Evaluating The Energy efficiency of Web Browser

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Abstract

With the constant software updates, software energy efficiency is missing from update notes, and it is important to consider software energy utilization in the development life cycle. Although software energy efficiency is vital, it has a number of drawbacks which can affect the battery life in case of laptops and tablets. However, efficient software can decrease the power bills in case for data center-based services. This paper measures the load time for certain URLs and the energy consumption for Cisco URL. The major findings and implications will encourage software developers to use tools that measure the efficiency of the software throughout developing the software and increase awareness about this issue.

I. Introduction

There are half a billion Firefox users in around the world [1]; this makes it one of the top 5 desktop browsers. Its usage peaked to 31.21% in November 2009; this was according to research that was conducted by Star-Counter. Firefox committee has set a plan for future versions and one release each month. With the new generation web engine"Quantum", Firefox are more secure and stable that before. But how about energy efficiency, are there any improvements in it? Are there any plans for measuring it? Firefox developers are more concerned about security and bugs fixing for the older version. Firefox receives bugs' report from individual testers throughout bugzilla websites. Firefox developers are more concerned about the security of users. Encrypting user information is something that is vital in the present generation. According to Firefox release notes, Firefox has improved in performance. This seems to be true because, as I navigated through the Bugzilla website, I never witnessed a single case that was bug related; nobody had complained about bugs, energy efficiency or energy consumption.

Firefox updates, or even new versions, have nothing related to the energy efficiency in their utilizing plan and the developers could be less concerned about battery life and how these updates all add up and affect the energy consumed. Software does not consume energy by itself but it can result in the hard-ware (CPU, Memory, and GPU) consuming high energy. Energy consumption is the product of the time that the software took to run and the power. Any peak in power or time can affect the energy consumption. Although a high peak in load or CPU-power consumption does not mean that this version is consuming high energy, it requires both (time, CPU-power) to be high.
We can, therefore, say this version is not energy efficient.

Since energy consumption (E) is an accumulation of power consumption (P) over the time (T), E=P*T. From this equation, we can conclude that reducing the run time will not solve the issue.

II. Related WORK

I. Manotas *et al*. have conducted interviews and surveys on green software developers from multiple technology companies. Compared to their work, my study is unique in several ways:(1) I measured the energy consumption including the load time and CPU power, (2) I compared the efficiency of multiple version, (3) I gave reasons that might cause the issue conduct interviews of 18 Microsoft participant and survey of 464 participants of different Technology companies like IBM, Google, and Microsoft. Both are about software efficiency and battery drainage issues with no consideration of energy usage in their development.

Analyze the questions and answers from around 800 users on STACKOVERFLOW Web site about energy consumption problem. In comparison, our choice of evaluating the energy efficiency no one measure CPU power measurement.

Pinto *et al*.[2] have identified 7 factors that contribute to the energy consumption issues and the solution that can mitigate the problems suggested by developers throughout analyzing STACKOVERFLOW questions and answers.

III. Methodology

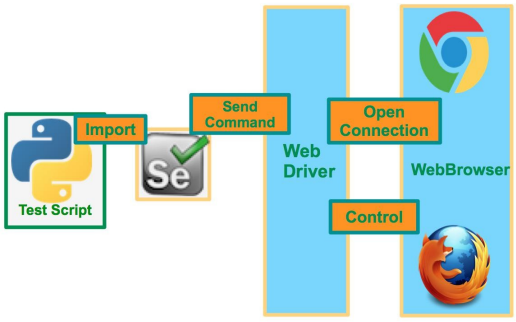


Fig. 1. Automated Test Framework.

Figure 1 depicts the automated test framework for Firefox web browser. At the high level it has the following components:

- The script was written using python 3 on Linux machine. Selenium was used as a tool for the test automation.
- The web Driver was used to automate and control browser.
- The load time was measured using python system time methods for four different run tests multiple times.
- The CPU power was measured on Marcher server and used as a parameter for the energy.

The python script imported selenium as a tool and selenium and python preferred to be version. Selenium is a browser automation tool. Selenium is a JavaScript software that gets injected inside the browsers and drives the browsers through a port. Selenium drives and controls a browser by giving it commands. A Web Driver is a general purpose library for automating web browsers and it can send actions to the browsers by using commands. In order to test and measure the load time for each version of Firefox web browsers, it requires that the web browser, web driver and selenium to be compatible. The web driver for Firefox, called geckodriver, has multiple versions and each version is compatible with certain Firefox releases. For example, while using geckodriver version 21 to test Firefox version 48, you will cause the script to crash and unclear errors will be show up in the terminal. My script tests 47 Firefox versions from 2018 back to 2016, which are navigated to URLs like Cisco and Twitter. To measure the page load time for a cashed URL, the script navigates the same URL twice.

Turning to the load time, it was measured using system time method. I found the method to be the most accurate time measurement for automated test, and this is because the test is automated and I preferred to eliminate human interactions. The get method returns control to the program whenever the page completed loading its content. The start and end for the python time system placed before and after get method and the elapsed time will be the page load time for the that URL. The power log software measured on the Marcher server is located in Texas State University, San Marcus. Although the software can measure the power of CPU, Memory and disk, I used it to measure the CPU-power where I found that there are no major differences in Memory-power for all versions and value kinds that are close to each other.

IV. RESULTS

The Load time was measured for multiple URLs like Cisco, Giph, and Twitter. They were then wired for multiple test runs. The load time is the mean of four different test runs, this is after removing the outliers that originate from unknown sources from the network.

Throughout the investigation of the Cisco Site component from network tap in the developer tools, I found that the site uses around 6 XHR, which is an abbreviation for XML Http Request.

Fig. 2. The Page Load Time For Cisco .

Fig. 3. The Page Load Time For Wired .

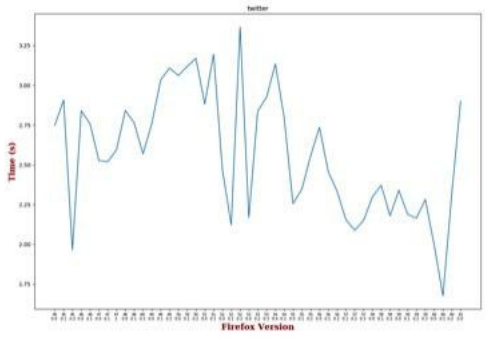


Fig. 4. The Page Load Time For Twitter .

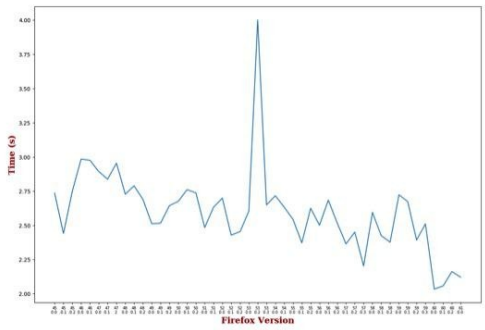
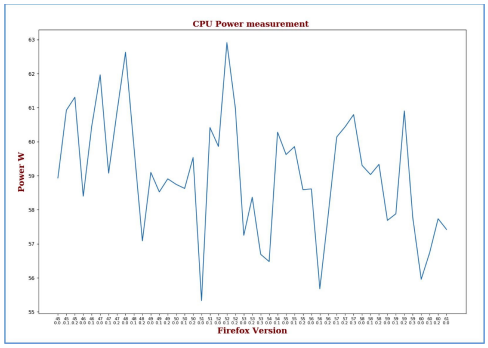


Fig. 5. The Page Load Time For Giphy .



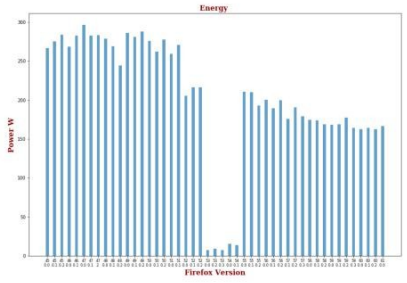


Fig. 6. Firefox Energy consumption

It is clear that the load time for the each URL is different from others. This depends with the web content file and the number of XHR requests that the developers use to retrieve sources like files, images, json and others from the server that are used to update web pages without the need to refresh the page. The more request by XHR or fetch the site uses, the more the time the site will take to load.

Analyzing web components from the network monitor, we can see that the more XHR used, the more time the page takes to load. The Gighy site is used mostly to access the resources compared to Cisco which is mostly used for XHR.

From The Figure 1, the dip in the graph that occurs between version 53.0 and 54.0.1 could be due to the addition or removal of a new feature from the web browser and especially from XHR.

In Figure 3, the load time fluctuated all over the versions with lower load time in the oldest version in almost all 45.0 and 46.0

Figure 4 shows that the load time at the newest version is lower than oldest. From the network monitor tab, we can see that it contained a mixture of XHR and Fetch and it was also considered as a heavy XHR site.

From Figure 5, after investigating the web contents from the network monitor, I noticed that the site used less request compared to the other Figures that mostly depended on Fetch API to fetch JavaScript files from the server.

Figure 6 represents the CPU power consumption for the Cisco site which is measured using a power meter software on Marcher server, a powerful server located in Texas State University-San Marcus. From Figure 6, I can conclude that there are no consecutive improvements in the consumption of the CPU. Although Firefox 51 consumed less CPU power, it took longer to load Cisco web contents. As such, the energy consumption for version 51.0 was higher than version 53.0 which consumed less power and it took moderate time to be loaded.

V. Conclusion

I believe that changing Code designs and using measurement tools is important for developers. By putting this into consideration, these developers can enable future development to more efficient softwares. In terms of Firefox web browsers, there are many factors that can affect the load time beside network traffic:

- Web contents including HTML and CSS file size and number of XHR request, which I found the main cause for higher load time
- TLS/SSL encryption methods, which encrypted and decrypted transmitted data over the internet.

The most Recent versions		The Best 3 Firefox		The Worst 3 Firefox	
FF-Version	Percentage of saving	FF-Version	Percentage of saving	FF-Version	Percentage of saving
61.0.0	-60.0385	53.0.2	94.6525	59.0.2	-77.9195
60.0.2	-65.3508	53.0.3	95.3946	57.0.1	-72.7972
60.0.1	-70.3136	53.0.0	95.5939	57.0.3	-71.9251

TABLE I
SUMMARY OF FIREFOX ENERGY SAVING

Table 1 compares Firefox versions to the baseline version, which is version 54.0.0.

As shown in Table 1, the most recent Firefox version, which is version 61.0.2, is not an energy efficient one compared to Firefox version 53.0.2. However, Firefox version 53 group is considered as an energy-saver. In contrast, version 53.0.3 has memory leaked issues.

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