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Review Paper on Open Shortage Path First (OSPF) Protocol in Network

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ABSTRACT

The OSPF is an open standard protocol that is most popularly used in modern networks. OSPF is a large and complex protocol, and as such we only provide an overview of some properties of the protocol. The purpose of any routing protocol is to efficiently distribute dynamic topological information among its participants to facilitate routing calculations upon which packet forwarding decisions are then based. Due to the shortage of RIP protocol, OSPF protocol is used in large network. It is a dynamic routing protocol used in Internet Protocol networks. Specifically, it is a link-state routing protocol and falls into the group of interior gateway protocols, operating within a single Autonomous system. OSPF was designed to support Variable-length subnet masking (VLSM) or Classless Inter-Domain Routing (CIDR) addressing models. OSPF detects changes in the topology, such as link failures, very quickly and converges on a new loop-free routing structure within seconds. There are two types of routing-Link State routing and Distance Vector routing. Dijkstra's is based on Link State routing. In Link State routing each router keeps track of its incident links and cost on the link, whether the link is up or down. Each router broadcasts the link state to give every router a complete view of the graph. Each router runs Dijkstra's algorithm to compute the shortest paths and construct the forwarding table. The topology of the network can be generated by collecting the OSPF messages. In this paper, we also give evaluation of OSPF routing protocols for IPv6.

Keywords: OSPF, RIP protocol, Link State Routing, Distance Vector Routing, EIGRP.

1. INTRODUCTION

Due to the shortage of RIP protocol, OSPF protocol is used in large network. OSPF is shortened form of Open Shortest Path First. The following are typical scenarios for using OSPF:

1. **When a single router or communications server must accommodate different sized TCP/IP networks:** Increasingly, ISPs need to divide or combine subnets to ensure the most efficient use of TCP/IP addresses. This capability, called variable length subnet masks (VLSM) or "classless" networking is supported by OSPF. In contrast, RIP does not allow a network to be segmented or combined with others to create networks of different sizes.

2. **When routing changes need to be propagated quickly:** RIP can create too much network downtime by taking too long to update routers with network changes; RIP needs a hold-down period to ensure that information it has generated has been properly propagated through the network. If a network has many routers, RIP updates can take several minutes to alert the entire network to the failure of a single router. OSPF updates are much faster than RIP updates.

3. **When more than 15 hops between routers are required:** More than 15 hops might be a requirement in some larger networks. RIP will only support15 hops between routers, but OSPF can support up to 255 hops.

4. **When routing advertisements need to be password-protected to prevent network instability or sabotage:** OSPF has packet authentication capability; RIP does not.

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

2. OSPF BACKGROUND

A mobile ad hoc network is a collection of wireless nodes that can dynamically be set up anywhere and anytime without using any pre-existing network infrastructure. It is an autonomous system in which mobile hosts connected by wireless links are free to move randomly and often act as routers at the same time. OSPF is a large and complex protocol, and as such we only provide an overview of some properties of the protocol. The purpose of any routing protocol is to efficiently distribute dynamic topological information among its participants to facilitate routing calculations upon which packet forwarding decisions are then based. In a link-state routing protocol such as OSPF, each router is independently responsible for describing the state of its local neighborhood (e.g. links to neighboring networks, routers, and hosts) to the rest of the network. The key OSPF concepts you need to understand to properly design an OSPF network are as follows:

• OSPF router relationships including tenuous systems, neighbors and adjacencies, backbones, and stub areas
• Variable-length subnet masks with OSPF
• OSPF "costing"
• OSPF packet authentication

In OSPF, the first step in the exchange of routing information is the creation of **adjacencies** between neighboring routers. A router first uses a Hello Protocol to discover its neighbors. Once neighbor routers have 'met' via the Hello Protocol, then they go through a database exchange process to synchronize their databases with one another. Only then neighbor routers can become adjacent and exchange routing protocol information.

Information about the state of a router's local neighborhood is then assembled into a **link-state advertisement** (LSA), which is then distributed to every other router by reliable intelligent flooding. The basic flooding process is straightforward: upon receiving an advertisement from a neighbor, a router acknowledges receipt of the advertisement and, if new, forwards the advertisement to all other neighbors. Thus, after a short period of convergence, each router in the network will have an identical topological database of LSAs to be used for routing calculations.

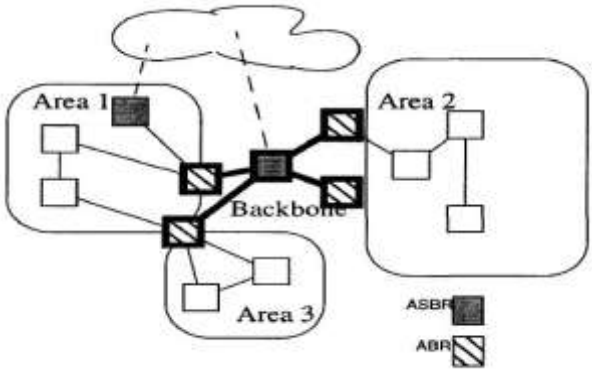

Figure 1. OSPF Terminology

OSPF is an interior routing protocol, designed to be used within a single autonomous system (AS). OSPF allows the AS to be divided into groups of networks called areas. Each area runs a separate copy of the basic link-state algorithm, and the topological details of the area are hidden from the rest of the AS, reducing routing traffic. All areas are connected by a single backbone area, in a logical hub and spoke configuration. Routers belonging to a single area are called internal routers. Routers which belong to more than one area are called area border routers (ABRs). All ABRs belong to the backbone by definition. Any router which exchanges routing information with an external AS is called an Autonomous System Boundary Router (ASBR).

OSPF defines five link-state advertisement (LSA) types which correspond to router's respective roles. All routers generate router links (type 1) LSAs for each area they belong to, which describe the state and cost of a routers links to that area.

Designated routers generate network links (type 2) LSAs which describe all routers attached to the transit network (subnet). ABRs generate summary link (type 3 &4) LSAs, which inject into an area a single destination (a network or ASBR respectively) outside of that area. ASBRs generate AS External (Type 5) LSAs, which describe a single destination external to the AS. Of the five types, only AS external LSAs are flooded throughout the AS, all others are only flooded within a single area. To prevent problems caused by 'immortal' LSAs, each contains an age field. An LSA's age is constantly incremented, both while being flooded and while installed in any link-state database. If an LSA's age reaches the value Max Age (defined as one hour), it is removed from the router's link-state database and reflooded as a signal for other routers to remove it. An LSA's originator congestion the LSA from the system at any time by prematurely setting the LSAs age to Max Age and flooding it. It is possible for more than one instance of an LSA to exist in the system at any one time. Thus each LSA has a sequence number When encountering multiple instances, the LSA with the greatest sequence number is considered newer. If the sequence numbers are equal, the age field and finally checksum are used as tie-breakers.

3. INTERIOR ROUTING PROTOCOLS

Interior routing protocols are classified into two categories: distance vectors and link state routing protocols. Link state routing protocols maintain a complete map of the network and associate a cost value with links between routers; these costs are used to determine the best route for forwarding data, typically the lowest cost path to a destination. [9]. Distance vector routing uses distance to the destination as the key routing consideration, this distance is typically the number of intervening routers or hops necessary to reach the destination using a given interface. Distance vector routing protocols typically favor the shortest paths available causing routers to forward packets out of interfaces which have shorter hop counts to the destination [10]. Routers periodically share routing information by flooding to neighboring routers; each recipient router uses this information to update their routing table before passing it on to other routers [11].

OSPF performs routing calculations based upon data stored within a Link State Database (LSDB); this database is a logical tree structure of the network topology [3]. The Dijkstra's algorithm is used to determine the shortest path from the source to the destination within the LSDB using the accumulating cost of links in the path [12]. The cost of a link is calculated based upon the bandwidth of the link; with higher bandwidths being allocated a lower cost, this can be manually changed by a network administrator [9]. The LSDB is maintained by routers who regularly send hello packets out their interfaces to neighbor routers and wait for a reply. If a reply has not been received within the time limit, the link state will change to down and the LSDB will be updated [13]. OSPF routers inform the network of changes to the LSDB using Link State Advertisements (LSA), these are flooded to routers in the same area periodically or whenever there is a change in a network link. Network topology changes must be reflected in the LSDB to ensure consistent routing throughout the network; once a LSA is received the router updates their copy of the LSDB and recalculates route costs accordingly [3].

The OSPF protocol uses a hierarchical structure which is split into areas to ensure that the LSDB of an area does not grow too large; using excessive bandwidth, memory and processing power to remain accurate. The hierarchical structure also helps to ensure that network performance is not degraded in large OSPF domains by limiting routing traffic flooding and LSA to within the routers current area [13]. Each area in OPSF is labelled with a unique 32 bit area ID, which are dotted decimal format and not compatible with IPv4 addresses, Area 0 is the backbone area of an OSPF domain, all OSPF areas need to connect to this backbone area; which manages all inter-area routing. OSPF has a number of advantages which make it a very popular routing protocol; it features rapid convergence when a topology changes and will support several routes to a destination with different costing associated with each route, this means that backup routes will be available if a route goes down. Another advantage is the hierarchical nature of the protocol; this allows OSPF networks to scale very well with negligible impact upon routing overhead [12]. However the memory requirements on routers to maintain the LSDB can become an issue especially in larger OSPF areas where large numbers of nodes need to be stored in the LSDB tree and shared using LSA which adds to routing overhead. Another problem with the OSPF protocol is the difficulty in configuring and managing areas which can be configured in a number of ways such as stubby or transit areas, this adds to the complexity of deploying the protocol.

4. THE OSPF UPDATE PROCESS

OSPF does not repeatedly broadcast routing tables to others and incrementally update hop counts. With OSPF, each router maintains a complete network map of the local area and sends updates and update acknowledgments when network changes occur or on 30 minute refresh cycles. OSPF sends only the minimum data required to communicate a change. This approach contrasts with RIP, where every router has a unique routing table tailored to its specific place in the network. In an OSPF network, every router within an area contains the same routing table information in the form of a network map. As shown in Figure 2, router E is added to an existing four router OSPF network consisting of routers A, B, C, and D. All

possess the same network map showing all routers in the network and their direct links to other routers. Before E is added, router A's topology database is as shown in Table 1.

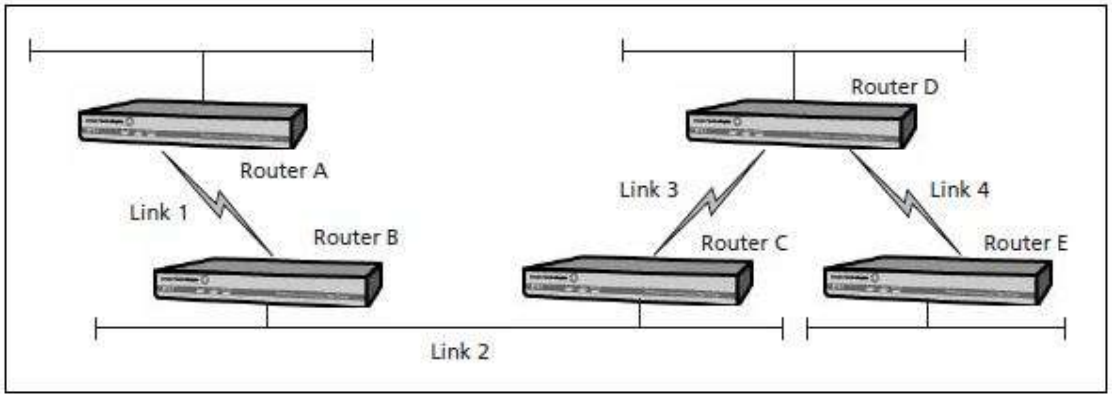

Fig. 2: Four-router network with Router E added

Table 1: Router A's topology database before Router E is added

From	*To*	*Total Cost*
A	*Link 1*	*1*
Link 1	*B*	*1*
B	*Link 2*	*2*
Link 2	*C*	*2*
C	*Link 3*	*3*
Link 3	*D*	*3*

Once router E is added, router E sends out notification (called a "link state advertisement") of its location to router D. Router D updates its network map and immediately forwards E's update message to router C, which immediately forwards E's update message to router B, and so on. Ultimately router A's routing table will include another entry showing that router D has access to router E over Link 4 with a cost (to router A) of 4. Indeed, the same advertisement generated by router E makes its way to router A.

OSPF's update process affords three benefits over RIP's:

1. OSPF routing updates take place less often, every 30 minutes or when network changes occur. Thus, OSPF optimizes network bandwidth by keeping the frequency of update traffic to a minimum.
2. OSPF updates typically propagate throughout the network more rapidly than do RIP updates, enabling OSPF networks to recover more rapidly from broken links.
3. OSPF does not have RIP's 15-hop-countlimitation. As a result, OSPF can accommodate many more routed network segments.

5. OSPF ROUTER RELATIONSHIPS

The concept of the OSPF area is a fundamental part of OSPF network design. OSPF is a CPU-intensive protocol, and unlike RIP networks OSPF networks are not bound by a hop count limitation. Very large OSPF networks can experience routing and update traffic problems that seriously impact network performance. In addition, routers in large OSPF networks require large amounts of memory. To avoid these problems, OSPF networks can be divided into more manageable OSPF "areas." OSPF areas are made up of "internal routers" and are linked to other areas by "area border routers" (ABRs). Supersets of OSPF areas are called "autonomous systems" (AS), which are linked to other autonomous systems by

"autonomous system border routers" (ASBR). OSPF autonomous systems can be interlinked by an exterior gateway protocol such as the Border Gateway Protocol (BGP). All OSPF routers must be capable of acting as internal routers, area border routers, or autonomous system border routers. Figure 4 illustrates these concepts. By grouping subnets into areas and areas into autonomous systems, network designers can create more efficient and manageable OSPF networks.

Routers within an area need only maintain network maps for their respective area. This feature minimizes routing updates from other areas and conserves router memory. The autonomous system concept further conserves system and router resources by minimizing the flow of routing updates and decreasing the resources required to keep track of these updates. Because traffic patterns and links vary by network, there is no definitive rule for the size and make up of an OSPF area. Nevertheless, a general rule of thumb is to limit areas to no more than 40 or 50 routers to ensure adequate OSPF network performance.

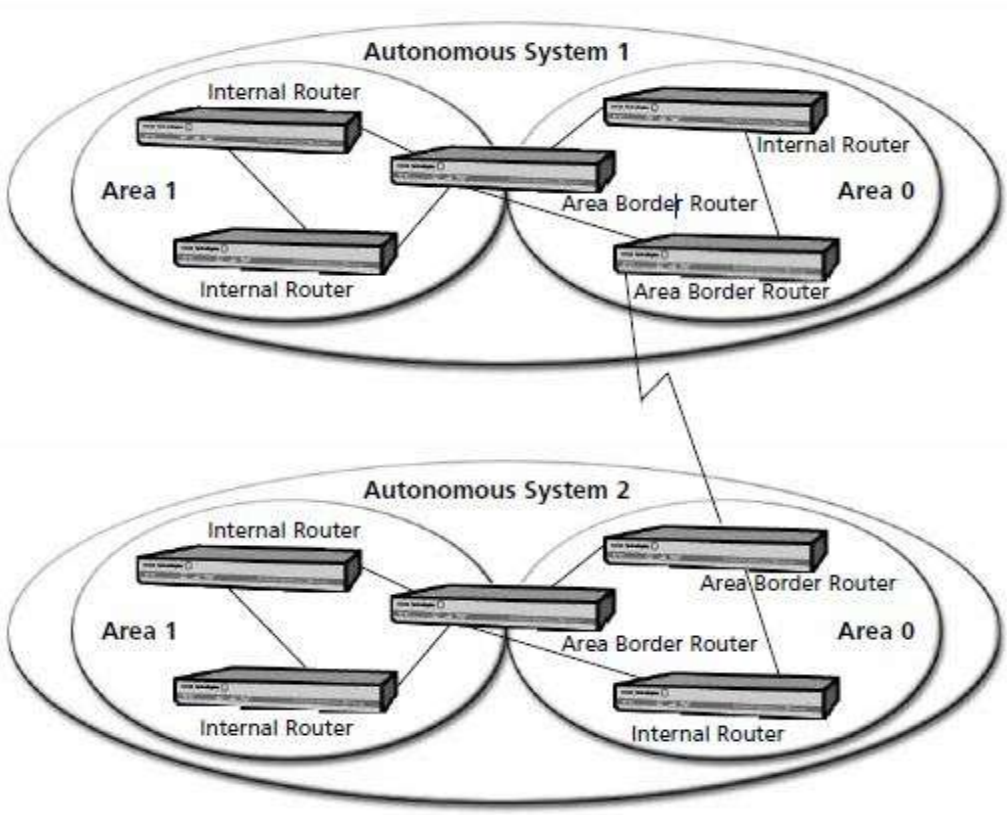

Fig. 3: OSPF autonomous systems and routers

6. EVALUATION OF OSPF ROUTING PROTOCOLS FOR IPv6

Internet Protocol version 6 (IPv6) is designed to address the problem of limited address space by providing 128bits of addressing space, providing 2128 IP addresses; a practically limitless addressing space for new internet enabled devices to utilize [3].IPv6 brings a number of improvements over IPv4 in addition to increased addressing space; IPv4 contains no security mechanisms: IPv4 relies upon higher level protocols to handle authentication and encryption of packets; this can lead to vulnerabilities when deploying IPv4 systems. This issue is addressed in IPv6 which increased security through the use of integrated Internet Protocol Security (IPsec) within the IPv6 protocol which provides authentication and using cryptographic keys [4].IPv4 includes no quality of service mechanisms: IPv6 adds support for Quality of Service (QoS) mechanisms through the use of flow control bits; these will enable routers to prioritise packets based upon QoS considerations and economise storage by aggregating routing tables [5].The core operation mechanisms of both OSPFv2 (for IPv4) and OSPFv3 (specifically designed to support IPv6) are very similar, with few major modifications. OSPFv3 maintains the same packet types as used in OSPFv2 namely; Hello, Link State Request, Link State Update, Link State Acknowledgement and Database Description, however changes were made to some of the fields preventing backwards compatibility between the versions [12]. OSPFv3 retains the domain and flooding scope areas from OSPFv2; it also adds a link local flooding scope; which is a requirement to support IPv6; routing both IPv4 and IPv6 traffic on the same network requires both versions of OSPF to be running simultaneously using dual-stack backbones [3]. OSPFv3 drops packets whose

instances IDs does not match by assigning an interface ID to the OSPF packets to differentiate between instances. OSPFv3 utilizes IPv6 IPsec extension Headers to provide authentication and encryption [3].

7. IMPLEMENTATION CONSIDERATIONS

Operating multiple protocols on a network is possible but has numerous issues which must be considered;

- Protocol interoperability: protocols are not designed to interoperate with one another; the metrics used by the different protocols may result in different paths to a destination being selected or the creation of routing loops.
- System resources: additional CPU and memory will be required to maintain multiple routing tables and process updates.

Due to these issues it is often ideal to select a single routing protocol per autonomous system, although this is not always possible in every situation. Examples include networks which require both IPv4 and IPv6 routing or situations such as an organization merger where multiple protocols are in use as different systems are brought together, alternatively departments with different network administrators may feature different protocols. From the strengths and weaknesses identified it can be argued that OSPFv3 will be most appropriate deployed in large networks which can make best use of its hierarchical nature and benefit from the scalability of the protocol, as well as networks which face budgetary constraints due to the flexibility of the hardware which the protocol can be deployed upon.

CONCLUSION AND FUTURE SCOPE

The new features and changes of these protocols have been highlighted and discussed; the strengths and weaknesses of protocol have also been evaluated. So paper has OSPF protocol study in detailed along with the disadvantages of OSPF - Difficult to configure and more memory requirements. Finally, we compared the IPv4 and IPv6 versions of popular routing protocol OSPF identified the changes made to these protocols to incorporate IPv6 Support. OSPF has advantages in large networks where its hierarchical nature increases scalability. Future work will involve collecting performance data such as network throughput, convergence speed or CPU and memory utilization for networks operating the IPv6 routing protocols. OSPF can be used in various real life problems of traffic, road map, goggle map, genetic engineering, biotechnology etc. where directed and undirected graph problems are solved with help of OSPF protocol.

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