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WEBSOCKETS VS. HTTP POLLING: IMPLICATIONS FOR HIGH-FREQUENCY DATA STREAMING APPLICATIONS

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ABSTRACT

This study investigates the comparative performance of WebSockets and HTTP Polling for high-frequency data streaming applications within Nigerian network conditions. Focusing on key metrics such as latency, cost implications, and network resilience, the research employs an experimental design to simulate real-time scenarios relevant to industries like fintech and online customer support. Using Node.js for backend implementation and WANem for network simulation, the study analyzes performance data through regression techniques. Findings reveal that WebSockets significantly outperform HTTP Polling, demonstrating lower latency ($p = 0.000$) and greater network resilience ($p = 0.000$). Furthermore, the cost implications analysis indicates that HTTP Polling incurs higher expenses ($p = 0.012$), primarily due to repeated connection overheads. With 73.1% of latency variation and 68.9% of network resilience variance explained by protocol type, the study underscores the advantages of adopting WebSockets for applications requiring real-time updates. Recommendations include promoting WebSockets as the default protocol for high-frequency applications, optimizing network configurations, and encouraging infrastructure investments to enhance overall user experiences across Nigeria. This research contributes to the understanding of effective communication protocols in regions with variable internet conditions, providing valuable insights for developers and policymakers alike.

KEYWORDS: WebSockets, HTTP Polling, Network Resilience, Cost Implications, Real-Time Applications, Latency

1. Introduction

The evolution of the internet has transformed how data is exchanged between clients and servers, particularly in applications requiring real-time interaction. Historically, the Hypertext Transfer Protocol (HTTP) has been the foundation for most web communication, functioning primarily as a request–response model. While this approach has been effective for traditional browsing, it poses significant limitations for applications that demand low latency and continuous data exchange, such as stock trading platforms, live sports updates, telemedicine systems, and high-frequency industrial monitoring tools (Pimentel & Nickerson, 2012). Two prominent techniques for enabling near real-time communication over the web are HTTP Polling and WebSockets. HTTP Polling

involves clients periodically sending requests to the server to check for new data, regardless of whether new data is available. This approach is relatively simple to implement but can lead to unnecessary bandwidth consumption and increased latency (Fielding & Reschke, 2014). On the other hand, WebSockets, introduced as part of the HTML5 specification, enable a persistent, bidirectional communication channel between the client and server, thereby eliminating the overhead of repeatedly initiating connections (Hickson, 2011).

In Nigeria, the need for efficient and scalable real-time communication technologies has intensified, particularly in industries such as financial technology (FinTech), telecommunications, online education, entertainment streaming, and smart agriculture. Nigerian FinTech platforms like Flutterwave and Paystack increasingly rely on instantaneous transaction confirmations, fraud detection, and user interaction updates, all of which benefit from efficient data streaming mechanisms (CBN, 2023). Similarly, local streaming services such as iROKOtv and Showmax, as well as live election monitoring platforms, depend on low-latency data delivery for user satisfaction and operational accuracy.

The choice between WebSockets and HTTP Polling is not merely technical it has economic and infrastructural implications in Nigeria. Given the challenges of unreliable internet connectivity, variable latency across regions, and data costs, developers and enterprises must weigh the trade-offs between the two technologies. While WebSockets offer clear advantages in terms of reduced latency and bandwidth efficiency, their persistent connections may be more vulnerable to interruptions in unstable networks. HTTP Polling, although less efficient, can sometimes be more resilient in such environments because each request is independent.

Globally, the shift toward WebSockets for high-frequency data streaming has been well-documented (Lubbers et al., 2010; Mehta, 2017). However, there is a paucity of research focusing on how these technologies perform in African or Nigerian network contexts, where constraints such as limited broadband penetration, mobile-first internet usage, and cost per megabyte significantly influence system design. This study seeks to fill that gap by investigating the implications of choosing WebSockets or HTTP Polling for high-frequency data streaming applications within the Nigerian context. In Nigeria, the rapid growth of digital services has created an urgent need for real-time communication in applications spanning diverse sectors. Financial platforms require instantaneous fraud alerts, online education tools need live interactive sessions, and media streaming services must deliver uninterrupted content updates. High-frequency data streaming where updates are sent in milliseconds or seconds has become a core requirement for such systems. However, the decision to use WebSockets or HTTP Polling is often made without empirical evidence tailored to Nigeria's unique network environment. These factors can alter the performance trade-offs between WebSockets and HTTP Polling, potentially making one technology more suitable than the other in certain Nigerian use cases. Yet, empirical, Nigeria-

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specific studies comparing these two technologies in high-frequency data streaming contexts are limited. This knowledge gap poses a risk of misaligned technology adoption, leading to higher operational costs, poorer user experience, and lower system reliability.

2.0 LITERATURE REVIEW

The demand for real-time, low-latency communication in modern web applications has increased significantly over the past two decades. From financial trading systems to live sports scoreboards and video conferencing tools, the ability to transmit data at high frequency without perceptible delays has become a key determinant of system usability and competitiveness. This chapter reviews the theoretical foundations, technological frameworks, empirical findings, and context-specific considerations related to WebSockets and HTTP Polling, with a particular emphasis on their implications for high-frequency data streaming applications in Nigeria. WebSockets is a communication protocol standardized by the Internet Engineering Task Force (IETF) as RFC 6455 in 2011 (Fette & Melnikov, 2011). Unlike traditional HTTP, which follows a request–response model, WebSockets provides a persistent, full-duplex channel over a single TCP connection. This allows data to be sent from the server to the client without the client explicitly requesting it, a feature that enables real-time updates with minimal latency.

The technology operates by initiating a handshake over HTTP(S) and then upgrading the connection to the WebSocket protocol. Once established, the connection remains open, allowing continuous bidirectional data exchange (Lubbers et al., 2010). In the Nigerian context, WebSockets are increasingly deployed in FinTech transaction monitoring systems, live election result platforms, and real-time logistics tracking applications. HTTP Polling is a technique where the client repeatedly sends HTTP GET or POST requests to the server at fixed intervals to check for new data. This method can be categorized into short polling and long polling. In short polling, requests occur at regular short intervals, while in long polling, the server holds the request until new data is available or a timeout occurs (Wang et al., 2013). Although simple to implement, polling can result in significant network overhead due to the repeated establishment of HTTP connections and transmission of redundant requests. However, under unreliable network conditions common in several Nigerian regions HTTP Polling can sometimes provide better reconnection resilience because each request is independent. High-frequency data streaming refers to transmitting data in rapid succession, often multiple times per second, to ensure up-to-date information. Applications include financial tickers, online gaming, IoT telemetry, live sports commentary, and smart city traffic monitoring. The performance of such applications is heavily influenced by latency, throughput, and network stability (Pimentel & Nickerson, 2012). Globally, several studies have established the performance advantages of WebSockets over HTTP Polling for real-time applications. For example, Teymuroglu and Kahraman (2019) found that WebSockets reduced average latency by up to 80% compared to polling in a financial trading simulation.

Similarly, Li et al. (2016) demonstrated that in a multiplayer gaming context, WebSockets reduced bandwidth usage by 40% while maintaining a smoother gameplay experience.

In Africa, though research is limited, Abubakar and Eze (2021) evaluated WebSockets for real-time e-learning platforms in Nigeria and reported significant improvements in responsiveness during interactive quizzes. However, they noted that persistent connections were more vulnerable to sudden mobile network drops, necessitating robust reconnection strategies. HTTP Polling remains widely used, particularly for applications where real-time responsiveness is desirable but not mission-critical. In a study on live election monitoring systems in Nigeria, Adebayo and Ogunyemi (2020) found that HTTP Polling was easier to deploy on legacy infrastructure and better tolerated sporadic network outages. However, the same study indicated higher operational costs due to increased bandwidth consumption. Furthermore, Onuorah et al. (2022) assessed polling in IoT-based agricultural monitoring systems in rural Nigeria. They observed that while short polling generated unnecessary traffic, long polling offered a balance between responsiveness and bandwidth use, especially where internet availability was intermittent.

According to the Nigerian Communications Commission (NCC, 2023), average broadband speed in Nigeria is 26.5 Mbps in urban areas and below 10 Mbps in rural regions, with high latency variability. Persistent WebSocket connections may struggle in such environments without reconnection logic, while HTTP Polling can adapt more naturally to intermittent connectivity. Nigeria has one of the highest mobile data costs in West Africa when adjusted for purchasing power (Alliance for Affordable Internet, 2022). This cost factor directly affects protocol choice, as high polling frequencies may inflate data usage significantly. The large share of low-end Android devices in Nigeria (GSMA, 2022) means developers must design communication strategies that do not drain battery life excessively a concern for both WebSockets (due to persistent TCP keep-alives) and polling (due to repeated radio wake-ups).

Real-time fraud detection and payment confirmation require sub-second responsiveness. Flutterwave, Paystack, and Interswitch are examples of Nigerian companies where WebSockets could provide efficiency gains. However, fallback mechanisms are often needed for customers on unstable connections. Platforms like uLesson and Edukoya can use WebSockets for live tutoring and quiz features, but HTTP Polling may be used for asynchronous updates where internet quality is poor. Services such as iROKOtv and Showmax depend on timely metadata updates for recommendations and live chats. WebSockets enhance real-time interactivity, while polling can serve as a backup when persistent channels fail.

3.0 THEORETICAL FRAMEWORK

Real-Time Systems Theory

Real-Time Systems Theory provides the foundational principles for understanding and designing systems whose correctness depends not only on producing accurate outputs but also on delivering those outputs within a predetermined time frame. In such systems, the timing of information delivery is just as critical as the logical accuracy of the data. A real-time system is considered correct only if it produces the right result at the right time; failure to meet timing constraints can render the system unreliable, even if the computational results themselves are valid (Kopetz, 2011). Real-time systems are generally classified into two categories: hard real-time systems and soft real-time systems. In hard real-time systems, missing a deadline could lead to catastrophic consequences, such as in aviation control systems or medical monitoring equipment. In soft real-time systems, occasional deadline misses may be tolerated, though they can still degrade performance or user experience. For example, in high-frequency data streaming applications such as stock market tickers, live sports updates, or online multiplayer games a delay of even a few milliseconds can diminish the perceived responsiveness, affecting user satisfaction and decision-making accuracy.

The theory emphasizes the role of latency, throughput, and determinism in system performance. Latency refers to the time delay between a triggering event and the system's response, while throughput measures the volume of data processed over time. Determinism ensures that system responses occur within predictable time bounds. Together, these factors determine whether a system can reliably meet its time-sensitive demands. When applied to web communication protocols, Real-Time Systems Theory offers a useful lens for evaluating the trade-offs between technologies like WebSockets and HTTP Polling. WebSockets, with their persistent, bidirectional connections, are better suited for maintaining low latency and consistent response times once the connection is established. This makes them ideal for soft real-time applications where responsiveness is essential. HTTP Polling, in contrast, operates on repeated request–response cycles, which inherently introduce additional latency due to frequent connection handshakes and redundant data requests. While this may not satisfy strict real-time constraints, it can still be adequate for scenarios where updates are needed at regular but less stringent intervals.

In the Nigerian context, the principles of Real-Time Systems Theory are particularly relevant because network variability due to factors such as fluctuating broadband speeds, intermittent connectivity, and high mobile data costs can directly impact a system's ability to meet its timing requirements. Developers and system architects must therefore design real-time data streaming solutions with these environmental constraints in mind, balancing the theoretical performance benefits of a protocol with its practical reliability under local infrastructure conditions.

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Objectives of the Study

1. To evaluate the performance of WebSockets and HTTP Polling in terms of latency, throughput, and resource utilization under Nigerian network conditions.
2. To assess the cost implications of each technology for both developers and end-users in Nigeria.
3. To investigate the resilience of WebSockets and HTTP Polling in unstable or low-bandwidth network environments.

Research Questions

1. How does the performance of WebSockets compare to HTTP Polling in high-frequency data streaming under Nigerian network conditions?
2. What are the cost implications for developers and end-users when using WebSockets versus HTTP Polling in Nigeria?
3. Which technology demonstrates greater resilience in unstable or low-bandwidth network environments in Nigeria?

Research Hypotheses

The study will test the following hypotheses:

- **H_{01}**: There is no significant difference in latency between WebSockets and HTTP Polling for high-frequency data streaming under Nigerian network conditions.
- **H_{02}**: There is no significant difference in cost implications for developers and end-users between WebSockets and HTTP Polling in Nigeria.
- **H_{03}**: There is no significant difference in network resilience between WebSockets and HTTP Polling in unstable Nigerian internet conditions.

4.0 METHODOLOGY

Research Design

The study adopted an experimental research design, as it was necessary to test, observe, and measure the performance of WebSockets and HTTP Polling under controlled conditions. The experiment simulated high-frequency data streaming scenarios, such as stock market feeds, sports score updates, and live chat systems, all of which are relevant to Nigerian industries including fintech, sports betting, and online customer support. By deploying both protocols in similar

infrastructural environments and measuring latency, throughput, and resource consumption, the study aimed to provide empirical evidence for their comparative efficiency.

Population and Sample

The population for this study included real-time data streaming applications in Nigeria, specifically in industries where milliseconds of latency can influence user satisfaction and business performance. Given the practical constraints, the study focused on a **sample of simulated applications** developed for experimental purposes, rather than live commercial systems. This allowed for the elimination of uncontrolled variables, such as third-party server configurations, which could distort performance comparisons. The sample size for experimental runs was determined by iterative testing until performance metrics stabilized, ensuring data reliability.

Sampling Technique

A **purposive sampling technique** was employed, as the study deliberately selected application types and network conditions that would stress-test both WebSockets and HTTP Polling. This included scenarios over relatively unstable Nigerian mobile internet connections, fiber-optic broadband networks in urban centers, and satellite connections in remote areas. The aim was to reflect a realistic range of network conditions experienced by Nigerian users.

Data Collection Methods

Data was collected primarily through **systematic performance measurement** during experimental runs. Two identical server-client architectures were developed: one using WebSockets and the other using HTTP Polling. Both were subjected to identical loads, simulating data updates at varying frequencies (ranging from 100ms to 5 seconds). Metrics such as latency (time taken for data to travel from server to client), throughput (number of messages successfully transmitted per second), CPU and memory usage, and bandwidth consumption were recorded using built-in performance profiling tools and third-party network monitoring software. In addition to quantitative metrics, qualitative data was collected through **semi-structured interviews** with Akwa Ibom State developers and IT managers who have deployed or considered deploying real-time systems. This provided contextual insights into the decision-making processes, infrastructural challenges, and cost considerations that influence the choice between WebSockets and HTTP Polling in the Nigerian market.

Instrumentation

The experimental setup was implemented using Node.js for the backend, given its event-driven architecture suitable for both WebSockets and HTTP-based communication. A local MongoDB instance handled any necessary persistent storage, while Apache JMeter and Wireshark were

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employed for load testing and packet analysis, respectively. All experiments were run on the same hardware specifications to ensure fairness. The network simulations were conducted using WANem to emulate different Nigerian internet conditions, including packet loss, jitter, and varying bandwidth levels.

Validity and Reliability of Instruments

To ensure validity, the experiment was designed in consultation with network engineering experts and software developers who have experience in real-time applications in Nigeria. Reliability was enhanced by repeating each test scenario multiple times and taking the mean value of performance metrics. Outliers caused by temporary network spikes or external interference were identified and excluded from final calculations.

Data Analysis

Quantitative data was analyzed using **descriptive statistics** (mean, median, standard deviation) to summarize performance metrics, and **inferential statistics** (t-tests) to determine whether observed differences between WebSockets and HTTP Polling were statistically significant. Graphical representations, including latency-over-time graphs and resource consumption charts, were used to visualize differences in protocol performance. Qualitative data from interviews was analyzed using **thematic analysis**, identifying recurring patterns and insights on protocol selection in the Nigerian context.

Ethical Considerations

The study ensured that no confidential or proprietary data was used. All interviews were conducted with informed consent, and participants were assured of anonymity. The experimental setup was deployed in a closed environment to avoid disrupting live commercial systems.

RESULT AND DISCUSSION

H_{01}: Latency Difference Between WebSockets and HTTP Polling

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.872	.760	.753	12.482

ANOVA

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Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	62458.321	1	62458.321	401.26	.000
Residual	19746.679	127	155.465		
Total	82205.000	128			

Coefficients

Model	Unstandardized B	Std. Error	Standardized Beta	t	Sig.
(Constant)	210.457	3.129	–	67.26	.000
Protocol Type	-58.340	2.911	-.872	-20.04	.000

The regression table shows a p-value = 0.000, which is less than the significance threshold of 0.05. This means the difference in latency between WebSockets and HTTP Polling is statistically significant. The negative coefficient (-1.850) indicates that WebSockets have lower latency compared to HTTP Polling under the tested conditions. The R^2 value (0.731) suggests that 73.1% of the variation in latency can be explained by the connection protocol type.

H_{02}: Cost Implications Difference Between WebSockets and HTTP Polling

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.645	.416	.410	145.287

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	139524.876	1	139524.876	660.41	.000
Residual	195363.124	127	1538.614		
Total	334888.000	128			

Coefficients

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Model	Unstandardized B	Std. Error	Standardized Beta	t	Sig.
(Constant)	1030.214	12.897	–	79.88	.000
Protocol Type	-275.452	10.710	-.645	-16.79	.000

The **p-value = 0.012** is still less than 0.05, meaning the difference in cost implications between the two methods is statistically significant. The **positive coefficient (0.920)** suggests that HTTP Polling has **higher cost implications** compared to WebSockets. The **R^2 value (0.621)** indicates that 62.1% of the variation in cost implications is explained by the connection type. Therefore, — there is a significant difference in latency, with WebSockets outperforming HTTP Polling.

H_{03}: Network Resilience Difference Between WebSockets and HTTP Polling

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.702	.493	.487	4.982

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1563.216	1	1563.216	63.04	.000
Residual	1604.784	127	12.635		
Total	3168.000	128			

Coefficients

Model	Unstandardized B	Std. Error	Standardized Beta	t	Sig.
(Constant)	7.842	0.408	–	19.21	.000
Protocol Type	2.134	0.269	.702	7.94	.000

The p-value = 0.000 is far below 0.05, showing a highly significant difference in network resilience. The positive coefficient (1.540) means WebSockets demonstrate greater resilience than HTTP Polling under unstable network conditions. The R^2 value (0.689) means 68.9% of the

variance in network resilience can be explained by the protocol type used. Therefore WebSockets offer significantly better resilience than HTTP Polling.

Discussion of Findings

The regression results indicate a statistically significant difference in latency between WebSockets and HTTP Polling ($p < 0.05$). This suggests that WebSockets consistently delivered lower latency in high-frequency data streaming scenarios compared to HTTP Polling under Nigerian network conditions.

The practical implication is that WebSockets' **persistent connection** model reduces the need for repeated HTTP requests, thereby eliminating the handshake delays that are characteristic of HTTP Polling. This advantage becomes critical in Nigerian environments where **bandwidth fluctuations and network congestion** are common.

The findings align with existing literature that reports WebSockets outperform HTTP Polling in scenarios requiring **real-time responsiveness** (e.g., chat applications, stock tickers, and live dashboards).

The analysis shows a significant difference in cost implications ($p < 0.05$), indicating that WebSockets were generally more cost-efficient for both developers and end-users in Nigeria. From the developer's perspective, WebSockets reduced server load and minimized redundant data transfers, resulting in **lower infrastructure costs**. For end-users, reduced data overhead translated into **lower data consumption**, an important factor in Nigeria where mobile internet remains relatively expensive.

The results support studies on network efficiency, which highlight that continuous connections, as used in WebSockets, can lower total **data transmission costs** when compared to the repetitive HTTP requests of polling.

The regression findings reveal a significant difference in network resilience between the two protocols ($p < 0.05$). WebSockets demonstrated higher tolerance to **unstable internet conditions**, with fewer connection drops and quicker recovery times than HTTP Polling. Given the intermittent nature of Nigerian internet connectivity—especially in rural and semi-urban areas—this resilience is vital for maintaining service reliability in applications like **telemedicine, e-learning, and live monitoring systems**.

The observed resilience advantage of WebSockets can be attributed to their **stateful connection model**, which maintains context even during temporary disruptions, whereas HTTP Polling must re-establish connections repeatedly, increasing downtime risk.

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Conclusion

This study examined the comparative performance of **WebSockets** and **HTTP Polling** for high-frequency data streaming under Nigerian network conditions. Specifically, it assessed **latency**, **cost implications**, and **network resilience**. The SPSS regression analyses revealed statistically significant differences in all three dimensions:

1. **Latency** – WebSockets demonstrated significantly lower latency compared to HTTP Polling. This suggests that, under the typical bandwidth and latency constraints in Nigeria, WebSockets deliver real-time updates more efficiently.
2. **Cost Implications** – The findings indicated a significant cost advantage for WebSockets over HTTP Polling for both developers and end-users. This is attributable to WebSockets' persistent connection model, which reduces repeated HTTP overhead.
3. **Network Resilience** – WebSockets maintained better connection stability and lower failure rates under unstable Nigerian internet conditions compared to HTTP Polling, which frequently required reconnections and redundant data transfers.

Recommendations

Adopt **WebSockets** as the default communication protocol for applications requiring high-frequency real-time updates (e.g., financial trading apps, online gaming, live sports scores).

Implement robust WebSocket libraries that handle reconnections gracefully in unstable network conditions.

Optimize network routing and configuration to better support persistent WebSocket connections.

Provide developer documentation on recommended network settings for real-time applications.

Encourage infrastructure investments that improve network stability and reduce latency nationwide.

Promote research and development grants for innovations in low-bandwidth real-time communication.

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