

# Comparative Study of Routing Protocols: Why OSPF Excels Over EIGRP and BGP

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**Abstract** - Routing protocols are essential for ensuring efficient and reliable data transmission in IP networks. Border Gateway Protocol (BGP), Open Shortest Path First (OSPF), and Enhanced Interior Gateway Routing Protocol (EIGRP) differ significantly in their design objectives and operational scope. This paper presents a theoretical comparison of these protocols with a focus on routing efficiency, convergence behavior, scalability, and administrative complexity. While BGP provides extensive policy-based control for inter-domain routing and EIGRP offers fast convergence within Cisco-centric environments, OSPF demonstrates superior overall performance for large enterprise and service provider intra-domain networks. OSPF's link-state architecture, hierarchical area design, standardized implementation, and deterministic shortest-path computation enable faster convergence, better scalability, and enhanced network stability compared to EIGRP and BGP. Furthermore, OSPF's vendor-neutral nature and strong support for load balancing and network segmentation make it more adaptable to heterogeneous network environments. The study concludes that OSPF is a more efficient, reliable, and practical routing protocol for most structured and multi-vendor network deployments.

**Keywords**—OSPF, BGP, EIGRP, Convergence, Scalability, Routing

## I. INTRODUCTION

Open Efficient routing is a cornerstone of modern IP networks, enabling timely and reliable delivery of data across diverse topologies. Routing protocols determine the paths that data packets follow and play a critical role in network performance, stability, and scalability. Among the widely used protocols, Border Gateway Protocol (BGP), Open Shortest Path First (OSPF), and

Enhanced Interior Gateway Routing Protocol (EIGRP) each serve distinct purposes. BGP is an exterior gateway protocol designed for inter-domain routing, offering policy-based control and the ability to manage routing decisions between autonomous systems (AS). EIGRP, a hybrid interior gateway protocol primarily deployed in Cisco networks, provides rapid convergence and simplified configuration within a single administrative domain.

In contrast, OSPF, a link-state interior gateway protocol, offers a robust, scalable, and standardized approach to intra-domain routing. Its hierarchical area-based design, deterministic shortest-path algorithm, and support for load balancing and network segmentation make it highly efficient for large enterprise and service provider networks. Unlike EIGRP, which is vendor-specific, or BGP, which is optimized for inter-domain policy control, OSPF combines reliability, fast convergence, and flexibility, making it suitable for heterogeneous environments.

This paper presents a theoretical comparison of these three protocols, examining their routing algorithms, convergence behavior, scalability, and administrative control. The focus is to demonstrate OSPF's advantages in achieving optimal network performance, stability, and adaptability over both EIGRP and BGP in intra-domain deployments.

## II. LITERATURE SURVEY

Routing protocols have been extensively studied to understand their efficiency, convergence, scalability, and applicability in different network environments. Early studies on routing optimization explored link-state and path-vector mechanisms, laying the foundation for modern routing protocols. Sukhov and Chemodanov [2] proposed a universal metric for dynamic routing, which highlighted the importance of deterministic path selection in ensuring stable network performance. Similarly, Xu et al. [4] analyzed OSPF's traffic engineering capabilities, demonstrating that careful weight assignment can optimize routing paths and reduce network congestion.

Barreto et al. [1] focused on OSPF's robustness under transient link failures, presenting emergency path schemas that enhance intra-domain reliability. Surveys comparing interior and exterior gateway protocols have been conducted to guide protocol selection. A study published in the *International Journal of Computer Science & Information Technology* [3] examined RIP, OSPF, and EIGRP, emphasizing OSPF's faster convergence and scalability advantages over RIP and EIGRP. Ali et al. [5] extended this comparison to IGP and EGP protocols, noting that BGP's policy-driven routing, while flexible, introduces higher configuration complexity and slower convergence compared to OSPF.

Hanif [6] analyzed CPU utilization for various routing protocols in simulation, showing that OSPF's link-state mechanism, despite higher memory usage, results in more predictable network performance than EIGRP or RIP. Nasir and Tariq [7] provided a comparative study highlighting OSPF's hierarchical area design and deterministic shortest-path calculation, which enables faster convergence and efficient intra-domain routing. The MSc thesis from Kwame Nkrumah University [8] further confirmed that OSPF outperforms EIGRP in convergence times in multi-router environments.

Recent studies have focused on IPv6 networks and multi-domain scenarios. Manzoor [14] evaluated route redistribution between OSPF, EIGRP, and BGP, emphasizing that OSPF maintains better stability and predictable path selection during redistribution. Munir et al. [10] analyzed OSPF and EIGRP convergence over IPsec tunnels, highlighting OSPF's superior adaptability in secure multi-homing environments. Karamela and Karras [11] provided a comparative analysis showing that OSPF consistently achieves lower convergence latency and higher reliability than EIGRP.

Yousif and Elnageeb [12] extended the performance evaluation to RIP, EIGRP, and OSPF, reinforcing the observation that OSPF's link-state algorithm offers faster adaptation to topology changes. Shahid et al. [13] studied EIGRP, OSPF, and BGP under IPv6 load-sharing scenarios, indicating that OSPF efficiently balances traffic while maintaining low convergence delays. Rangwala et al. [9] and the *EAI Endorsed Transactions* study [15] concluded that OSPF is preferable for intra-domain, multi-vendor networks due to its standardized implementation, deterministic routing, and support for hierarchical network design.

Collectively, these studies establish that while BGP provides strong inter-domain policy control and EIGRP offers vendor-specific advantages, **OSPF emerges as the most efficient and reliable protocol for large-scale, heterogeneous intra-domain networks** [1]–[15]. Its deterministic shortest-path computation, hierarchical area architecture, and load-balancing capabilities make it highly suitable for enterprise and service provider environments.

## III. ROUTING PROTOCOL DESIGN AND PERFORMANCE PARAMETERS

The Routing protocols differ in design principles, operational scope, and performance characteristics, which directly affect network efficiency and reliability. OSPF, EIGRP, and BGP

each implement distinct routing mechanisms to achieve optimal data delivery. OSPF is a link-state interior gateway protocol that calculates the shortest path using Dijkstra's algorithm and maintains a complete topology map of the network, enabling deterministic and fast convergence [2], [7]. Its hierarchical area-based design reduces routing table size, limits the scope of link-state advertisements, and improves scalability for large intra-domain networks [3], [7].

EIGRP, a Cisco-proprietary hybrid protocol, combines distance-vector and link-state features, achieving rapid convergence within homogeneous networks, but it lacks standardization across vendors and shows reduced scalability compared to OSPF [5], [14]. BGP, a path-vector exterior gateway protocol, is designed for inter-domain routing, emphasizing policy-based path selection and autonomous system control, which introduces complexity and slower convergence within large-scale networks [5], [13].

Performance parameters such as convergence time, routing overhead, administrative flexibility, and loop prevention are critical for protocol selection. Studies show that OSPF consistently provides faster convergence, predictable routing behavior, and efficient resource utilization compared to EIGRP and BGP [1], [6], [11]. These characteristics make OSPF highly suitable for enterprise and service provider networks where reliability and stability are paramount.

#### IV. PROTOCOL COMPARISON AND SUITABILITY

OSPF, EIGRP, and BGP serve distinct network roles. OSPF excels in intra-domain environments due to fast convergence and hierarchical scalability [3], [7], [11]. EIGRP performs well in Cisco-centric networks but lacks multi-vendor compatibility [5], [14], while BGP is ideal for inter-domain routing with policy-based control [5], [13].

#### V. CONCLUSION

This theoretical study compared OSPF, EIGRP, and BGP in terms of design, performance, and network suitability. OSPF's link-state architecture, hierarchical area design, and deterministic shortest-path computation provide faster convergence, scalability, and stability in intra-domain networks [2], [3], [7], [11]. EIGRP, while offering rapid convergence in Cisco environments, lacks multi-vendor compatibility and standardized implementation [5], [14]. BGP is essential for inter-domain policy control but exhibits slower convergence and higher configuration complexity [5], [13]. Overall, OSPF emerges as the most efficient and reliable protocol for enterprise and service provider networks, combining adaptability, stability, and optimized routing performance [1]–[15].

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