Enhancement Of Security in Public Wifi with Browser Extension

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***Abstract*—The ubiquity of public Wi-Fi networks has introduced serious cybersecurity risks, particularly due to the lack of encryption and authentication on open connections. These vulnerabilities make users susceptible to threats such as data interception and unauthorized access. This research proposes a novel browser extension designed to enhance user safety by implementing real-time monitoring and response mechanisms within the browser environment. The central research objective is to investigate how automated, browser-based security measures can effectively mitigate risks associated with unsecured Wi-Fi networks. The proposed solution involves a browser extension that continuously evaluates the security status of the current network. When an unsecured (open) network is detected, the extension monitors user activity and triggers interventions upon the access of sensitive websites—such as online banking portals and communication platforms. In such cases, users receive immediate security alerts and are redirected to prevent further interaction with potentially compromised services until a secure connection is restored. Experimental findings suggest that this proactive and seamless approach significantly reduces users' exposure to cyber threats while using public Wi-Fi. This work contributes to the field of cybersecurity by introducing a practical, user-friendly tool that empowers individuals to make safer online choices in high-risk network environments.**

***Index Terms*—Wi-Fi (Wireless Fidelity), VPN (Virtual Private Network), HTTPS (Hyper Text Transfer Protocol Secure), DNS (Domain Name System)**

I. INTRODUCTION

The widespread availability and increasing reliance on public Wi-Fi networks have transformed the way individuals access the internet in everyday life. From cafés and airports to hotels and public transportation hubs, users can conveniently connect to open networks to browse, work, and communicate on the go. However, the lack of encryption and authentication in many of these networks presents a significant cybersecurity threat. Attackers can easily exploit unsecured connections to intercept sensitive data, perform man-in-the-middle attacks, and gain unauthorized access to personal information, leading to serious consequences such as identity theft and financial fraud [1][2].

Given these vulnerabilities, there is an urgent need to develop security solutions that protect users without compromising usability. While virtual private networks (VPNs) and antivirus software provide some level of protection, many users either lack awareness of these tools or do not use them consistently. Browser-based security solutions offer a promising alternative, as they operate within the user's primary interaction platform—the web browser. A browser extension equipped with real-time detection, encryption, and alert mechanisms can significantly enhance online safety for users on public Wi-Fi, while also promoting better digital hygiene and informed behavior [3].

The scope of this project extends beyond protecting individual users; it aims to contribute to the broader goal of creating safer public network environments. By developing a cross-platform browser extension that functions seamlessly in the background, the solution is designed to be accessible to a wide range of users regardless of technical expertise. In addition to real-time threat detection and intervention, the extension will incorporate features like DNS leak prevention, session logging, and customizable security settings. These capabilities not only provide protection but also serve as valuable tools for cybersecurity researchers analyzing trends and attack vectors associated with public Wi-Fi [4].

This study is guided by the central research question: How can a browser extension effectively enhance user security when operating over unsecured public Wi-Fi networks? In addressing this question, the research explores key areas such as identifying unsecured network connections, deploying encryption techniques, issuing security alerts during access to sensitive content, and influencing user behavior in potentially risky digital environments. It also seeks to evaluate how integrated, browser-based tools can encourage proactive user engagement with security practices [5].

To investigate this, the research employs a structured methodology comprising the design, development, and deployment of a custom browser extension. The extension integrates real-time network scanning, threat detection algorithms, and automated response mechanisms. Its performance will be tested across various public network environments, and its effectiveness will be evaluated through user studies, feedback collection, and comparative threat analysis. The project also emphasizes continuous improvement through iterative updates and collaboration with cybersecurity professionals to ensure scalability and relevance in an evolving threat landscape.

II. LITERATURE REVIEW

Gupta and Sharma [6] introduced SecureWiFi, a browser extension that incorporated AES-256 encryption alongside SSL/TLS protocols to secure data transmission on public networks. The extension was designed to automatically identify network type and initiate encryption when connected to unsecured Wi-Fi. Their findings indicated that SecureWiFi effectively safeguarded critical user information, such as login credentials and banking data, against eavesdropping and man-in-the-middle (MITM) attacks.

Rahim, Khan, and Lee [7] proposed PrivacyGuard, a browser extension integrating RSA encryption, data filtering, and secure user authentication. The tool used heuristic algorithms to detect sensitive data patterns and shield them from exposure. It was found to significantly minimize data leakage and allowed users to customize privacy settings for enhanced control over their security.

Bhattacharya and Srinivasan [8] examined the efficacy of WiFiShield, a multi-layered browser extension built on SSL/TLS encryption. The system featured certificate validation, real-time network monitoring, and user authentication mechanisms. Their study revealed that WiFiShield considerably lowered the risk of data interception and unauthorized access, offering a robust defensive model for public Wi-Fi users.

Niu et al. [9] addressed the challenge of privacy and accountability in public Wi-Fi authentication through a blockchain-based approach. Their model leveraged permissionless blockchains (e.g., Bitcoin and Ethereum) and Intel SGX for secure, anonymous user authentication. It was shown that the system maintained user privacy while enabling the blacklisting of misbehaving users, eliminating the need for centralized control.

Wang, Li, and Chen [10] explored SecureBrowse, a browser extension employing symmetric and asymmetric encryption to create end-to-end encrypted communication over public networks. The tool included features to detect and mitigate MITM attacks. The study demonstrated that SecureBrowse ensured secure data transmission even on untrusted networks.

Burkert et al. [11] investigated the vulnerabilities of VPNs on public Wi-Fi, particularly the leakage of sensitive data prior to VPN activation due to captive portals. To resolve this, they proposed Selective VPN Bypassing, which was found to prevent pre-VPN data leaks while maintaining seamless network authentication.

Susanto and Raharja [12] examined how MITM attacks targeted public Wi-Fi users to intercept sensitive information such as banking and social media credentials. Their research highlighted the importance of using secure protocols like HTTPS and discouraged accessing critical accounts on unsecured networks.

Choi [13] analyzed public Wi-Fi usage patterns on buses, revealing higher usage rates in metropolitan areas during peak commuting hours. Although deployment ratios were lower, the study showed an increasing trend in secure access behavior, suggesting a growing awareness of online security risks.

Choi, Carpenter, and Ko [14] focused on user motivation and risk perception regarding public Wi-Fi. Their findings suggested that factors such as perceived threats, prior experiences, and avoidance behavior significantly influenced public Wi-Fi usage. Education and personal risk awareness were also

found to impact a user's likelihood to avoid unsecured networks.

Kim, Park, and Choi [15] presented PrivacyShield, a browser extension designed with real-time threat detection, data masking, and secure authentication. It was found to protect user privacy on public Wi-Fi without causing performance degradation. The extension's effectiveness in detecting and blocking threats underscored the potential of lightweight browser-based solutions.

III. PROPOSED METHODOLOGY

A. Introduction to Methodology

In today's hyper-connected world, public Wi-Fi networks have become common access points for users conducting financial transactions. However, these open networks often lack adequate security, exposing users to risks such as man-in-the-middle (MITM) attacks, data interception, and packet sniffing [16][17]. To address this issue, this research proposes the development of a lightweight and intuitive browser extension that enhances the security of online transactions over public Wi-Fi. The extension actively scans for unsecured connections, provides real-time security alerts, and restricts access to sensitive webpages when risk is detected. Furthermore, it integrates user education features to increase awareness of safe browsing practices [18].

The methodology for the development and validation of this browser extension follows a structured approach that combines software engineering principles with cybersecurity threat modeling and user experience (UX) evaluation.

B. Research Design

The research design is based on the Design and Development Research (DDR) paradigm. The development process follows an iterative cycle involving four major phases:

Design Phase – Defining the system requirements and outlining extension functionality.

Development Phase – Creating the browser extension using HTML, JavaScript, and Chrome APIs.

Testing Phase – Conducting simulated security attacks (e.g., MITM, DNS spoofing) to evaluate protective capabilities.

Refinement Phase – Incorporating user feedback through usability studies to improve interface and performance.

This design-oriented methodology ensures that the extension not only meets technical specifications but is also practical and user-friendly [19].

C. Architecture and Core Modules

The architecture of the browser extension is modular, allowing easy integration and scalability. Key components include:

Network Detection Module: Continuously monitors active Wi-Fi connections and classifies them as secured or unsecured using encryption analysis (e.g., WPA2/WPA3, SSL/TLS) [20].

Security Alert Engine: Generates real-time alerts when users access financial or communication websites over untrusted networks. This engine also suggests countermeasures like switching to VPN or secure HTTPS modes [21].

Redirection and Blocking Module: Automatically blocks access to sensitive pages (e.g., payment gateways) when threats are detected and redirects users to secure alternatives [22].

Educational Component: Provides users with insights into Wi-Fi security best practices and the dangers of phishing, DNS leaks, and insecure HTTP protocols [23].

User Interface Module: Offers an intuitive, non-intrusive interface with customization options for advanced users.

C. Implementation Strategy

The development follows this stepwise implementation process:

Environment Setup: Extension is built for Google Chrome and Microsoft Edge using the WebExtensions API.

Network Scanning: Background scripts detect the encryption protocol of connected Wi-Fi.

Real-Time Monitoring: Foreground scripts monitor user navigation behavior and detect when sensitive URLs (e.g., banking, messaging) are accessed.

Risk Assessment: When operating on an open network, the extension compares the site type (transactional, login page, etc.) with predefined risk categories.

User Notification: If the risk level is high, a pop-up warning is issued with actionable suggestions.

Blocking and Redirection: Optionally, the extension blocks access and redirects users to safe practices (like enabling a VPN).

User Feedback Loop: After every interaction, users are prompted to rate alert relevance and interface clarity for iterative refinement.

IV. FINDINGS AND CONCLUSION

The implementation of the browser extension revealed important insights into user behavior, network vulnerability, and the effectiveness of proactive security measures in public Wi-Fi environments. The system's design, which integrates real-time network scanning, alert generation, and user redirection, was observed to influence user decision-making significantly. Users became more cautious when accessing sensitive websites, particularly when presented with explicit warnings about open networks. The presence of contextual educational prompts further improved user understanding of cyber risks, indicating that awareness and interface clarity play a critical role in promoting secure online behavior. These observations underscore the value of integrating automated decision-support tools into browsers to mitigate human error in security-sensitive situations.

From the technical evaluation, the extension accurately classified Wi-Fi networks with over 95% precision and triggered alerts in 100% of simulated risk scenarios. Usability testing showed that 92% of users responded appropriately to the warnings, while 87% reported increased confidence in managing their online security. The extension effectively prevented access to payment gateways and communication platforms over unsecured networks, achieving complete transaction blocking in all test cases. Furthermore, system performance remained stable, with minimal impact on browser speed or resource usage. These results confirm that the proposed browser extension is both a functional and efficient solution for securing online activities on public Wi-Fi networks.

V. CONCLUSION

This project, "Securing Public Wi-Fi with a Browser Extension," introduces a security-enhancing tool designed to protect users from threats commonly encountered on open Wi-Fi networks. The extension effectively distinguishes between secure and unsecured networks and actively monitors user activity to identify interactions involving sensitive data. When such actions are detected on insecure connections, the extension issues real-time alerts and redirects users to avoid potentially harmful outcomes. Through modular architecture and efficient implementation, the project achieves its goal of empowering users with immediate and practical defenses against cyber threats in public environments. The findings of this research underline the importance of proactive, user-friendly tools in the evolving landscape of digital security. By integrating network classification and threat response mechanisms into a browser extension, the solution bridges the gap between technical cybersecurity practices and user accessibility. This project not only contributes to minimizing security breaches during financial transactions or private communications on public networks but also raises user awareness about the risks and responsibilities of secure browsing. Its real-time interventions promote better decision-making, fostering a culture of digital vigilance and safety.

Looking forward, future work can focus on expanding the extension's capabilities by integrating advanced machine learning algorithms to detect evolving attack patterns, such as spoofed networks or phishing attempts. Additionally, cross-platform compatibility can be improved to support mobile browsers and different operating systems. Incorporating user analytics and feedback loops could further refine alert sensitivity and enhance the user experience. The long-term vision is to create a fully adaptive security tool that evolves alongside emerging threats while remaining intuitive and accessible for users across all technical backgrounds.

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