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IR.1101 RÉSEAUX/NETWORKS

REPORT

[PROJECT 1]

Dynamic Routing Protocols

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# Introduction

Dynamic routing protocols serve as pivotal mechanisms for routers to exchange routing information fluidly and responsively. They allow networks to automatically adjust to changes, ensuring continuous and efficient routing. These protocols simplify network management and reduce administrative load, enabling complex routing configurations. Their use greatly enhances network scalability and improves overall design and functionality compared to static routing.

Since Eric C. Rosen introduced the Exterior Gateway Protocol (EGP) in 1982, dynamic routing has evolved significantly, leading to the development of various advanced protocols. These have enhanced network efficiency and robustness.[1]

Routing protocols monitor network changes and disseminate this information across routers, making the choice of the correct protocol crucial. They are mainly categorized into two types: distance vector and link state[2].

This project focuses on the exploration of dynamic routing protocols, specifically analyzing and experimenting with Distance-vector (RIP) and link-state (OSPF) protocols.

## Distance-Vector Routing

Distance vector routing protocols disseminate updates among neighbouring routers, defined as routers connected by a shared link and configured with the same routing protocol. These routers are only cognizant of their own interface network addresses and those of remote networks accessible via their neighbours. However, they do not have knowledge of the overall network topology.

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Figure 1 Distance Vector Routing Protocols[3]

The characteristics of Distance Vectors routing protocol are given below:

* Distance Vector routing protocol defines its routing table where all neighbours are directly connected with the table at a steady period.
* New information should put in each routing table instantly when the routes become unreachable.
* Distance Vector routing protocols are easy and effective in smaller networks and thus require little management.
* Distance Vector routing is mainly based on hop counts vector.
* The Distance Vector algorithm is iterative.

### Routing Information Protocol (RIP)

The Routing Information Protocol (RIP) is a distance-vector routing protocol that fundamentally operates on the principles of distance and direction, utilizing hop count as its primary metric. It was designed for smaller IP networks.[4]

RIP, utilizing the Bellman-Ford algorithm, gauges route reliability through an Administrative Distance, with lower values indicating higher reliability. The primary metric for RIP is hop count, with a maximum of 15 hops, the 16-hop count is considered unreachable.

Routing Information Protocol is class-full routing protocol.

* RIPv1 uses classful routing, all subnets in a network class must have the same size. There is also no support for router authentication, making RIP vulnerable to various attacks.

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Figure 2 RIP-Ver1 Packet Format[5]

* RIPv2 included the ability to carry subnet information, thus supporting Classless Inter-Domain Routing (CIDR). The hop count limit of 15 remained. Route tags were added in to allows a distinction between routes learned from the RIP protocol and routes learned from other protocols.

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Figure 3 RIP-Ver2 Packet Format[6]

* RIP next generation (RIPng) is the extension of RIPv2 for IPv6 support.

表格

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Figure 4 RIPng Packet Format[6]

## Link-State Routing

Link-state routing emerged as a solution to the limitations of distance vector routing, offering functionalities such as rapid response to network changes using triggered updates, swift adaptation to network alterations, and self-healing for non-functional routes. It conserves bandwidth by dispatching updates solely on change occurrence and communicates link status changes through Link State Advertisements (LSAs).

图示

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Figure 5 Link State Routing[7]

Link state protocol has the following characteristics[7]:

* Each router possesses the identical database.
* Provides hierarchical structure.
* Include and maintain several paths in the topology table for the destination.
* Efficient and fast convergence without any loop.
* Have much more precise metrics.

Link-state routing protocols are tailored for expansive, enterprise-scale networks. Their complexity requires more intricate configuration, maintenance, and troubleshooting efforts compared to distance vector routing protocols. Despite these challenges, link-state protocols address and resolve numerous limitations inherent to distance vector protocols.

### 1.2.1 Open Shortest Path First (OSPF)

The Open Shortest Path First (OSPF) protocol functions as a link-state routing mechanism. Within the context of OSPF, the term ‘link’ corresponds to a router’s interface, and its ‘state’ represents various characteristics of that interface, including its IP address, subnet mask, and the type of network to which it is connected, this state also details the interface's connectivity with neighbouring routers. [4]

OSPF employs the Dijkstra algorithm to determine the most cost-effective paths to all known destinations[8]:

* **Link State Advertisement Generation**: Upon detecting routing changes, routers generate Link State Advertisements (LSAs) detailing their link states.
* **LSA Exchange and Flooding**: Routers exchange these LSAs with all others through a flooding process, ensuring each maintains an updated link state database.
* **Shortest Path Tree Calculation**: Routers construct a shortest path tree to all destinations using the Dijkstra algorithm, effectively pinpointing the least cost paths.
* **Recalculation on Changes**: Whenever changes occur in the OSPF network, the Dijkstra algorithm recalculates to find new least cost paths.
* **Algorithm Utilization**: Each router applies the Dijkstra algorithm as the root of the tree, continually updating the shortest and least costly paths to various destinations.

Collectively, all the individual link states together make up the link-state database. OSPF uses this database to find the best routes across the network.

## Comparison

|  |  |  |
| --- | --- | --- |
|  | Distance-Vector | Link-State |
| Metric | Utilizes hop count | Uses the shortest path algorithm |
| Perspective | View the network from neighbour’s view | Maintains a comprehensive network view |
| Updates | Sends updates periodically | Has event triggered updates. |
| Convergence | Slow convergence | Faster convergence |
| Loops | Susceptible to routing loops | Better at preventing routing loops |
| Configuration | Easier to configure and manage | More complex in configuration |
| Resources | Requires less memory and CPU | Needs more memory and CPU |
| Bandwidth | Consumes a lot of Bandwidth | More efficient in bandwidth usage |
| Sharing | Exchanges full routing tables with neighbours | Exchanges link-state updates among routers |
| Distance vector  vs.  Link state |  |  |
| RIP  vs.  OSPF | 图示  描述已自动生成 | 图示  描述已自动生成 |

Table 1 Distance vector vs. Link state Routing Algorithm[10][11]

# Implementation

To gain a comprehensive understanding of dynamic routing protocols, particularly the distinctions between RIP and OSPF, Use Cisco to build the following simulation scenario:

## Small-Scale Network (Suitable for RIP)

* Set up a small network comprising several routers and multiple subnets.
* Configure RIP on the routers and verify the propagation and updating of information.

**此处插入搭建的模拟场景图**

#### Results and analysis

**此处插入分析**

### Large Enterprise Network (Suitable for OSPF)

* Build a simulated network of a large enterprise, including multiple areas and an extensive distribution of routers.
* Configure OSPF among the routers, implement area segmentation, and observe and verify routing choices within and between areas.

**此处插入搭建的模拟场景图**

#### Results and analysis

**此处插入分析**

### Hybrid Network (Coexistence of RIP and OSPF)

* Design a network that utilizes both RIP and OSPF, considering the transition and coexistence strategies between the protocols.
* Observe and validate the routing information exchange and path selection between different protocol areas.

**此处插入搭建的模拟场景图**

#### Results and analysis

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# Conclusion

This report has conducted an in-depth analysis of dynamic routing protocols, with a focus on the distinct characteristics and operational differences between Distance-vector (RIP) and Link-state (OSPF) protocols. As networking infrastructures advance, dynamic routing protocols continue to play a crucial role in sustaining communication channels that are efficient, reliable, and capable of scaling.

RIP, with its Distance-vector approach, stands out for its straightforwardness and ease of configuration, which suits smaller, less complex networks. Its reliance on hop count as a routing metric and periodic updates simplifies routing decisions. However, this simplicity comes at the cost of limited scalability, vulnerability to routing loops, and slower convergence times.

In contrast, OSPF is a Link-state protocol tailored for extensive, intricate network landscapes. It leverages Link State Advertisements (LSAs) to form a detailed representation of the network and employs the Dijkstra algorithm for optimal path calculation, leading to quicker convergence. While OSPF provides a more robust solution, adept at handling the dynamic nature of modern networks, it demands greater computational power and involves more complex configuration processes.

Ultimately, the choice between RIP and OSPF should be informed by the network's size, complexity, and specific demands for administrative ease, efficiency, and scalability. Each protocol serves its purpose within its intended scope, and the decision should align with the network's operational objectives and resource availability.

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