Intermediate Routing with IS-IS

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Abstract

Networks today rely upon redundancy for smooth operation, and dynamic interior gateway routing protocols (IGRPs) such as IS-IS and OSPF are a necessary component of a redundant architecture. Intermediate-System to Intermediate-System (IS-IS) routing was developed when routing protocols other than IP were in full production, while OSPF was developed as an IP layer enhancement. Though less widely used in the business world, the ease of IS-IS implementation coupled with a wide range of options as well as overall efficiency and stability allows IS-IS to maintain some advantages over other IGRPs and more modern architectures.

While IS-IS architecture makes it both strong and unfamiliar in the modern data network environment, its' performance efficiency and flexibility have pushed it into the enterprise in global business environments. IS-IS has some distinct advantages over its more popular peer, OSPF, but these IGRPs now compete with platforms that offer software designed networking, routing at the application layer.

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Popular routing protocols have been classified as interior and exterior for many years with BGP as the chief exterior protocol for routing between ISPs and other ISPs or their customers by way of autonomous system numbers (ASNs). Within an autonomous system, a network governed by a single entity, any of a suite of interior gateway routing protocols (IGRPs) could be selected based on network size and complexity as well as administrator preferences. The development of algorithms and means of data collection from routers led to a classification of IGRPs as either vector state or link state with link state generally being more advanced (Altin et al.,2013). Open Shortest First Path (OSPF), and Intermediate-System to Intermediate-System (IS-IS) are among the most popular. Link state routing protocols such as IS-IS and OSPF have a hierarchical routing topology based on network advertisements between neighboring routers; links are assigned metrics, or costs, and the Dijkstra algorithm computes a shortest path tree (SPT) for each destination. IGRPs allow routers to dynamically respond to network changes (Callon, 1991). IS-IS, while not as widely implemented as OSPF, is a highly efficient protocol capable of handling a multitude of traffic management needs with minimal input. IGRPs in general, however, are seeing increased competition from the more recent developments in software defined networking (SDN) and similar platforms such as Open/R (Clark et al.,2016). Though less widely used in the business world, the ease of IS-IS implementation coupled with a wide range of options as well as overall efficiency and stability allows IS-IS to maintain some advantages over other IGRPs and more modern architectures.

Discussion

In 2017, during an interview with Google network engineer Amin Vahdat, Jennifer Rexford, an SDN expert from Princeton, asked why Google's 2013 architecture report indicated an investment in IS-IS (and BGP) despite a platform choice which would have operated sufficiently without IS-IS configuration. Vahdat responded that the company chose not to do a forklift but instead increased their own SDN expertise as they slowly converted portions of the network over time (Clark et al.,2016). Per Vahdat, "So, while I agree that BGP

and IS-IS are not where we want to be long term, they certainly have provided us with a critical evolution path to move from a non-SDN network to an SDN one" (Clark et al.,2016, para. 35). Vahdat notes google started thinking about the infrastructure change in 2008 (Clark et al.,2016). Another team in 2003 also observed the inadequacies of link state routing protocols for optimal routing citing load-balancing issues and destination-based forwarding as shortcomings of both IS-IS and OSPF (Diot et al.,2003).

Despite these studies, in the early 2000s, IGRPs were in widespread use and studied for their individual advantages for consideration in future network buildouts. A University of Pennsylvania study in 2001 examined the process of sending and receiving network advertisements by OSPF and IS-IS routers in point-to-multipoint networks specifically; the study acknowledges the limited frame of this study within the menu of network topologies but concluded that IS-IS was the more efficient protocol in terms of packet arrival times and use of memory resources (Oran, 2001). At the time of Oran's study, IGRPs had mostly pushed IPX, DECnet, and SNA out of router base software packages and network certification courses. An IGRP gains strength in popularity due to increased knowledge, understanding, and vendor support as well as the nature of network convergence; when two routing domains merge, redistribution is required if the IGRPs are different, and this complicates routing algorithms (Callon, 1991). With regards to "popularity", IS-IS is less common in enterprise networks to the point where new Dell switch platforms no longer support it. Following some bugs with IS-IS operation on a family of data center switches including the 100G capable Z9100, the Dell OS10 operating system does not even have options to run IS-IS as a routing protocol (Dell, 2020).

IS-IS reliance on Open Systems Interconnect (OSI) addresses for implementation adds to IS-IS' robust capabilities. Unlike other IGRPs, IS-IS is a layer 2 protocol allowing IS-IS to natively carry multiple protocols including IPv6 (Callon, 1991). OSPF version 2 was widely implemented before the development of OSPF version 3 with support for address families such as IPv6. IS-IS also natively supports traffic engineering options which recognize label switched paths as a viable next hop whereas these options must be explicitly configured in OSPF using a unique type of link state advertisements (LSAs) (Juniper, 2021). The IS-IS OSI address family architecture could provide some stability and security enhancements as well as the neighbor relationships do not

depend on IP and are therefore not as vulnerable, however, OSI addressing also is perceived as antiquated and possibly troublesome to document and implement. OSI addresses such as 49.0001.1921.6800.1001.00 do not convert easily to friendly DNS names and may be unsupported by IP based network management platforms.

The OSI IS-IS implementation, despite the need to document otherwise unusable addressing structures, is extremely simple. IS-IS routers are grouped into areas to limit unnecessary route exchange; IS-IS links are classified as level 1 or level 2 or both depending on whether they have links to routers handling other areas. IS-IS neighbors are seen as soon as layer 2 connectivity is active (Callon, 1991). As a layer 2 protocol, IS-IS seems to run in the background silently compared to OSPF which may require extensive knowledge about LSA packet types in large, complicated networks. OSPF' might be described as highly granular, allowing for various network segments called stub areas to connect to a backbone, area 0. A robust suite of rules governs the way OSPF LSA packets are handled by backbone routers, autonomous system boundary routers, and stub area routers on the various OSPF defined network topologies.

Conclusion

Data networks rely on dynamic routing information exchanges to perform extremely well to support today's business needs. Any of the IGRPs have some advantages over their IGRP peers. IS-IS is widely used in the carrier environment for its flexibility, but enterprise networks such as Google have enough commonalities, with respect to size and global reach, with carrier networks that IS-IS may be the better option in their data center environments. OSPF likewise can support legacy applications as well as IPv6 and MPLS in version 3, and being a well-defined standard with a wide circle of knowledge and expertise provides benefit beyond technical qualifications. However, as the enterprise service providers depend more heavily on superior routing performance, the need for traffic engineering brings routing into the applications environment. Innovation in meeting service requirements continues to drive routing protocol development. Time will tell if IS-IS (version 1) gains strength and is adopted by newcomers whose networks are growing or if an OSPF v4 working group is formed to compete with SDN architectures or extend the roadmap for legacy networks and networking equipment.

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