Web Page Load under different Cellular Networks

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I. Abstract

Many web sites today are designed to cater well to both the desktop and mobile users. For most companies, their website is the first customer facing platform, if not the only platform to interact with the customers. People can judge their service providers solely based on the way their website is designed. In fact, 75% of consumers admit that they judge the credibility of a business based on their website design. A good web design, keeping the customer satisfaction as their topmost goal always tend to gain popularity among the people. After all, customers are king in every business. With a good web design, companies attract more customers to use their platform. With more customers, there is more profit for the companies. Also, the companies can focus on reducing the cost involved in web page loads by being intelligently following certain best practices which are discussed further in the paper.

II. Introduction

According to a survey [4], 79% of shoppers reported that they would not return to purchase from a slow loading website. After Virgin America redesigned its website pushing usability, accessibility, and responsive design forward with the fastest load time and booking process of any airlines, the conversion rate increased by 12%, there was a 20% decrease in web-related phone calls and the company also completed a successful IPO. Websites must be mobile-friendly and optimized to adapt to various interfaces. According to comScore [5], the number of users accessing content online through their mobile devices has surpassed those who use a desktop. Therefore, we concentrate on the performance of websites under different cellular networks and do a comparative study in this paper.

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III. Related Work

[8] In this paper, we can show that tuning TCP parameters is not negligible and directly yields significant improvements. Nevertheless, QUIC still outperforms even our tuned variant of TCP. This performance advantage is mostly caused by QUIC's reduced RTT design during connection establishment, and, in case of lossy networks due to its ability to circumvent head-of-line blocking.

[9] In this work we perform a large-scale study of a real site, Wikipedia, explicitly asking (a small fraction of its) users for feedback on the browsing experience. The analysis of the collected feedback reveals that 85% of users are satisfied, along with both expected (e.g., the impact of browser and network connectivity) and surprising findings (e.g., absence of day/night, weekday/weekend seasonality) that we detail in this paper. Also, we leverage user responses to build supervised data-driven models to predict user satisfaction which, despite including state-of-the art quality of experience metrics, are still far from achieving accurate results (0.62 recall of negative answers).

[10] This paper studies the complexity of the websites, which is also a factor contributing to the page load time just like web graph measure, website popularity or the nature of web traffic.

[1] PARCEL splits functionality between the mobile device and the proxy based on their respective strengths, and in a manner distinct from both traditional browsers and existing cloud-heavy approaches. We conduct extensive evaluations over an operational LTE network using a prototype implementation of PARCEL. Our results show that PARCEL reduces page load times by 49.6%,

and radio energy consumption by 65% compared to traditional mobile web browsers. Further, our results show that PARCEL continues to perform well under client interactions, owing to its judicious functionality split.

[2] In this paper, we introduce Prophecy, a new acceleration technology for mobile pages. Prophecy simultaneously reduces energy costs, bandwidth consumption, and page load times. In Prophecy, web servers precompute the JavaScript heap and the DOM tree for a page; when a mobile browser requests the page, the server returns a write log that contains a single write per JavaScript variable or DOM node. The mobile browser replays the writes to quickly reconstruct the final page state, eliding unnecessary intermediate computations. Prophecy's server-side component generates write logs by tracking low-level data flows between the JavaScript heap and the DOM.

IV. Overview of the Project

From the related works, it has been observed that the websites with more Javascript and Third-Party Content in their web page take more time to load compared to the others. In this paper, the performance of different websites under different network conditions are compared. The network conditions are preset to different Cellular Network configurations for this study and the experiments are carried out.

V. Implementation and Evaluation Details

A total of 16 websites from different categories have been selected for this experiment. Google Lighthouse has been used to measure the performance of the websites. A router and an end machine are used for this project. The different network conditions are set in the router using comcast [11], which helped in achieving packet level throttling in the network.

opera.com	Search Engine
gov.uk	Information Site
gravatar.com	unique avatar providers
imgur.com	online image sharing
vtm.be	TV Channel
wordpress.com	content management system
sciencedirect.com	Science Research DB
imdb.com	Internet Movie Database
wikipedia.org	online encyclopedia
github.com	Software Version Control
Live.com	MS Web Service Platform
researchgate.net	scientists networking site
Csdn.net	China Software Dev Network
Taobao.com	Chinese online shopping
Aliexpress.com	online shopping
Amazon.com	online shopping

Following is the default mobile network throttling preset in Lighthouse.

A. *The mobile network throttling preset [6]*

This is the standard recommendation for mobile throttling:
Latency: 150ms
Throughput: 1.6Mbps down / 750 Kbps up.
Packet loss: none.
These exact figures are used as Lighthouse's throttling default and represent roughly the bottom 25% of 4G connections and top 25% of 3G connections (In Lighthouse it is sometimes called "Slow 4G" used to be labeled as "Fast 3G"). This preset is identical to the WebPageTest's "Mobile 3G - Fast" and, due to a lower latency, slightly faster for some pages than the WebPageTest "4G" preset.

By modifying the preset throttling, the following network conditions were set up for different Cellular Network Generations [7] and the experiment has been repeated in all these network conditions:

B. *2G Network Conditions*

Latency: 700ms
Throughput: 300kbps
Packet loss: none.

C. *3G Network Conditions*

Latency: 250ms
Throughput: 1.6Mbps
Packet loss: none.

D. 4G Network Conditions

Latency: 50ms
Throughput: 25Mbps
Packet loss: none.

VI. PERFORMANCE COMPARISON

Wikipedia has been observed to be the best performing site overall and imgur.com has been performing worst in all the cases considered [Fig 1].

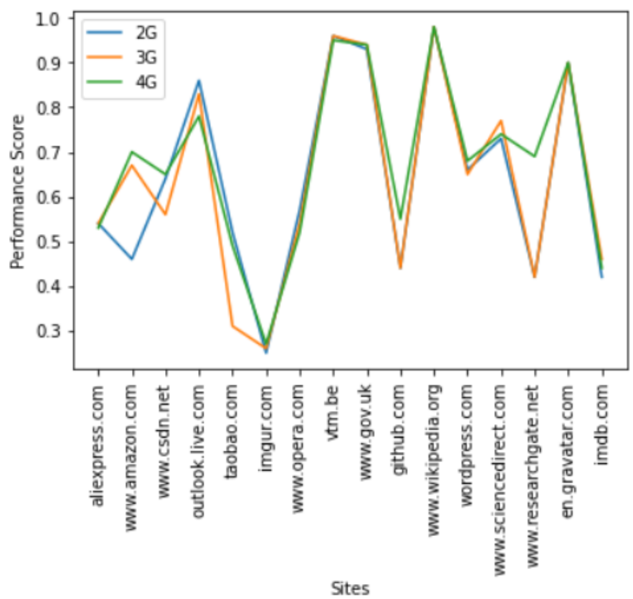

Fig. 1: Performance Score

The performance of most websites across all the cellular networks were the same, except for amazon.com which performs very poorly in 2G and researchgate.net which performs much better in 4G compared to 3G and 2G, both of whose performance overlap.

All the best performing sites pre-connect to the required origins(servers) in which the loading content are stored so that the delay is reduced substantially [Fig 2].

JS payloads are very big in imgur.com which contributes to the longer bootup time.

Network server latency is one of the characteristics which contributes to the performance of websites. It is an indication the server is overloaded or has poor backend performance [Fig 3].

Page load time is primarily affected by the number of objects requested from the non-origin

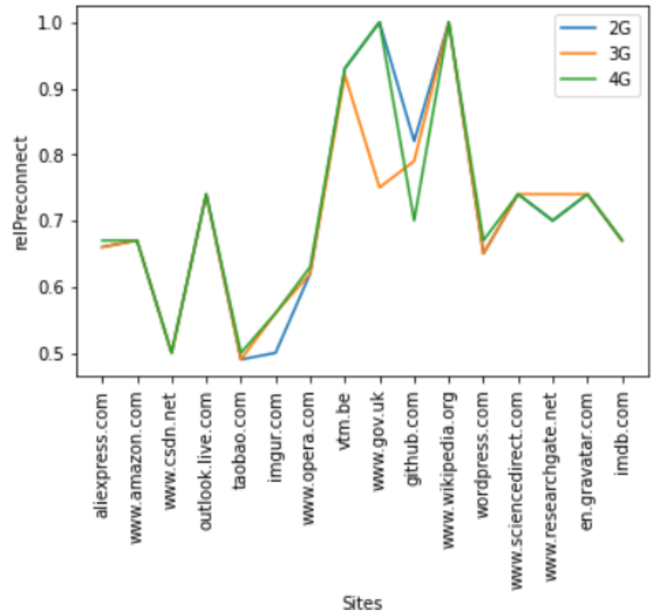

Fig. 2: Pre-connect score

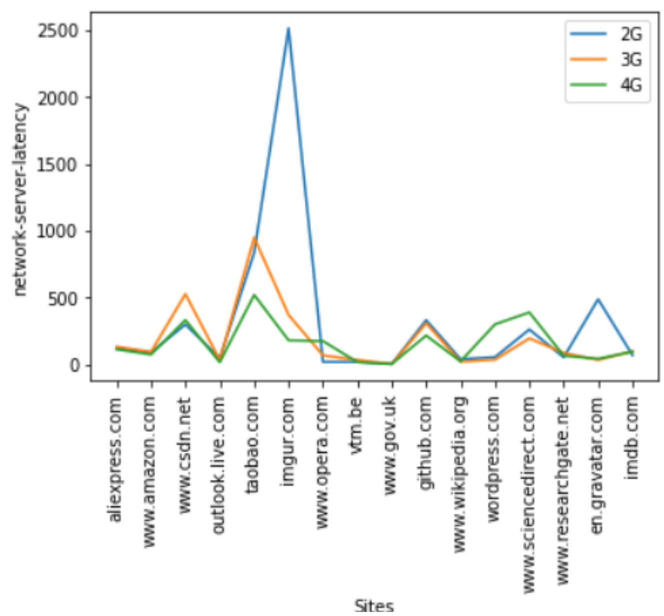

Fig. 3: Network server latency score

servers, size of the objects and the types of content requested. Non-origin servers include the third-party servers like advertising agencies and analytics services which account for most non-origin objects, and CDNs for most bytes. But the impact of having several numbers of objects in non-origin servers on download time is very low due to browser optimizations, contributing to only about 15%. Javascript is found to be present at a higher fraction in the non-origin websites compared to the website providers themselves [Fig 4 and 5].

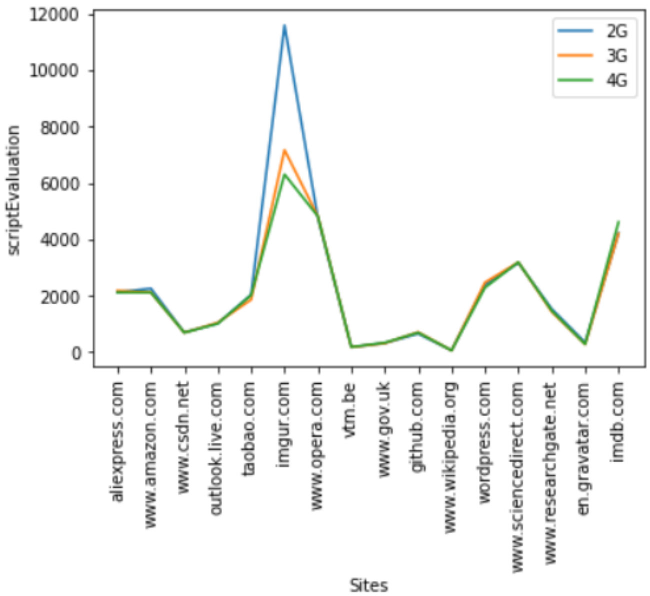

Fig. 4: Script evaluation time taken by different sites

Third-party code can contribute to significant impact on load performance. Therefore, it is a good practice to load third-party code after the page has primarily finished loading. Most poorly performing sites like imgur.com and amazon.com have been impacted by these third-party code, which needs to be taken care of.

It is recommended to load only the contents that are visible on the screen during the initial web page load and the remaining contents can be loaded progressively as the user scrolls down the page. Loading all the page contents at once contributes to much higher delay which still exists in sites like imgur.com and amzon.com which has to be completely avoided.

Speed Index is an important metric contributing to the performance of a web page. It is the average time at which visible parts of the page are displayed. It is expressed in milliseconds and dependent on size of the view port[Fig 6].

First Meaningful Paint is the time it takes for a page's primary content to appear on the screen. It is often used as a primary metric for user-perceived loading experience. Though imgur.com is consistently performing bad in other metrics, its First Meaningful Paint Score is towards the median[Fig 7], which means the users are at least

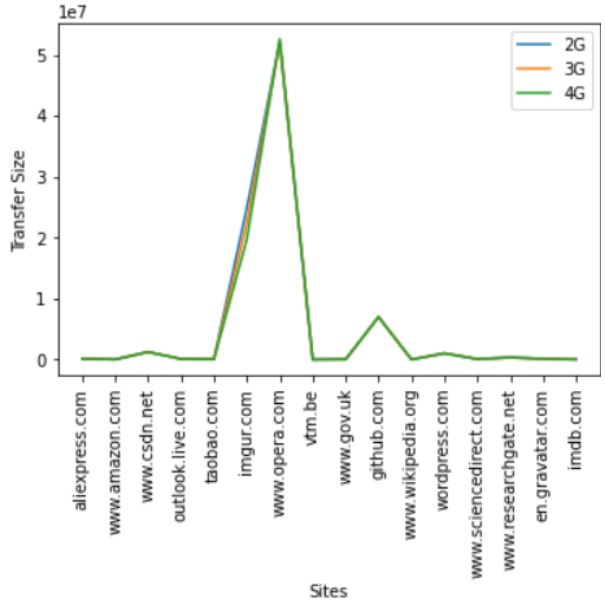

Fig. 5: Transfer Size

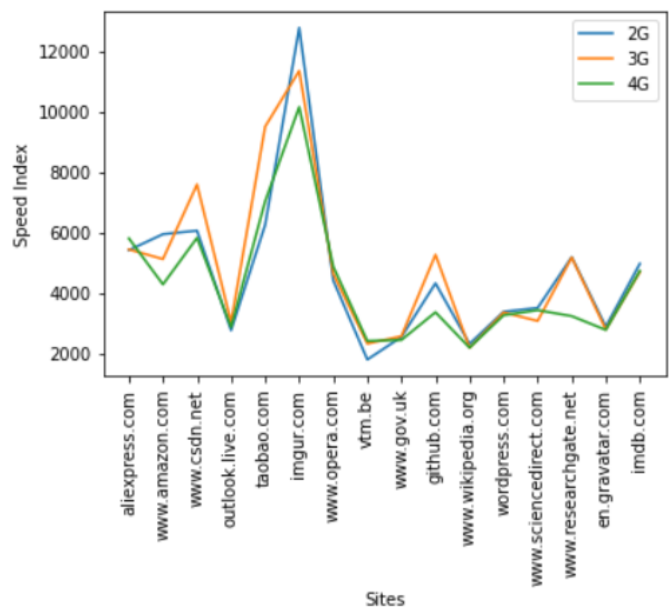

Fig. 6: Speed Index comparison among websites

not displayed the blank screen until all the contents are loaded which is one good thing about the site. On the other hand, for the sites like github.com and researchgate.net, the First Meaningful Paint Score is very low. This means that the users are not displayed any meaningful content for a relatively longer time compared to the other sites.

The time taken for the page to become fully interactive with the users is the lowest for Wikipedia and very few other websites like gov.uk

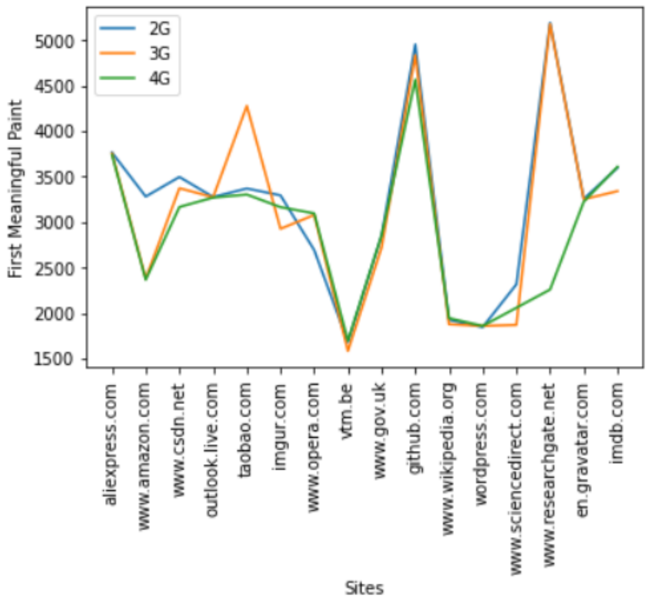

Fig. 7: First Meaningful Paint comparison among websites

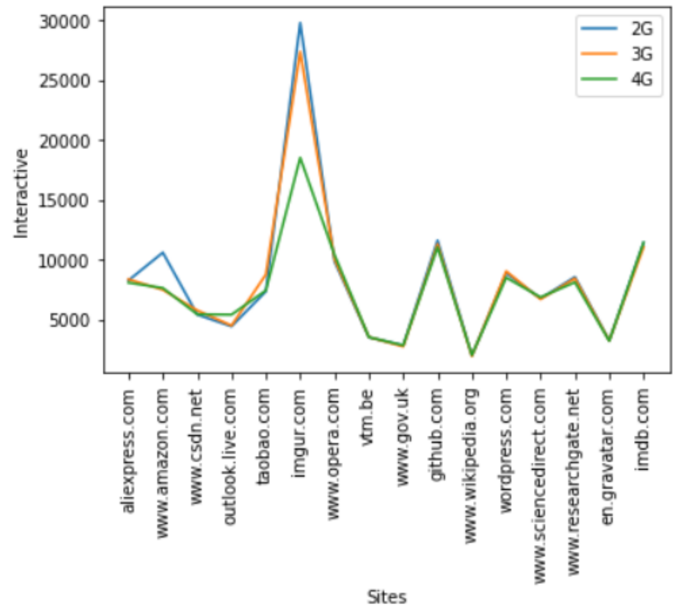

Fig. 8: Interactive comparison among websites

and en.gravatar.com have their scores close to Wikipedia. Imgur.com has the worst score in terms of interactive as well, which makes it a poorly performing site overall][Fig 8].

VII. Conclusion

Complexity of the websites should be in such a way that it balances performance, usability and business interests. From the experiments and the performance comparison, it can be concluded that the different Cellular Networks do not contribute much to the performance of the websites, but the JS payload and the number of external servers impact the page loading time significantly.

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