

# A Survey on Hybrid SDN-Based Intelligent Routing Framework for Multi-Protocol Redistribution in Enterprise IPv4 Networks

Ms. P. Vijayalakshmi<sup>1</sup>, Dr. G. Sophia Reena<sup>2</sup>

<sup>1</sup>*Research Scholar, Department of Computer Science, PSGR Krishnammal College for Women, Coimbatore, Tamilnadu, India.*

<sup>2</sup>*Associate Professor and Head, Department of Information Technology, PSGR Krishnammal College for Women, Coimbatore, Tamilnadu, India.*

**Abstract**—Enterprise IPv4 networks typically function as heterogeneous environments where numerous routing protocols coexist due to organizational expansion, legacy equipment, vendor-specific installations, and various administrative requirements. Redistribution between routing domains might therefore result in inefficient pathways, routing loops, inconsistent metrics, longer convergence times, and substantial configuration complexity. The Hybrid SDN-Based Intelligent Routing Framework for Multi-Protocol Redistribution in Enterprise IPv4 Networks is a proposed conceptual framework that synthesizes the evolution of conventional enterprise routing, multi-protocol route redistribution, SDN-based routing, and intelligent routing mechanisms. The architecture introduces an SDN controller as an intelligent coordinating layer while maintaining legacy routers and current routing protocols. Topology discovery, route classification, policy-aware redistribution, network-state monitoring, intelligent path selection, and controlled forwarding policy installation are all included in the suggested design. The Survey identifies several major research challenges like interoperability, routing-loop prevention, controller scalability, telemetry accuracy, explainability of intelligent judgments, security, and safe cohabitation between distributed routing protocols and centralized SDN control. In the end, parameters including convergence time, packet loss, throughput, end-to-end delay, control overhead, route stability, and policy-compliance rate are used to suggest an evaluation technique. The study concludes that hybrid SDN provides a promising migration strategy for enterprise networks in which complete replacement of traditional routing infrastructure is impractical.

**Index Terms**—Software-Defined Networking, SDN, intelligent routing, IPv4, route redistribution, OSPF, EIGRP, RIPv2, BGP, enterprise networks, machine learning, traffic engineering, hybrid networking.

## I. INTRODUCTION

Enterprise networks have traditionally evolved incrementally rather than being designed as homogeneous infrastructures from the beginning. New branches, data centers, cloud connections, mergers, security zones, and technology upgrades frequently introduce additional routing domains. As a result, a single enterprise may contain multiple Interior Gateway Protocols (IGPs), such as Open Shortest Path First (OSPF), Enhanced Interior Gateway Routing Protocol (EIGRP), and Routing Information Protocol Version 2 (RIPv2), together with Border Gateway Protocol (BGP) for external connectivity.

The coexistence of these protocols is technically feasible, but it increases the complexity of routing management. Each protocol has its own method of calculating path preference. OSPF uses a link-state model and shortest-path computation, EIGRP uses the Diffusing Update Algorithm (DUAL), and BGP makes policy-oriented path-selection decisions. EIGRP's architecture and its redistribution behavior are documented in RFC 7868, which explicitly describes scenarios in which OSPF and RIP routes are redistributed into EIGRP. Route redistribution provides interoperability between routing domains, but it does not automatically create a common routing

metric or guarantee optimal global behavior. BGP traffic-engineering guidance, for example, treats route redistribution and best-path selection as distinct policy mechanisms

The emergence of Software-Defined Networking provides a fundamentally different method of managing such heterogeneous environments. SDN separates the control plane from the data plane and enables centralized, programmable network control. RFC 9522 notes that centralized SDN control can improve network-resource utilization because the controller can consider network-wide state rather than relying solely on independent local decisions. [R]RFC Editor SDN is therefore attractive for enterprise environments in which conventional routing protocols must continue operating while a more intelligent coordination mechanism is introduced. A hybrid architecture need not replace OSPF, EIGRP, RIPv2, or BGP, it can maintain those protocols for distributed routing while an SDN controller aggregates network-state information, enforces policies, assesses potential paths and coordinates redistribution.

This survey investigates the research foundations necessary for such an architecture and proposes a conceptual framework for hybrid SDN-based intelligent routing and multi-protocol redistribution in enterprise IPv4 networks.

## II. SURVEY OBJECTIVES

The primary objective of this survey is to provide a comprehensive review of conventional IPv4 routing protocols commonly used in enterprise network environments and to examine the technical challenges associated with multi-protocol route redistribution. The survey further aims to analyze Software-Defined Networking (SDN) architectures and assess their suitability for managing heterogeneous enterprise networks that employ multiple routing protocols. In addition, it reviews intelligent and machine-learning-based routing approaches, with particular emphasis on their potential to improve routing decisions, network adaptability, performance, and resource utilization. Another key objective is to identify the limitations and challenges of existing approaches to route redistribution and SDN-based routing, including scalability, convergence, interoperability, routing loops, and centralized control concerns.

Based on the findings from the existing literature, the survey proposes a conceptual hybrid architecture that integrates traditional IPv4 routing protocols, SDN-based centralized control, and intelligent decision-making mechanisms to support efficient and adaptive multi-protocol route redistribution. Finally, the survey defines an evaluation methodology for future implementation and experimental validation of the proposed framework, considering performance parameters such as routing convergence, throughput, latency, packet loss, scalability, reliability, and control overhead.

## III. ENTERPRISE IPV4 ROUTING ENVIRONMENT

### 3.1 Routing Protocol Heterogeneity

IPv4 enterprise networks may contain several routing domains with different requirements. OSPF is commonly associated with scalable intra-domain link-state routing, EIGRP provides an advanced distance-vector-based approach, RIPv2 is suitable for simpler environments, and BGP is primarily used for policy-based inter-domain routing. CIDR and classless addressing require routing protocols to carry explicit prefix-length information. RFC 4632 identifies OSPF, RIPv2, EIGRP, and BGP4 among protocols supporting classless routing.

The resulting heterogeneous environment can be represented as:

Enterprise network = {RIPv2 domain + OSPF domain + EIGRP domain + BGP edge + static routes + SDN domain}

Each domain can independently make routing decisions. The problem arises when routes need to cross the boundaries between these domains.

### 3.2 OSPF

OSPF is a link-state routing protocol that maintains topology information and computes shortest paths. Its link-state model allows routers to develop a relatively detailed representation of the routing domain. OSPF is particularly attractive for enterprise networks because it supports hierarchical design and classless IPv4 routing. However, when OSPF routes are redistributed into another protocol, information such as the original route type and metric must be translated into the target protocol's routing model.

### 3.3 EIGRP

EIGRP can retain information about the originating routing protocol during redistribution. This makes protocol-origin information valuable when designing automated redistribution mechanisms.

### 3.4 RIPv2

RIPv2 is comparatively simple and uses a hop-count-based metric. Its simplicity makes it unsuitable for many large modern enterprise deployments, but legacy networks may continue to contain RIPv2 segments.

The continued existence of legacy routing infrastructure is important to the proposed hybrid architecture because an SDN migration strategy should not necessarily require immediate replacement of all existing routers.

### 3.5 BGP

BGP differs significantly from traditional IGPs because its routing decisions are strongly policy-oriented. BGP path selection considers attributes such as AS path, local preference, MED, next hop, and other policy information. RFC 3272 describes route redistribution and best-path selection as important components of BGP traffic engineering. RRFC Editor Consequently, an intelligent framework must not treat all routing metrics as directly comparable. A lower OSPF cost, for example, does not automatically mean that a path should be preferred over a BGP path.

## IV. MULTI-PROTOCOL ROUTE REDISTRIBUTION

### 4.1 Concept

Route redistribution is the process through which routes learned by one routing protocol are introduced into another routing domain.

A simplified example is:

OSPF → EIGRP → BGP

Or:

RIPv2 → OSPF → EIGRP

Redistribution enables interoperability but introduces a semantic translation problem because each protocol has a different concept of route quality.

### 4.3 Route-Loop Risk

Consider a network in which an OSPF route is redistributed into EIGRP and subsequently redistributed back into OSPF. Without route tagging and filtering, the receiving OSPF domain may treat the redistributed route as a new external route.

The resulting process can be represented as:

OSPF → EIGRP → OSPF

If the framework does not maintain route provenance, the same prefix can potentially re-enter its originating routing domain.

## V. SOFTWARE-DEFINED NETWORKING

### 5.1 SDN Architecture

The traditional networking architecture integrates routing intelligence and packet forwarding within individual network devices. SDN separates these functions, allowing a logically centralized controller to make network-level decisions.

A conventional model can be represented as:

Host → Router → Router → Destination

where each router independently participates in routing decisions.

The SDN controller maintains a broader view of network topology and state. RFC 9522 identifies separation of the control and data planes, centralized control, and programmability as fundamental SDN concepts. RFC Editor.

## VI. INTELLIGENT ROUTING IN SDN

### 6.1 Motivation

Traditional routing protocols generally optimize according to predefined algorithms and metrics. They do not necessarily account for real-time application demand, congestion, historical traffic patterns, or multiple simultaneous QoS requirements. Machine learning can potentially improve routing by using network-state information to predict or select better paths.

A general intelligent routing loop is:

Network Monitoring → State Collection → Feature Extraction → Decision Model → Path Selection → Flow Installation → Performance Monitoring

## 13. Comparison of Routing Approaches

| Feature                   | Traditional Routing     | Static Redistribution   | SDN Routing  | Proposed Hybrid Framework |
|---------------------------|-------------------------|-------------------------|--------------|---------------------------|
| Distributed operation     | High                    | High                    | Lower        | High                      |
| Global network visibility | Limited                 | Limited                 | High         | High                      |
| Legacy protocol support   | High                    | High                    | Variable     | High                      |
| Automatic redistribution  | Limited                 | Rule-based              | Possible     | Intelligent               |
| Traffic awareness         | Limited                 | Limited                 | High         | High                      |
| ML/RL support             | Low                     | Low                     | High         | High                      |
| Route provenance          | Protocol-dependent      | Manual                  | Programmable | Explicit                  |
| Loop prevention           | Configuration-dependent | Configuration-dependent | Programmable | Policy + provenance       |
| QoS-aware decisions       | Limited                 | Limited                 | High         | High                      |
| Incremental deployment    | High                    | High                    | Medium       | High                      |
| Explainability            | High                    | High                    | Variable     | Configurable              |

## VII. CONCLUSION

The literature indicates that no single routing technology completely addresses the requirements of modern heterogeneous enterprise networks. Traditional protocols remain valuable because they are mature, distributed, widely deployed, and resilient. Their principal limitation is that they operate primarily within their own routing domains and do not naturally provide a global optimization view. SDN addresses the visibility and programmability problem by introducing logically centralized control. Specifically identifies centralized SDN control as a mechanism for improving resource utilization and enabling network-wide traffic engineering. Intelligent routing addresses another limitation: static routing policies may not react optimally to changing traffic conditions. Deep reinforcement-learning research demonstrates that routing decisions can be adapted to network state and traffic variability. The proposed framework is therefore intended not as a replacement for traditional routing but as an intermediate architecture capable of introducing SDN and intelligence into existing enterprise networks.

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