Are popular websites' load times different from those of less popular ones?

It's more complicated than you think.....

Advanced Statistics Final Project

We browse the web every day.

When we visit a website, we wait before it fully loads.

- This is called the load time, T_{load}: it measures the time it takes for your browser to download all the resources on the webpage and do book-keeping work. Note that this does not include the rendering time, the time it takes for your graphics to render the webpage.

Question: Given two categories of websites, are their load times different?

Website Popularity Measure

We use the ALEXA ranking, which provides a daily ranking of the top 1m most visited websites in the world.

Data url: http://s3.amazonaws.com/alexa-static/top-1m.csv.zip, changes daily, random day $\stackrel{\triangle}{=}$ random sample
Two-sample t-test for means: Sample $n1$ top-ranked ALEXA 1m websites and $n2$ bottom-ranked ALEXA 1m websites. Compare the distributions.

Dilemma: ALEXA accounts for both resource-provider websites (a website that serves e.g. images to others) and content-provider websites (a website that serves actual content); we don't want to include resource provider websites' hompages (usually a landing page) in our sample. Solution next page

Loading Time Measure: T_{load}

We use the Chrome web browser in the headless mode, driven by a script, to visit each website. $\leftarrow$ Simulation of user-controlled browsing experience

$T_{load} = T_{resources} + T_{page} + T_{storage}$ $\leftarrow$ excludes only page rendering time (device-dependent)

Which websites to sample?

A webpage is valid iff:

- Either HTTP mode or HTTPS mode returns status code 200 (success)
- It may be accessible either via `http://` or `https://`, or both;
- For `https`, the encryption certificate must be valid.
- Take

$$T_{\text{load}} = \begin{cases} \min\{T_{\text{https}}, T_{\text{http}}\} & \text{if both} \\ T_{\text{https}} & \text{if only https} \\ T_{\text{http}} & \text{if only http} \end{cases}$$

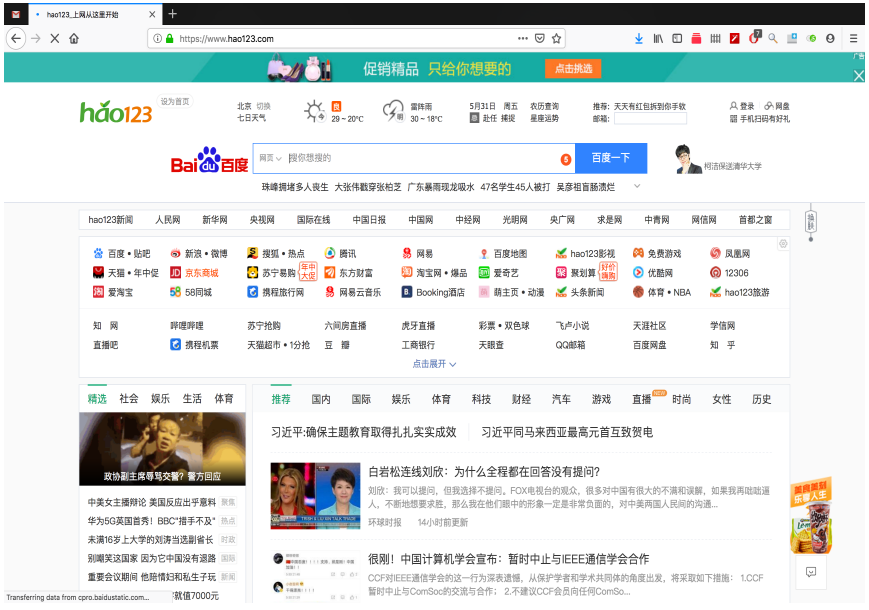
Remarks

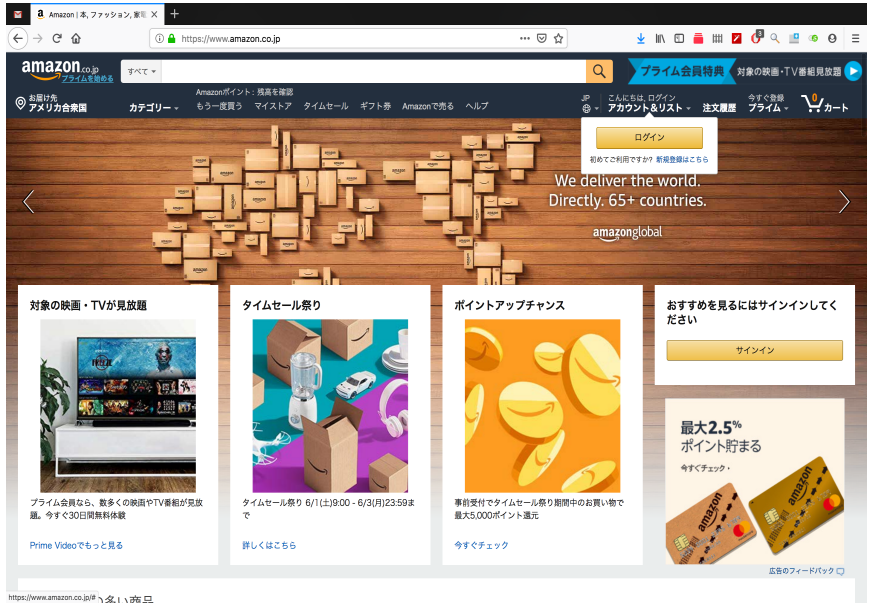
This weeds out a large number of "resource provider" websites, e.g. `googleapis.com` returns a `404 Not Found` status code.

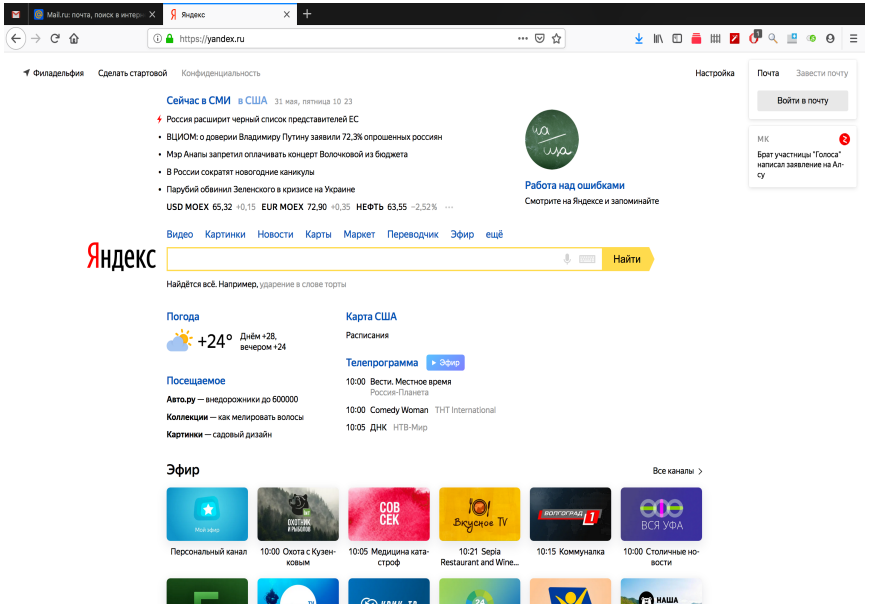
For network turbulence, We take the avg in the load times distribution X : $T_{load} = \overline{X}$ for $n = 3$

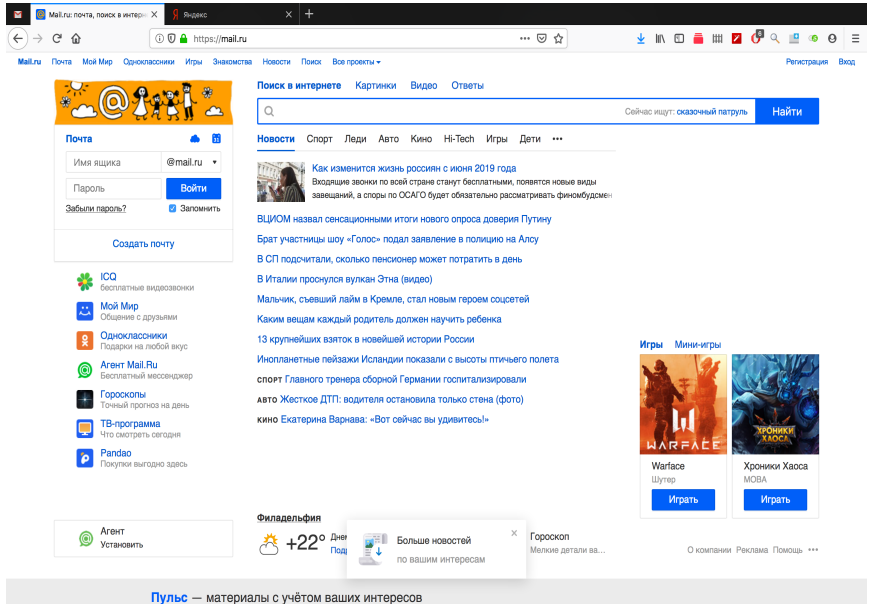
Our sampling distribution comes from the population distribution of all valid websites in the ALEXA top 1m ranking.

Examples of top-ranked websites from all over the world

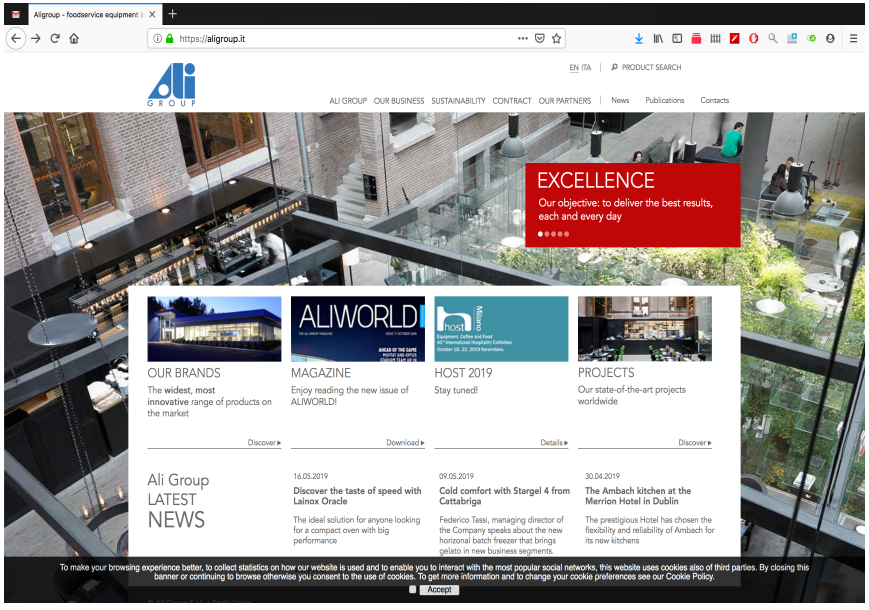


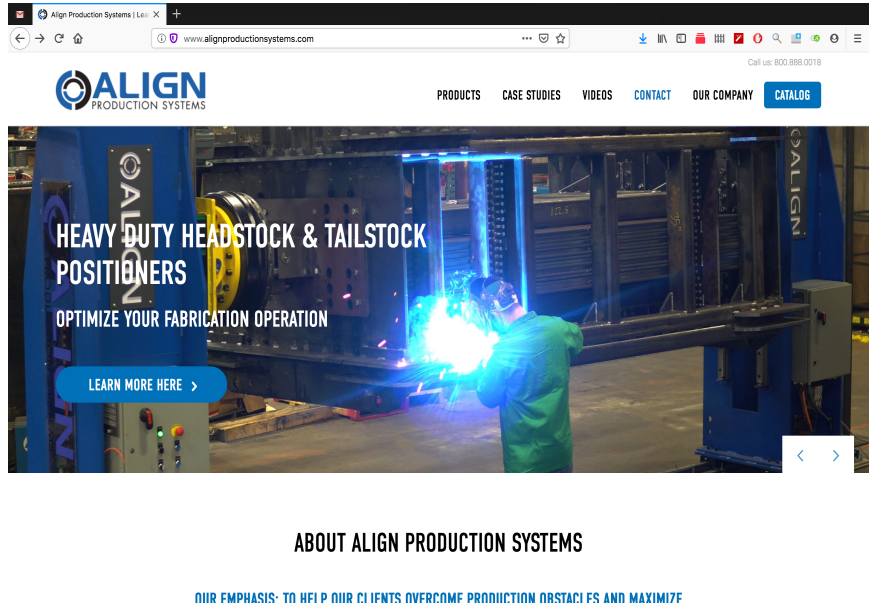


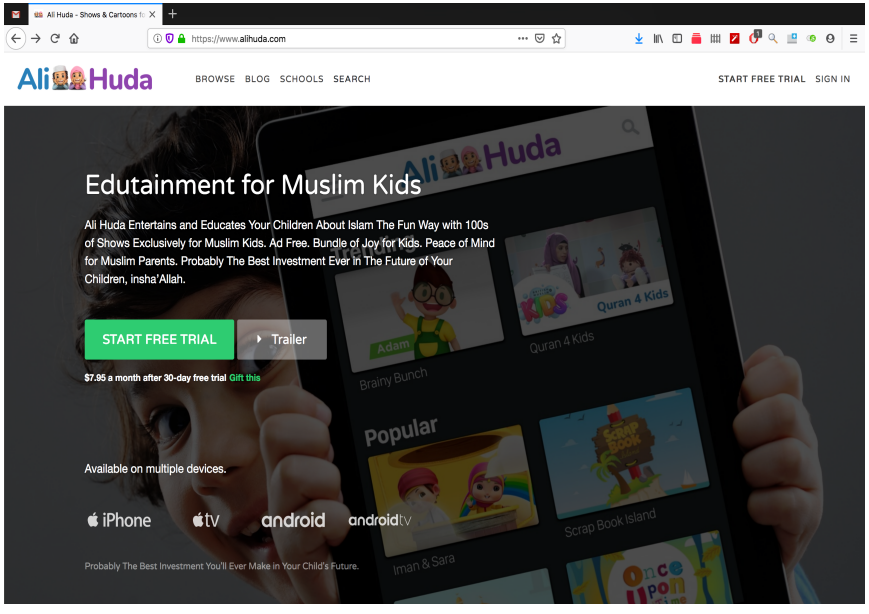


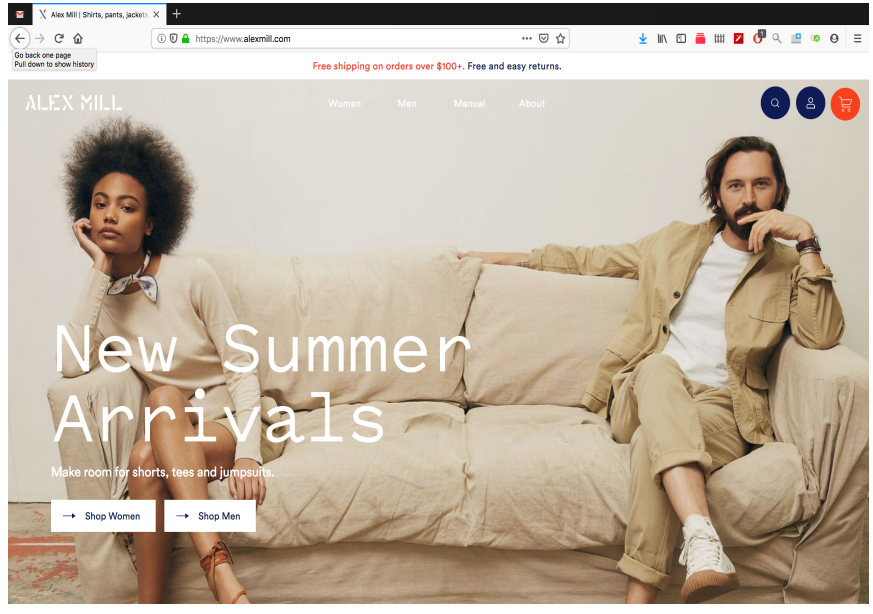


Examples of bottom-ranked websites from all over the world









Potential problems

- Landing pages might still be included in the sample
- Measurement is inherently US-centric; we're taking latency measurements from US east coast, so websites in other parts of the world (e.g. Russia, China, India) will behave poorly for T_{load}.

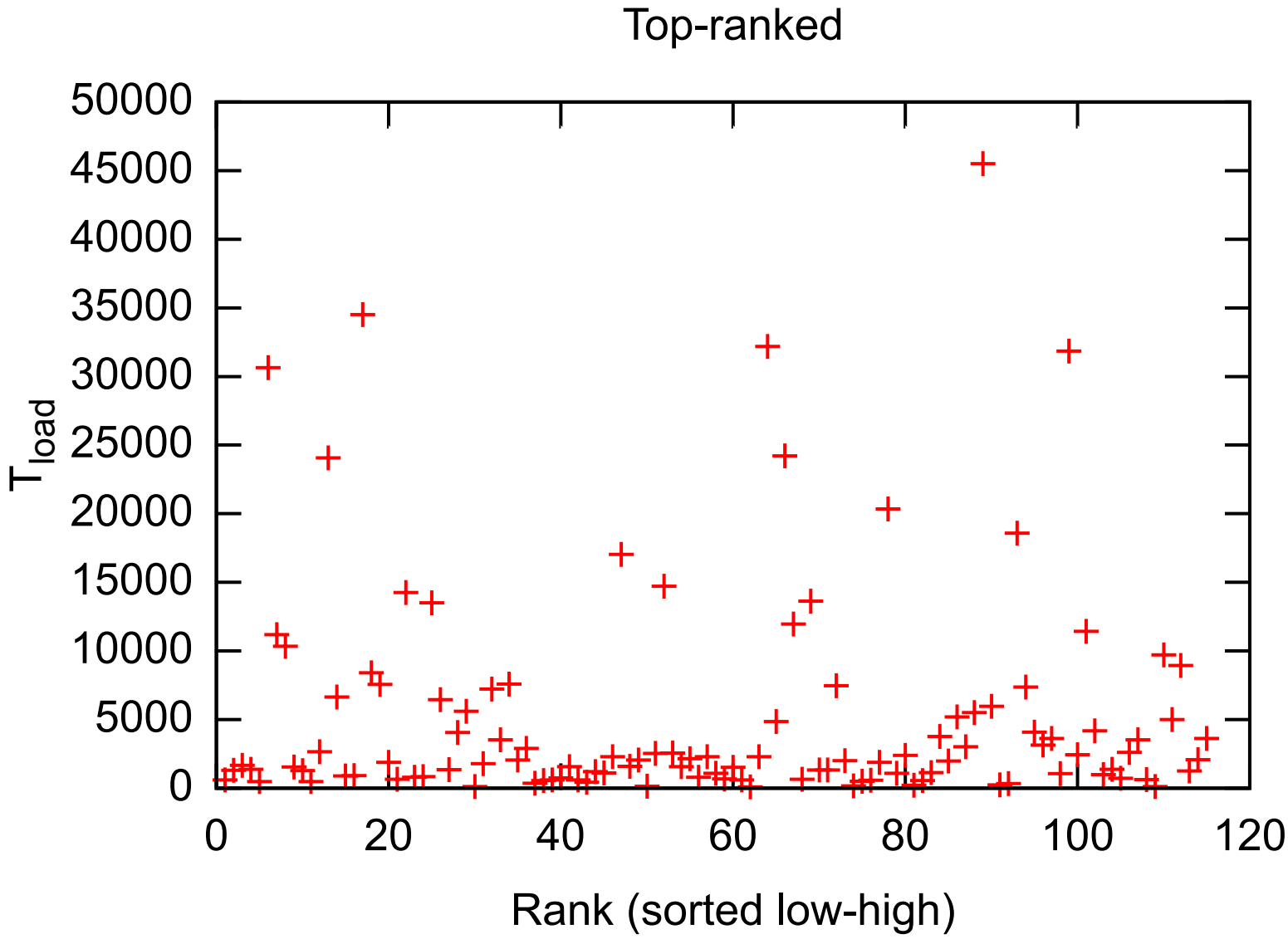
Test: 2-sample t-test for means, two tails

Conditions ($n_1 = 115, n_2 = 138$)

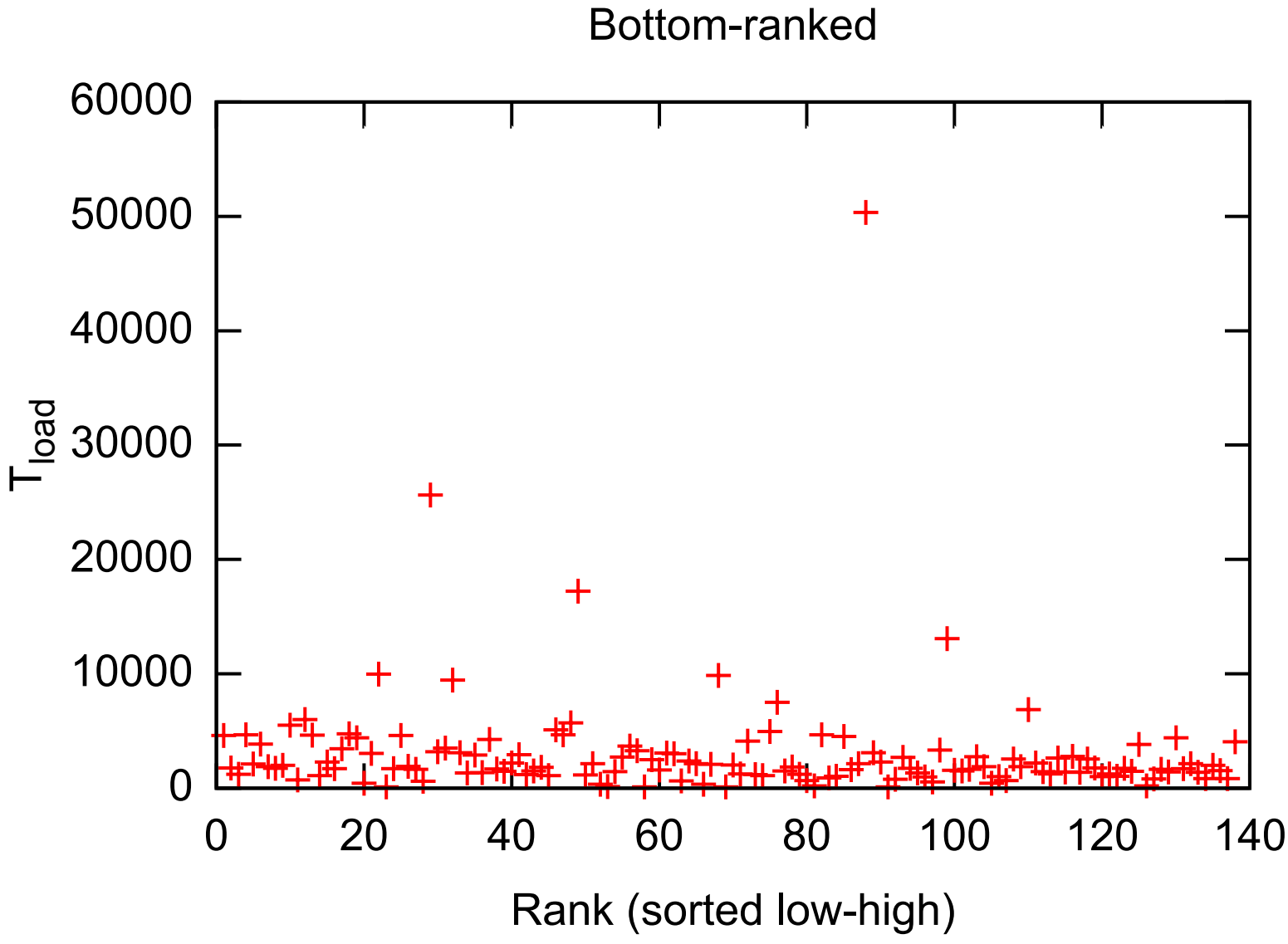
- Random: $\surd$, the ALEXA rank is taken for a random day
- Independent: $\surd$, our population size N is the total number of active websites, which is very very large... But $n_1, n_2 < 200$ is small.
- Normal: $\surd$, $n_1, n_2 > 30 \rightarrow$ CLT holds.

We do the 2-sample t-test for two distributions: the distribution of T_{load} for top-ranked websites and the distribution of T_{load} for bottom-ranked websites.

T_{load} distribution for Top-ranked 115 sites



T_{load} distribution for bottom-ranked 138 sites



Hypotheses

H_0: That the mean of avg page load time for sites ranked 1-115 = the mean of avg page load time for sites ranked bottom 1-138

H_a: That the mean of avg page load time for sites ranked 1-115 $\neq$ the mean of avg page load time for sites ranked bottom 1-138.

t-test results ($\alpha = 0.05$)

Let T_1, T_2 be our distributions. T_1 is the top-ranked website distribution, T_2 is the bottom-ranked website distribution.

$$S_{T_1} = 8106.177131633802$$

$$S_{T_2} = 5085.949930330646$$

$$\overline{T_1} = 5329.4502753620545$$

$$\overline{T_2} = 3064.815464975765$$

$$t^* = \frac{\overline{T_1} - \overline{T_2}}{\sqrt{S_{T_1}^2/n_1 + S_{T_2}^2/n_2}} = 2.5997102453932923$$

$$p(t > t^* | \mathrm{df} = \min\{n_1, n_2\} - 1 = 114) = 0.00528 < \alpha = 0.05.$$

Conclusion

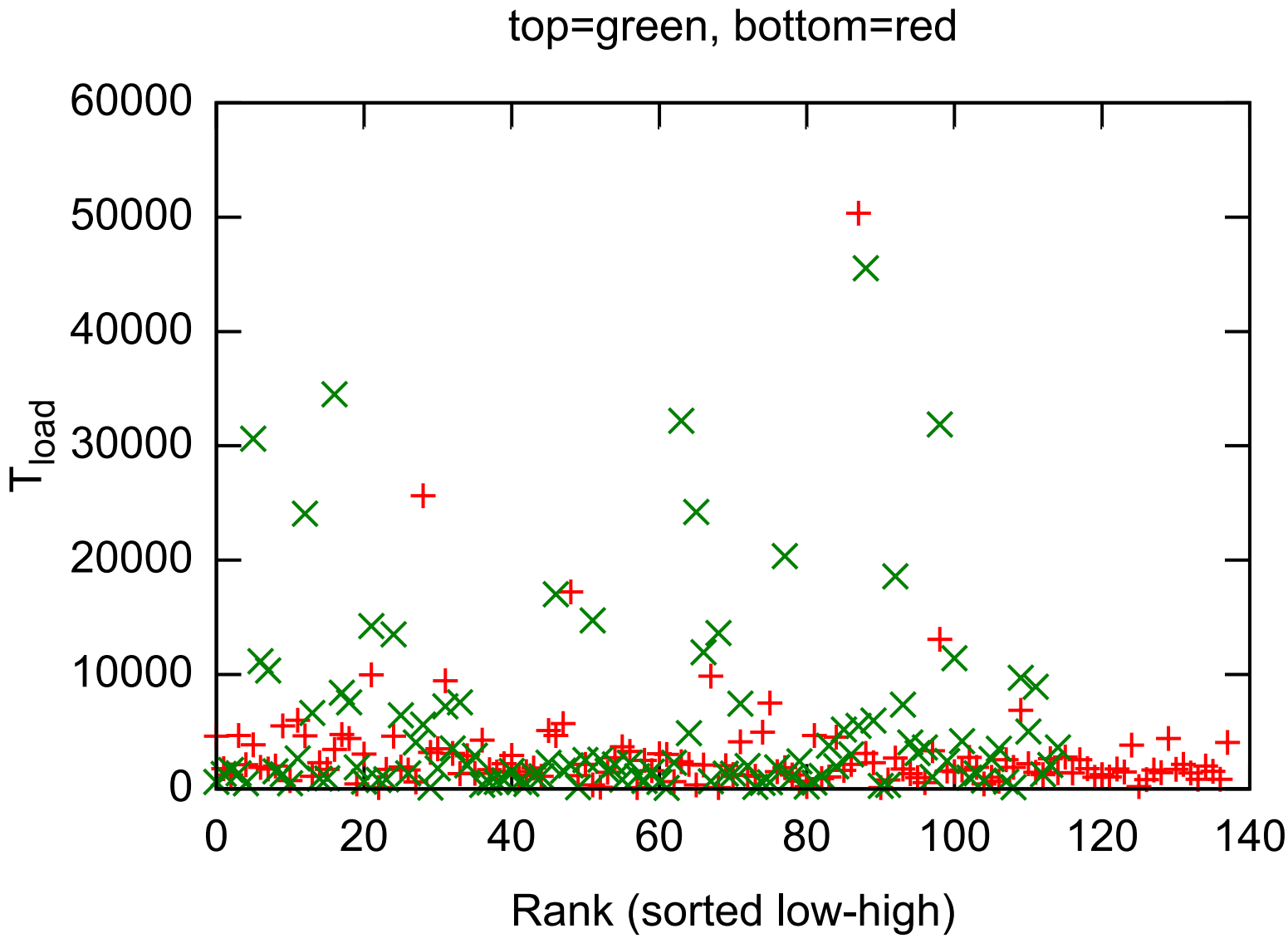
We have to reject H_0. There is suff evidence to conclude that bottom-ranked sites load faster, on average.

- $p = 0.005282249701030417$ with $\alpha = 0.05$!

Why do low-ranked sites load faster? Small sites are frequently located on large platforms (e.g. `wordpress.com`, `tumblr.com`); these large platforms have the infrastructure and the sites might have less multimedia content.)

- Also, large sites might serve a more local audience (e.g. 163.com or mail.ru)

Combined scatterplot, T in millisecs



Future work

- Sample more websites
- We took the mean of three load times. We should take more?
- Stddev is really, really high. Is there a way to further minimize stddev?
- Take geolocated measurements.
- Do more work on identifying landing pages and content farms
    - they may harm the integrity of sample data collected