GOALS
Is it faster?

H2 vs H1 performance in the real world

Network scenarios

Cell Networks

Browsers

Mobile devices

Site characteristics

MEASUREMENT Methodology

Real User Monitoring

Navigation Timing API; enriched

Edge clusters serve 50% H2 and 50% H1

Fair and unbiased comparison possible

Straight transition; no de-optimization

No specific TCP tuning

ANALYSIS
Per URI
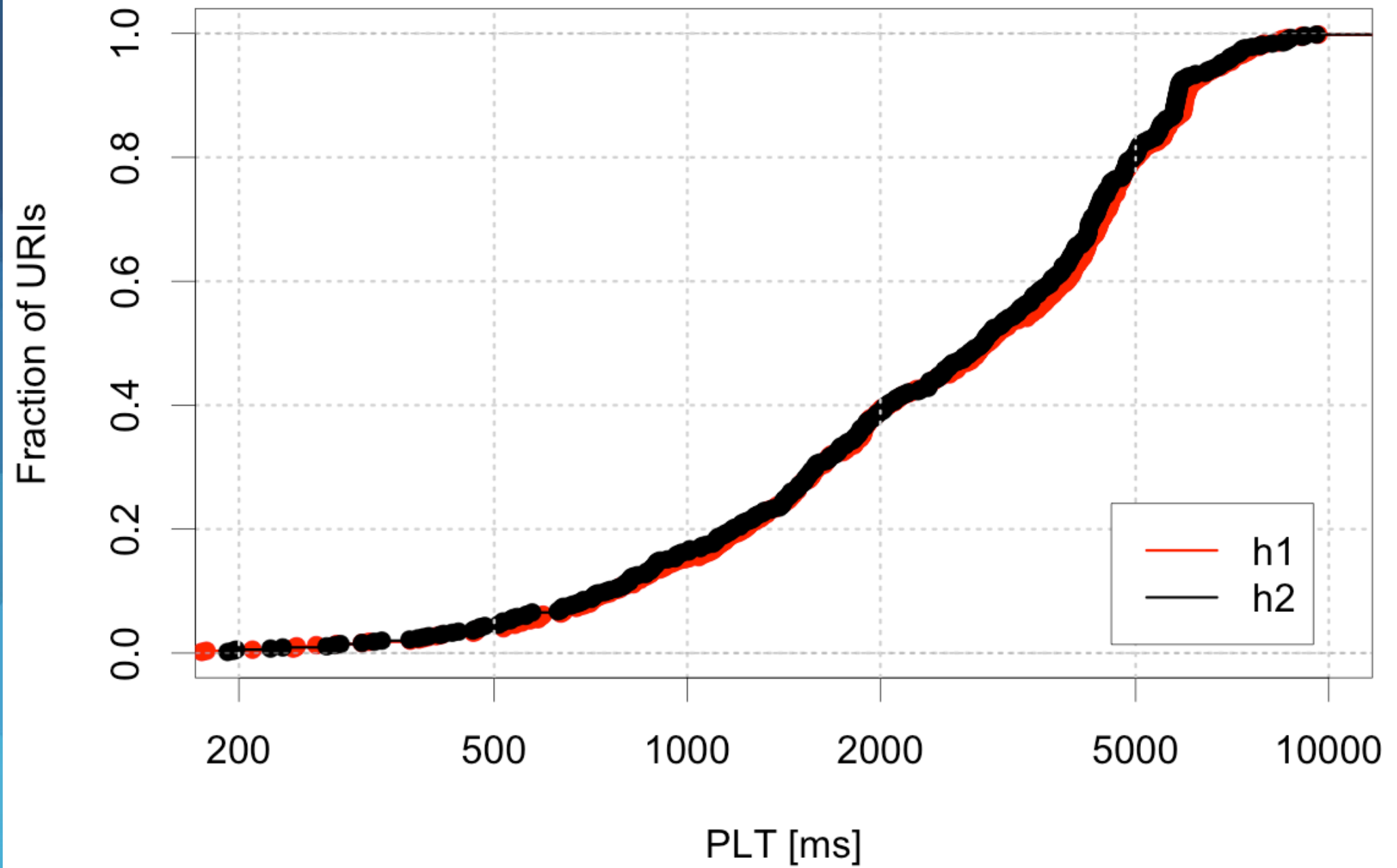
No domination of popular sites

Statistical significance

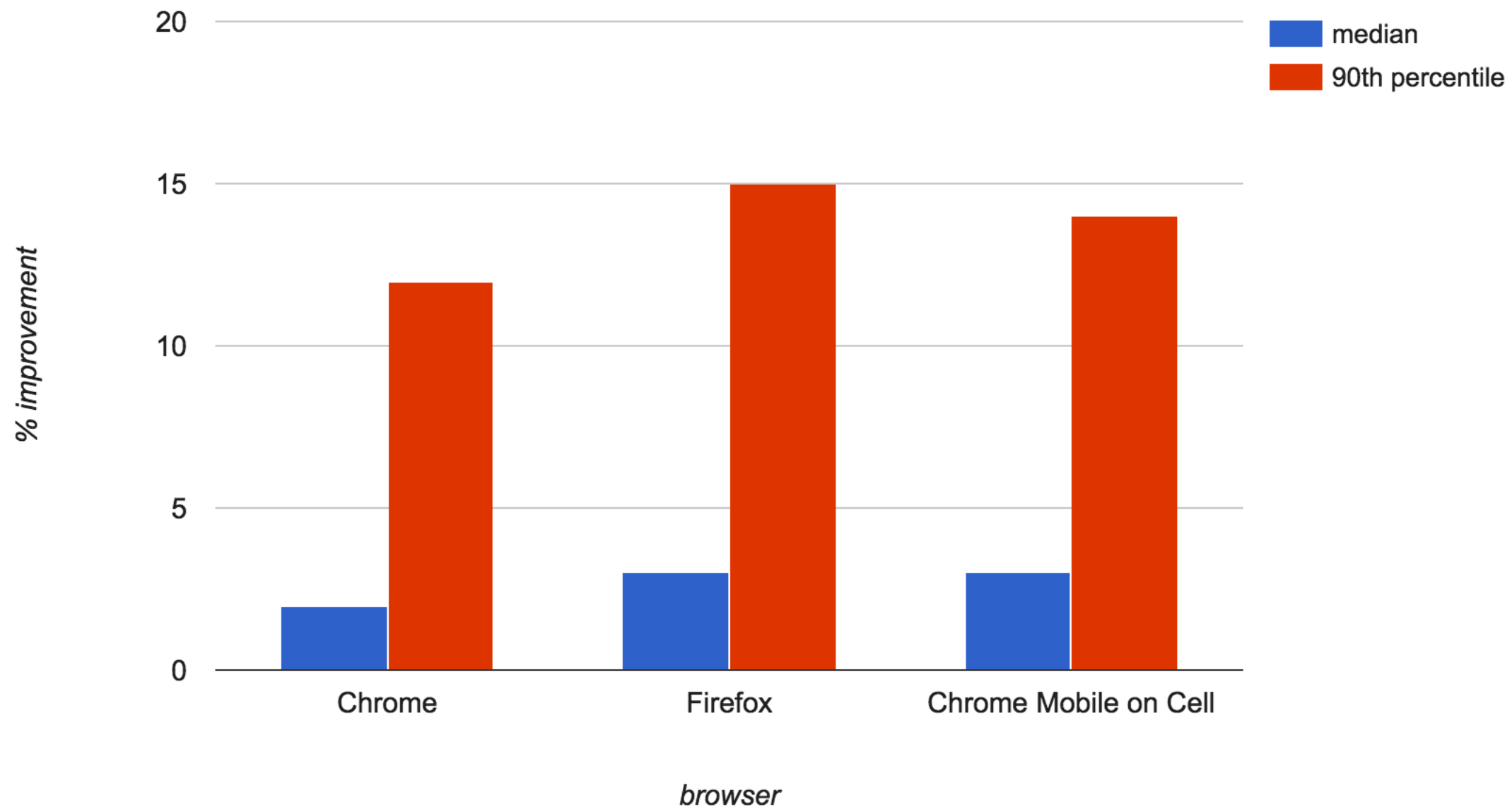Median: sites and user experience

Long tail: sites and user experience

Interesting information for customers

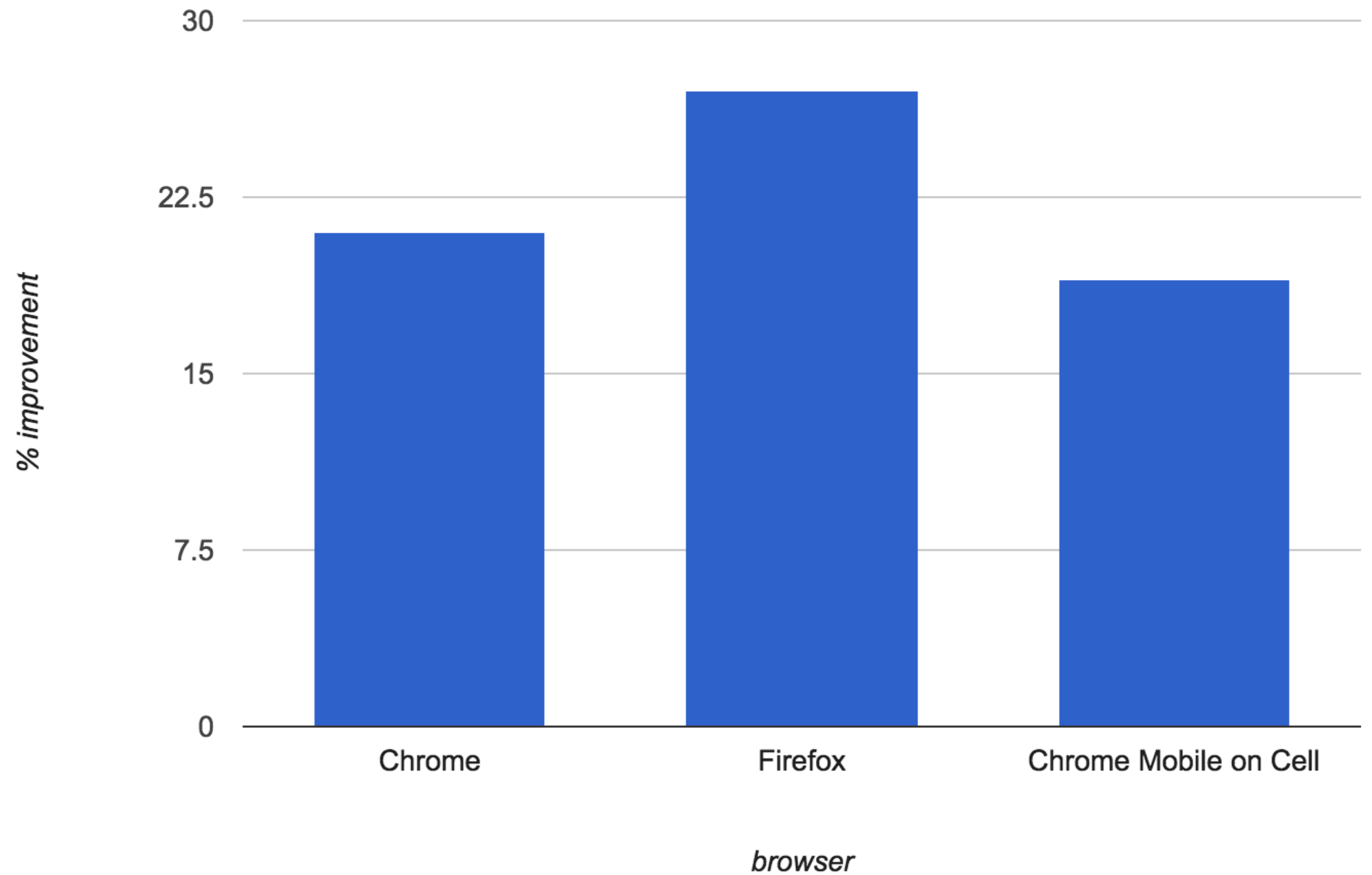# Median Page Load Times (PLT)
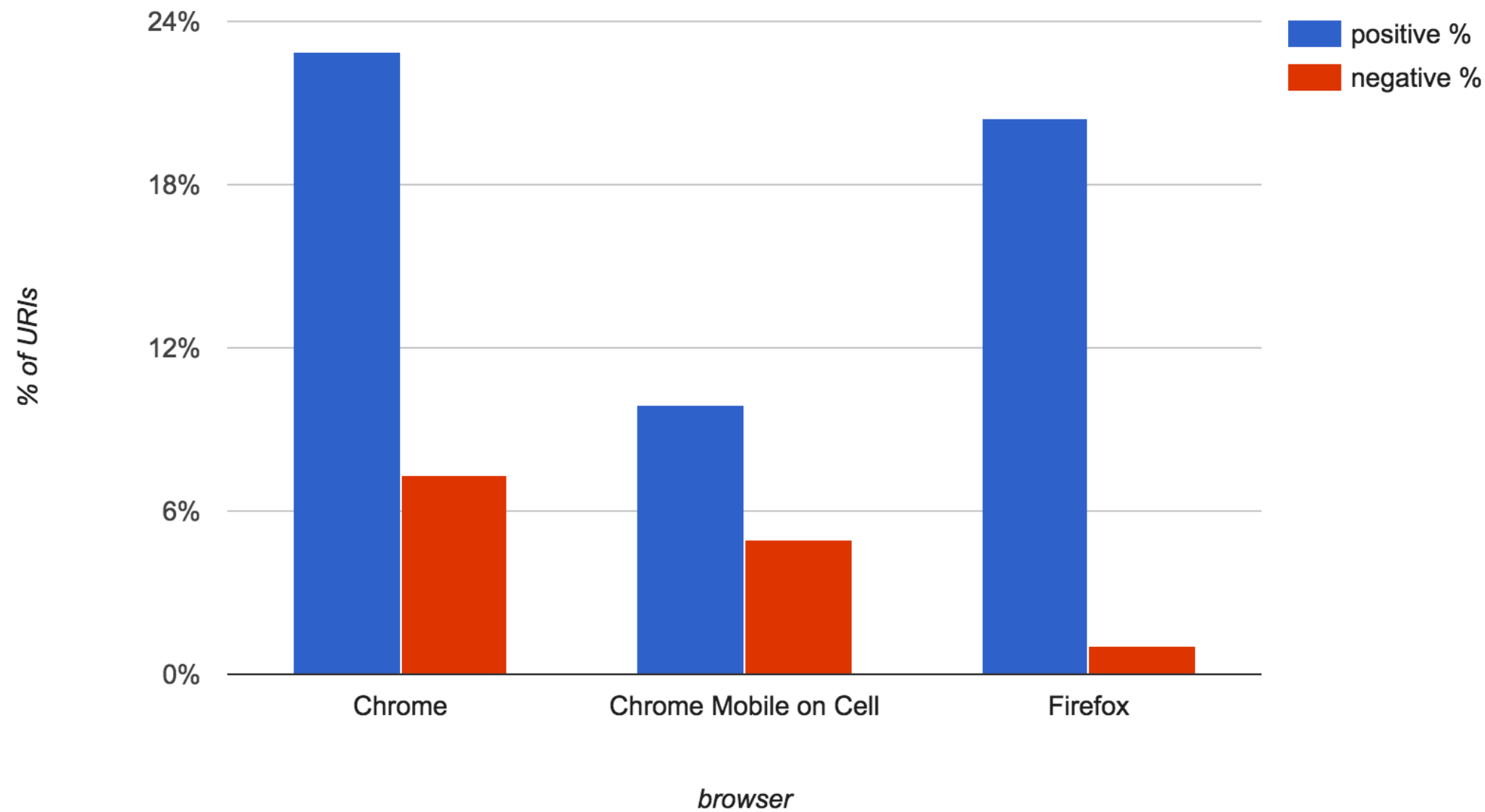

chrome; non-cell

Median PLTs Speedup

Some URIs see a impressive speedup

90th Perc PLTs and Sites Speedup

Reduced bad user experience

Statistical Significance

Regression analysis

Slowdowns non reproducible

3rd Party Objects

Protocol	Remote Address	Type	Size	Time	Priority	Connection Id	Timeline – Start Time
h2	23.5.219.40:443	document	10.5 KB	32 ms	Highest	446	
h2	23.5.219.40:443	stylesheet	25.4 KB	26 ms	Highest	446	
h2	23.5.219.40:443	script	43.8 KB	29 ms	High	446	
h2	23.5.219.40:443	script	92.3 KB	66 ms	Medium	446	
h2	23.5.219.40:443	png	12.4 KB	27 ms	Low	446	
h2	23.5.219.40:443	jpeg	144 KB	66 ms	Low	446	
h2	23.5.219.40:443	jpeg	96.4 KB	65 ms	Low	446	
h2	23.5.219.40:443	jpeg	10.4 KB	36 ms	Low	446	
h2	23.5.219.40:443	script	24.9 KB	50 ms	Medium	446	
h2	23.5.219.40:443	script	7.9 KB	51 ms	Medium	446	
h2	23.5.219.40:443	script	4.7 KB	51 ms	Medium	446	
h2	23.5.219.40:443	font	32.3 KB	12 ms	Highest	446	
http/1.1	[2001:428:7008::3f96:c11]:443	script	5.8 KB	22 ms	Low	519	
h2	23.5.219.40:443	media	104 KB	21 ms	Low	446	
h2	23.5.219.40:443	script	12.8 KB	11 ms	Low	446	
h2	23.5.219.40:443	stylesheet	4.4 KB	16 ms	Highest	446	
h2	23.5.219.40:443	xhr	6.0 KB	11 ms	High	446	
h2	23.5.219.40:443	png	2.4 KB	11 ms	Low	446	
h2	23.5.219.40:443	xhr	4.3 KB	1.36 s	High	446	
h2	216.58.194.206:443	gif	119 B	12 ms	Low	373	
h2	23.5.219.40:443	xhr	2.4 KB	14 ms	High	446	
h2	23.5.219.40:443	xhr	8.7 KB	11 ms	High	446	
h2	23.5.219.40:443	xhr	7.6 KB	11 ms	High	446	
http/1.1							

Clean site; most object and bytes on h2

17% median reduction in PLT

3rd Party Objects

302	http/1.1	173.241.250.143:443		650 B	351...	Lowest	2352			
302	http/1.1	173.241.250.143:443		625 B	352...	Lowest	2351			
302	http/1.1	173.241.250.143:443		650 B	351...	Lowest	2353			
200	h2	184.87.76.129:443	xhr	1.3 KB	90 ms	High	2144			
200	h2	184.87.76.129:443	jpeg	20.3 ...	18 ms	Low	1755			
200	h2	184.87.76.129:443	jpeg	14.4 ...	21 ms	Low	1755			
200	h2	184.87.76.129:443	jpeg	10.1 ...	21 ms	Low	1755			
200	h2	184.87.76.129:443	jpeg	10.7 ...	23 ms	Low	1755			
200	http/1.1	93.184.216.180:443	script	1.3 KB	18 ms	Low	1909			
200	http/1.1	93.184.216.180:443	script	1011 B	28 ms	Low	1909			
200	http/1.1	93.184.216.180:443	script	17.0 ...	36 ms	Low	1909			
200	http/1.1	93.184.216.180:443	script	1.3 KB	45 ms	Low	1909			
200	h2	184.87.76.129:443	script	3.7 KB	24 ms	Low	1755			
200	http/1.1	151.101.40.222:443	script	31.4 ...	17 ms	Low	2220			
200	http/1.1	151.101.40.222:443	script	11.8 ...	60 ms	Low	2220			
200	http/1.1	173.241.250.209:443	script	727 B	49 ms	Lowest	2108			
200	http/1.1	173.241.250.209:443	script	726 B	89 ms	Lowest	2108			
200	http/1.1	173.241.250.209:443	script	726 B	101...	Lowest	2274			
200	http/1.1	173.241.250.209:443	script	726 B	82 ms	Lowest	2285			
200	http/1.1	173.241.250.209:443	script	714 B	107...	Lowest	2273			
200	h									
200	h									
200	http/1.1	25.5.209.250:443	script	46.2 ...	29 ms	Low	2484			
200	h									
200	h									
200	h									
200	http/1.1	72.21.203.136:443	xhr	471 B	432...	High	2550			
200	h2	184.87.76.129:443	script	3.2 KB	25 ms	Low	1755			

80 domains; most of them not on h2

No significant reduction in PLT

CELL
network emulation

- Dynamics of cellular connectivity
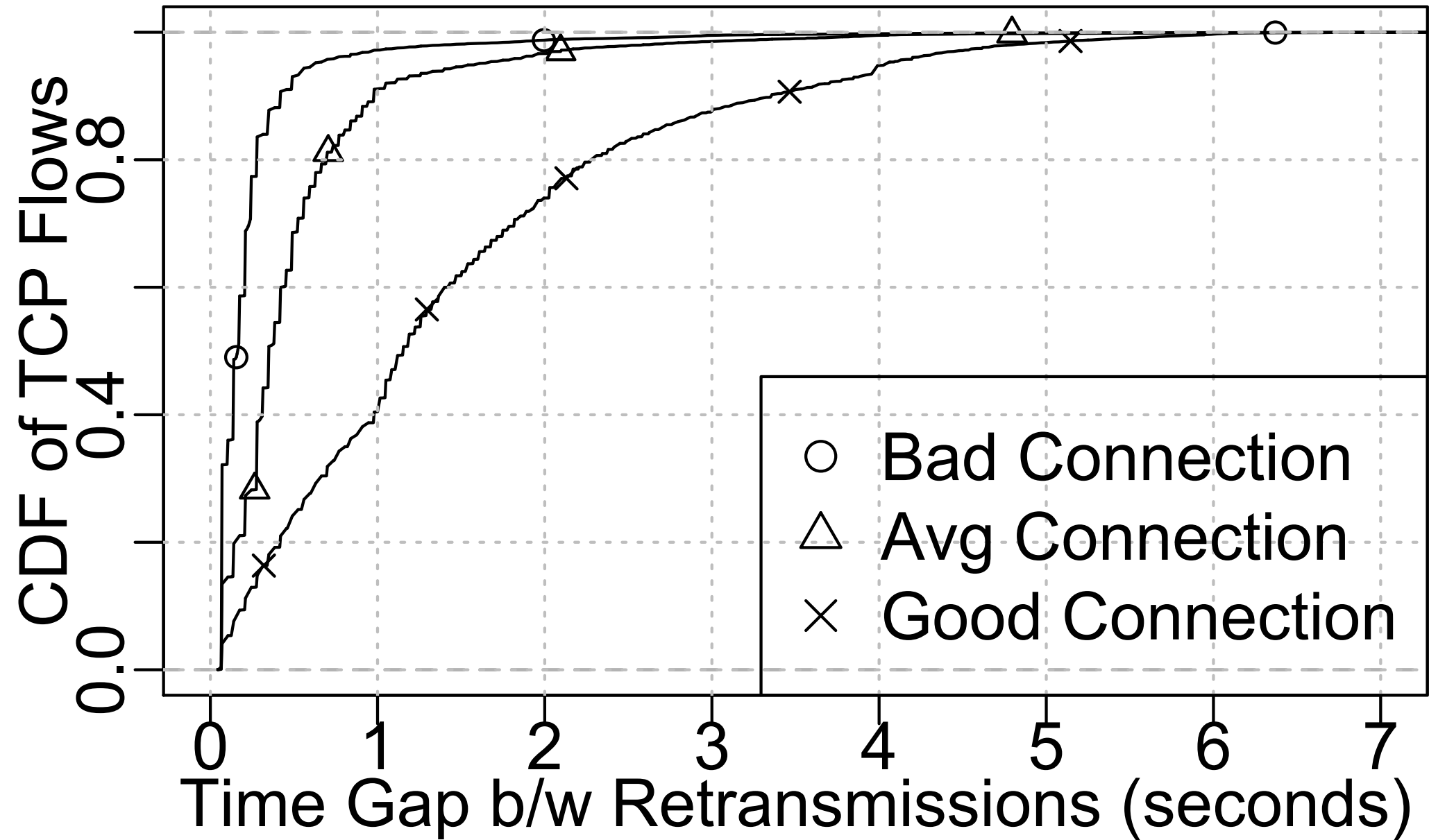- Production network traces
- Analysis
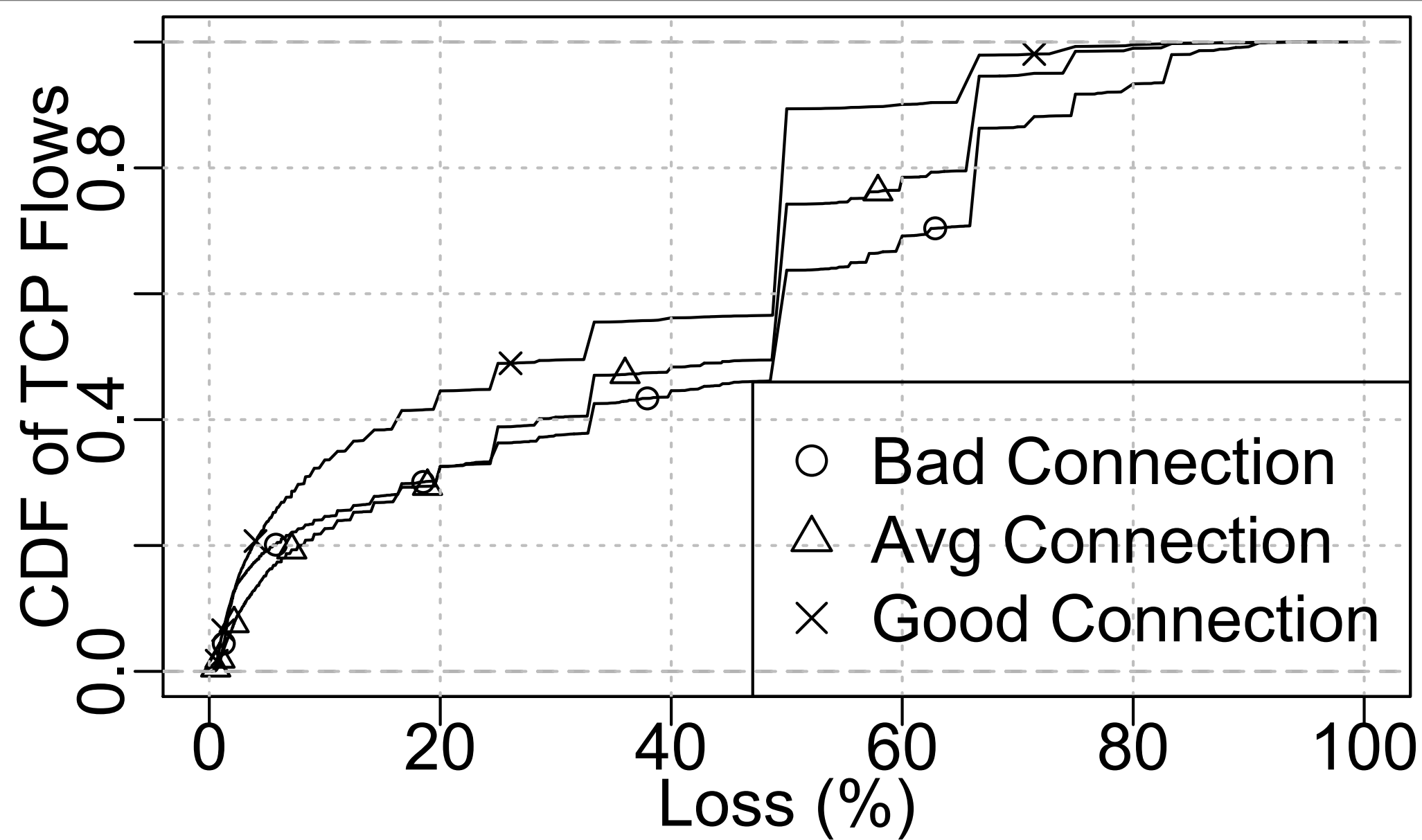- Emulation on simple testbed
- Page load measurements
- Sharding; Initial Congestion Window

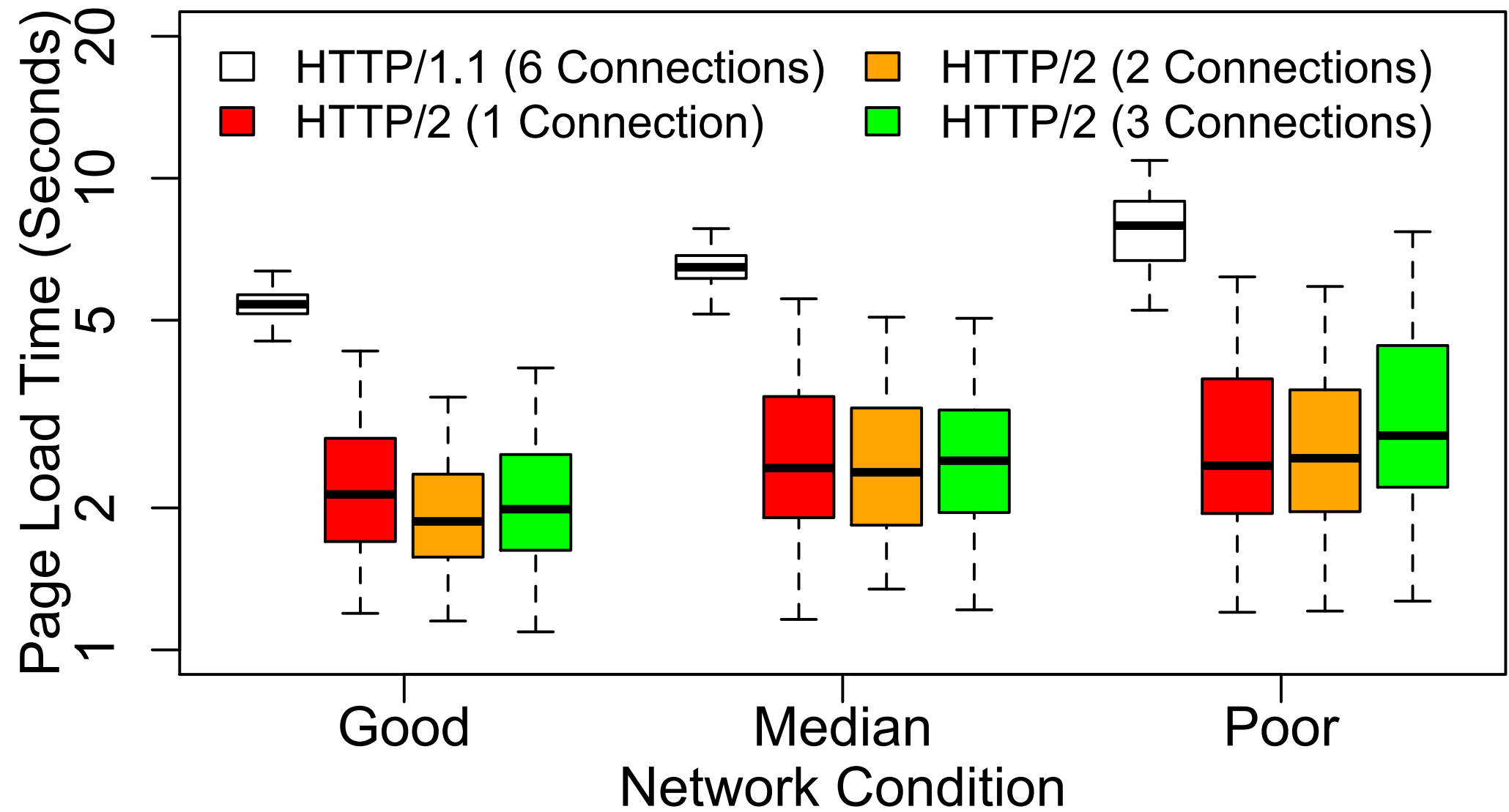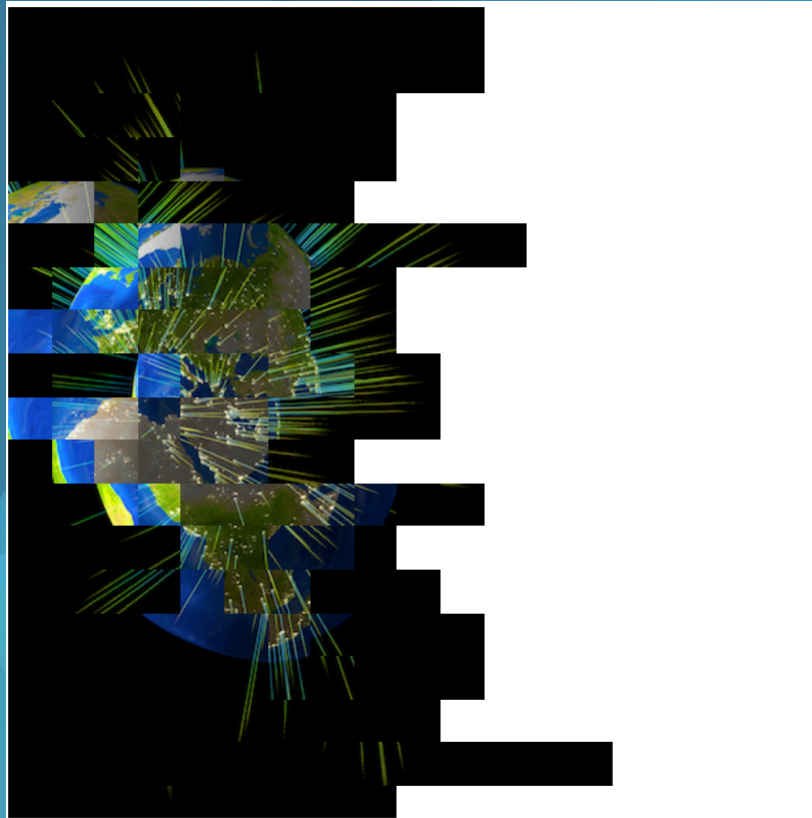**TIME GAPS** between loss events

focus on connections with loss

LOSS FRACTION when loss occurs

more frequent loss -> more loss per occurrence
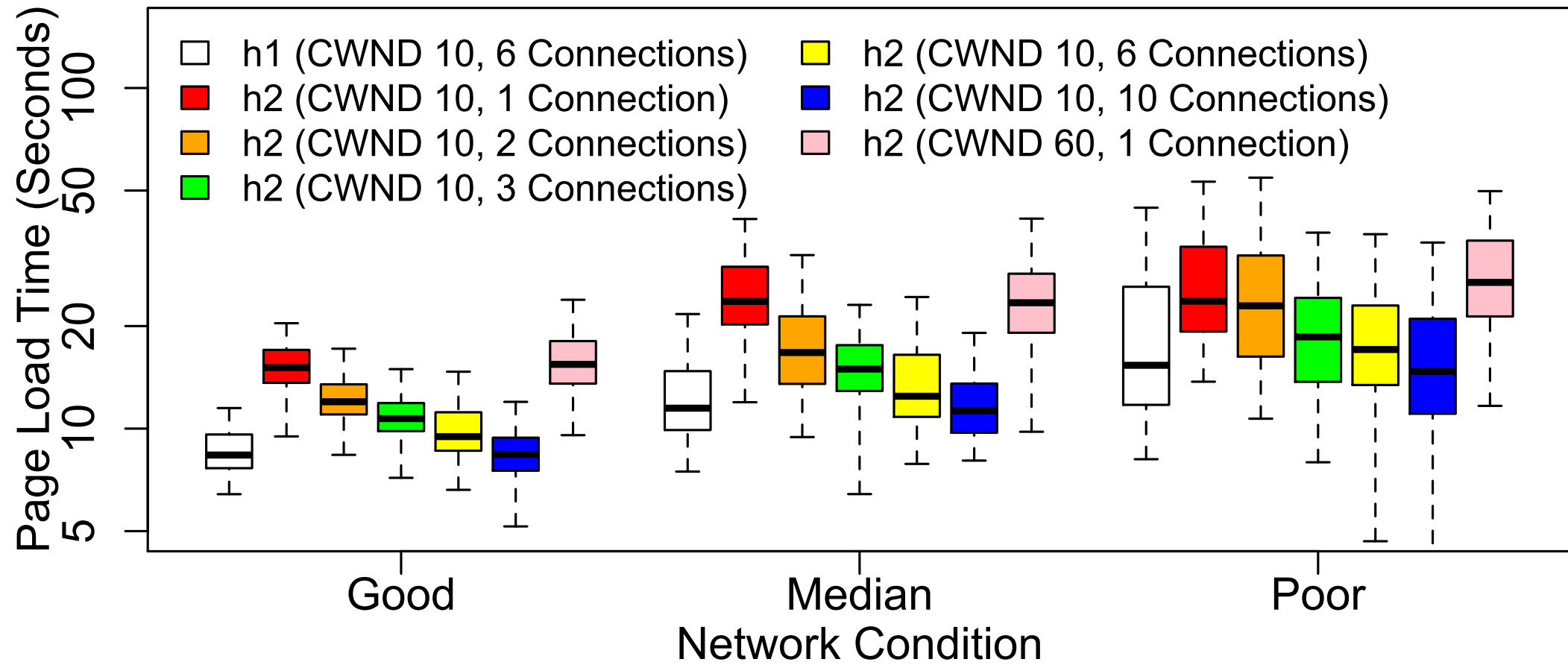
POSTER BOY

365 objects
2 KB

H2 always better

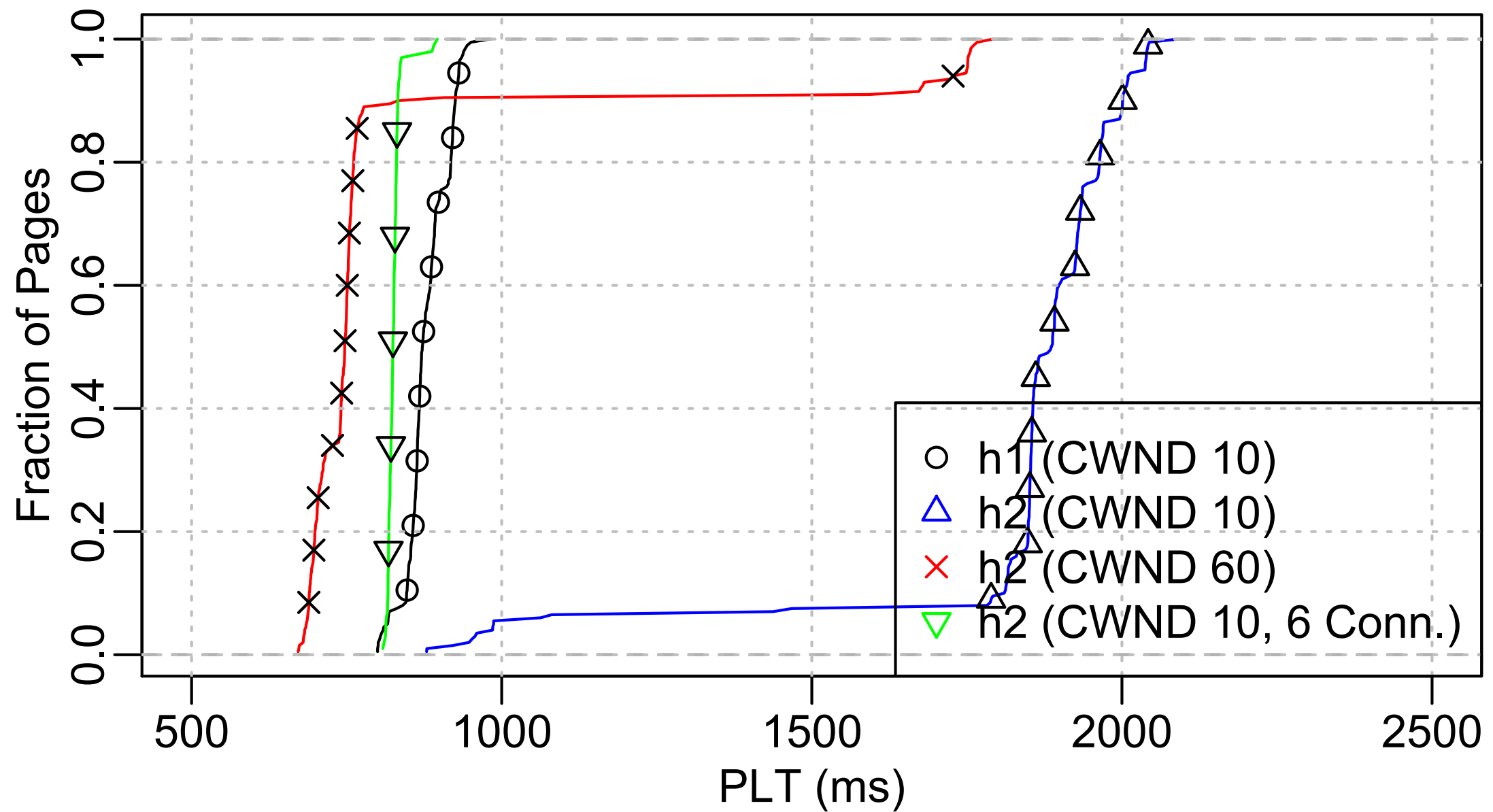More connections don't help

ANTI H2

10 Objects
435 KB

H1 shines!

Sharding helps
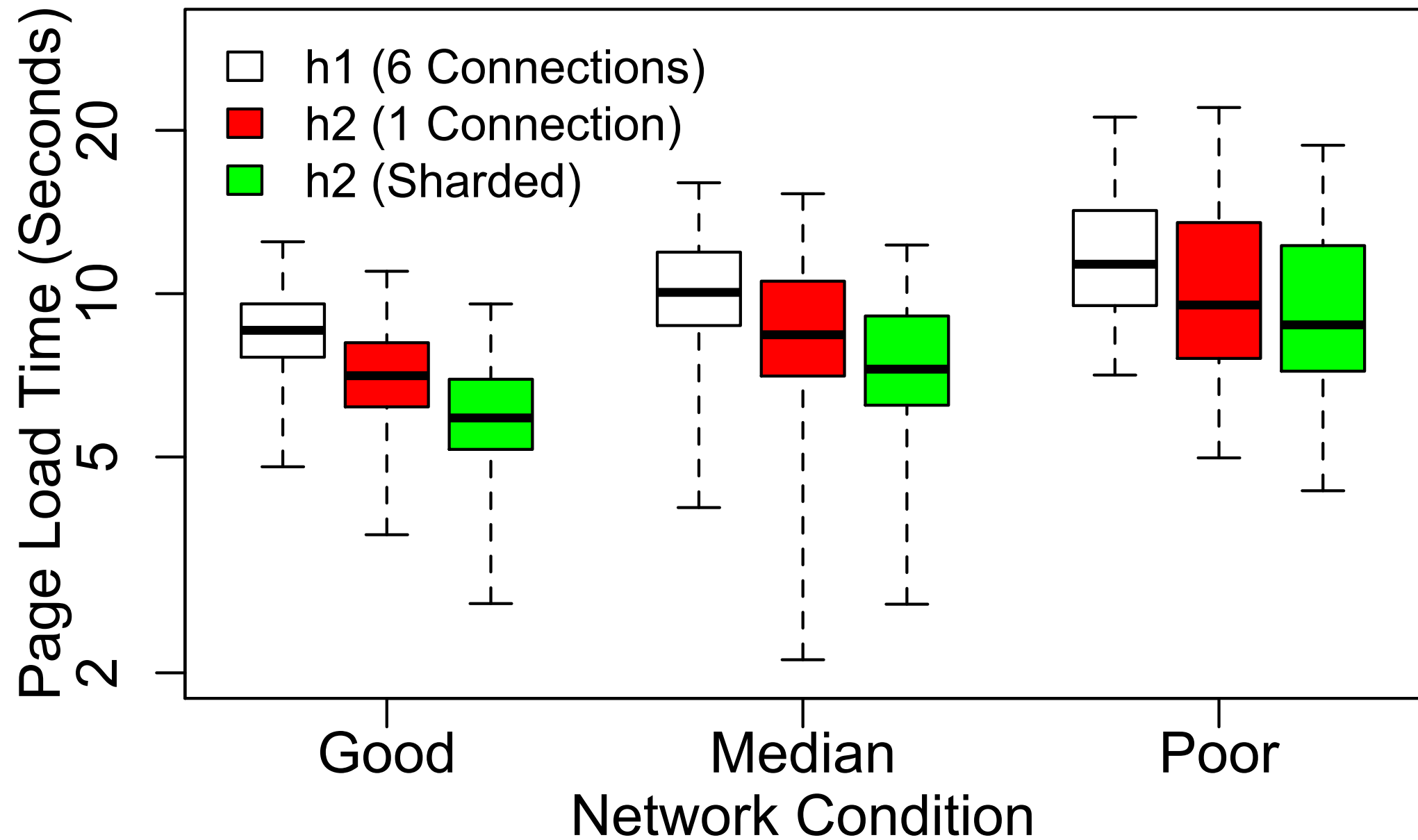
Increased ICW doesn't help

TCP ICW no loss

Increased ICW helps without loss

HTTP ARCHIVE

**136 objects
Total 2 MB**

Legend:
- h1 (6 Connections)
- h2 (1 Connection)
- h2 (Sharded)

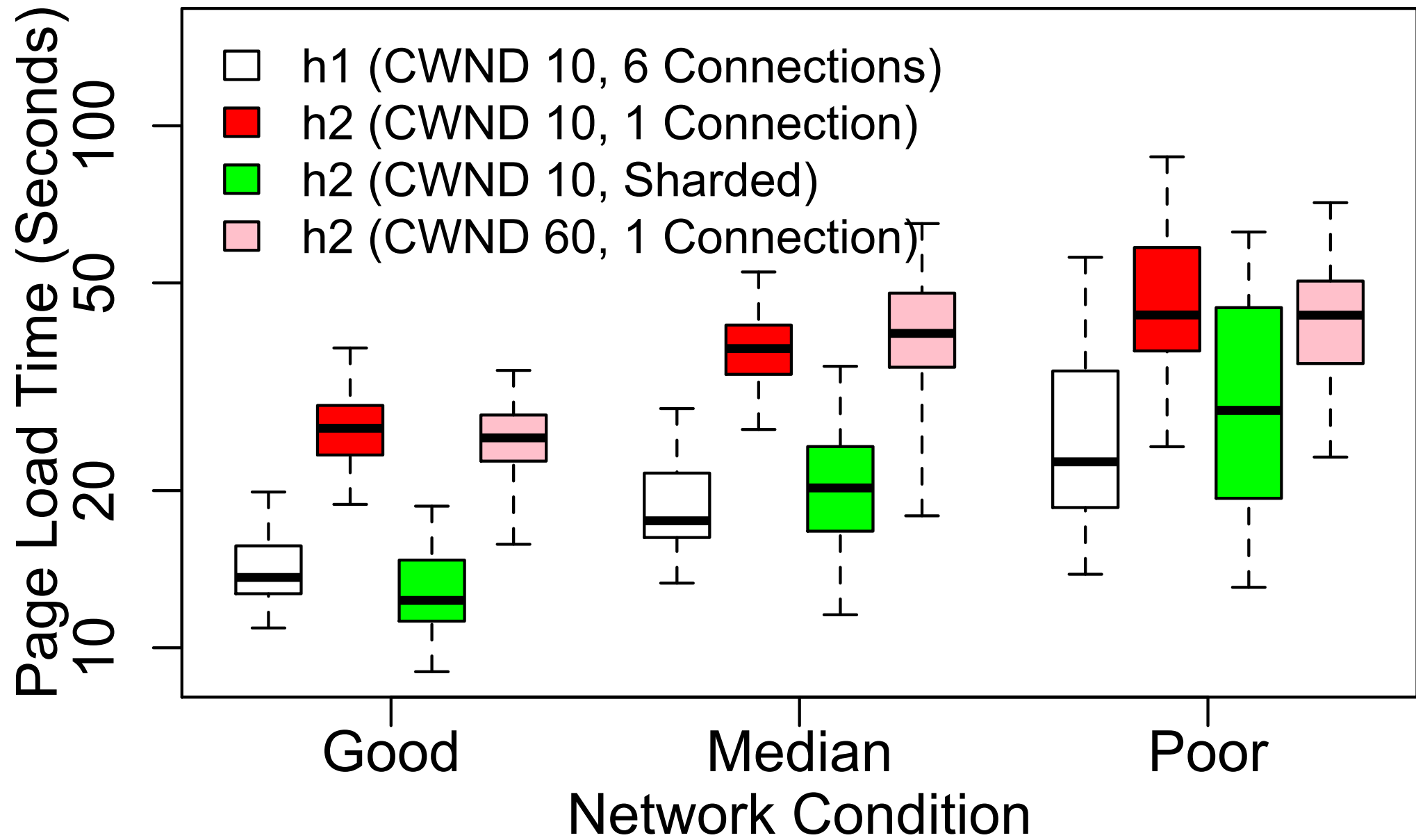Page Load Time (Seconds) vs Network Condition (Good, Median, Poor)

H2 significantly faster

(Smart) sharding helps

HTTP ARCHIVE

136 objects
Total 8 MB

H2 suffers from only one connection

(Smart) sharding helps

CONCLUSION

H2 is not always a straight win

Depends on the site characteristics

Depends on the fraction of bytes on H2

Losses hurt H2 (only 1 TCP connection)

Sharding can help in lossy scenarios

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1,400+ Networks
650+ Cities
120+ Countries

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