COSC 417 Topics in Networking

TOPIC 4: IGP ROUTING

SCHEDULE

1. *IGP*
    1. *Types of IGP routing*
    2. *Distance-Vector routing protocol*
    3. *Bellman-Ford algorithm*
    4. *RIP*

WHAT WE'VE LEARNT SO FAR

- From the previous lectures, we are dealing with:
  - A network of autonomous systems, with each AS having a common administrator and routing policy
  - Routing between autonomous systems is handled via Border Gateway Protocol (BGP)
  - BGP is split into external (eBGP) and internal (iBGP) protocols

IBGP AND FULL MESH

- Recall from last lecture that internal (iBGP) routing has some special limitations placed on how we advertise routes
- Specifically, routes received via iBGP may *NOT* be re-advertised to other nodes in the network
- As a result, iBGP requires that the network be in *full mesh* to be able to properly route traffic in and out of the AS

SO WHAT'S THE PROBLEM?

- So external BGP (eBGP) works fine for routing between autonomous systems, but the constraints on iBGP pose problems
- In particular, *full mesh* becomes more and more of a problem as the size of the network scales up - maintaining full mesh with thousands or tens of thousands of nodes within an AS isn't possible

WHAT DO WE DO ABOUT IT?

- Since eBGP is working fine for external, inter-AS routing, so there's no need to change that – and we've already standardized on it
- But for internal, intra-AS routing where we have a single administrative domain – we can use a different routing protocol, known as a *Interior Gateway Protocol* (IGP)

INTERIOR GATEWAY PROTOCOL

- The IGP is responsible for routing traffic between routers or nodes within an autonomous system
- Solves the problem of how we route traffic within an AS that isn't full mesh, when we can't re-advertise a route learnt via iBGP
- Since IGP routing is an internal process under one administrative domain, it doesn't have to be standardized the way BGP is (more than one algorithm is available)

TYPES OF IGP PROTOCOL

- IGP protocols can be broadly classified into two types:
  - Distance-vector protocols
    - RIP, RIPv2, RIPng
    - IGRP (Cisco)
  - Link-State routing protocols
    - OSPF
    - IS-IS

CHOICE OF ROUTING PROTOCOL

- Which routing protocol an AS uses internally is a policy decision up to the administrators
- This decision is going to have an impact on how traffic is routed within and through the AS
- Many potential influencing factors in choice: topology, size, security concerns, hardware provider, etc

DISTANCE-VECTOR ROUTING PROTOCOLS

DISTANCE VECTOR ROUTING

- Distance vector routing is among the first type of routing used in computer networking
- In D-V routing, routers aren't required to have a full map of the network topology – they rely on simply knowing their neighbours
- Fairly simple and straightforward routing protocols, but less common today due to the popularity of link-state routing

BELLMAN-FORD ALGORITHM

- The Bellman-Ford algorithm is used to compute the shortest path between two vertices in a weighted graph
- Each edge between two vertices has some *weight* associated with it, which makes that edge more or less preferable (determines the *cost* of using that particular edge)

HOW BELLMAN-FORD WORKS

- Begin by assigning an infinite weight to all neighbouring vertices
- From the starting vertex, begin exploring edges and determining the cost to get to neighbouring vertices, recalculating costs as necessary
- After N-1 repetitions (where N is the number of vertices), weights will have been properly assigned across the graph

AS A FORMULA

- Consider that the function d(x,y) is the distance from X to Y
- The function for the cost of traversing a single edge is c(x,y)
- Bellman-Ford can then be expressed as:

$$d(x,y) = \text{minimum}(c(x,a) + d(a,y), c(x,b) + d(b,y), \ldots)$$

- This is recursive – the distance between X and Y can be expressed as the sum of distances for the nodes interlinking X and Y

ROUTING INFORMATION PROTOCOL (RIP)

- The first routing protocol to be standardized was the *Routing Information Protocol*, known as RIP – became a standard (RIPv1) in 1988
- Actually came about much earlier than the standard – used experimentally by Xerox in the 70s, incorporated into UNIX in 1982

WEIGHTS IN RIP ROUTING

- RIP considers one metric: the hop count
- Each edge between routers in the network is a hop, so RIP tries to find the shortest path in terms of the least number of routers required to traverse across
- The maximum hop count is 15 – this limit prevents routing loops, but also limits the network topology of a network running RIP

ADVERTISEMENTS IN RIP ROUTING

- Every 30 seconds, routers running the RIP protocol will exchange their distance vectors (distance to their neighbours) with their neighbours
- As network topology changes, these advertisements allow routers to adjust their routing tables → distances may increase or decrease, making one route preferable to another

MANAGING FAILURES

- If no advertisement is heard from a router for 180 seconds, that router is considered “dead”, and routes that use that neighbour are considered invalid
- This information is then advertised to neighbours, so the failure of a particular link is quickly passed along through the whole network, allowing all routers to re-adjust their routing tables

PROBLEMS WITH RIP ROUTING

- RIP routing has some problems, which is in part why it isn't used that frequently anymore:
  - Slow Convergence
  - Count-To-Infinity problem

CONVERGENCE IN NETWORKING

- Convergence, in networking terms, is when all routers within a network have the same topological information
- Recall that initially, the Bellman-Ford algorithm uses infinite weights for all vertices and then recalculates
- When that calculation is done for all routers in the network and there is no further recalculation to be done, the network has converged

THE PROBLEM OF CONVERGENCE

- Because RIP sends out advertisements every thirty seconds, and neighbours only share information with neighbours, it can take a *long* time for RIP to propagate routing information
- N-1 iterations for Bellman-Ford – if N is large (large network) then we're going to need a *lot* of iterations for convergence
- Even a small network with a handful of nodes can take minutes to converge – large networks can take hours if not days or weeks – untenable in today's very large networks

THE COUNT TO INFINITY PROBLEM

- A separate issue is the count-to-infinity problem that distance-vector routing protocols exhibit
- In the event of a link failure to one router, other routers can begin advertising routes to each other, back and forth, to this disconnected router, continually increasing the cost
- This is known as “Bad news travels slowly” – it takes a while for failures to propagate
- If the hop count wasn’t limited to 15 in RIP, this could ostensibly continue forever, hence the “infinity” part of the name

COUNT-TO-INFINITY EXAMPLE

- Consider three routers, X, Y, and Z
- Router X → Router Y → Router Z
- The link between router Y and router Z goes down
- Before Y can share this information, it receives a route to Z from X (via Y) with some cost
- It re-advertises this route back to X with a cost + 1
- Since the route from X to Z is via Y, this in turn makes that route cost more → a vicious feedback loop as X and Y keep increasing the route cost to Z

RIP NOWADAYS

- Due to the issues and limitations that are associated with RIP, and distance-vector protocols in general, they are rarely seen nowdays
- Occasionally, still used in enterprise networks – they have the benefit of being simple and easy to set up
- That being said, RIPv2 (1993) and RIPng (Next Generation) show that RIP isn't completely out of date – support for CIDR addressing (v2) and IPv6 networking (ng)

RIP ON ROIDS

- Interior Gateway Routing Protocol (IGRP) is a proprietary version of RIP developed by Cisco, which overcomes a lot of the original limitations
- Much higher hop count (up to 255 hops, instead of 15)
- Allows multiple metrics to be used besides hop count (latency, congestion, actual $ cost, physical link distance, etc)
- No longer supported by most Cisco hardware, but eventually led to Enhanced Interior Gateway Routing Protocol (EIGRP), which we'll talk about next class – a hybrid between distance-vector and link-state

NEXT CLASS

- Next class, we'll look at link-state routing protocols, which are more commonly used today
- This includes OSPF and IS-IS

SO LONG, FOLKS!