

Introduction to IP Routing

This lecture introduces the topic of IP routing protocols. After this lecture you should be able to: list the advantages of dynamic routing over static routing, list three factors that affect link cost, look up an Autonomous System Number, and classify the most common routing protocols (OSPF and BGP) as interior or exterior routing protocols.

Introduction

Routing (sometimes called forwarding) refers to how each host chooses the interface on which to transmit a packet.

As described earlier, routing is done by comparing the destination IP address with network addresses (netmask and IP address) stored in a routing table.

Most hosts have a single network interface and use a simple static (fixed) routing table that contains only the local host address (typically 127.0.0.1) and the address of a router that is configured as the default gateway. The default gateway is usually configured (along with the host's IP address and netmask) as part of configuring the host's network interface. This is often done using the DHCP (Dynamic Host Configuration Protocol).

Although only a convention, the address of the gateway is often set to be the same as the network address with the least-significant bit set to one.

Exercise 1: What is likely to be the default gateway address for the network 192.168.1.0/24? Could the default gateway be at address 192.168.1.32? Could it be at 192.169.0.1?

Routers are hosts that have multiple interfaces and can forward packets between different networks. Routers range from very simple ones designed for home use to very complex ones designed for service providers that can route millions of packets per second (PPS).

Static vs Dynamic Routing

The simplest way to manage routing tables is static routing. The routing tables are set up by a network administrator and remain fixed until updated manually. While this approach is simple, it cannot adapt automatically to changing network conditions such as a link failures or heavy traffic.

Dynamic routing allows routing tables to be adjusted automatically to meet changing network con-

ditions. Dynamic routes are updated with changes based on network status.

With dynamic routing there is no central coordinator that makes routing decisions and updates different routers' routing tables. Instead, each router collects network connectivity information from other routers and makes its own routing decisions. Dynamic routing therefore depends on:

- protocols to distribute network connectivity information
- distributed algorithms that can compute routing tables using this information

Link Costs

There are often multiple possible paths between two hosts. Routing algorithms need a way to determine the best link to use. This is done by assigning each link a "cost." This cost is rarely related to an actual monetary cost. Instead it is related to the (un)desirability of choosing a particular link for some other reason such as data rate, delay, utilization or other factors that might affect routing decisions. In practice there are well-established formulas that take these factors into account to compute the link cost.

Although the definition of link cost is somewhat arbitrary, all routers that share link costs for the purpose of making routing decisions need to use the same rules for setting link costs.

Exercise 2: Should a router choose the lowest-cost or the highest-cost path when deciding to route a packet? What might be a suitable choice for a cost metric based on the interface data rate?

Autonomous Systems

The Internet is very large and contains millions of routers. It is not possible to design routing algorithms

that involve every router. Instead, the Internet is divided up into what are called Autonomous Systems (AS) and different routing algorithms are used for routers within an AS and for routers that connect ASs.

An AS is typically an organization (company, school, ISP, government, etc) that owns or controls all of the routers and hosts within the AS. There may be policy reasons (cost, security) why different ASs may want to make different routing decisions. In addition, different AS may have different ways of calculating link costs.

Each AS is assigned a unique ASN (AS number) by the relevant regional address registry and one or more IP address range(s) (an IP network). In the America ASNs are assigned by ARIN (American Registry for Internet Numbers) and can be searched for using the site <http://whois.arin.net/>.

Exercise 3: What is BCIT's ASN? What is the largest network associated with this ASN?

There are over 100,000 ASs. However, not all inter-domain routers need to be aware of how to route traffic for each AS. Many of these routers can use default routes. In other cases, address aggregation (discussed later) can be used to reduce the size of the routing tables.

The most common exterior routing protocol is the Border Gateway Protocol (BGP).

Although BGP performs dynamic routing, the allowed routes are usually highly constrained by service provider configuration. These policy decisions are determined by agreements between service providers. For example, two service providers may decide to exchange traffic with each other without cost ("peer") or one agree to pay the other to carry their traffic.

Interior vs Exterior Routing Protocols

Interior

An interior routing protocol is used within an AS. These protocols handle a relatively small number of routers (perhaps up to 100). The most common interior routing protocol, OSPF, uses a flooding algorithm. This algorithm is used to send information about the state of each link between routers to every other router. This allows each router to build a map of the connectivity between each of the routers. From this map an algorithm (Dijkstra's Algorithm) is used to find the lowest-cost path to every other router in the network. We will study the operation of OSPF in detail later.

Exercise 4: If there are 80 routers in a network and each one has three neighbours, how many link costs need to be transferred and stored by each router?

Exterior

An exterior routing protocol is used between ASs. A border router implements both interior and exterior routing protocols on two interfaces and routes packets between the global internet and the AS's networks. This is also known as an inter-domain router.