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Title of Proposal: A Security Analysis of Vulnerabilities in Common Routing Protocols (RIP, OSPF, and BGP)

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Abstract

Routing protocols such as Routing Information Protocol (RIP), Open Shortest Path First (OSPF), and Border Gateway Protocol (BGP) are essential for enabling communication across modern computer networks. Despite their critical role, these protocols were not originally designed with strong security mechanisms, making them susceptible to a range of vulnerabilities and attacks. This research provides a comprehensive security analysis of RIP, OSPF, and BGP, focusing on their inherent weaknesses, common attack vectors, and existing mitigation techniques.

The study examines how RIP is vulnerable to route poisoning and spoofing due to its lack of authentication, while OSPF, although more secure, can still be exploited through link-state advertisement (LSA) manipulation and insider threats. BGP, as the core protocol of the global Internet, is particularly exposed to large-scale attacks such as prefix hijacking and route leaks, which can disrupt global connectivity.

A qualitative research methodology will be adopted, involving a systematic review of recent academic literature and comparative analysis of protocol behaviours under attack conditions. The findings highlight that while several mitigation strategies exist, their adoption remains inconsistent, leaving networks exposed to evolving threats.

The study concludes by emphasizing the need for stronger security integration within routing protocols and wider implementation of existing defence mechanisms. It also recommends future research directions focusing on automated detection systems and secure protocol design to enhance the resilience of network infrastructures.

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Introduction

Context and Background

Modern networks rely on dynamic routing protocols to exchange reachability information. Interior Gateway Protocols like RIP (Routing Information Protocol) and OSPF (Open Shortest Path First) manage routes within a single autonomous system, while BGP (Border Gateway Protocol) handles inter-domain routing across the Internet. By design, these protocols assume a level of trust among routers [1]. For example, as one industry analyst notes, “If one router says, ‘Here’s a new prefix,’ its peer believes it. Without authentication, this trust can be easily abused” [1]. Indeed, researchers and standards bodies have documented that fundamental flaws and misconfigurations in routing protocols are regularly exploited: the White House’s 2024 *Internet Routing Security Roadmap* stresses that BGP “does not provide adequate security” and lacks built-in origin validation or integrity checks [2]. Similarly, domain-wide incidents in 2024 showed that even academic and research networks suffered from route leaks and hijacks that disrupted global connectivity [3], [4]. These incidents highlight that RIP, OSPF, and BGP—all pillars of network routing—remain vulnerable in today’s environment.

Research Problem

Despite the critical role of routing, comprehensive analysis of their security weaknesses is still needed. While each protocol has published extensions (e.g. cryptographic authentication, RPKI, BGPsec), real-world adoption is far from universal [1], [5]. For instance, as of early 2026, approximately 55% of routed IPv4 prefixes are covered by RPKI Route Origin Authorizations (ROAs) [6], and many networks do not drop invalid routes [7]. Meanwhile, new attack methods continue to emerge (e.g. the recent OSPF “disguised LSA” exploit [8], [9] and BGP implementation bugs [10], [11]).

Aim and Objectives

The aim of this work is to perform a security analysis of vulnerabilities in RIP, OSPF, and BGP. Specifically, this study will identify and categorize known vulnerabilities and attack vectors for each protocol (for example, RIP route poisoning, OSPF LSA spoofing, and BGP prefix hijacking); experimentally validate these vulnerabilities in a controlled lab environment; evaluate mitigation measures, such as protocol authentication, filtering, and RPKI, to see how effectively they block attacks; and propose best practices and countermeasures for securing these protocols. We will examine both protocol design flaws and implementation issues (e.g. Cisco’s OSPF DoS bugs [12] or open-source BGP bugs [10]).

Significance of the Research

Routing security underpins the stability of the Internet. As noted by industry experts, BGP’s “fatal flaw” is its blind trust – any AS can announce routes for prefixes it doesn’t own, and other networks must trust it [13]. Real-world examples illustrate the impact: in early 2022 alone, there were thousands of BGP route leaks and hijacks globally [3]. One dramatic case in mid-2024 disrupted Cloudflare’s 1.1.1.1 DNS service via a combination of a malicious prefix hijack and a misconfiguration leak [14]. Such events can enable traffic interception, surveillance, and denial of service. By thoroughly analyzing these vulnerabilities and demonstrating both attacks and defenses, this research will help network operators understand the risks and strengthen routing integrity. Ultimately, improving the resilience of RIP, OSPF, and BGP will benefit all Internet users by reducing outages and preventing malicious traffic manipulation [4].

Literature Review

Introduction to the Literature Review

Routing protocols have long been recognized as security-critical yet inherently vulnerable. RIP (Routing Information Protocol) is the simplest of the three. RIPv1 had no security at all, and RIPv2’s optional MD5 authentication is infrequently used [1]. Thus, an attacker on a network can easily send forged RIP responses to poison routing tables or announce incorrect metrics. For example, laboratory studies show that a rogue router can flood RIP peers with a fake route advertisement, causing traffic to follow a malicious path [15]. Because RIP routers accept any update from neighbors (by default), a single unauthorized device can hijack or blackhole routes. In practice, VLAN or interface filtering is often needed to isolate RIP updates; if left open, networks remain exposed to RIP poisoning attacks [1].

RIP - ATTACK

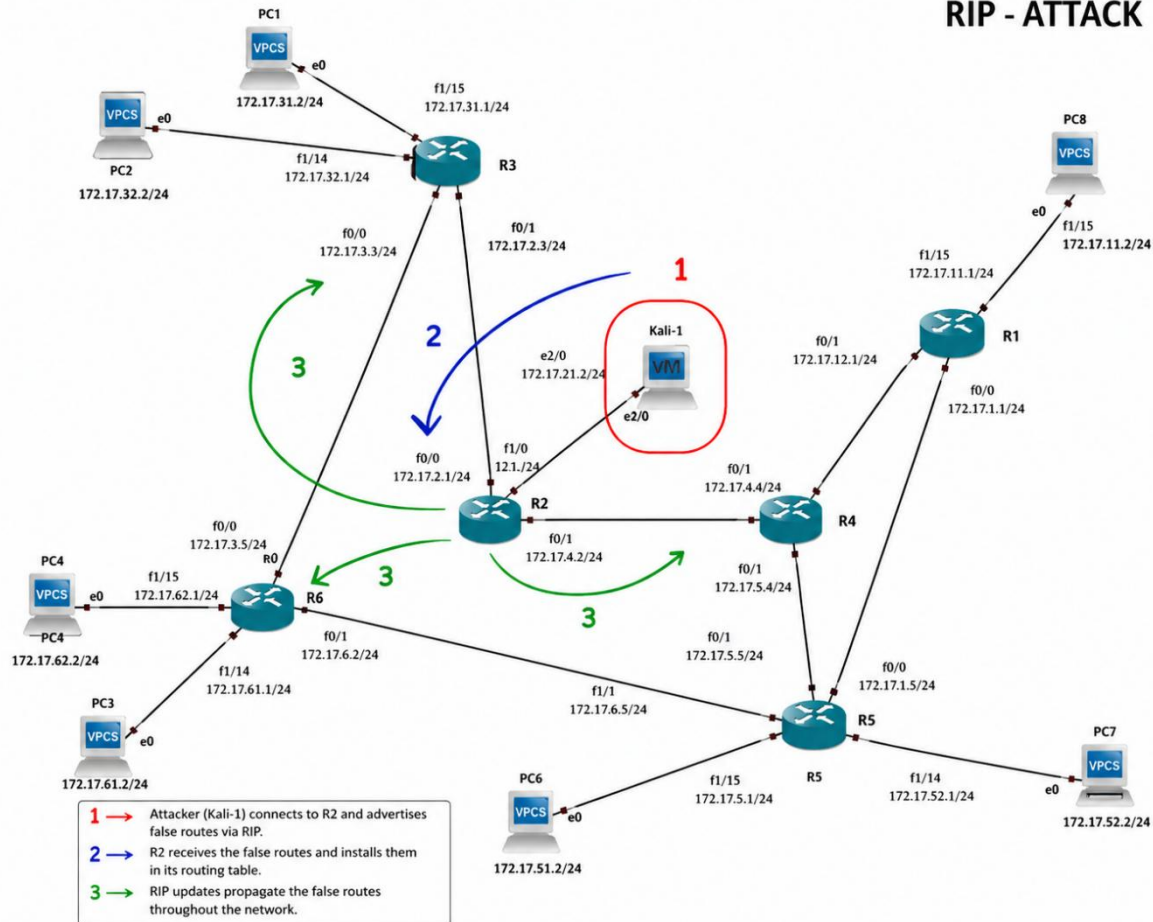


Figure 1: Example of a RIP route poisoning attack. A malicious node (red) injects false RIP updates to divert traffic [15].

In OSPF (Open Shortest Path First), a link-state protocol, routers flood the network with Link State Advertisements (LSAs) to build a topology map. OSPF supports cryptographic MD5 authentication on neighbor adjacencies, which can prevent spoofing [16]. However, vulnerabilities remain. A key problem is *LSA poisoning*: an attacker on the OSPF network can craft fake LSAs that corrupt others' topology databases. Notably, a well-known "disguised LSA" attack was described in the literature [8],[9]. In OSPF, routers consider two LSAs identical if their sequence number, checksum, and age match, ignoring the payload. An attacker exploits this by flooding a falsified LSA (with fake link information) that matches a genuine LSA's sequence, so it appears to be duplicate. Legitimate routers will accept this disguised LSA and not "fight back," unknowingly inserting incorrect link data. Meanwhile, the real LSA from the victim router is ignored as a duplicate. This can effectively poison the network's routes (see Figure 2). Experimental and formal analyses have confirmed this flaw, which can be mounted by any router that can send LSDB updates [8], [9]. Other OSPF attacks include LSDB flooding (sending excessive LSAs to overload routers) and DDoS of control plane via

malformed updates [12]. OSPF's built-in protections (LSDB throttling, SPF backoff timers, and the Down bit) help, but if authentication is off or poorly managed, the network is vulnerable to interior gateway assaults [17], [18].

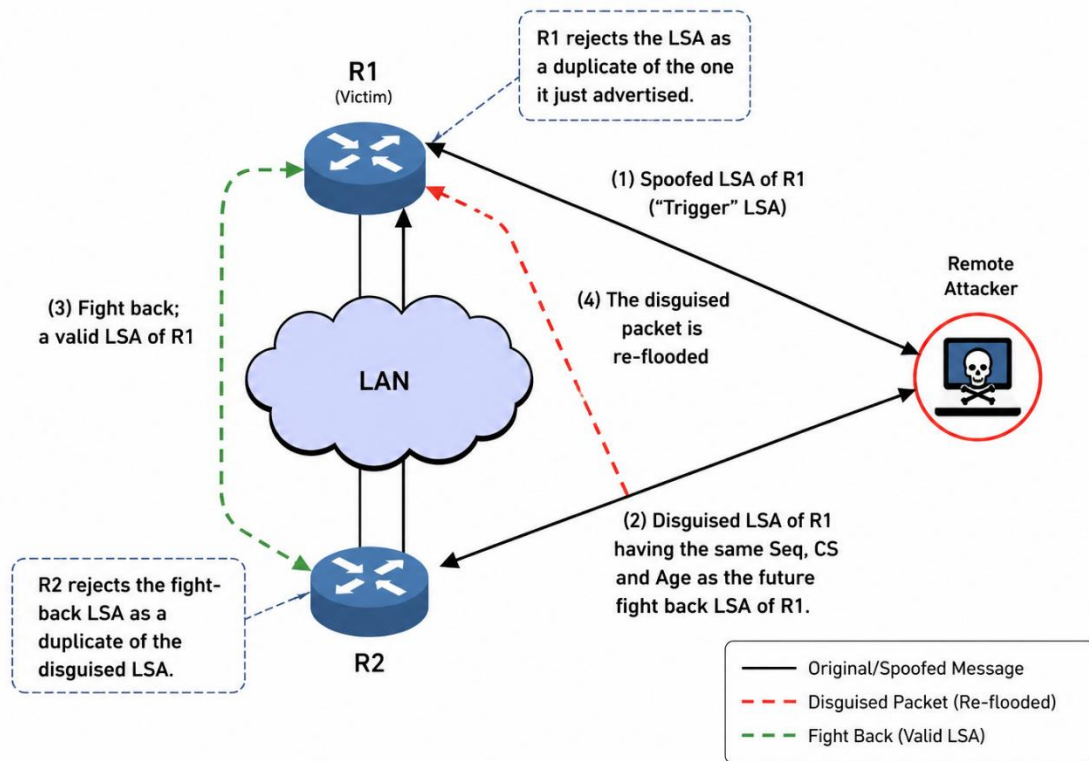


Figure 2: OSPF "disguised LSA" attack. The attacker sends a fake LSA with the same sequence and age as R1's true LSA. R1 treats it as duplicate and does not counteract, but R2 (which hasn't seen R1's LSA yet) installs the fake LSA, poisoning the LSDB [8].

The most publicized vulnerabilities involve BGP (Border Gateway Protocol). BGP's fundamental weakness is its lack of origin authentication and integrity checking [2], [13]. Simply put, any AS can announce any IP prefix, and other ASes have no cryptographic guarantee that it's legitimate. Attackers exploit this to perform prefix hijacking (advertising a victim's IP range to divert traffic) and path hijacking (altering AS_PATH to reroute traffic). Route leaks announcing routes outside intended policy are also common. In early 2024, the research and education community saw multiple incidents: one network accidentally leaked customer routes into the research backbone, and conversely leaked research routes to a commercial ISP, causing global outages [19]. Worse, in July 2024 a malicious outside AS hijacked a U.S. research network's prefix, disrupting critical research traffic [20], [21]. Statistics confirm the scale: Qrator's monitoring recorded over 18,000 route hijacks in just Q1 2022 [3]. BGP hijacks can have severe consequences – they've been used for espionage, cryptocurrency theft, and widespread outages [22]. For instance, the Cloudflare 1.1.1.1

DNS outage on 27 June 2024 was caused by a combination of a hijack and a leak [14]: an unrelated network announced a /32 route for 1.1.1.1 and another network leaked the broader 1.1.1.0/24, fooling many routers into sending queries off path.

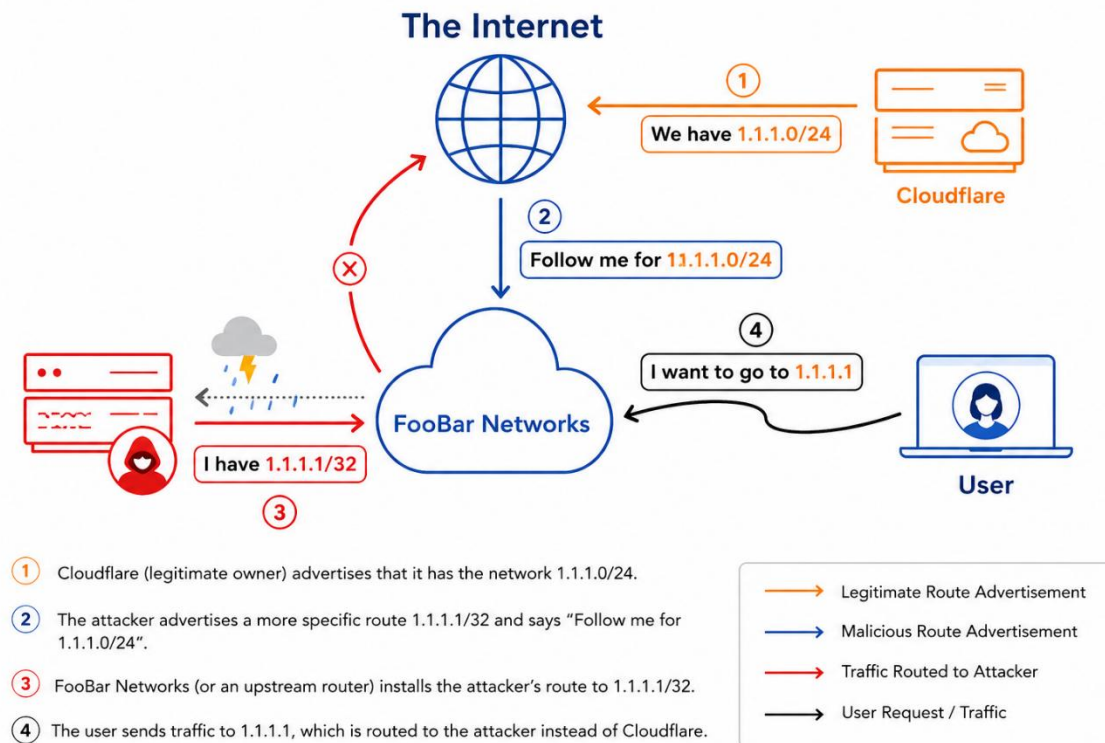


Figure 3: BGP prefix hijacking example. Cloudflare normally advertises 1.1.1.0/24. An attacker announces a more specific 1.1.1.1/32, pulling traffic from Internet paths (longest-prefix match) [14]

BGP does offer some defenses: MD5/TCP-AO for session security, Maximum Prefix Limits, TTL Security (GTSM) to block off-path spoofing, and most importantly the Resource Public Key Infrastructure (RPKI) for origin validation [23], [24]. These controls can block illegitimate announcements if properly deployed. For example, as Internet experts note, Route Origin Authorization (ROA) deployment is a “proven, effective mitigation strategy” against route hijacks [21]. However, global adoption is still limited: as of end-2023 only about 22.7% of ASes perform ROV (route origin validation) on received updates [7]. Similarly, prefix filtering (whitelists/blacklists in BGP routers) is recommended, but operators often misconfigure it or use stale IRR databases. The FedTech report underscores that BGP’s assumed trust model can be “manipulated by attackers in different ways,” and that even accidental misconfigures pose major risks [13].

Table 1: Summarizes key threats and countermeasures for RIP, OSPF, and BGP

Protocol	Common Vulnerabilities	Attack Example	Mitigations
RIP	No built-in auth (RIPv1); RIPv2 auth often unused [1]; easy to spoof updates.	<i>Route poisoning</i> : fake RIP update causes routers to choose malicious next hop [25].	Use MD5 authentication; restrict RIP on trusted links; passive interfaces; ACL/filtering
OSPF	Trusting link-state database; non-encrypted LSAs; aged-seq vulnerability [8] [9].	LSA spoofing: send a “disguised LSA” with identical seqno to poison LSDB [8]; flooding DoS [12]	Use MD5/HMAC auth; configure area boundary filters; enable LSA throttling, SPF backoff; monitor for abnormal LSDB updates
BGP	No origin validation; AS-PATH spoofing; policy breaches; inter-AS trust model [2].	<i>Prefix hijack</i> : announce victim prefix (e.g. 1.1.1.1/32) to steal traffic [14]; <i>Route leak</i> : announce internal routes to Internet [26]	RPKI/ROA and Route Origin Validation [21]; strict prefix/AS-PATH filters; Max-prefix limits; GTSM (TTL filter); BGPsec where available

Research Gap

Existing literature has documented many specific attacks (e.g. BGP prefix hijacking, OSPF LSA attacks) and partial solutions, but few recent studies comprehensively compare all three protocols. For instance, academic surveys often focus on BGP security or general routing threats [2], but RIP is seldom analyzed in recent research due to its outdated status. By bringing together both older and cutting-edge findings (e.g. Cisco’s 2023 OSPF exploit [8] and 2024 BGP incident reports [3]), this review lays the groundwork for our empirical study.

Theoretical and Technical Frameworks

We build on threat modelling concepts and protocol analysis frameworks. For RIP (a distance-vector protocol), the lack of path information invites the theoretical framework of factual correctness vs. consistency checking [21]. S-RIP’s idea of cross-validation hints at using graph-theoretic consistency checks. For OSPF (link-state), the technical framework involves LSDB integrity and graph algorithms (Dijkstra) – thus attacks can be

seen as injecting false graph edges (routes) or tampering with LSA metadata. For BGP (path-vector), we employ the concept of origin and AS-path validation: ROA (Route Origin Authorization) from RPKI is a cryptographic trust framework, whereas legacy BGP trusts AS Path and communities as informal policy frameworks. We will also use known security taxonomy (e.g. the “Kailash” attack taxonomy in BGP) to classify threats. These frameworks allow us to compare for instance, how distance-vector protocols (RIP) without path info compared to path-vector (BGP) in terms of vulnerability to masquerading (prefix impersonation) [7].

Relation to the Study

The reviewed literature underscores the need for our comparative analysis. It provides specific examples and definitions of vulnerability modes that we will test or simulate. For example, the Cisco OSPF LSA injection advisory[9] informs our OSPF threat model, and studies on RPKI-invalid prefixes [19] inform our assessment of BGP origin validation. We will relate these findings by examining each protocol’s vulnerability surface: RIP’s limited authentication, OSPF’s reliance on adjacency trust, and BGP’s lack of built-in verification. The literature also highlights evaluation metrics, such as success rate of injection attacks and network disruption extent, which we will adopt in the methodology.

Literature Summary

In summary, routing protocols face well-known vulnerabilities: RIP’s simplicity makes it susceptible to route poisoning and impersonation [7], OSPF can be corrupted by false LSAs in the absence of strong authentication [14], and BGP continues to suffer prefix hijacks and leaks due to its trust model [2]. Recent research confirms that enabling authentication and filtering mitigates these issues, but adoption is uneven. The gap lies in integrating these insights into a cohesive security evaluation. Our study will build on the literature to develop a structured analysis of vulnerabilities, identify cases where existing defenses fall short, and recommend improvements consistent with modern network practices.

Research Design and Methodology

The research will use a mixed analytical and experimental approach. First, complete a detailed threat analysis of RIP, OSPF, and BGP by reviewing standards, RFCs, and recent vulnerability reports. This includes classifying threat actors and their capabilities, as well as mapping out attack vectors (drawing on sources like RFC 4593/4272 and the 2024 Roadmap [2]). Next, we will implement test scenarios in a controlled lab environment to validate the vulnerabilities and measure their effects.

Specifically, we plan to use a network emulator (e.g. GNS3 or virtual machines) with virtual or physical routers running popular implementations (Cisco IOS, FRRouting, etc.). For RIP, we will set up a multi-hop IPv4 network, enable RIPv2, and attempt to inject forged RIP Response packets using a custom Python script or Scapy [15]. Then test the impact on routing tables and end-to-end connectivity, both with and without authentication enabled. For OSPF, we will configure an OSPFv2 area and simulate the disguised LSA attack. This involves capturing a valid LSA, crafting a malicious LSA with the same age/seq no. but modified link data, and flooding it to neighbors [8]. We will observe whether routers incorporate the fake LSA and trigger convergence loops. Will also test LSDB flooding by generating many rapid LSA updates and observing CPU utilization or SPF calculation errors. For BGP, will create a small Internet topology with multiple ASes. Using router CLI or scripts, we will simulate a prefix hijack (advertising an unowned prefix) and a route leak scenario. Will examine how far the hijacked prefix propagates and how long it persists. Crucially, the BGP tests with RPKI and filtering will enable us to assess how effectively these defenses block the attack.

Materials and Tools

Now use Linux servers or network appliances running Cisco IOS/JunOS or open-source routing suites (FRRouting, Quagga). Packet crafting and analysis will utilize Scapy and Wireshark. For BGP/RPKI tests, we may employ an RPKI validator (like Routinator) and public ROA data to simulate origin validation. Will also analyze live BGP data (via tools like RIPE RIS or BGPStream) to cross-check our findings against real-world announcements.

Data Collection

Throughout experiments, we will log routing tables, update messages, and traffic flows. Key metrics include convergence time, reachability (packet loss), and router CPU/memory load. For each attack scenario, we will record whether it succeeds and quantifies its impact. Results will be compared against a “baseline” of normal routing, and with different mitigations applied. Additionally, we will document any practical difficulties or implementation quirks (e.g. different router vendors handling authentication differently).

By combining qualitative analysis (from protocol specs and previous studies [2]) with quantitative experiments, the study will rigorously evaluate how each vulnerability operates and how defenses perform under realistic conditions.

Expected Outcome

Anticipated Results

We anticipate a detailed classification of vulnerabilities for each protocol. For RIP, experiments will likely show that without authentication, routers quickly accept false updates (e.g. a fake node advertising a nonexistent prefix with zero distance will poison routes) [24]. OSPF tests should demonstrate that forged LSAs can propagate and disrupt routing unless MD5/SHA authentication is enabled, verifying Cisco's advisory findings [9]. For BGP, we expect to reproduce basic hijack scenarios (advertising a partner's prefix) and see the degree of propagation in a test environment. With RPKI validation turned on, we anticipate blocking of known-invalid routes, but also potential false alarms due to operational misconfigurations (as found by Monet et al. [10]).

Overall, the result will be a comparative security profile: for example, we may find that OSPF with MD5 can resist the studied attacks (intra-domain), whereas BGP still accepts many hijacks absent RPKI.

Implications

The findings will have practical implications. By quantifying how each protocol fails under attack, network operators can better prioritize defenses. For instance, if our OSPF simulations show that MD5 authentication effectively neutralizes LSA spoofing with minimal overhead [8], then organizations will be strongly advised to enable it. The comparative framework will clarify where industry efforts are needed: if BGP remains the weakest link (likely) because of slow RPKI rollout, this suggests focusing on policy changes or additional tools (like prefix filtering, MANRS guidelines) to mitigate risk [6].

Limitations

Several limitations are expected. First, scope of simulation: testing in lab environments may not capture the full complexity of the Internet, such as global BGP topology or router resource constraints. Results from small-scale experiments may not directly scale, though they will indicate feasibility of attacks [5]. Second, data availability: for BGP, we rely on public route collector data and cannot simulate nation-scale incidents. Third, rapid evolution: routing protocols and implementations are updated; vulnerabilities may be patched faster than we can fully analyze in the research timeframe. Fourth, external validity: our findings assume worst-case attackers which may not always be realistic. We will note these constraints and focus on lessons that generalize, such as the necessity of cryptographic authentication and vigilant monitoring [6].

Timeline

The project is planned for three months. Key milestones are:

- **Weeks 1–2:** Conduct detailed literature review and threat modeling. Compile known vulnerabilities and defenses from sources (RFCs, academic papers, industry reports [2]). Finalize experimental design.
- **Weeks 3–4:** Build and configure the lab environment. Deploy virtual routers (for RIP, OSPF, BGP scenarios). Verify normal protocol operation.
- **Weeks 5–7:** Execute attack experiments. In Week 5 focus on RIP: attempt route injection attacks, test RIPv2 authentication. Week 6 on OSPF: perform LSA spoofing, flooding, and test MD5. Week 7 on BGP: simulate prefix hijacks and leaks, evaluate impacts.
- **Weeks 8–9:** Gather and analyze data. Compare attacked vs baseline scenarios. Measure mitigation effectiveness (e.g. test RPKI/filters in BGP). Document any unexpected behaviors.
- **Weeks 10–11:** Draft the report, including introduction, literature review, experimental findings, tables and figures. (Intermediate drafts will be peer-reviewed for clarity.)
- **Week 12:** Final revisions and submission. Polish writing, ensure all figures (e.g. embedded diagrams) and tables are clear. Prepare complete reference list.

Milestones include Literature Review Complete (end Week 2), Lab Setup Done (end Week 4), Experiments Completed (end Week 7), Data Analysis and Draft Written (end Week 11), and Project Report Submitted (end Week 12). This schedule allows buffer time for unexpected delays (e.g. debugging the simulated network) and for incorporating feedback [15].

Conclusion

This research will produce a thorough, up-to-date security analysis of RIP, OSPF, and BGP, addressing a crucial need in network security scholarship. By comparing vulnerabilities across protocols, it will clarify which weaknesses are due to design versus deployment practices. The mixed-methods approach ensures both theoretical and practical insights: we will connect the dots from academic studies and real-world incidents to concrete experiments that demonstrate each protocol's failure modes. The anticipated deliverables include a taxonomy of routing attacks, a framework for evaluating routing protocol security, and actionable recommendations (such as enabling strong authentication and adopting RPKI routing validation). Ultimately, this

study aims to advance the state of the art by synthesizing knowledge on routing protocol security and guiding the secure operation of network infrastructure in a rapidly evolving threat landscape.

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