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Review Paper on OSPF protocol for directed & undirected graph problems

Kirti[1], Lokesh Kumar[2]

[1]Dept. of Computer Science, Rohtak Institute of Engineering and Management, Rohtak, Haryana, India
[2]Assistant Professor & HOD, Dept. of Computer Science & Engineering, Rohtak Institute of Engineering & Management, Rohtak, Haryana, India

ABSTRACT

This chapter examines the Open Shortest Path First (OSPF) Protocol, one of the most commonly used interior gateway protocols in IP networking. OSPFv2 is an open-standard protocol that provides routing for IPv4. OSPFv3 offers some enhancements for IP Version 6 (IPv6). OSPF is a complex protocol that is made up of several protocol handshakes, database advertisements, and packet types. OSPF is an interior gateway routing protocol that uses link-states rather than distance vectors for path selection. OSPF propagates link-state advertisements (LSAs) rather than routing table updates. Because only LSAs are exchanged instead of the entire routing tables, OSPF networks converge in a timely manner. OSPF uses a link-state algorithm to build and calculate the shortest path to all known destinations. Each router in an OSPF area contains an identical link-state database, which is a list of each of the router-usable interfaces and reachable neighbors. Open Shortest Path First (OSPF) is one of the most widely used intra-domain routing protocol. It is well known that OSPF protocol does not provide flexibility in terms of packet forwarding to achieve any network optimization objective. Because of the high cost of network assets and commercial and competitive nature of Internet service provisioning, service providers are interested in performance optimization of their networks. This helps in reducing congestion hotspots and improving resource utilization across the network, which, in turn, results in an increased revenue collection. One way of achieving this is through Traffic Engineering. Currently traffic engineering is mostly done by using MPLS. But legacy networks running OSPF would need to be upgraded to MPLS. To achieve better resource utilization without upgrading OSPF network to MPLS is a challenge. In this paper we present a simple but effective algorithm, called Smart OSPF (S-OSPF) to provide traffic engineering solution in an OSPF based best effort network. We formulate an optimization problem based on the traffic demand to minimize the maximum link utilization in the network. Routing of the traffic demand is achieved using OSPF. We have simulated S-OSPF on real networks of two service providers. Simulation results show that S- OSPF based traffic engineering solution performance very closely follows the optimal solution.

1 INTRODUCTION

OSPF is an interior gateway protocol (IGP) for routing Internet Protocol (IP) packets solely within a single routing domain, such as an autonomous system. It gathers link state information from available routers and constructs a topology map of the network. The topology is presented as a routing table to the Internet Layer which routes datagrams based solely on the destination IP address found in IP packets. OSPF supports Internet Protocol Version 4 (IPv4) and Internet Protocol Version 6 (IPv6) networks and features variable-length subnet masking (VLSM) and Classless Inter-Domain Routing (CIDR) addressing models. OSPF detects changes in the topology, such as link failures, and converges on a new loop-free routing structure within seconds. It computes the shortest path tree for each route using a method based on Dijkstra's algorithm, a shortest path first algorithm.

OSPF has two primary characteristics. The first is that the protocol is open, which means that its specification is in the public domain. The second principal characteristic is that OSPF is based on the SPF algorithm, which sometimes is referred to as the Dijkstra algorithm, named for the person credited with its creation. OSPF is a link-state routing protocol that calls for the sending of link-state advertisements (LSAs) to all other routers within the same hierarchical area. Information on attached interfaces, metrics used, and other variables is included in OSPF LSAs. As OSPF routers accumulate link-state information, they use the SPF algorithm to calculate the shortest path to each node.

As a link-state routing protocol, OSPF contrasts with RIP and IGRP, which are distance-vector routing protocols. Routers running the distance-vector algorithm send all or a portion of their routing tables in routing-update messages to their neighbors. The routing policies for constructing a route table are governed by link cost factors (external metrics) associated with each routing interface. Cost factors may be the distance of a router (round-trip time), data throughput of a link, or link availability and reliability, expressed as simple unit less numbers. This provides a dynamic process of traffic load balancing between routes of equal cost. An OSPF network may be structured, or subdivided, into routing areas to simplify administration and optimize traffic and resource utilization. Areas are identified by 32-bit numbers, expressed either simply in decimal, or often in octet-based dot-decimal notation, familiar from IPv4 address notation.

2 OSPF FEATURES

OSPF offers all the functionality of oldest routing protocol Routing Information Protocol (RIP), plus:

• Variable-length subnet mask (VLSM) support
• Routing updates without the 30-second "hold down" period required by RIP
• Up to 255 routed segments between routers
• Packet authentication of routing updates with both simple password and MD5 authentication
• Bandwidth optimization, including less frequent routing updates and a choice of metrics for defining the best links between routers.

3 OSPF OPERATION OVERVIEW

To create and maintain routing information, OSPF routers complete the following generic link-state routing process, shown in Figure 3-1, to reach a state of convergence:

1. **Establish neighbor adjacencies:** OSPF-enabled routers must form adjacencies with their neighbor before they can share information with that neighbor. An OSPF-enabled router sends Hello packets out all OSPF-enabled interfaces to determine whether neighbors are present on those links. If a neighbor is present, the OSPF-enabled router attempts to establish a neighbor adjacency with that neighbor.

2. **Exchange link-state advertisements:** After adjacencies are established, routers then exchange link-state advertisements (LSAs). LSAs contain the state and cost of each directly connected link. Routers flood their LSAs to adjacent neighbors. Adjacent neighbors receiving the LSA immediately flood the LSA to other directly connected neighbors, until all routers in the area have all LSAs.

3. **Build the topology table:** After the LSAs are received, OSPF-enabled routers build the topology table (LSDB) based on the received LSAs. This database eventually holds all the information about the topology of the network. It is important that all routers in the area have the same information in their LSDBs.

4. **Execute the SPF algorithm:** Routers then execute the SPF algorithm. The SPF algorithm creates the SPF tree.

5. **Build the routing table:** From the SPF tree, the best paths are inserted into the routing table. Routing decisions are made based on the entries in the routing table.

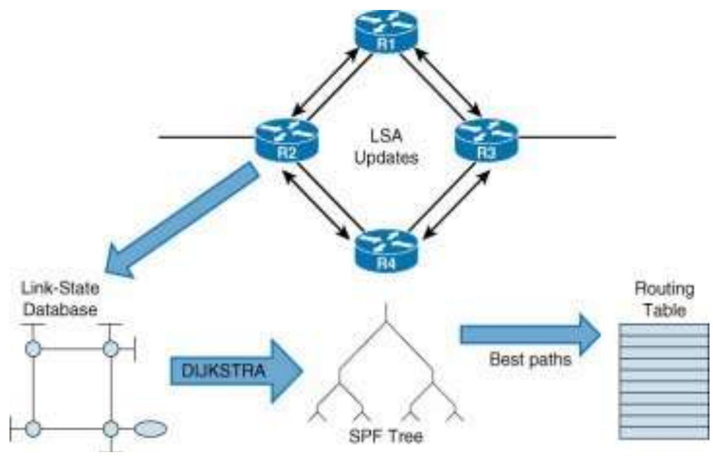


Figure 3-1 OSPF Operation

3.1 HIERARCHICAL STRUCTURE OF OSPF

If you run OSPF in a simple network, the number of routers and links are relatively small, and best paths to all destinations are easily deduced. However, the information necessary to describe larger networks with many routers and links can become quite complex. SPF calculations that compare all possible paths for routes can easily turn into a complex and time-consuming calculation for the router.

One of the main methods to reduce this complexity and the size of the link-state information database is to partition the OSPF routing domain into smaller units called areas, shown in Figure 3-2. This also reduces the time it takes for the SPF algorithm to execute. All OSPF routers within an area must have identical entries within their respective LSDBs. Inside an area, routers exchange detailed link-state information. However, information transmitted from one area into another contains only summary details of the LSDB entries and not topology details about the originating area. These summary LSAs from another area are injected directly into the routing table and without making the router rerun its SPF algorithm.

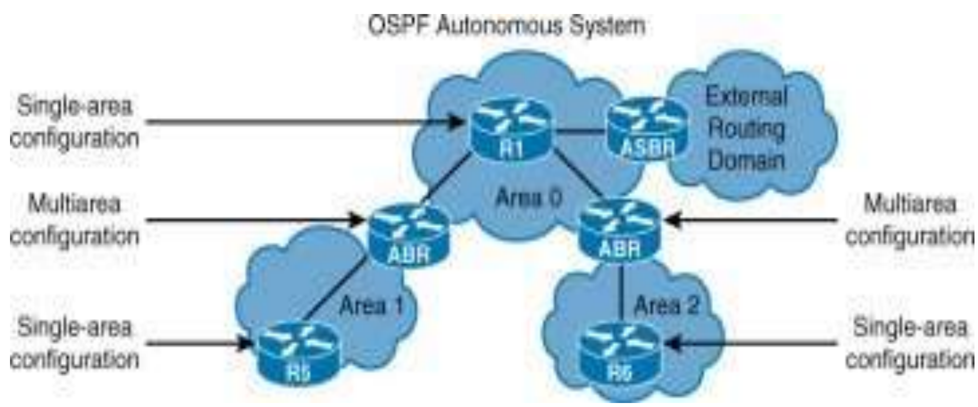


Figure 3-2: OSPF Hierarchy

OSPF USES A TWO-LAYER AREA HIERARCHY:

- **Backbone area, transit area or area 0:** Two principal requirements for the backbone area are that it must connect to all other nonback bone areas and this area must be always contiguous; it is not allowed to have split up the backbone area. Generally, end users are not found within a backbone area.
- **Nonbackbone area:** The primary function of this area is to connect end users and resources. Nonbackbone areas are usually set up according to functional or geographic groupings. Traffic between different nonbackbone areas must always pass through the backbone area.

IN THE MULTI-AREA TOPOLOGY THERE ARE SOME SPECIAL COMMONLY USED OSPF TERMS:

- **ABR:** A router that has interfaces connected to at least two different OSPF areas, including the backbone area. ABRs contain LSDB information for each area, make route calculation for each area and advertise routing information between areas.
- **ASBR:** ASBR is a router that has at least one of its interfaces connected to an OSPF area and at least one of its interfaces connected to an external non-OSPF domain.
- **Internal router:** A router that has all its interfaces connected to only one OSPF area. This router is completely internal to this area.
- **Backbone router:** A router that has at least one interface connected to the backbone area.

The optimal number of routers per area varies based on factors such as network stability, but in general it is recommended to have no more than 50 routers per single area.

4 LITERATURE SURVEY

As long as a number of IP addresses can be used, the routing configuration is required so that these computers can communicate with each other even in different network. Misconfiguration of the routing table can cause problems that can interface the data transmissions such as packet loss and delay. The worst problem that can happen is the loss of important information that is sent. This disorder can occur because the improper configuration of routing tables on the routers, the router device is down, or loss connections between routers. There are two different way to configure routing tables in the router. The routing tables on the routers can be configured by using static routing or active routing. Used for a Computer network that is not too large, it is advantageous to using static routing. In addition to save router resources, the configuration is not too difficult. When the computer network is larger, the use of static routing will be harder for administrators who are responsible to manage the routing tables. The number of entries in the routing table and also the accuracy of each entry is a key factor for the performance of the computer network. If there are changes that occur in the topology, routing tables must be updated soon. So the packet sent on the network is not discarded because of an error in the routing table. The classification of routing protocol:

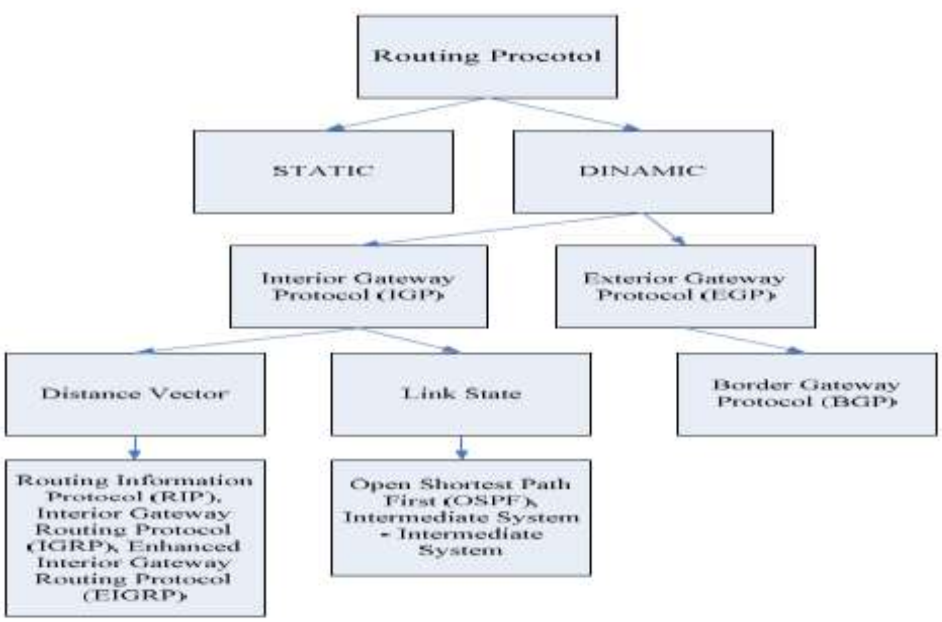


Fig.4 Routing protocol classification

[1] OSPF (Open Shortest Path First) and EIGRP (Enhanced Interior Gateway Protocol) are routing protocol which is a member of IGP (Interior Gateway Protocol). OSPF and EIGRP will distribute routing information between routers in the same autonomous system. This research wills find how OSPF routing protocols works.

[2]This paper looks at an approach for tuning dynamic routing systems using link metrics and focusing on the EIGRP dynamic routing protocol in order to get consistent and expected failover of dynamically routed links in complex networks. It examines: architectural issues for designing enterprise network backbones with redundant links; operational routing issues associated with configuring "hot spare" routers and contingency backbone sites; and finally a metrics system for tuning the routing system where multiply redundant links (redundant groups of redundant links) are used.

[3]In this paper we evaluate the Enhanced Interior Gateway Routing Protocol (EIGRP) via packets simulation. EIGRP, an intra-domain routing protocols developed by Cisco, is mainly based on the Diffusing Update Algorithm (DUAL) which computes shortest paths distributed without creating routing-table loops or incurring counting-to-infinity problem. Previous studies showed EIGRP's ability to adapt quickly to routing changes in medium-scale networks.

[4]This paper presents the implementation decisions to be made when the choice is between protocols that involve distance vector or link state or the combination of both. There have been a large number of static and dynamic routing protocols available but choice of the right protocol for routing is dependent on many parameters critical being network convergence time, scalability, memory and CPU requirements, Security and bandwidth requirement etc.

[5] In this paper, we model power of core routers which are using OSPF and EIGRP protocols. The model can accurately predict the power consumption of the routers with an important speedup. Also we establish the total quantity of routers required to support thousands of servers in the mentioned network.

[6]This paper settles an open question with a positive answer: Optimal traffic engineering (or optimal multi commodity flow) can be realized using just link-state routing protocols with hop-by-hop forwarding. Today's typical versions of these protocols, Open Shortest Path First(OSPF) and Intermediate System-Intermediate System (ISIS),split traffic evenly over shortest paths based on link weights. However, optimizing the link weights for OSPF/ISIS to the offered traffic is a well-known-hard problem and even the best setting of the weights can deviate significantly from an optimal distribution of the traffic.

[7]This paper will compare the convergence delay caused by link failures in both EIGRP and OSPF.

5 CONCLUSION AND FUTURE SCOPE

CONCLUSION

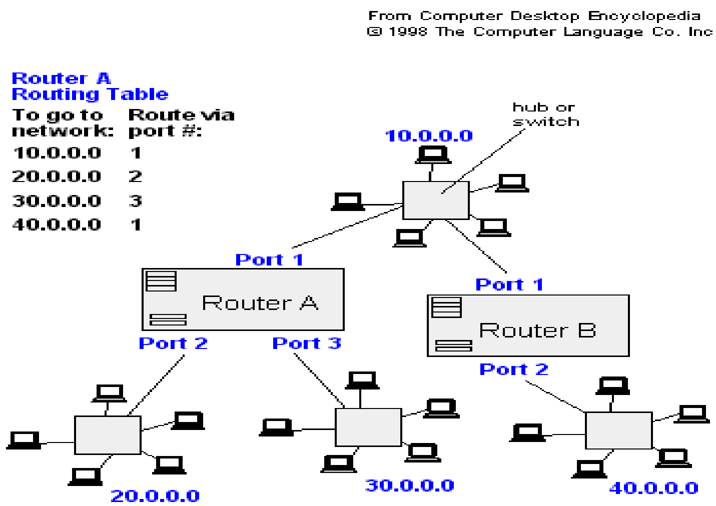
Results for directed and undirected graphs are successfully implemented in MATLAB 2013a with desired results. The OFDM implementation is to store vertices in an array or linked list will produce a running time of $O(|V|^2 + |E|)$. For sparse graphs (with very few edges and many nodes), it can be implemented more efficiently storing the graph in an adjacency. This will produce a running time of $O((|E|+|V|) \log |V|)$.
Finally, we made sure that it is a correct algorithm (e.g., it always returns the right solution if it is given correct input).With the help of two mathematical results:

Lemma 1: Triangle inequality
If $\delta(u,v)$ is the shortest path length between u and v, $\delta(u,v) \leq \delta(u,x) + \delta(x,v)$
Lemma 2:
The subpath of any shortest path is itself a shortest path.
We can claim that any time we put a new vertex in network. We can say that we already know the shortest path to it.

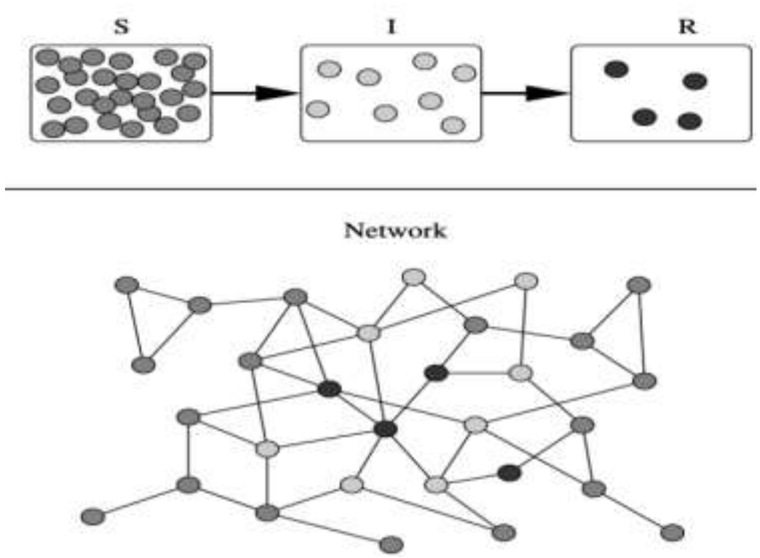
FUTURE SCOPE

1. Traffic Information Systems are most prominent use
2. Mapping (Map Quest, Google Maps), where multiple ways are available for same destination. (i.e. low nodes high edges)

3. Routing Systems



4. Epidemiology: to model the spread of infectious diseases and design prevention and response strategies. Vertices represent individuals, and edge their possible contacts. It is useful to calculate how a particular individual is connected to others. Knowing the shortest path lengths to other individuals can be a relevant indicator of the potential of a particular individual to infect others.



5. Wireless extensions of OSPF to support mobile ad hoc networking, with major focus on design and implementation of one of the most promising proposals
6. IPv6 Addresses with Embedded IPv4 Addresses using OSPF protocol.
7. Genetic interaction network

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About Author

Kirti is pursuing M.T ECH. from Rohtak Institute of Engg. & Mngt. Rohtak (2013-2015) and obtained B.TECH. degree in Computer Science & Engg. from co. affiliated by Maharshi Dayanand University 2013. Implementation of OSPF protocol for directed & undirected graph problem in real life scenario.