Overview of Internet Routing Protocols

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I. Abstract

Routing Protocols are the key in the way we communicate. They are the way in which information is directed and transferred across a network to it's destination. Routing Protocols discover available routes across a network, build routing tables, and make routing decisions to successfully and effectively transfer data packets from their origin to their destination [1]. A Routing Protocol shares information first with immediate neighbors, then their neighbors, and then throughout the network. Over time, the routers 'learn' the topology of the network and become more efficient [3].

"However, the interesting case is when the destination is not directly reachable. In this case, the host or gateway attempts to send the datagram to a gateway that is nearer the destination. The goal of a routing protocol is very simple: It is to supply the information that is needed to do routing [C. Hedrick; RFC 1058; June 1988] [4]."

Routing Protocols use the IP address in the header of packets to provide the technical infrastructure which routing protocols use to transmit packets across the Internet. An Internet Protocol transfers packets between networks and provides the software bridge that combines the whole system together. Every network Routing Protocol performs three basic functions od discovering other routers on the network, route managing all the possible destinations for each network message, and path determining of making dynamic decisions for where to send each network message [2].

II. Types of Routing Protocols

There are many different methods of traversing a network, hence a multitude of algorithms have been developed since the beginning of computer networking. Routing Protocols fall into two categories Distance Vector or Link State [4]. Distance Vector Routing Protocols allow routers to work with less information concerning the network, allowing for greater efficiency. Conversely, Link State Routing Protocols enable a router to build and track a full map of the entire network links in a given region [2].

Distance Vector protocols advertise their routing table to all directly connected neighbors at regular frequent intervals using a lot of bandwidth and are slow to converge. When a route becomes unavailable, all router tables must be updated with that new information. The problem is with each router having to advertise that new information to its neighbors, it takes a long time for all routers to have a current accurate view of the network. Distance vector protocols use fixed length subnet masks which aren't scalable [1]. A common internet routing protocol that uses a Distance Vector algorithm is Internet Gateway Routing Protocol that was developed by Cisco.

Link State protocols advertise routing updates only when they occur which uses bandwidth more effectively. Routers don't advertise the routing table which makes convergence faster. The routing protocol will flood the network with link state advertisements to all neighbor routers per area to converge the network with new route information. The incremental change is all that is advertised to all routers as a multicast update. They use variable length subnet masks, which are scalable and use addressing more efficiently [1]. A common internet routing protocol that uses Link State is Open Shortest Path First Routing Protocol that we will expand on the innerworkings below.

III. History and Key Structures

Internet protocols were designed for use in interconnected systems of packet-switched computer communication networks. They provide infrastructure for transmitting blocks of data, originally called datagrams and now referred to as data packets, from sources to destinations, where sources and destinations are hosts identified by standard IP addresses. There are no mechanisms to augment end-to-end data reliability, flow control, sequencing, or other services commonly found in host-to-host protocols. The internet protocol can capitalize on the services of its supporting networks to provide various types and qualities of service [5].

The first basic function of internet protocols was assigning addresses. Addresses are fixed length of four octets or 32 bits. An address begins with a network number, followed by local address (called the "rest" field). There are three formats or classes of internet addresses: in class a, the high order bit is zero, the next 7 bits are the network, and the last 24 bits are the local address; in class b, the high order two bits are one-zero, the next 14 bits are the network and the last 16 bits are the local address; in class c, the high order three bits are one-one-zero, the next 21 bits are the network and the last 8 bits are the local address [5].

A distinction was made between names, addresses, and routes. A name indicates what we seek. An address indicates where it is located. A route indicates how to get there. The internet protocol deals primarily with addresses. It is the task of higher level, like a host-to-host or application, protocols to make the mapping from names to addresses. The internet module maps internet addresses to local net addresses. It is the task of lower level, like a local net or gateways, that procedures to make the mapping from local net addresses for routing [5].

In the routing of messages from one internet module to another, packets may need to traverse a network whose maximum packet size is smaller than the size of the original packet. To overcome this challenge, a fragmentation mechanism is provided in the internet protocol. Fragmentation of an internet datagram is necessary when it originates in a local net that allows a large packet size and must traverse a local net that limits packets to a smaller size to reach the destination [5].

An early implementation developed in 1983, by ARPANET, that is still widely used today is the Transmission Control Protocol or TCP. A TCP module would call on the internet module to take a TCP segment (including the TCP header and user data) as the data portion of an internet datagram. The TCP module would provide the addresses and other parameters in the internet header to the internet module as arguments of the call. The internet module would then create an internet datagram and call on the local network interface to transmit the internet datagram [5].

IV. RIP

Researchers developed Routing Information Protocol in the 1980s for use on small- or medium-sized internal networks that connected to the early Internet. RIP is capable of routing messages across networks up to a maximum of 15 hops [2]. It was written by C. Hedrick from Rutgers University in June 1988 and has since become the most common Internet routing protocol for routing within networks. His protocol was based on a distance vector algorithm called the Bellman-Ford algorithm, after Bellman's development of the equation used as the basis of dynamic programming, and Ford's early work in the area. The RIP routing protocol uses UDP because it is particularly efficient, and there are no problems if a message gets, which is fine for router updates where another update will be coming along shortly anyway [4].

Routing Information Protocol enabled routers discover the network by first sending a message requesting router tables from neighboring devices. Neighbor routers running RIP respond by sending the full routing tables back to the requestor, whereupon the requestor follows an algorithm to merge these updates into its own table. At scheduled intervals, RIP routers then periodically send out their router tables to their neighbors so that any changes can be propagated across the network [2]. RIP works by routing database that stores information on the fastest route from computer to computer, an update process that enables each router to tell other routers which route is the fastest from its point of view, and an update algorithm that enables each router to update its database with the fastest route communicated from neighboring routers. Each RIP router on a given network keeps a database that stores the following information for every computer in that network: IP Addresses, Gateway, Distance, Timers, and Route change flag. A flag that indicates that this information has changed, used by other routers to update their own databases [4].

The RIP algorithm works in two stages of updating and propagating. At regular intervals each router sends an update message describing its routing database to all the other routers that it is directly connected. Some routers will send this message as often as every 30 seconds, so that the network will always have up-to-date information to quickly adapt to changes as computers and routers come on and off the network. When a router X finds that a router Y has a shorter and faster path to a router Z, then it will update its own routing database to indicate that fact. Any faster path is quickly propagated to neighboring routers through the update process, until it is spread across the entire RIP network. A mathematical description of this algorithm is shown below [4].

V. OSPF

Open Shortest Path First is a true link state protocol developed as an open standard for internet routing across large multi-vendor networks. The OSPF routing algorithm was created to provide an alternative to RIP, based on Shortest Path First algorithms instead of the Bellman-Ford algorithm. It uses a tree that describes the network topology to define the shortest path from each router to each destination address. Since OSPF keeps track of entire paths, it has more overhead than RIP, but provides more options [4]. The Open Shortest Path First Routing Protocol was created to overcome some of its limitations of RIP including: fifteen hop count restriction, inability to organize networks into a routing hierarchy, and significant spikes of network traffic generated by repeatedly resending full router tables at scheduled intervals [2].

A link state protocol will send link state advertisements to all connected neighbors of the same area to communicate route information [1]. OSPF enabled routers discover the network by sending identification messages to each other followed by messages that capture specific routing items rather than the entire routing table [2]. Since the Open Shortest Path First Routing Protocol is link state based, meaning it maps the entire local working network, it depends on two key distinctions: areas and convergence.

Fast convergence is accomplished with the SPF (Dijkstra) algorithm which determines a shortest path from source to destination. The routing table is built from running SPF which determines all routes from neighbor routers. Since each OSPF router has a copy of the topology database and routing table for its particular area, any route changes are detected faster than with distance vector protocols and alternate routes are determined [1].

The Open Shortest Path First Routing Protocol manages areas by using a hierarchy with assigned areas that connect to a core backbone of routers. Each area is defined by one or more routers that have established adjacencies. OSPF has defined backbone area 0, stub areas, not-so-stubby areas and totally stubby areas. It is preferable to have all area 0 routers connected with a full mesh using an Ethernet segment at a core office. This provides for high performance and prevents partitioning of the area should a router connection fail [1].

VI. IGRP

Interior Gateway Routing Protocol is a distance vector routing protocol developed by Cisco systems for routing multiple protocols across small and medium sized Cisco networks. It is proprietary which requires that you use Cisco routers. This contrasts with IP RIP OSPF, which are designed for multi-vendor networks [1].

Cisco developed Internet Gateway Routing Protocol as another alternative to RIP. However, the newer Enhanced IGRP made major improvements starting in the 1990s. EIGRP supports classless IP subnets and improves the efficiency of the routing algorithms compared to older IGRP. Conversely, it does not support routing hierarchies, like RIP. Interior Gateway Routing Protocol was originally created as a proprietary protocol runnable only on Cisco family devices, EIGRP was designed with the goals of easier configuration and better performance than even OSPF [2].

An important difference is that since IGRP advertises less frequently, it uses less bandwidth than RIP but converges much slower since it is 90 seconds before IGRP routers are aware of network topology changes. IGRP does recognize assignment of different autonomous systems and automatically summarizes at network class boundaries. As well there is the option to load balance traffic across equal or unequal metric cost paths [1].

VII. Summary

Internet Routing Protocols are the brains and operations to the way information travels across the internet. They have not only made digital communication possible but enabled the great befits we enjoy with our digitally connected world. Their structure has been well defined from its early beginnings of using IP addresses and string information in packet headers to guide traffic through routers. From the original standard Routing Information Protocol to newer improvements with Link State algorithms like OSPF to Distance vector methods found in Cisco's IGRP. Internet Routing Protocols are the key to our communication and the backbone of our future.

VIII. Refences

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