

Today's Web QoE

Webpages are complex entities

- Fetch hundreds of objects shared over tents of domains through multiple connections
- Parse and execute JavaScript and CSS
- Dynamic requests and personalized views via cookies

Both academia and industry rate Web QoE with page completion time – onLoad –

- Alexa reports onLoad and quantiles
- Google ranks search results according to onLoad

Tools

HTTP Archive Waterfall ¹

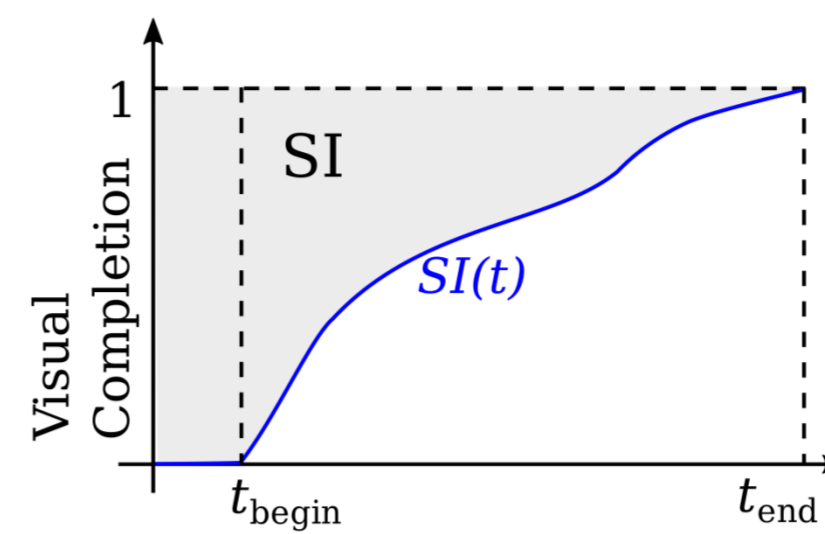
WebPagetest ²

ShowSlow ³

Google's Speed Index

Considers visual progress of page loading process

$$SI = \int_{begin}^{end} \left(1 - \frac{painted}{total}\right) dt$$



Major Drawbacks

Computationally expensive

Distorts experiments by inflating realization time (DOM +41%, onLoad +22%).

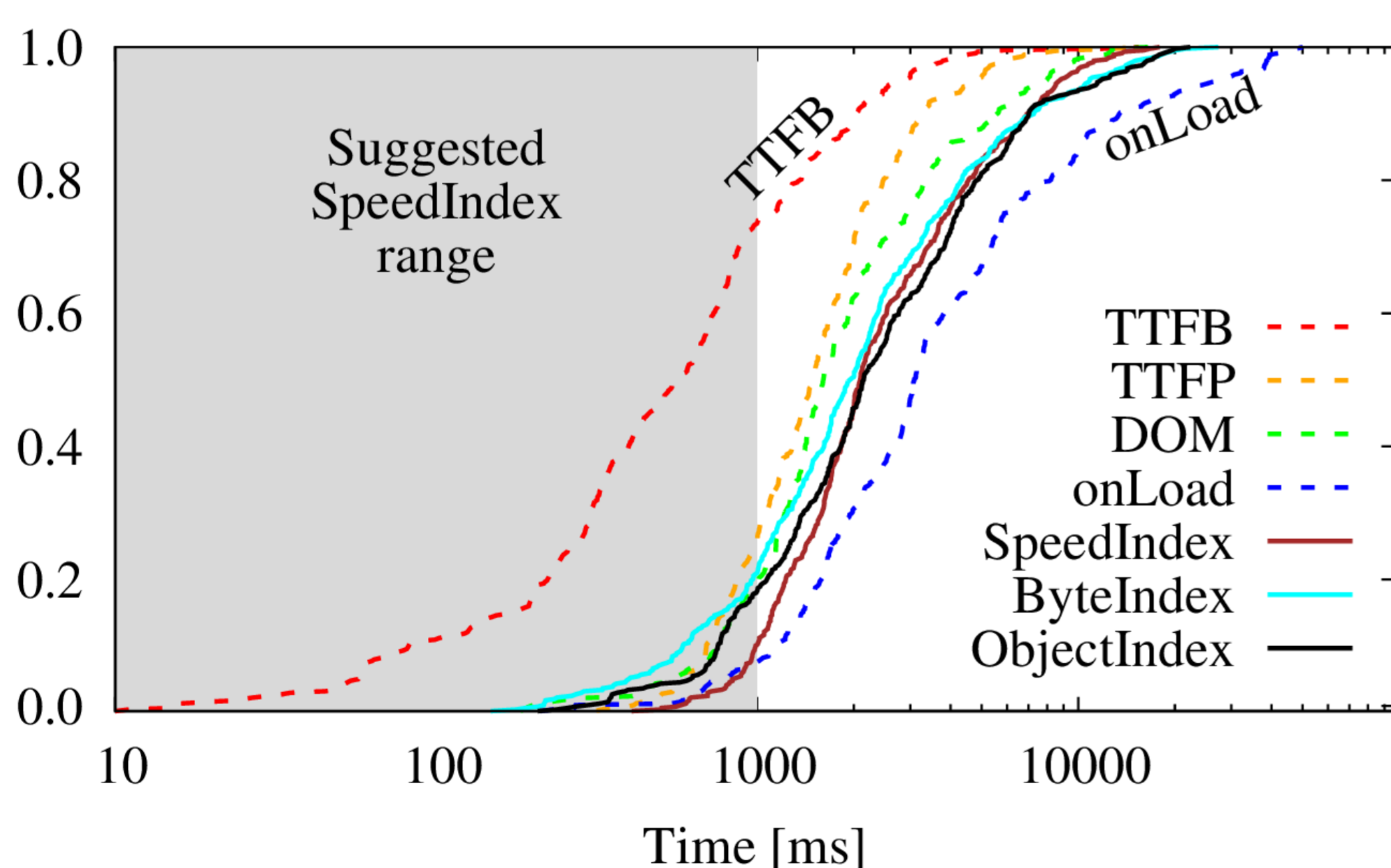
No spatial bias considered (center VS sides do not have the same visual importance)

Inconsistent across platforms (video frames on desktop, paint events on mobile)

Web QoE Metrics – What to compute, where, how

Type	Metric Name	Layer			Description
		L3	L4	L7	
Time Instant	TTFB (TTLB)	≈	✓	✓	First (last) byte of payload received
	DOM	X	X	✓	Document Object Model (i.e., <i>index.html</i>) fetched and parsed
	onLoad	X	X	✓	All bytes of payload received
	TTFP (TTLP)	X	X	✓	First (last) paint event rendered on screen
Time Integral	SpeedIndex	X	X	✓	Integral of complementary visual progress
	ByteIndex	≈	≈	✓	Integral of complementary byte-level completion
	ObjectIndex	X	X	✓	Integral of complementary object-level completion
Compound Scores	YSlow	X	X	✓	Yahoo's 23 weighted expertise-driven heuristics
	PageSpeed	X	X	✓	Google's PageSpeed Insight heuristics
	dynaTrace	X	X	✓	dynaTrace's compound score
Human Perception	MOS (Mean Opinion Score)	X	X	X	User rating based on personal experience

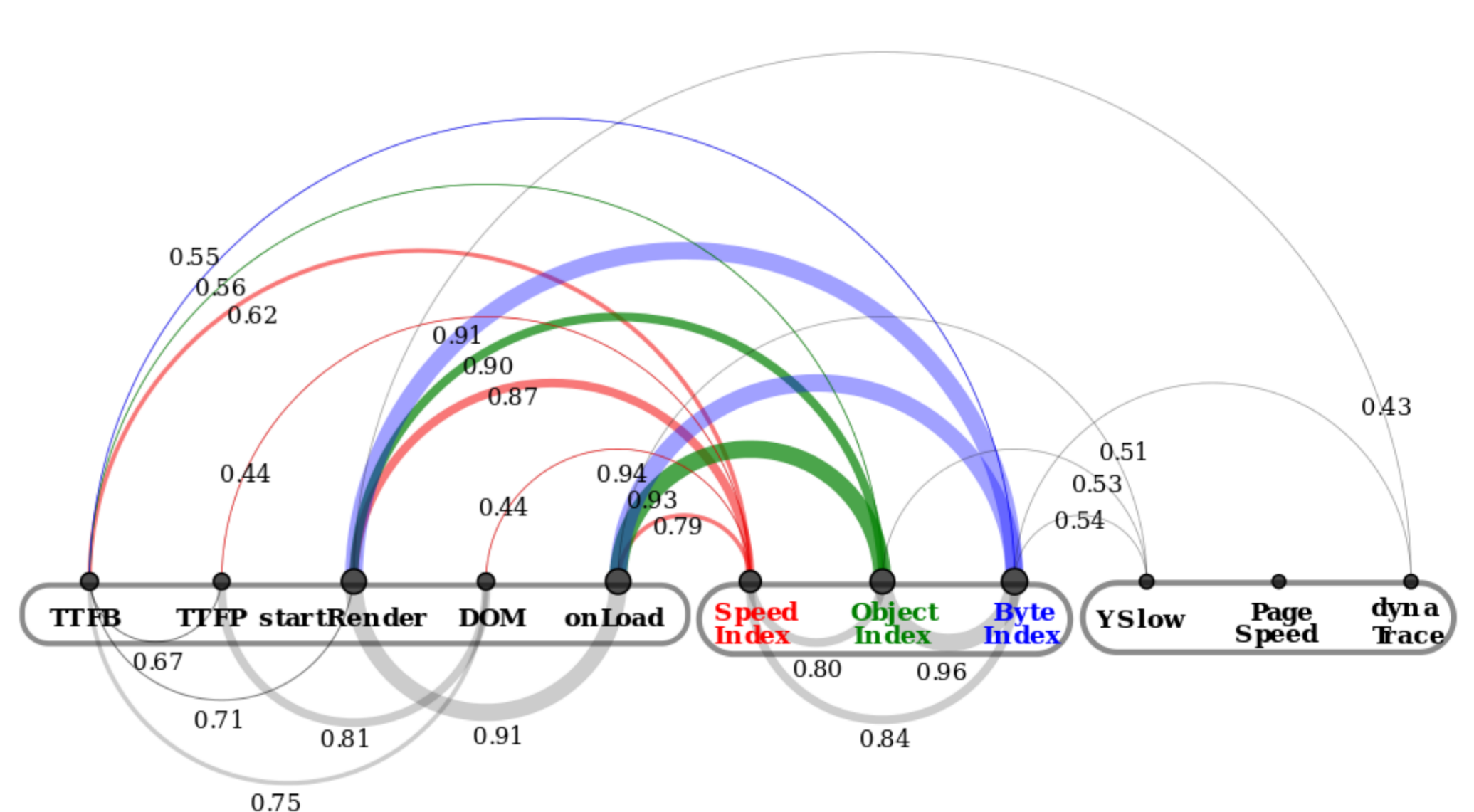
Time Instant and Time Integral Metrics



Experimentations over Alexa top-100 Webpages (10 runs)

- Events have an order relationship (no first paint possible before first byte)
- Metrics show a significant variance (e.g., onLoad: median=3s, 90th=13s)
- {Object, Byte}Index are clustered with SpeedIndex hinting for similarities

How do such metrics correlate?



Pearson correlation coefficient between metric pairs

- {Object, Byte}Index are highly correlated with the SpeedIndex and with several time instant metrics, suggesting for a sound replacement
- Compound metrics (Yslow, Page Speed) are poorly correlated

1: <https://developers.google.com/web/tools/chrome-devtools/profile/network-performance/resource-loading>
2: <http://www.webpagetest.org/>

3: <http://www.showslow.com/>
4: <https://sites.google.com/a/webpagetest.org/docs/using-webpagetest/metrics/speed-index>