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"Performance Comparison of Web Browsers"

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***Abstract*-- Web browsers are essential software applications that enable users to access and interact with information available on the World Wide Web. With the rapid growth of web technologies and online services, browser performance has become a critical factor influencing user experience. Different browsers offer varying levels of speed, memory efficiency, security features, and compatibility with modern web standards. This study focuses on the performance comparison of popular web browsers such as Google Chrome, Mozilla Firefox, Microsoft Edge, and Opera. The evaluation is based on key performance parameters including page load time, memory consumption, CPU utilization, JavaScript execution speed, and overall responsiveness. The analysis is conducted using benchmarking tools and real-world browsing scenarios to observe how each browser performs under similar conditions. The results help identify the strengths and limitations of each browser and provide insights into their efficiency in handling modern web applications. The study aims to assist users and developers in selecting the most suitable browser based on performance requirements and system resources**

***Keyword*-- Web Browser, Performance Comparison, Page Load Time, Memory Usage, Benchmarking, Web Performance Introduction**

I. INTRODUCTION

Web browsers are one of the most important software applications used to access information on the internet. They act as a bridge between users and the World Wide Web by interpreting web technologies such as HTML, CSS, and JavaScript to display web pages in a readable and interactive format. web browsers have evolved significantly with the advancement of web technologies and the increasing demand for faster and more efficient internet access **[1]**. Today, users rely heavily on web browsers for various activities such as online communication, streaming media, online learning, cloud computing, and web-based applications. As a result, browser performance plays a crucial role in providing a smooth and efficient user experience. A browser with slow performance can lead to longer page loading times, increased system resource usage, and poor responsiveness, which may negatively affect productivity and usability**[2]**.There are several web browsers available in the market, each designed with different features and performance optimizations.

Popular browsers such as Google Chrome, Mozilla Firefox, Microsoft Edge, and Opera compete to provide better speed, security, compatibility, and resource management. While some browsers focus on faster page rendering and JavaScript execution, others prioritize privacy protection, energy efficiency, or reduced memory consumption**[3]**. Due to these differences, it becomes necessary to compare the performance of various browsers under similar conditions. Performance comparison helps evaluate how efficiently browsers handle tasks such as loading websites, executing scripts, managing multiple tabs, and utilizing system resources. Understanding these factors can help users select the most suitable browser according to their needs and system capabilities**[4]**.This study focuses on analyzing and comparing the performance of major web browsers using key parameters such as page load time, memory usage, CPU utilization, and JavaScript processing speed. The goal of this comparison is to identify the strengths and limitations of each browser and provide insights into their efficiency in handling modern web applications**[5]**.

II. LITERATURE REVIEW

Several researchers have studied the performance of web browsers using different evaluation methods and benchmarking tools. These studies mainly focus on parameters such as page load time, memory consumption, CPU usage, and JavaScript execution speed. Researchers have compared popular browsers like Google Chrome, Mozilla Firefox, Microsoft Edge, and Opera to understand their efficiency and resource management[1]. Previous studies show that browsers based on the Chromium engine often provide faster page rendering and better compatibility with modern web applications. However, some browsers consume more system memory while others focus on better resource management and privacy protection. The results these studies indicate that browser performance may vary depending on system configuration, workload, and the type of websites being accessed[2]. Therefore, a comparative analysis of web browsers based on different performance parameters is important to identify their strengths and limitations and to help users choose the most suitable browser according to their needs[3].

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III. Problem Statement

Web browsers are widely used for accessing information and running web applications on the internet. However, different browsers show variations in performance, such as page loading speed, memory consumption, CPU usage, and responsiveness**[1]**. Users often experience slow performance or high system resource usage while using certain browsers, especially when multiple tabs or heavy websites are open. Therefore, it becomes important to evaluate and compare the performance of different web browsers in order to identify which browser provides better efficiency and user experience under similar conditions**[2]**.

IV. Objective

To study different popular web browsers and their features**[1]**. To analyze the performance of web browsers based on key parameters such as speed, memory usage, and CPU utilization**[2]**. To compare the performance of different browsers under similar testing conditions**[3]**. To identify the strengths and weaknesses of each browser**[4]**. To help users select the most suitable browser based on performance**[5]**.

V. Research Objectives

To conduct a systematic performance comparison of popular web browsers**[1]**. To evaluate browser performance using parameters like page load time, memory consumption, and JavaScript execution Speed**[2]**. To analyze how efficiently different browsers manage system resources**[3]**. To determine which browser performs better in real-world browsing scenarios**[4]**. To provide insights that can help improve browser performance and user experience**[5]**.

VI. Methodology

Diagramatical Representation.

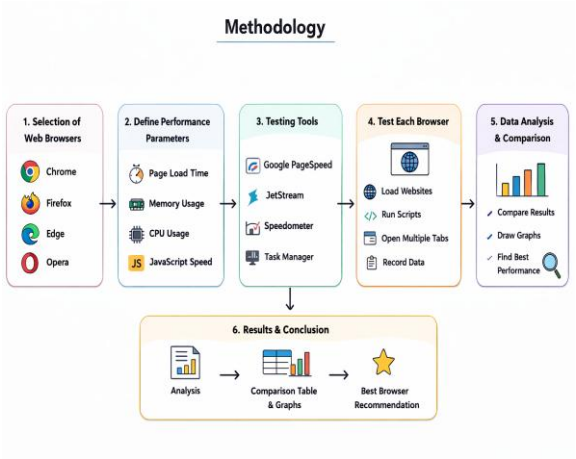

Fig.1 Overview of Research Methodology

VII. Data Collection

Select web browsers: Google Chrome, Mozilla Firefox, Microsoft Edge, and Opera**[1]**. Use the same system configuration and internet connection for testing**[2]**. Load selected websites and run web applications in each browser**[3]**. Use benchmarking and system monitoring tools to collect data**[4]**. Repeat the tests multiple times to ensure accurate results**[5]**. Store the collected data for further analysis and comparison**[6]**.

VIII. Metrics Studied

Page Load Time – Time taken to fully load a webpage**[1]**. Memory Usage – Amount of RAM used by the browser**[2]**. CPU Utilization – Percentage of CPU used during browsing**[3]**. JavaScript Execution Speed – Speed of running JavaScript code**[4]**. Browser Responsiveness – Smoothness while switching tabs and loading pages**[5]**.Tools Used

IX. Tools Used

Google Page Speed Insights – To analyze website loading performance**[1]**. JetStream Benchmark – To test JavaScript and web application performance**[2]**. Speedometer – To measure browser responsiveness**[3]**. Task Manager / System Monitor – To observe CPU and memory usage**[4]**.

X. Test Environment

To ensure fair and accurate comparison, all browsers were tested under the same hardware and network conditions. Using the same environment helps avoid external factors that could affect browser performance.

System Configuration

Component	**Specification**
Processor	Intel Core i5 / Equivalent
RAM	8 GB
Storage	SSD 256 GB
Operating System	Windows 10 / Windows 11
Internet Connection	Broadband (50 Mbps)
Browsers Tested	Google Chrome, Mozilla Firefox, Microsoft Edge, Opera

All browsers were updated to their latest stable versions before conducting the experiments.

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XI. Experimental Setup

The performance evaluation was conducted by opening the same set of websites and running standard benchmark tests in each browser. Each test was repeated multiple times and the average values were recorded to ensure reliability.

Websites used for testing:

Google.com
YouTube.com
Wikipedia.org
Amazon.com
News websites

Benchmark tests performed:

Page loading
performance
JavaScript execution speed
System resource consumption
Browser Responsiveness

XII. Experimental Results

The collected results from different tests are summarized in the tab

Browser	Avg Page Load Time (sec)	Memory Usage (MB)	CPU Usage (%)	JavaScript Benchmark Score
Google Chrome	1.8	820	32	215
Mozilla Firefox	2.0	650	28	198
Microsoft Edge	1.7	600	24	205
Opera	2.2	590	22	190

XIII. Performance Comparison

Page Load Time

Microsoft Edge showed the fastest page loading performance, closely followed by Google Chrome. Opera required slightly more time to load pages compared to other browsers.

Memory Usage

Google Chrome consumed the highest amount of RAM due to its multi-process architecture. Opera and Microsoft Edge demonstrated better memory efficiency.

CPU Utilization

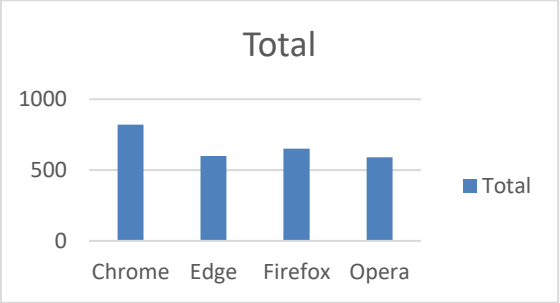
Opera and Edge used the least CPU resources during browsing, which helps improve overall system performance.

JavaScript Performance

Google Chrome achieved the highest JavaScript benchmark score due to its optimized V8 JavaScript engine.

Browser	Page Load Speed	Memory Usage	CPU Usage	JavaScript Performance	Overall Rating
Google Chrome	Very Fast	High	Medium	Excellent	4.5 / 5
Mozilla Firefox	Fast	Medium	Medium	Very Good	4 / 5
Microsoft Edge	Very Fast	Low	Low	Very Good	4.6 / 5
Opera	Medium	Low	Low	Good	3.8 / 5

Memory Usage of web browsers.



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Short Analytical Observation

From the experimental results, it can be observed that Chromium-based browsers such as Chrome and Edge demonstrate superior performance in terms of speed and compatibility**[1]**. However, Chrome consumes higher system memory compared to other browsers. Microsoft Edge shows better resource optimization while maintaining high performance. Firefox provides balanced performance with enhanced privacy features. Opera performs efficiently with lower CPU usage and additional built-in features such as ad blocking and VPN services**[2]**.

XIV. Analysis And Discussion

The results show that browser performance depends on different factors such as architecture, rendering engine, and optimization techniques. Chromium-based browsers like Chrome and Edge generally perform better in terms of speed and compatibility with modern websites**[1]**. However, Chrome consumes more memory compared to other browsers. Edge provides a balanced combination of speed and resource efficiency, making it suitable for users who want good performance with lower system resource usage**[2]**. Firefox performs well in maintaining balanced performance and privacy protection, while Opera offers additional features such as built-in VPN and ad blocking, which may slightly affect its performance results**[3]**. Overall, the performance differences between browsers are noticeable but not extreme, and the best choice may vary depending on user requirements and system capabilities**[4]**.

XV. Conclusion

This study presented a performance comparison of four widely used web browsers: Google Chrome, Mozilla Firefox, Microsoft Edge, and Opera. The evaluation was conducted using parameters such as page load time, memory consumption, CPU utilization, and JavaScript performance**[1]**.The results indi+cate that Google Chrome provides excellent speed and JavaScript performance but uses more memory. Microsoft Edge demonstrates efficient resource management while maintaining fast browsing speed. Firefox offers balanced performance with strong privacy features, while Opera provides additional built-in tools and efficient CPU usage**[2]**.Therefore, the selection of a browser depends on user priorities such as speed, resource usage, and additional features**[3]**.

XVI. Future Scope

In the future, this study can be extended by including more web browsers and testing different versions of the same browser to analyze performance improvements over time**[1]**. The research can be expanded by testing browser performance on different operating systems such as Windows, Linux, and macOS to observe how system environments affect browser efficiency**[2]**. Future work can also analyze browser performance on mobile devices such as smartphones and tablets, as mobile browsing has become increasingly common**[3]**. Additional performance parameters such as security features, battery consumption, network efficiency, and privacy protection can be included for a more comprehensive evaluation**[4]**. More advanced benchmarking tools and automated testing frameworks can be used to obtain more accurate and detailed performance measurements**[5]**. Future studies may also evaluate browser performance while running modern web applications such as cloud-based tools, streaming platforms, and online gaming services**[6]**. Another area for future research is analyzing the impact of browser extensions and plugins on overall browser performance and system resource usage**[7]**. Machine learning techniques can also be applied in future research to analyze browser performance patterns and predict optimal browser configurations**[8]**.

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