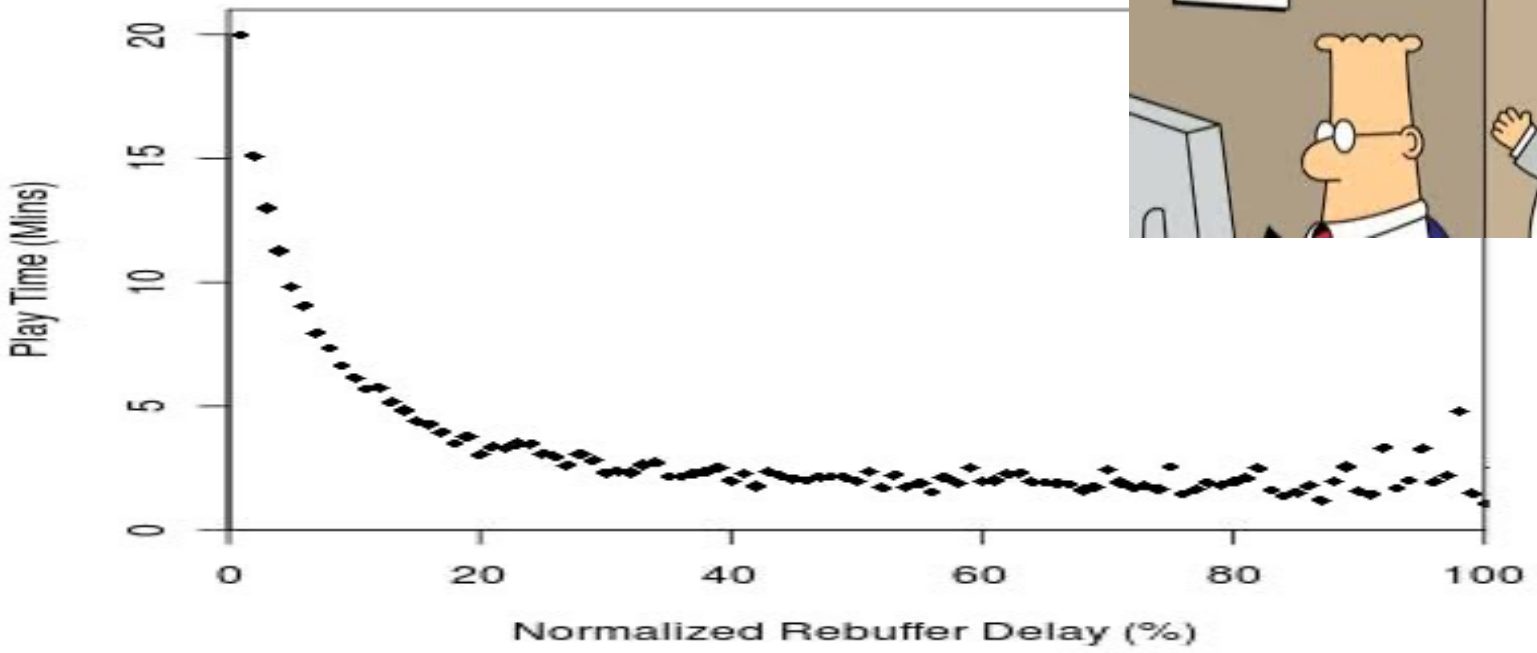


Possible Threat: Users who are better off can afford better network connectivity, resulting in less rebuffering. They can also afford access to more interesting content causing them to watch longer.

Confounding variables: Connectivity, Content, Geography.

Threats to Causality





Possible Threat: Users watching videos during office hours watch less, so as not to catch the eye of the boss☺. Also rebuffers more likely due to peak hour Internet traffic jams.

Confounding variables: Time (day of week, time of day), geography.

Randomized Experiments

Idea: Equalize t[illegible]act of [illegible]unding variables using ran[illegible]sher 1937)

1. Randomly assign[illegible]receive "treatment" A.
2. Compare outc[illegible]t versus the "untreated" control group.

Treatment = Degradation in Video Performance

Hard to do:

Operationally
Cost Effectively
Legally
Ethically

Our Novel Technique: Quasi Experiments

Idea: Isolate the impact of treatment (poor video perf) and by matching confounding factors (content, geo, connectivity, etc).

Treated
(Poor video perf)

Control or Untreated
(Good video perf)

Randomly pair up viewers with same values for the confounding factors

Hypothesis:
Performance➔Behavior

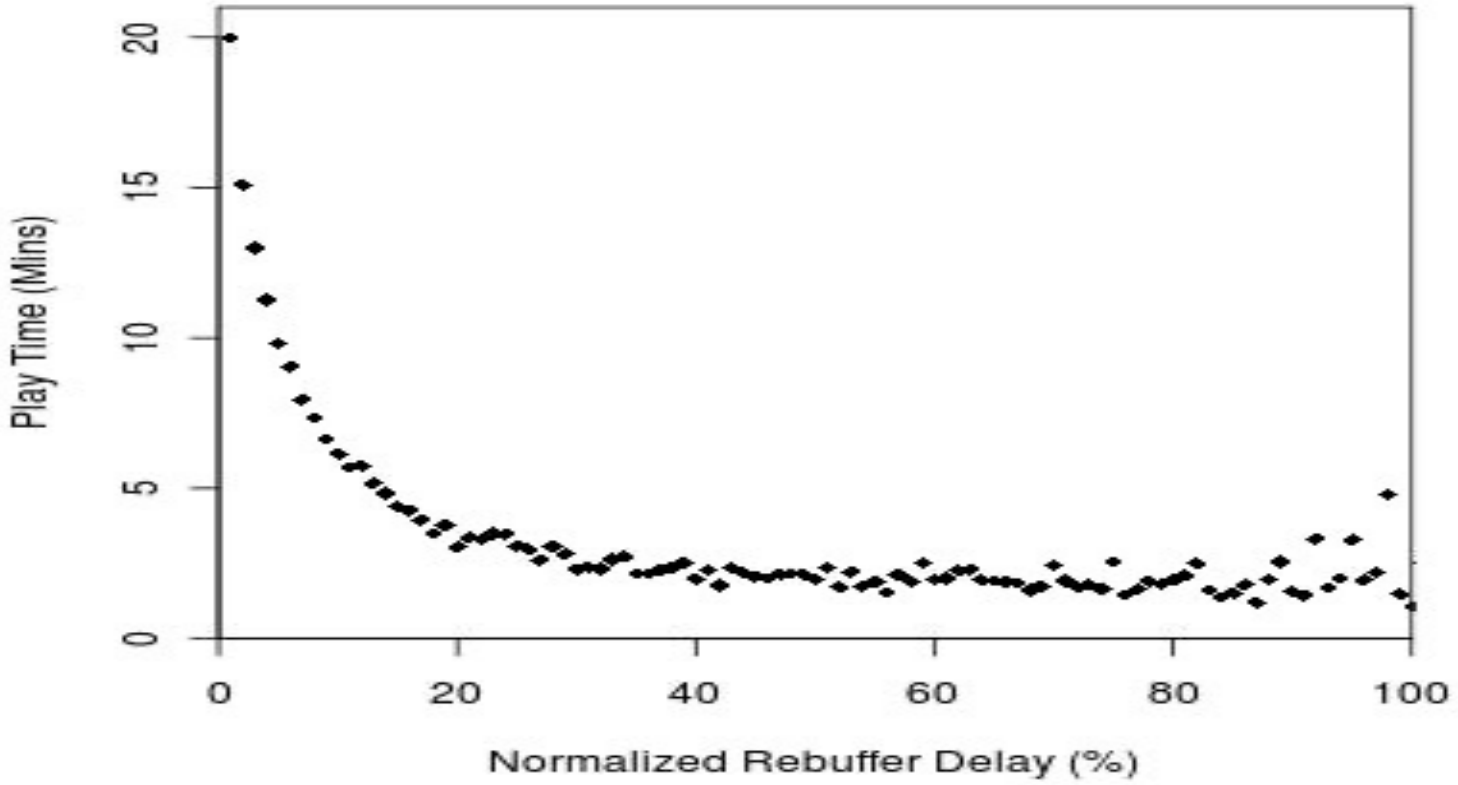
+1: supports hypothesis
-1: rejects hypothesis
0: Neither

Outcome

Statistically highly significant results:100,000+ randomly matched pairs

Viewer Engagement

Does rebuffering reduce the average time a viewer plays a video?



Strong negative correlation (-0.421): increased normalized rebuffer delay correlates with decreased play time.

Quasi-Experiment for Viewer Engagement

Treated
(video froze for ≥ 1% of duration)

Control or Untreated
(No Freezes)

Same geography, time,connection type, same point in time within same video

Hypothesis:
More Rebuffers
➔Smaller Play time

Outcome

For each pair, outcome = playtime(untreated) – playtime(treated)

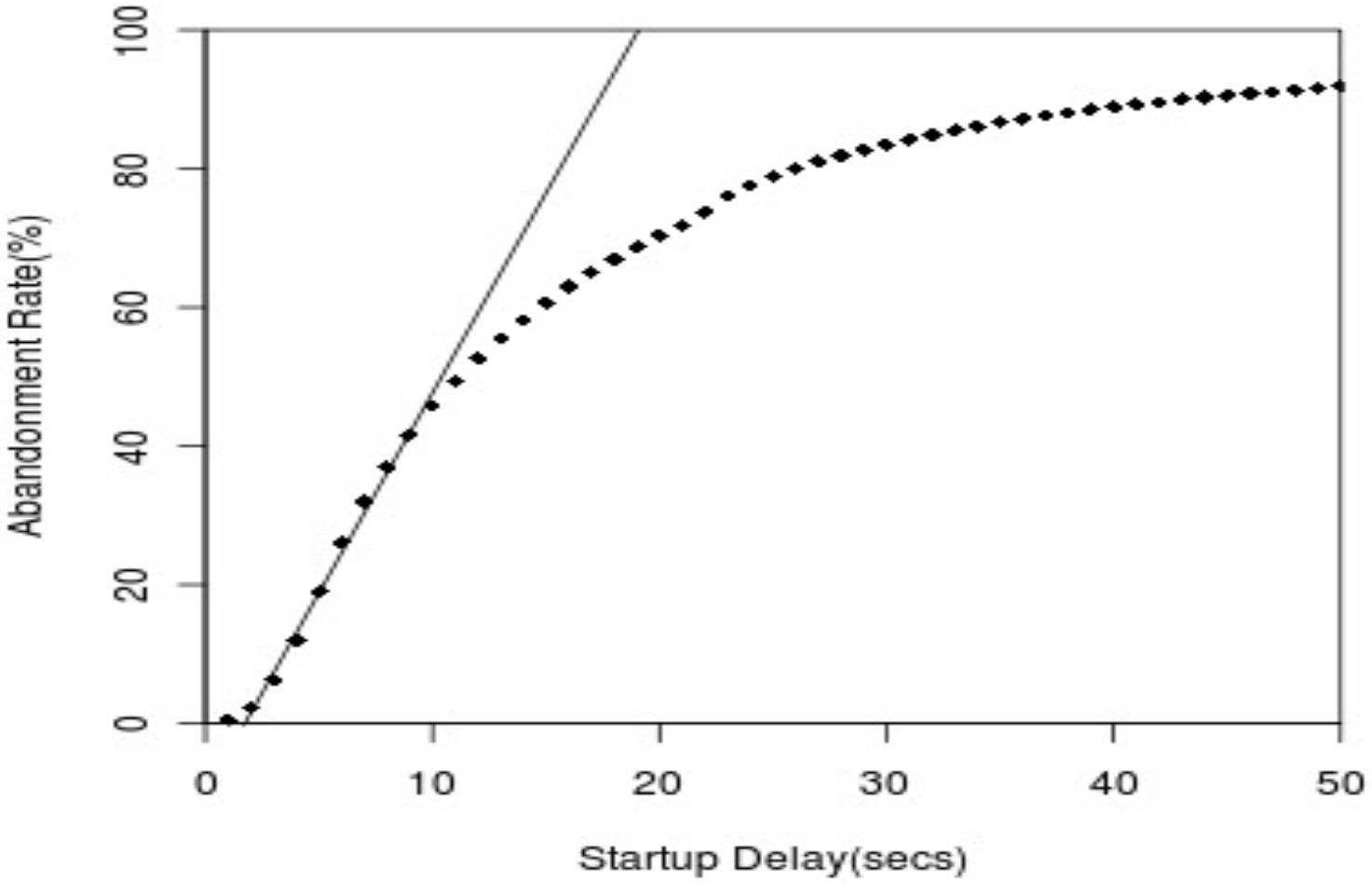
Results of Quasi-Experiment

Normalized Rebuffer Delay (γ%)	Net Outcome
1	5.0%
2	5.5%
3	5.7%
4	6.7%
5	6.3%
6	7.4%
7	7.5%

A viewer experiencing rebuffering for 1% of the video duration watched 5% less of the video compared to an identical viewer who experienced no rebuffering.

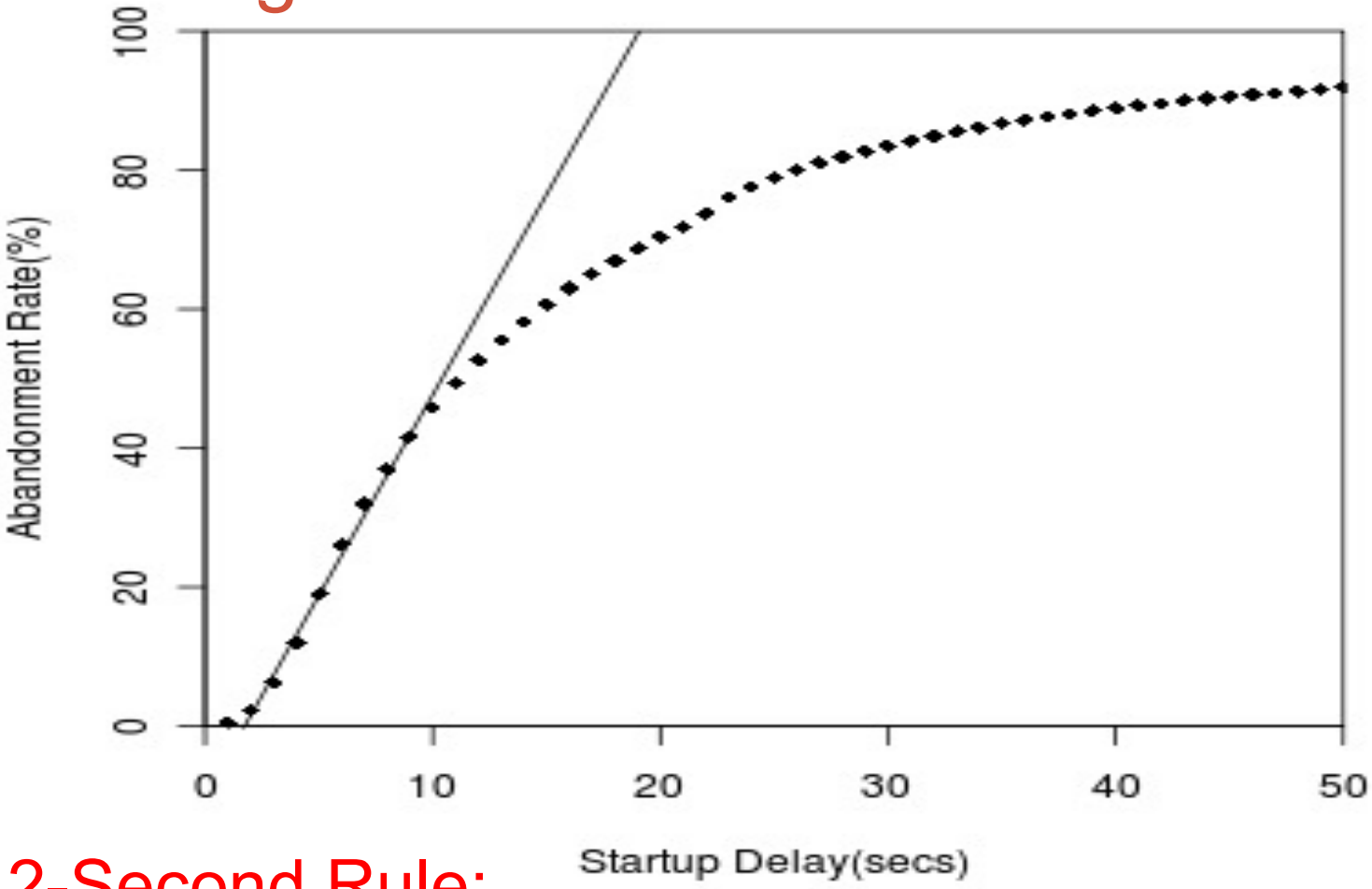
Viewer Abandonment

How long will viewers wait for a video to startup?



Abandonment rate = %viewers who loose patience and abandon before the video starts up

How long will viewers wait for a video to startup?



2-Second Rule:

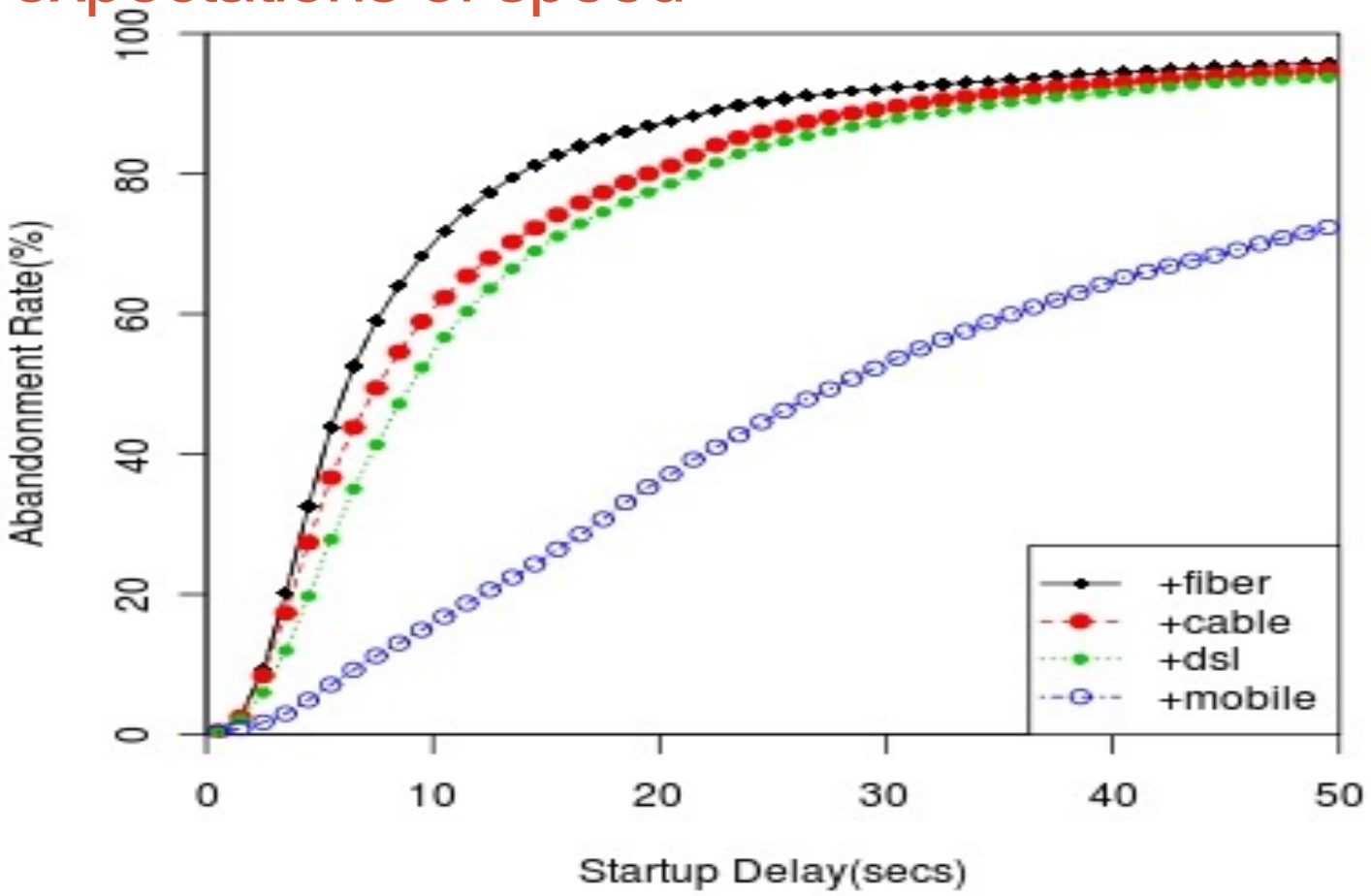
a) Viewers start to abandon if startup delay exceeds 2 secs.

b) At 5 seconds,~ 25% abandoned. At 10 seconds, ~ 50% gone.

Anyone for the *Lightning* Express?

"Express train crosses the nation in 83 hours."
New York Times, June 4th 1876.

Time is relative: viewer patience is influenced by expectations of speed



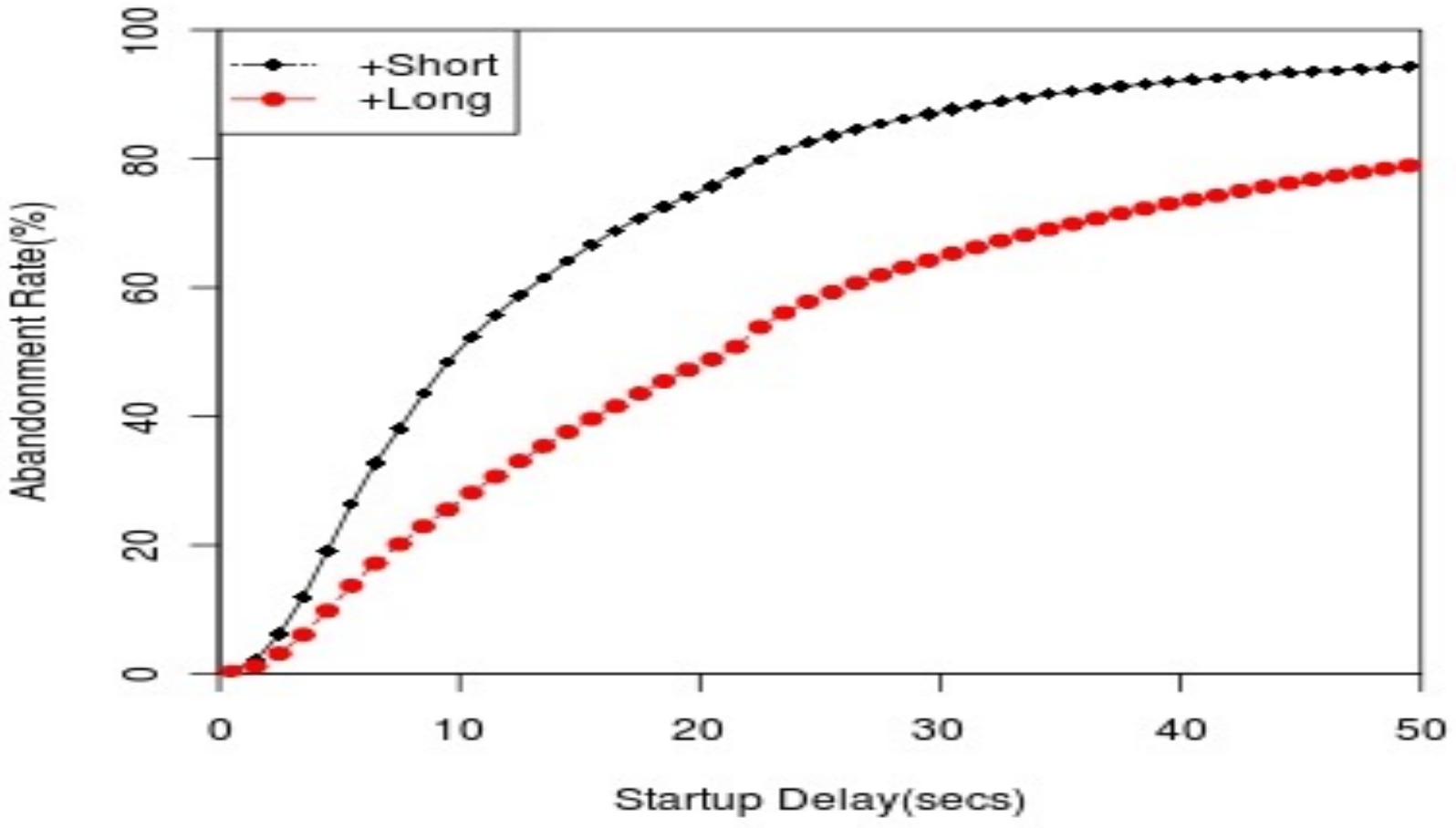
Viewers with better connectivity have less patience for startup delay and abandon sooner

What is more frustrating?

Waiting 30 minutes for a long plane ride?

Waiting 30 minutes for a short cab ride?

Viewer patience is related to perceived value



Viewers are less tolerant of startup delay for short videos (e.g, news clips) in comparison to longer videos (e.g, movies)

Two ways of waiting that video viewers love to hate…

Slow-loading Video

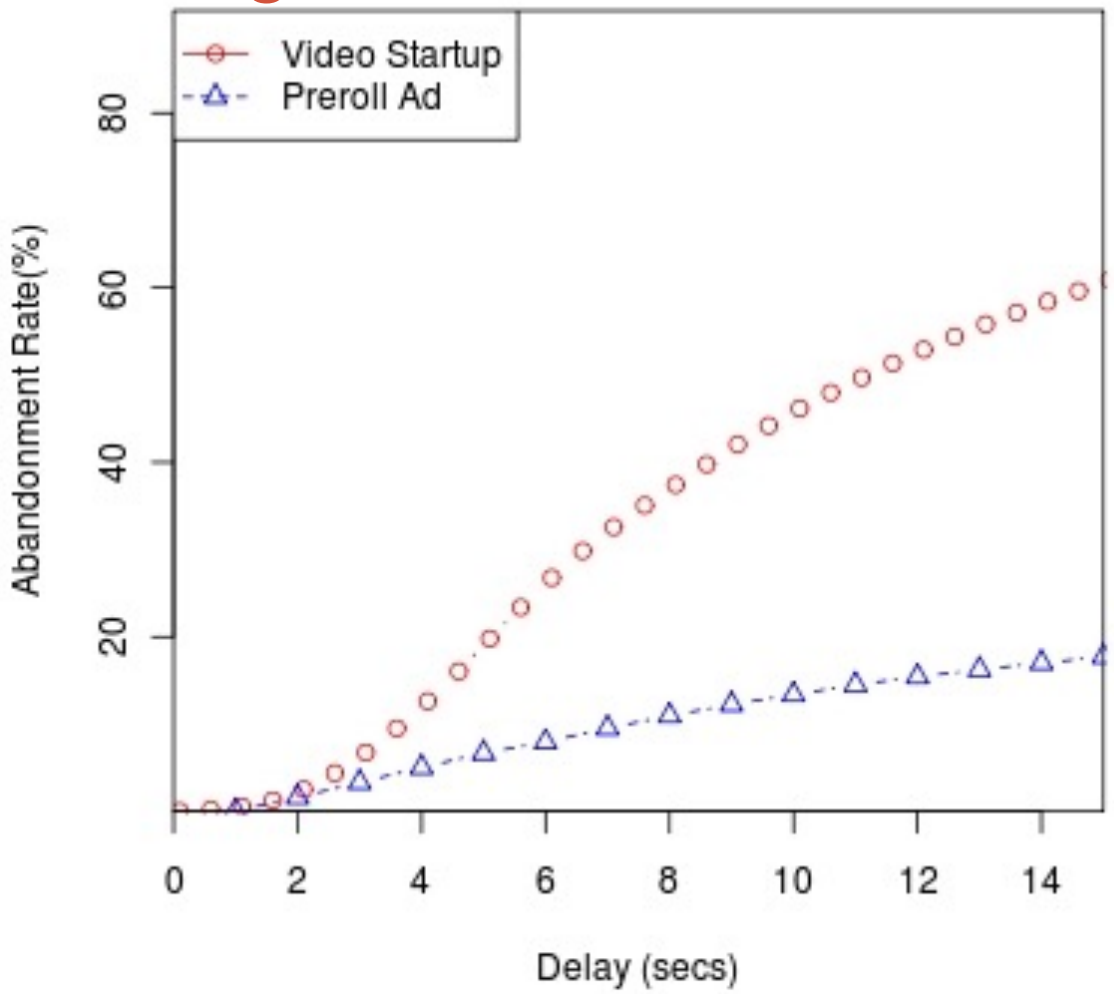
Waiting for a video to startup since the video is still buffering.

Pre-roll ad

Waiting for the video to begin while watching a pre-roll ad.

Who is more frustrated and more likely to abandon?

Viewers are more patient with ads than performance glitches



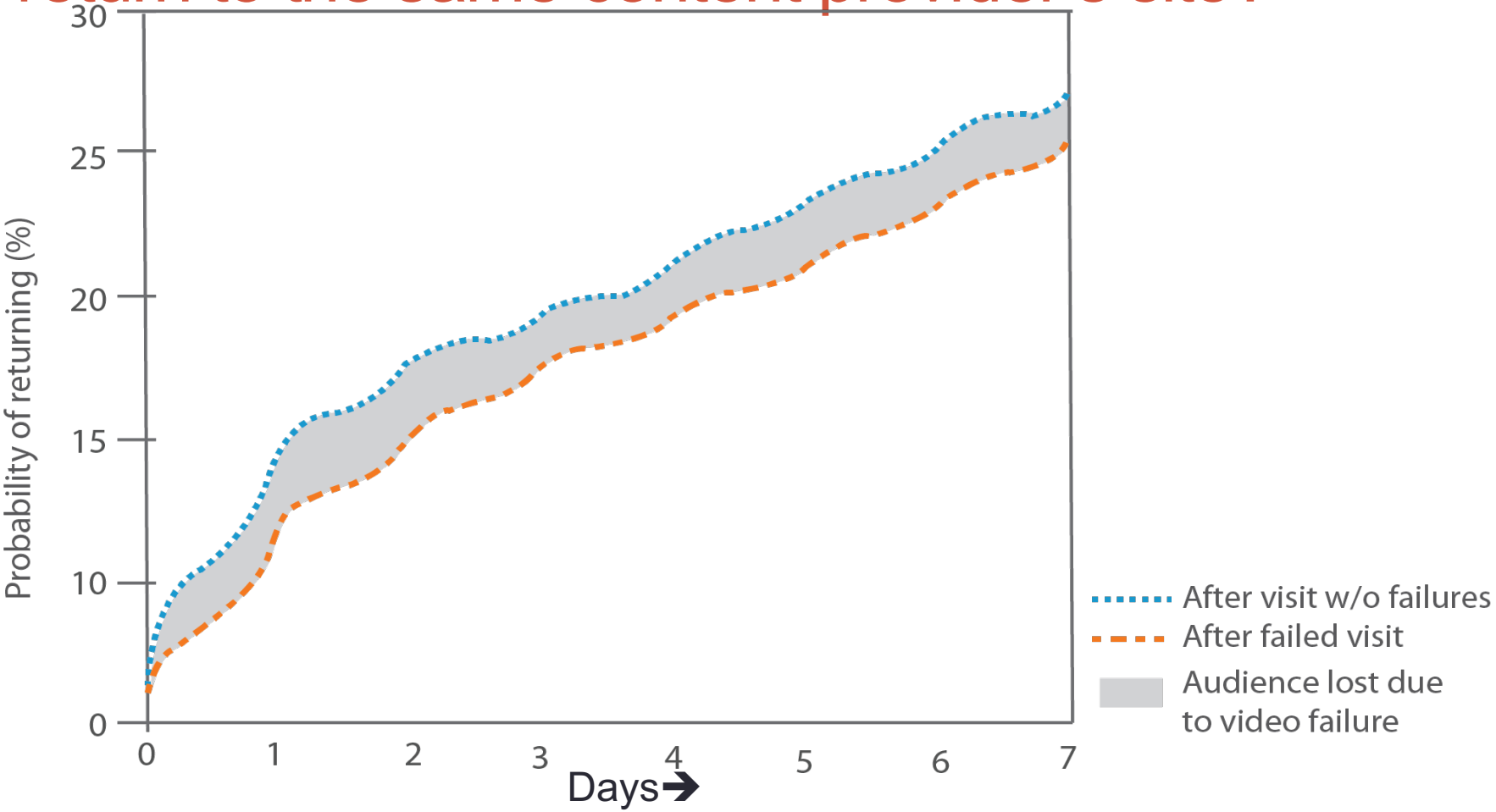
Abandonment rate 3X more for slow-loading video than pre-roll ad.

Slow-loading Video:
Unexpected wait of unknown duration, leading to more frustration.

Pre-roll Ad:
Expected wait of known duration, so less frustration.
Viewers accept ads as an implicit form of payment for the content.

Repeat Viewership

Do failures reduce the likelihood that a user will return to the same content provider's site?



Repeat Viewership = Probability that a viewer returns to the same site within a given period to play more videos.

Quasi-Experiment for Repeat Viewership

Treated (Experienced a failed visit)

Control or Untreated (Experienced a successful visit)

Same geography, connection type, time, content provider site, same prior viewing behavior

Hypothesis:
Failed visit ➔ Viewer returning to site

Outcome

For each pair, outcome =
+1, if treated returns but not untreated
-1, if untreated returns but not treated
0, otherwise

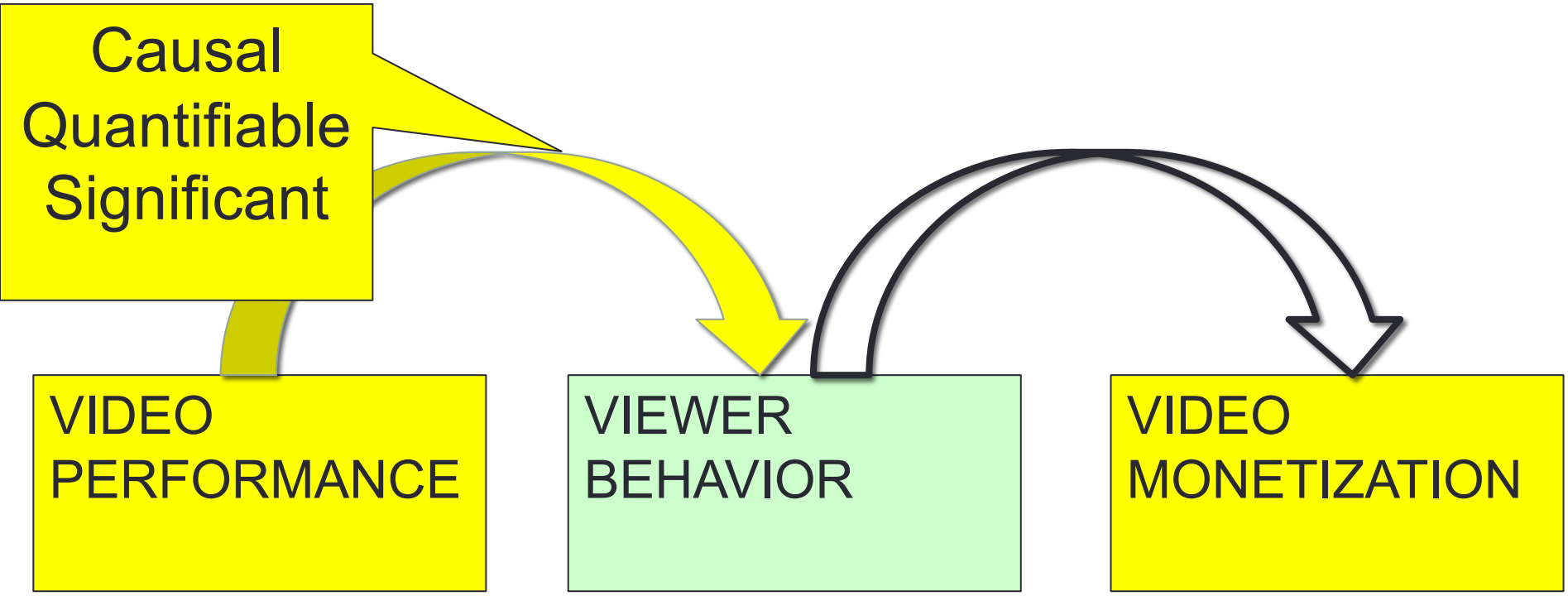
Results from Quasi-Experiment

A viewer experiencing a failed visit *is* *less likely* to return to the same content provider's site within a week than a similar viewer that had a successful visit.

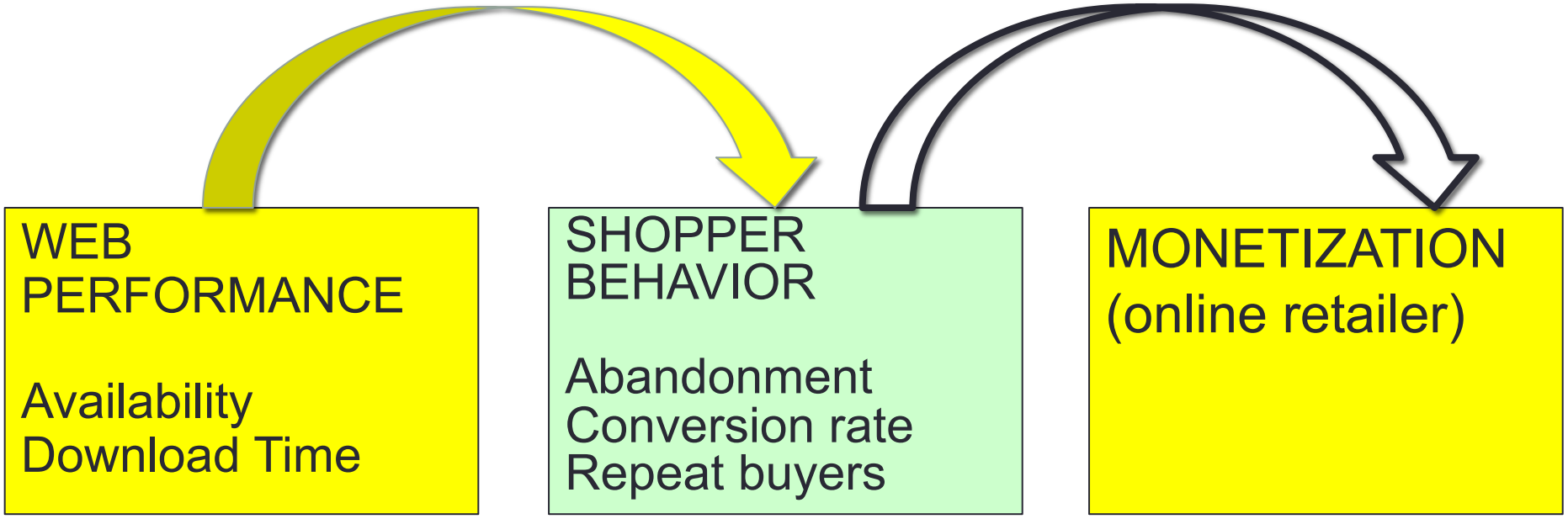
(Difference = 2.3%)

Concluding Remarks

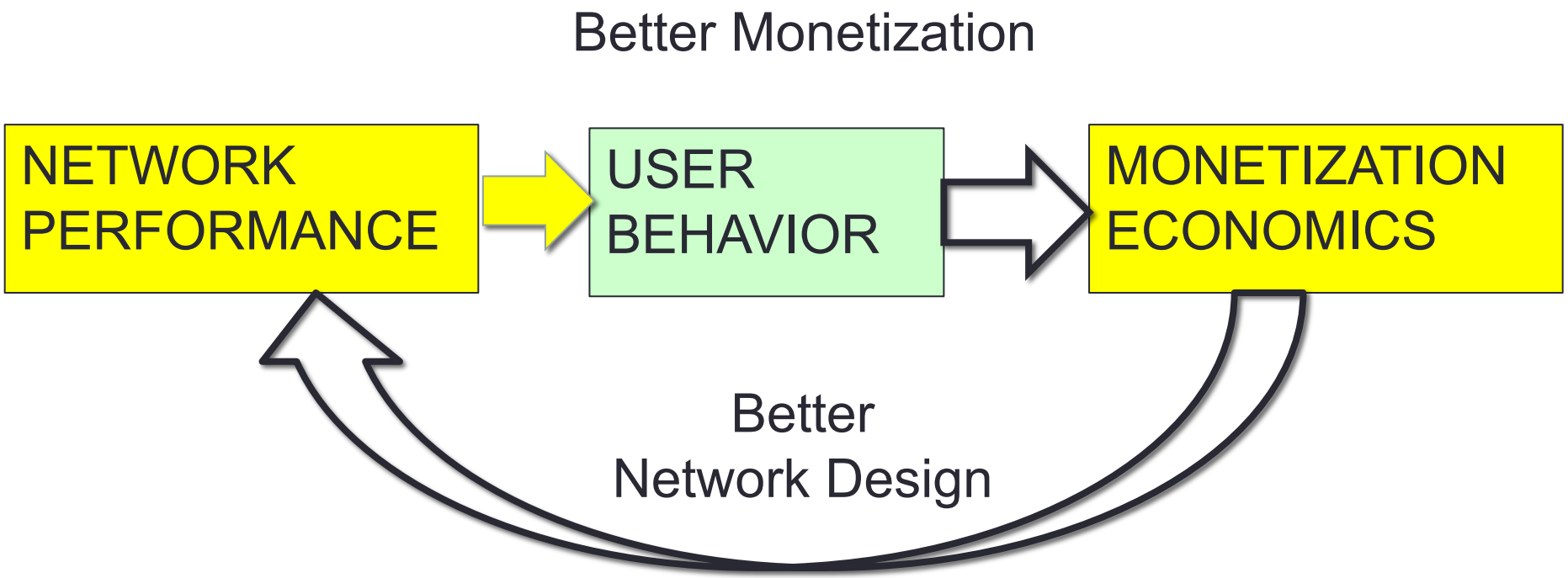
Answers the question: "Why Performance?"
Quantifies the economic value of video performance



Economic Value of Web Performance?



Holistic Network Design: A New Science in the Making



Every real-world network has a virtuous cycle!

Our Techniques	Traditional QOE user studies
Quasi-Experimental	Controlled experiment
Less knowledge/control of the experimental subjects	More knowledge/control of the experimental subjects
Millions of diverse users (devices, content, geo, etc)	Much fewer users Limited diversity
Cheap	Expensive

Questions?

Video Stream Quality Impacts Viewer Behavior: Inferring Causality using Quasi-Experimental Designs, ACM Internet Measurement Conference (IMC), 2012. (Also, IEEE/ACM TON, 2013)