Improving User Perceived Page Load Time using Gaze

Conor Kelton†, Jihoon Ryoo†, Aruna Balasubramanian, Samir R. Das
†Students with equal contribution

Stony Brook University

Motivation

- Websites exploding in number! (Over 1.1 B today)
- Performance of these sites is important:
  - Google Uses Page Speed as major ranking factor
  - Amazon Reports $1.6 B in profit per 1 second decrease in site load time

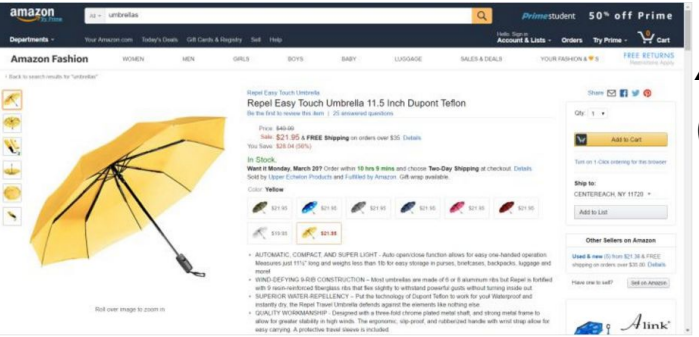
Good Performance Yields

Results in Optimizations

Hypothesis: Traditional Metrics for Page Load Time Do ***Not*** relate to the user experience

- If true, then the effect of optimizations on user **Quality of Experience** (QoE) is **uncertain**

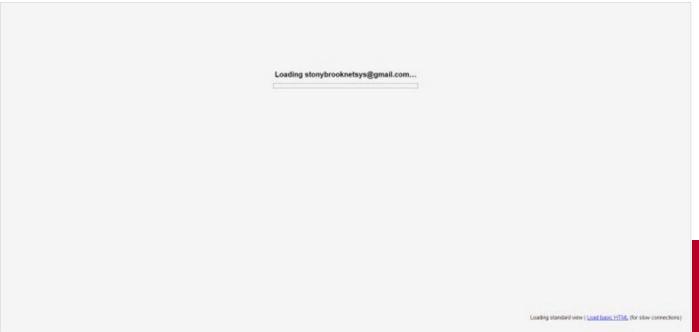
Does Window.OnLoad() capture the user's experience?



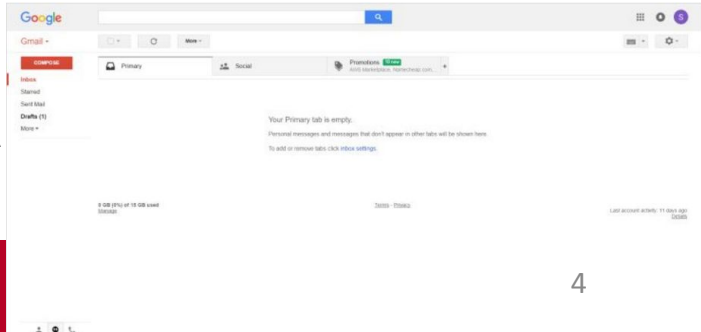
Amazon.com: 7.9 s (OnLoad)

Amazon.com: 1.5s (ATF Loaded)

Gmail.com: 0.9 s (OnLoad)

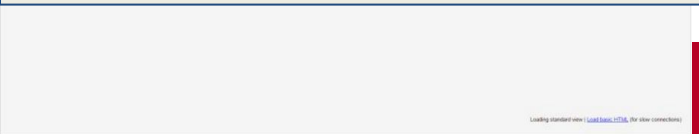


Gmail.com: 5.1s (ATF Loaded)



Does Window.OnLoad() capture the user's experience?

Similar Mismatches of user QoE to other PLT metrics such as ***Speed Index****, and* ***DOMContentLoaded****.*



The *uPLT*: ***u**ser-perceived **P**age **L**oad **T**ime*

- How to determine if users are actually experiencing this disconnect?

Real User Studies!

When is the Page Loaded?

uPLT

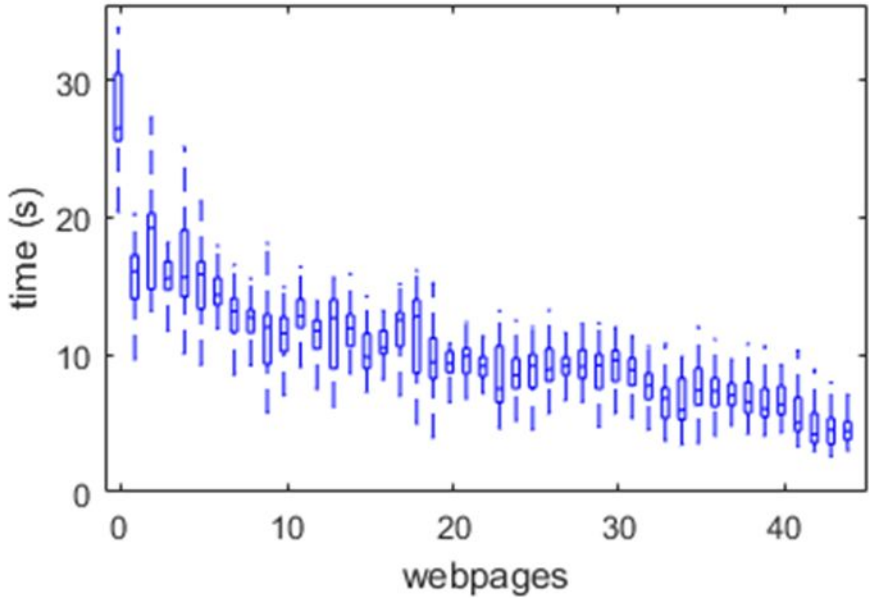
The uPLT User Study Logistics

Related Work
[CoNext '16]
eyeorg

- ***Consistency:***
  - Website loads shown as **videos** to the user
- ***Quality:***
  - Measure user's reaction times
  - Filter out erroneous responses

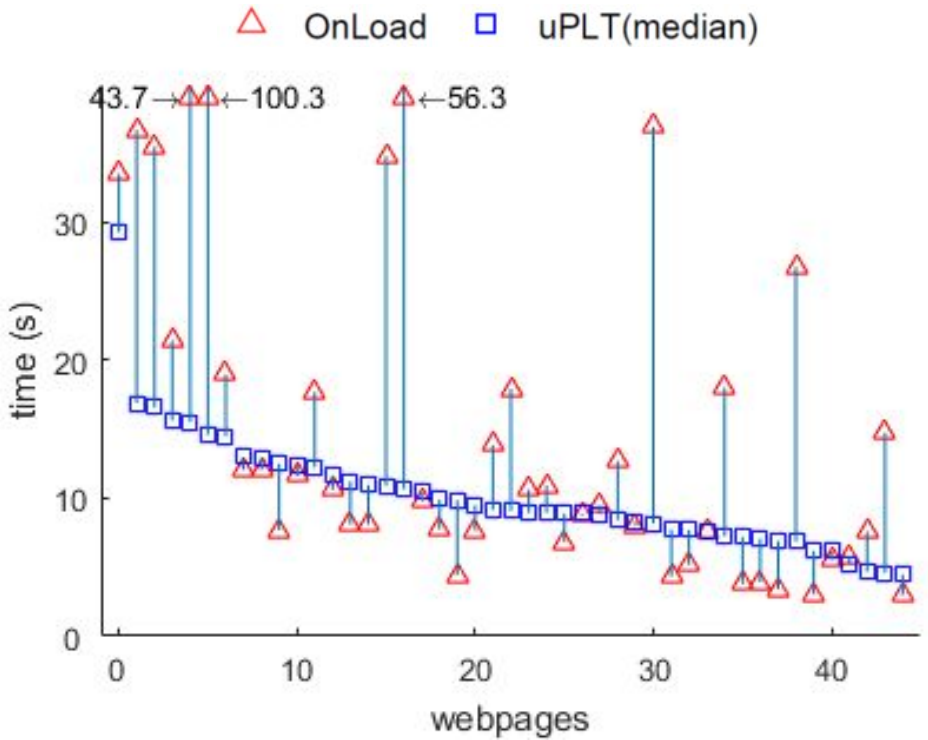
User Study Results: uPLT Spread

- Narrow spread in *25th - 75th %tiles* shows consensus among users



User Study Results: OnLoad vs uPLT

- OnLoad indeed over-to-under estimating user experience



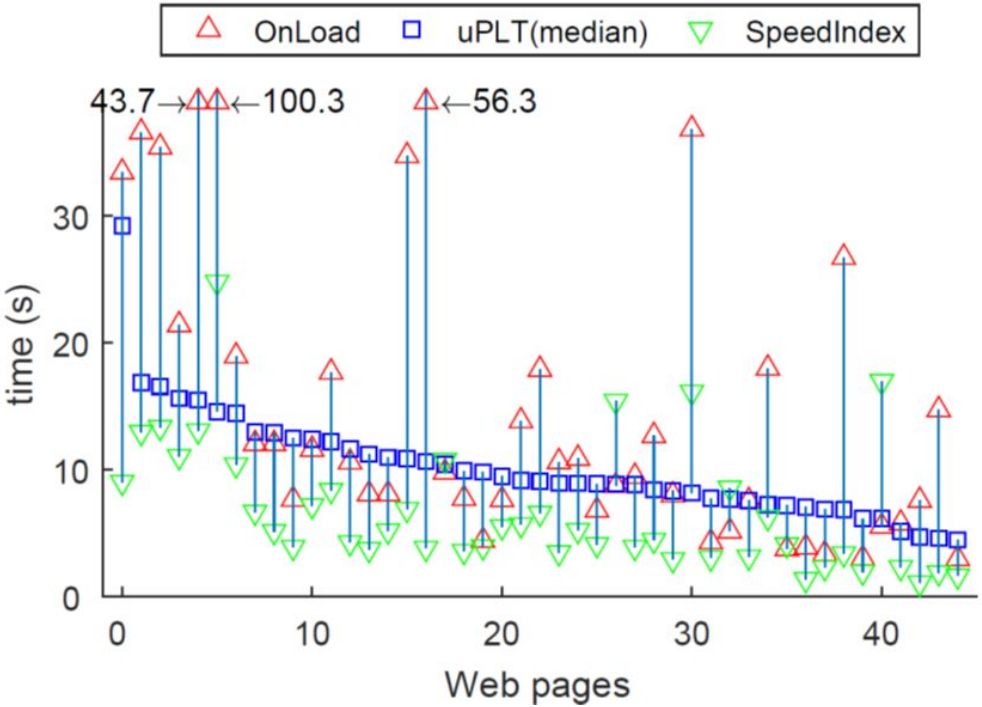
uPLT Results in the Wild

- Overall Observation:

  Corr(uPLT, OnLoad) = ***.46***

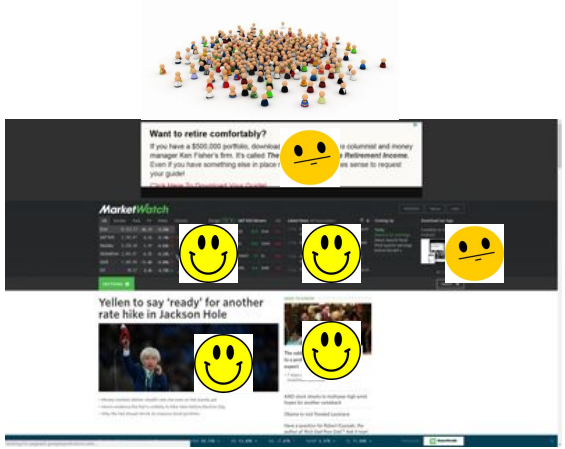
  Corr(uPLT, Speed Index) = ***.44***

- Additional analyses across site categories/ network conditions in paper



Our Goal: Optimize Web loads for uPLT

- Intuition: Loading objects important to users first should improve the **user experience**



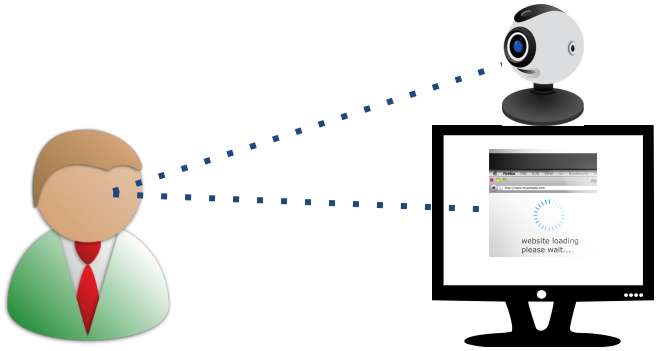
- ***How to find objects important to the user?***

Leveraging Gaze Tracking

Software Aided
Commodity Webcam Tracking

- *User Eye Gaze* has been used to track *user attention*
- Low cost, personalized, gaze tracking becoming feasible

Gaze Collection and User Study



- Like uPLT, *Gaze* also captured during real user studies!
- Webcam based tracker
- 50+ Lab participants, same 45 Web sites as uPLT study
- Goal: To find attention on Web objects from user Gaze tracks

Going from Gaze to Object Importances

- Human Gaze consists of rapid *saccades* interspersed with stable *fixations* which mark points of user attention

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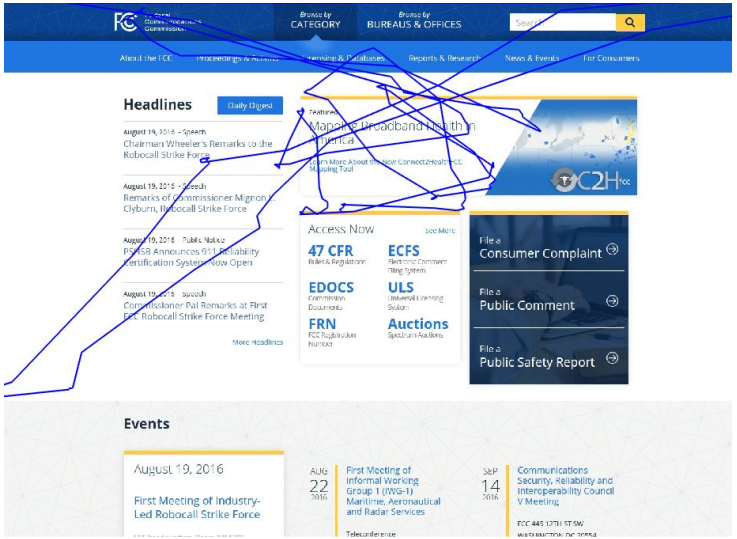

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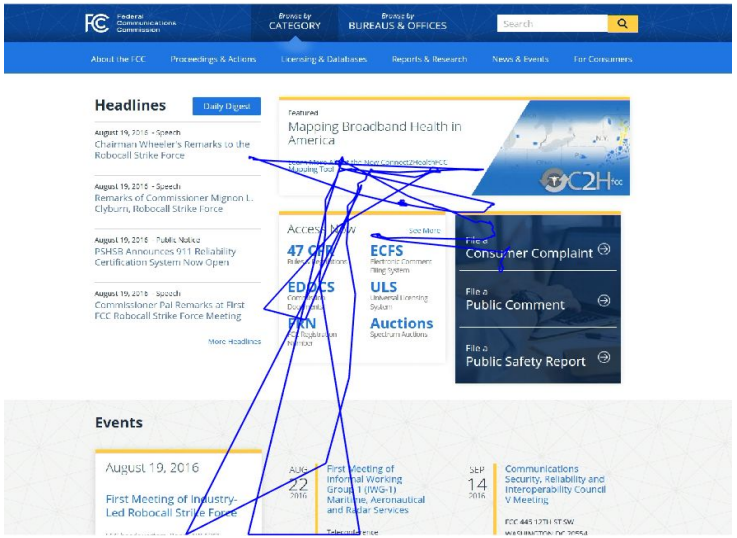

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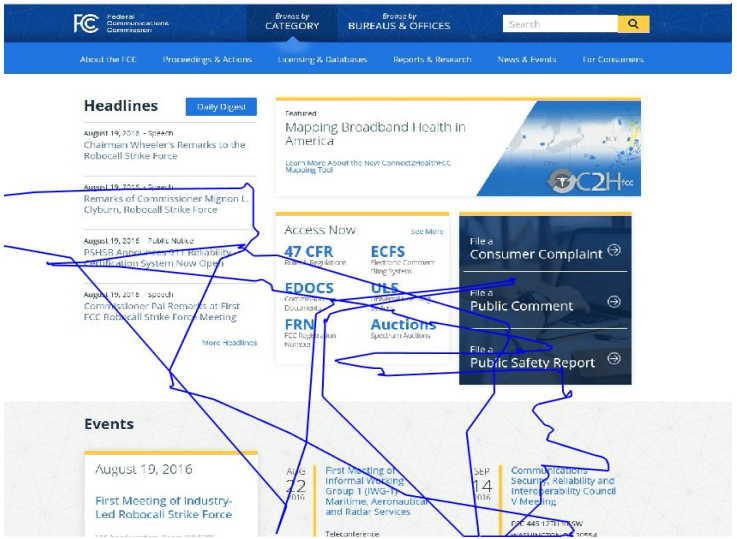

Going from Gaze to Object Importances

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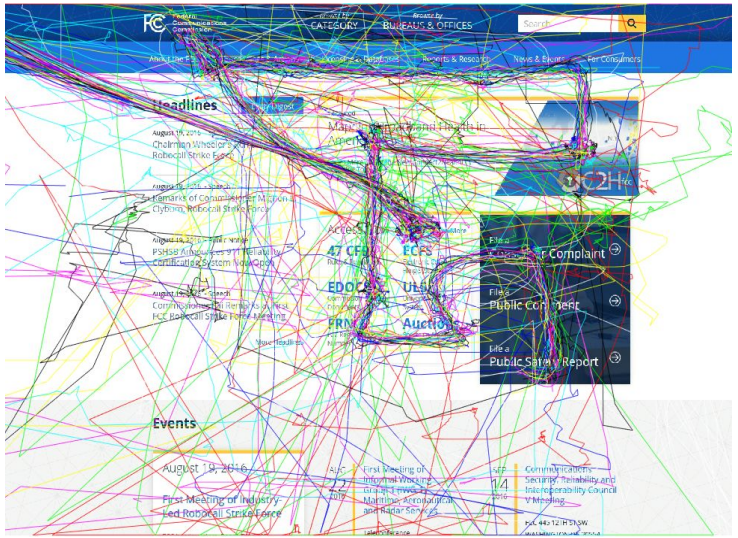
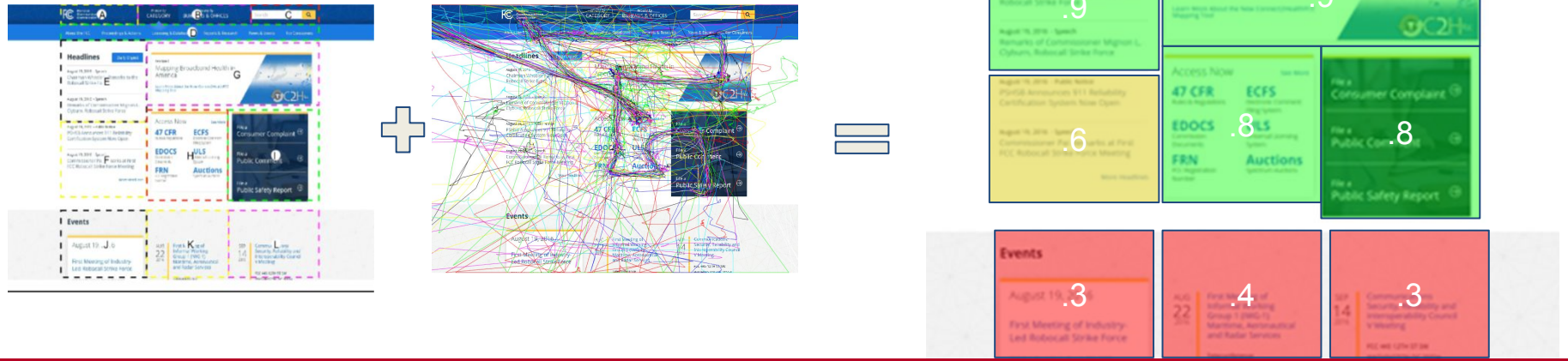
- Fixations overlap across users

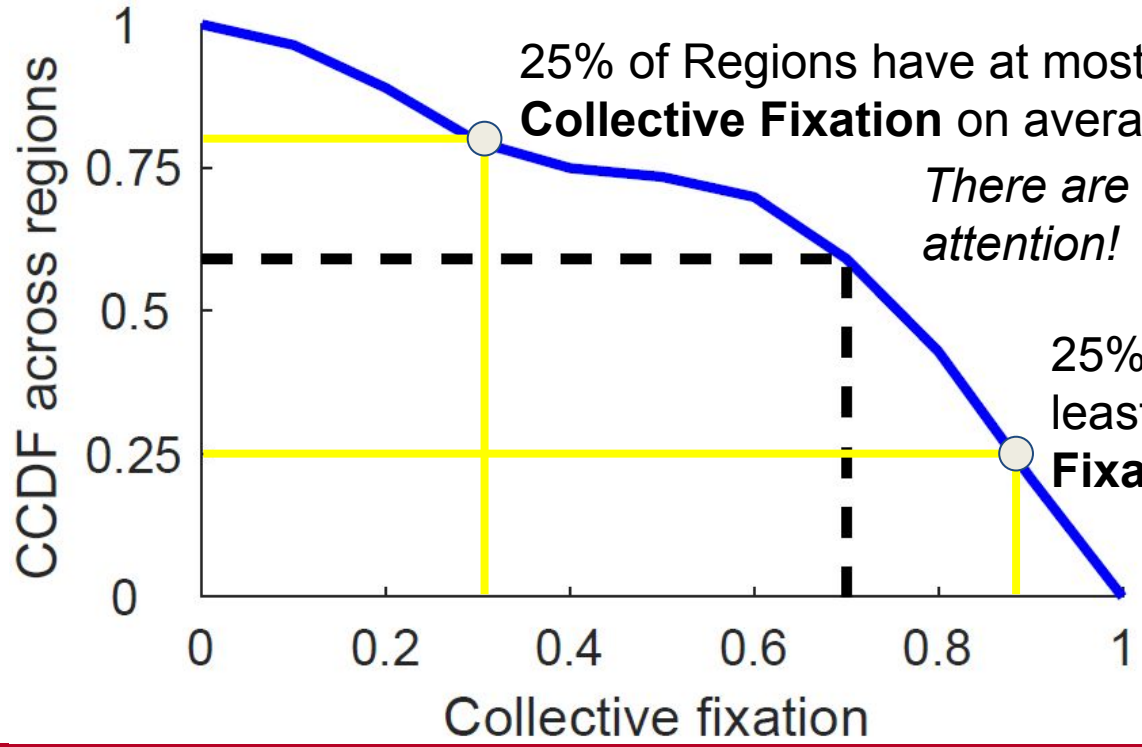


Gaze: Collective Fixation

- First Divide Web page into its ***Visual Regions***
- Map the fixations of all users onto the visual regions
- ***Collective Fixation*** is the fraction of users who fixate on a region



Combining Collective Fixation Results



25% of Regions have at most .3 **Collective Fixation** on average

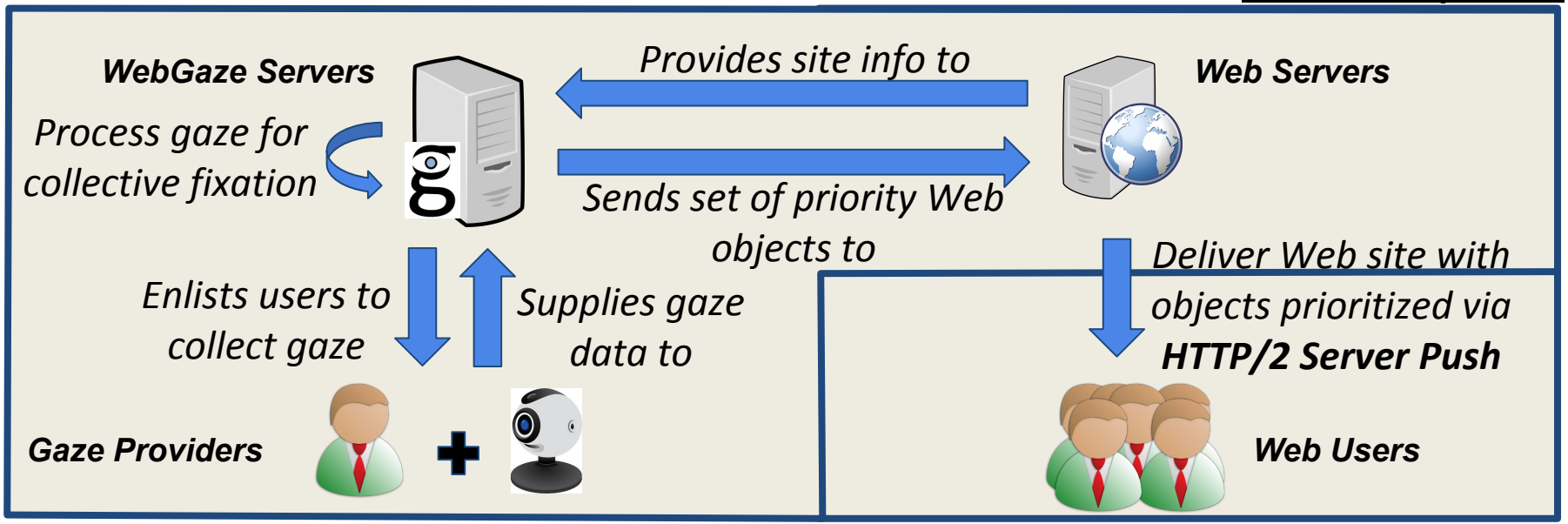
There are objects with low user attention!

25% of Regions have at least .9 **Collective Fixation** on average

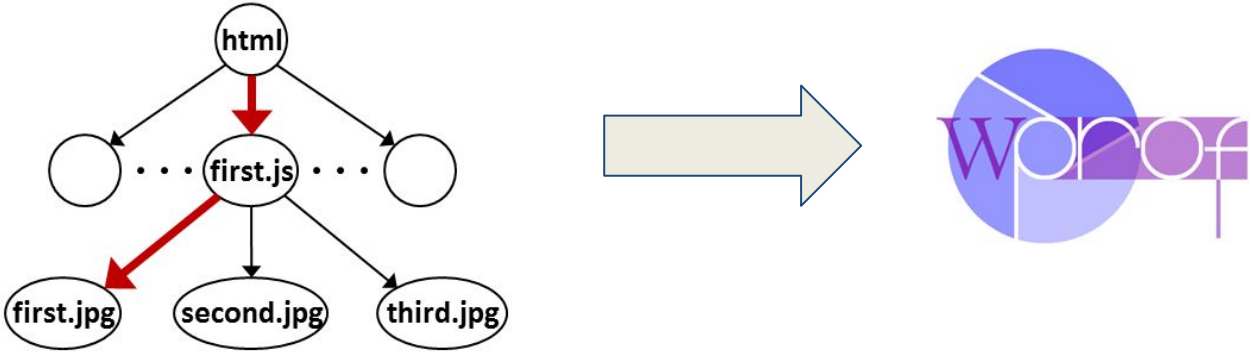
A subset of objects have high user attention!

WebGaze

A Web Prioritization System for *uPLT*

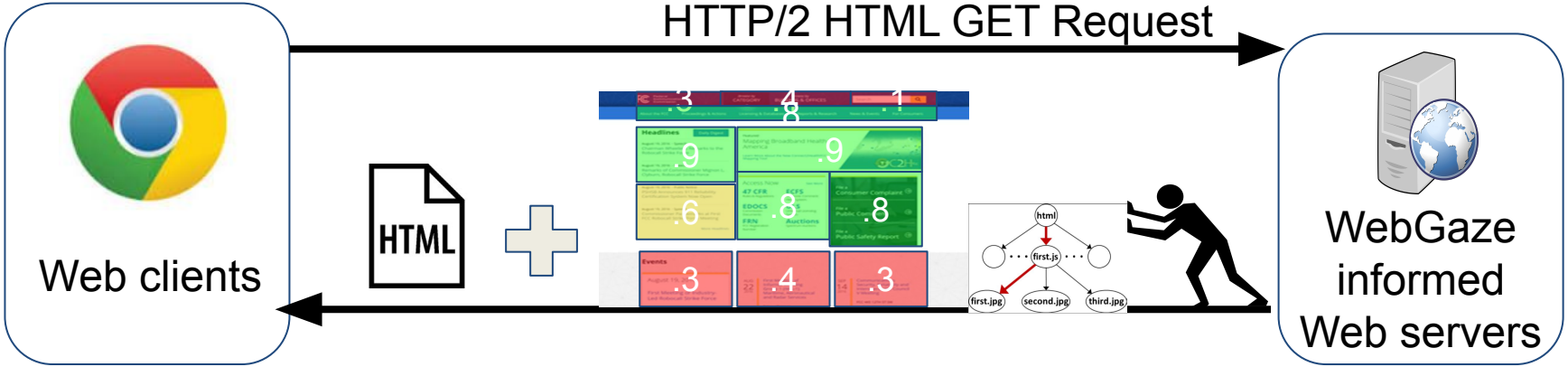


Prioritization Details: Webpage Dependencies



- Web page objects exhibit object *dependencies* on one another
- WebGaze finds and prioritizes these dependencies

Prioritization Details: Server Pushes



- WebGaze pushes objects of high *Collective Fixation* and their *dependencies* with HTML
- HTTP/2 is Multiplexed: Resources will contest for bandwidth
- WebGaze Pushes only objects above a *Collective Fixation Threshold*

WebGaze User Study Implementation

- Download **same 45 pages from uPLT study** locally
- Serve from **HTTP/2 Push enabled Web server**
- Take **videos** of Website loads
- Host videos on **Microworkers to obtain uPLT** from real users

WebGaze Evaluation Comparisons

Default

No Prioritization

Default under HTTP/2

Push All

Pushes all resources identified in the page load

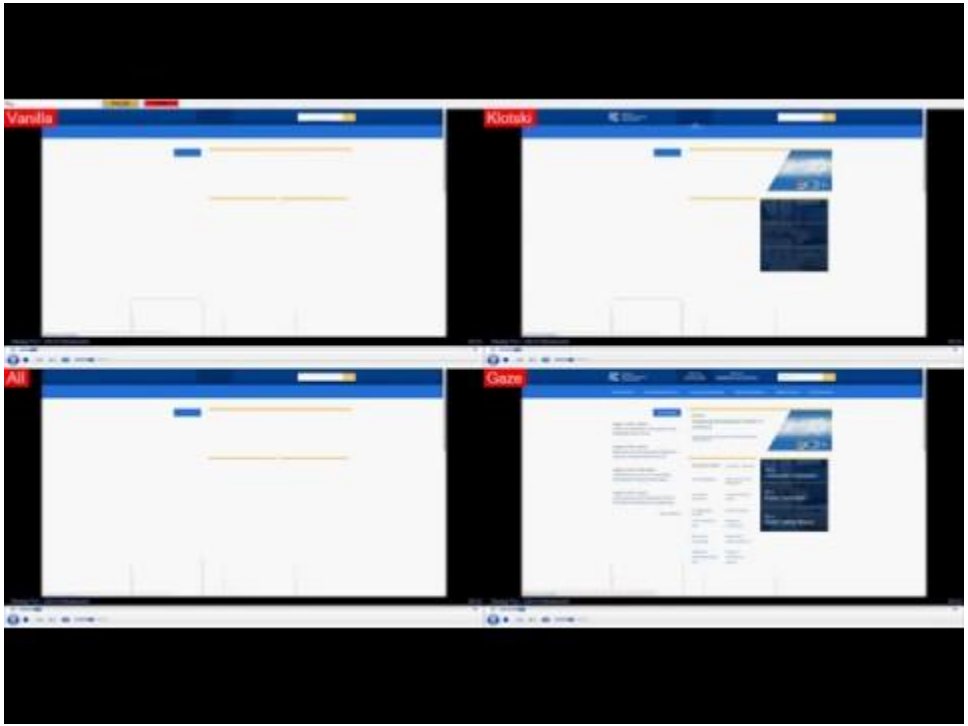
Klotski [NSDI '15]

Pushes all objects that can be loaded in a static user tolerance limit (5 seconds)

State of the art prioritization

WebGaze: Demonstration

Default



Klotski

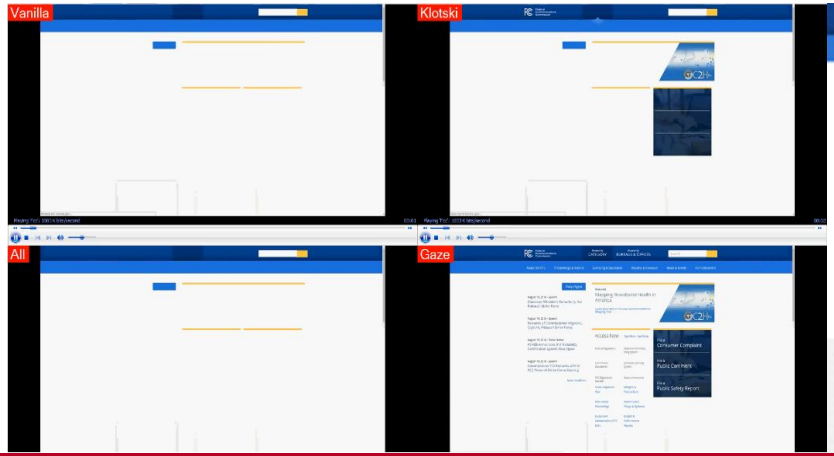
Push-All

WebGaze

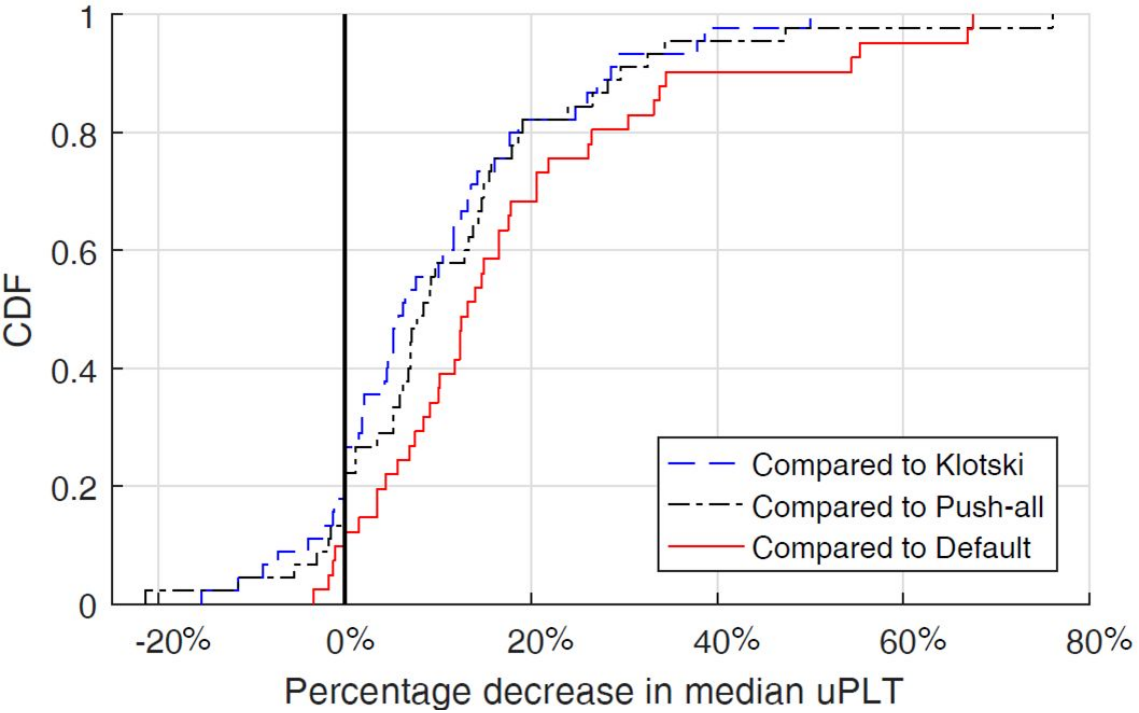
WebGaze: Demo uPLT Results

Default: 12 seconds
Push-All: 10 seconds
Klotski: 9 seconds
WebGaze: 7 seconds

Freeze frame of load process at 6 seconds



WebGaze: Performance Results



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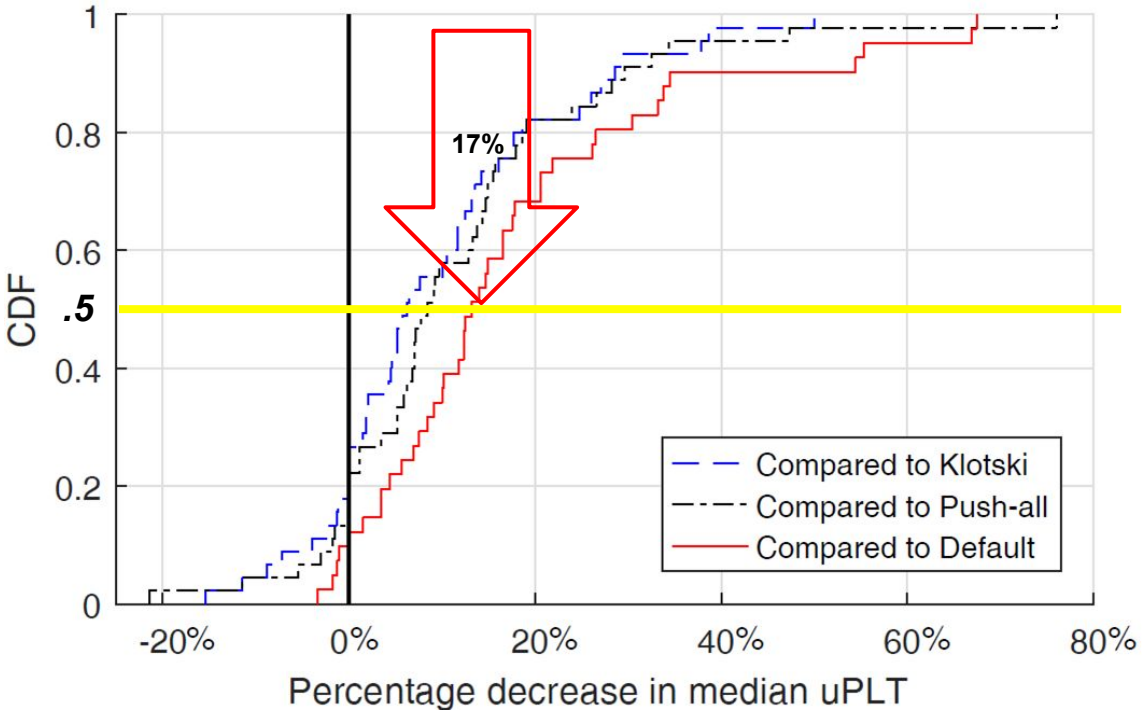

- Delivering objects identified by gaze early does help!

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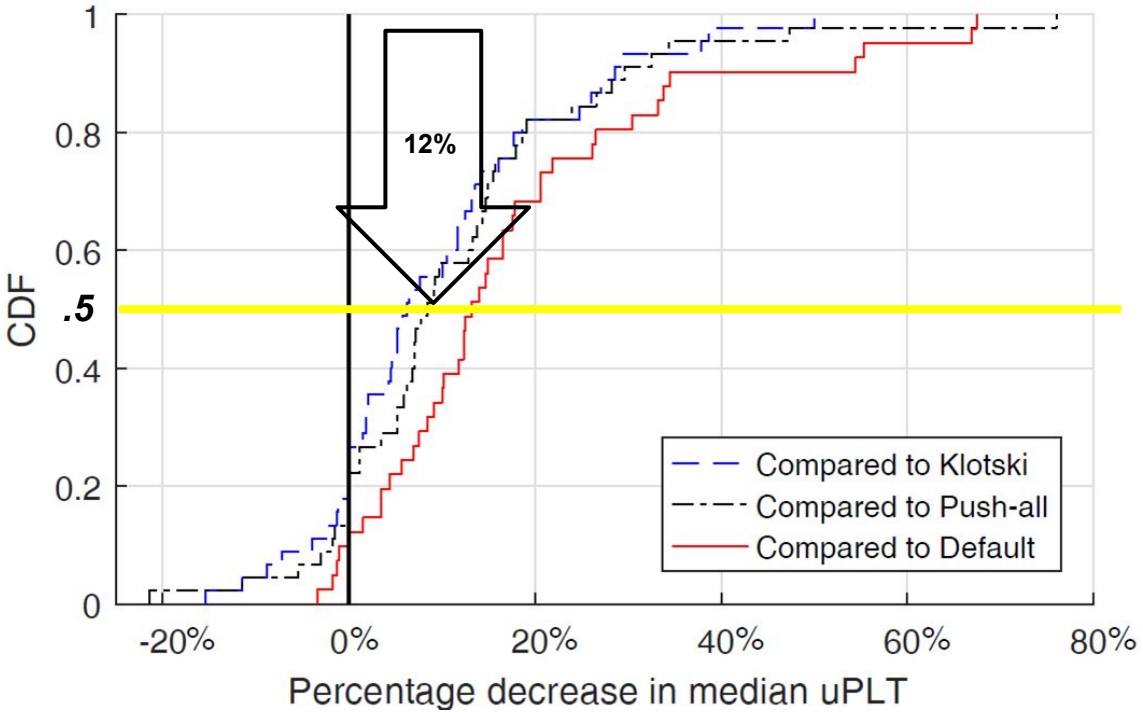

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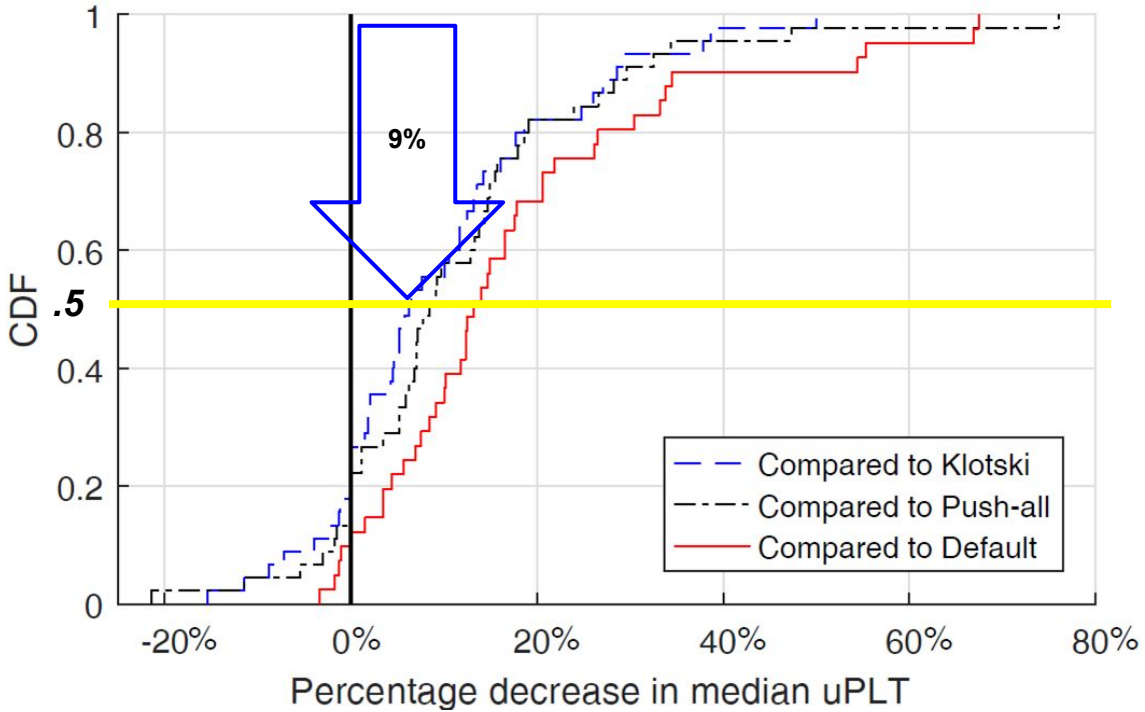

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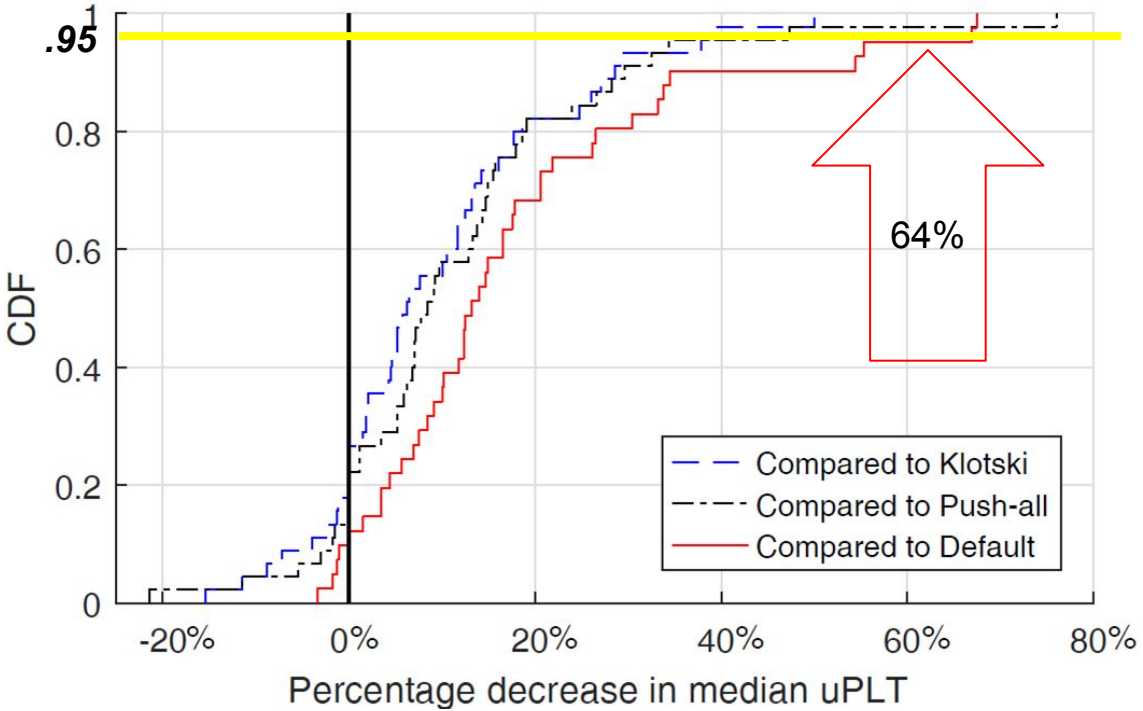
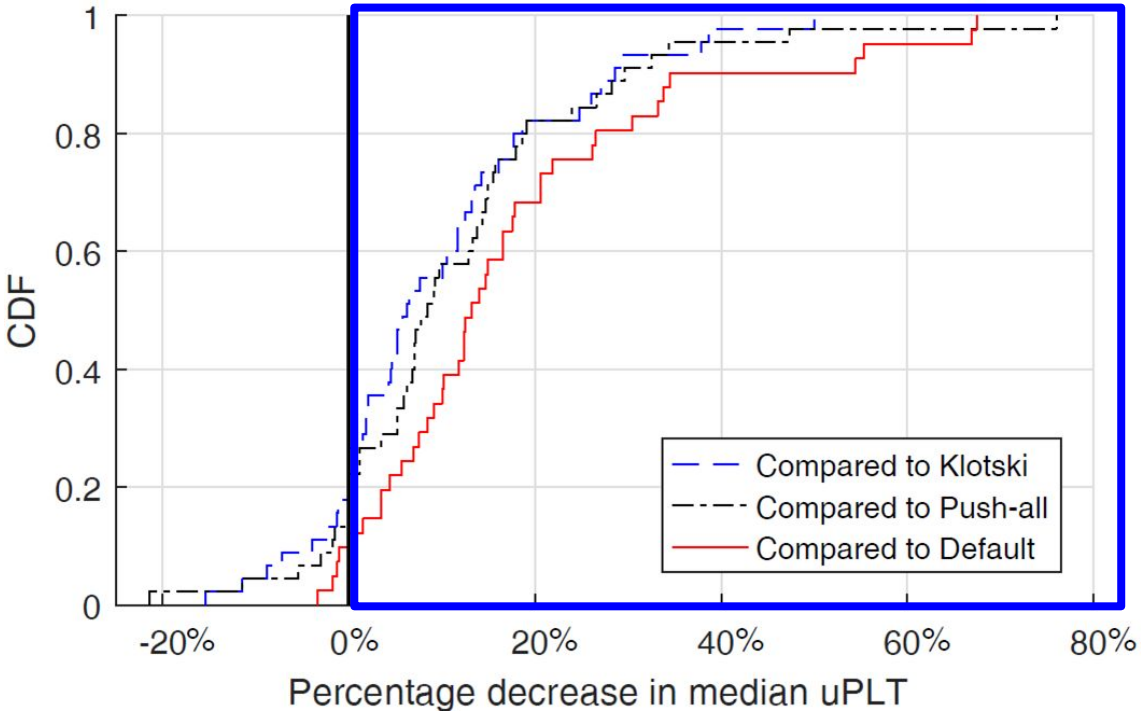


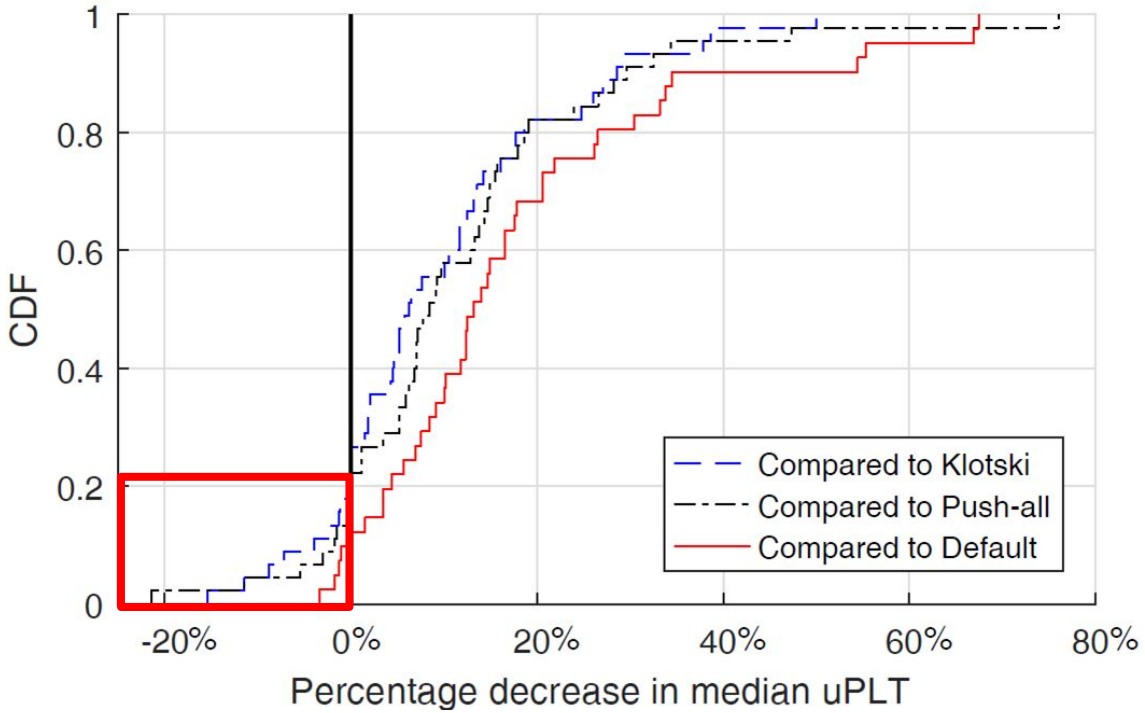
- Delivering objects identified by gaze early does help!
- *Case studies and comparisons to PLT metrics in the paper*

WebGaze: *Why We Do Better*



- uPLT Improvements over Default come from **general prioritization**
- uPLT Improvements over Push-all come from **ATF prioritization**
- uPLT Improvements over Klotski come from **prioritizing the right set of ATF objects**

WebGaze: *Why We Do Worse*



- *Comparing to Push-All:* Pushing everything sometimes works!
- *Comparing to Klotski:* Klotski thresholds objects, preventing worst case push performances

WebGaze: Where to?

- Formally optimize the trade off between collective fixation and object size at the Webgaze Servers
- Using saliency to predict gaze, i.e. automatic gaze feedback
- WebGaze for Mobile

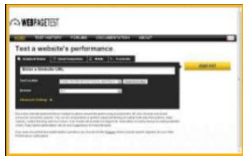
Conclusion

Webgaze

- www.gaze.cs.stonybrook.edu
- uPLT Results - Low Correlation with Traditional PLT Metrics
- Gaze Data - Subset of Web Objects Viewed Significantly!
- Side By Side Loads of Optimized Sites - uPLT Improvements up to 64%
- More Work to Come!

A Visually Oriented Metric: The Speed Index

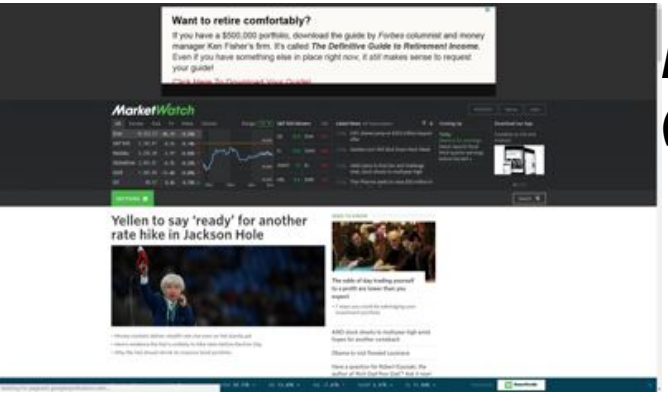
$$\textit{Visual Completeness (VC)} = \quad - \quad$$



$$\textit{Time Interval (TI)} = 0.1\ s$$

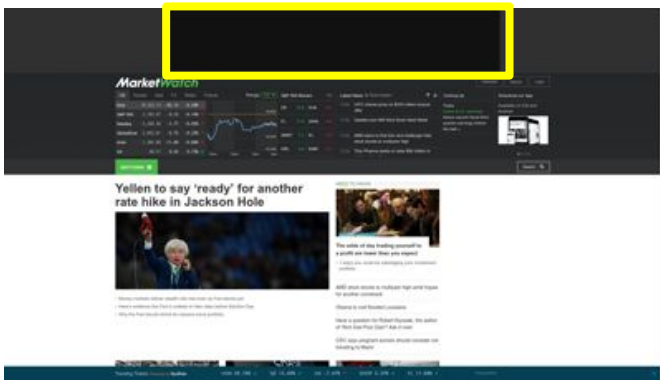
$$\textit{Speed Index} = \sum_{\quad} \textit{TI} \left(1 - \frac{VC}{100}\right)$$

Does Speed Index do a Better Job?



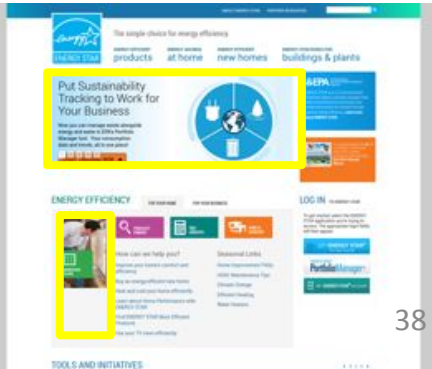
Marketwatch.com: 14.5s (Speed Index)

Marketwatch.com: 7.5s (Most ATF Rendered)



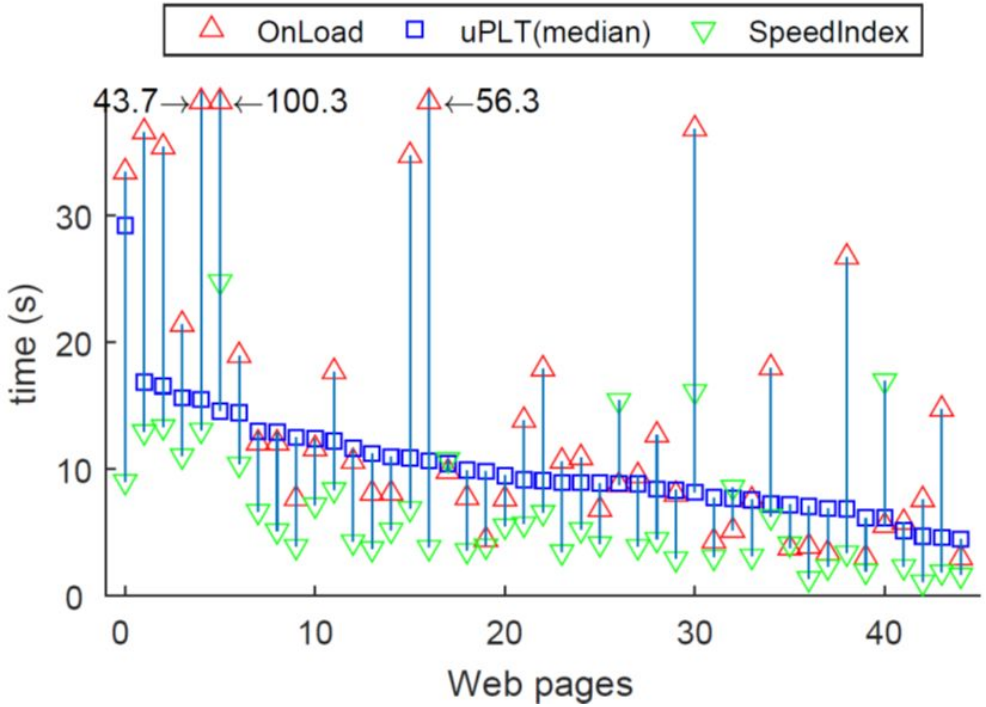
Energystar.gov: 3.7s (Speed Index)

Energystar.gov: 7.8s (ATF Rendered)

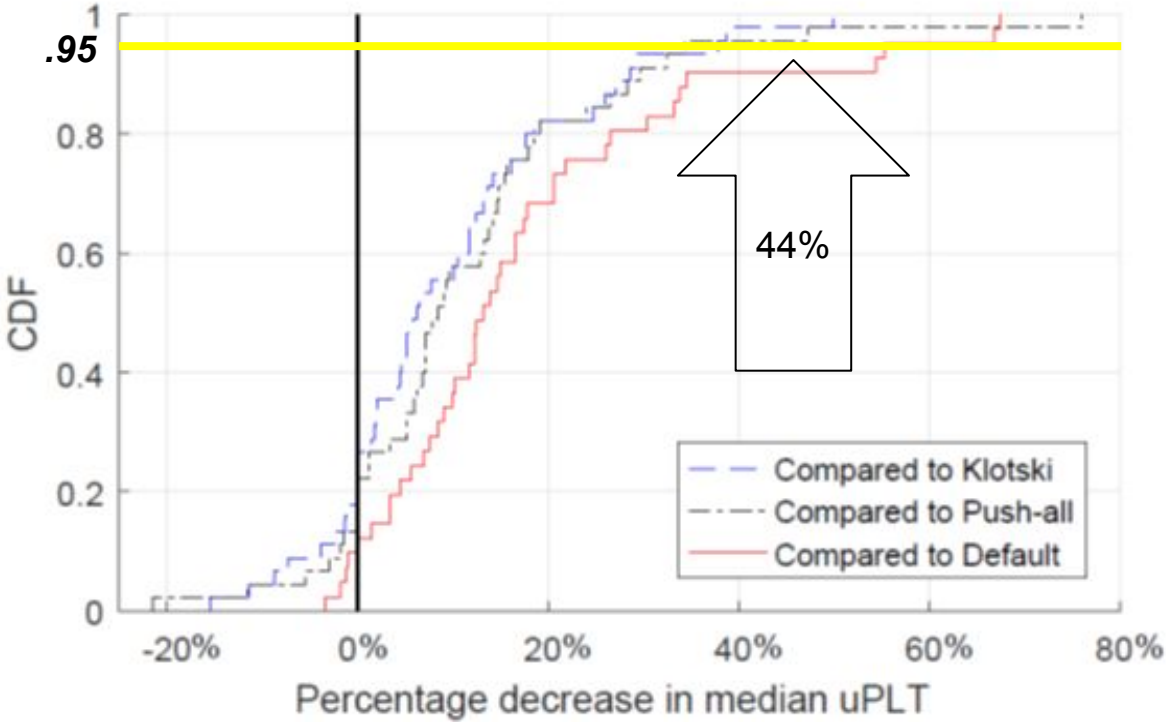


Speed Index vs. uPLT in the Wild

- Speed Index also not trending well with user experience



WebGaze: Performance Results



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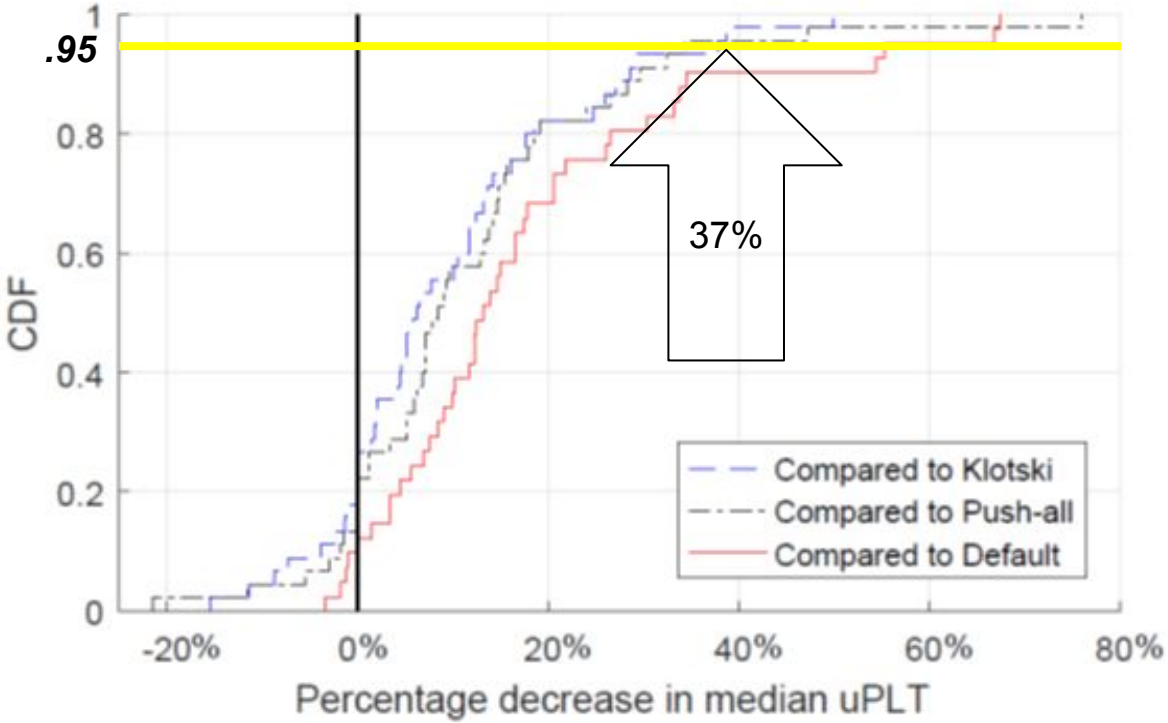

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