International Journal of Information Technology and Knowledge Management
July-December 2012, Volume 5, No. 2, pp. 323-325

PATH EXPLORATION IN INTER-DOMAIN ROUTING USING ECHOLOCATION

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ABSTRACT: Internet has largely expanded in several ways. First, the number of ASes connected to the Internet has increased enormously. Second, the number of connections per AS to the network has also significantly augmented. Third, the number and diversity of the applications supported in the Internet have remarkably increased as well. This tendency has increased the demands on the scale of the network, and hence is placing significant pressure on the scalability and convergence of BGP. In the present work an algorithm based on echolocation is proposed for path exploration which is implemented using SCILAB -which is open source software.

Keywords: AS, ASes, SCILAB, BGP

1. INTRODUCTION

The current Internet is a decentralized collection of computer networks from all around the world. Each of these networks is typically known as a domain or an autonomous system (AS). An autonomous system is a network or group of networks under a common routing policy, and managed by a single authority. Today, the Internet is basically the interconnection of more than 20,000 autonomous systems. Every one of these autonomous system usually uses one or more interior gateway protocols (lOPs), such as Intermediate System to Intermediate System (IS-IS) or Open Shortest Path First (OSPF), to exchange routing information within the autonomous system it is known as intra-domain routing on the hand, Inter-domain routing focuses on the exchange of routes to allow the transmission of packets between different autonomous system.

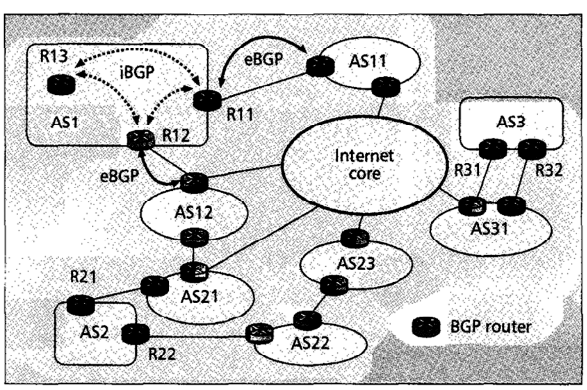

Figure 1: A Simplified Interdomain Scenario
(Extracted from [5])

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Figure 1 illustrates a simplified inter-domain scenario depicting the interconnection of several ASes. All the ASes represented in the figure have multiple connections to the network. This is a common practice nowadays, and it is mainly used for resilience and load balancing. When an AS is connected to multiple different ASes, it is referred to as a multi-homed AS. On the other hand, ASes connected to a single AS are known as single-homed ASes. All the ASes illustrated in Figure 1 are multi-homed except AS3. Even though AS3 is dually connected to the Internet, both connections are with the same AS (AS31).

2. TYPES OF AUTONOMOUS SYSTEMS

The Internet is thus composed of three different types of ASes:

- Single-homed stub ASes such as AS3 in Figure 1
- Multihomed stub ASes such as AS1 and AS2 in Figure 1
- Transit ASes, which can be classified into very large transit ASes making up what is usually referred to as the Internet core, and smaller-sized transit ASes such as AS11, AS12, AS21-AS23, and AS31 in Figure 1.

3. TYPES OF STUB AUTONOMOUS SYSTEMS

The two types of stub ASes crowd together mostly medium and large enterprise customers, content service providers (CSPs), and small network service providers (NSP5). These two groups correspond to the largest fraction of ASes present in the Internet. The third type includes most Internet service providers (ISP5) in the Internet.

4. HIERARCHICAL RELATIONSHIPS BETWEEN AUTONOMOUS SYSTEMS

In today's Internet, there is a hierarchy of transit ASes. This hierarchical structure is rooted in the two different types of relationships that could exist between ASes (i.e., customer-provider or peer-to-peer). Thus, for each transit AS any directly connected AS is either a customer or peer.

At the top of this hierarchy the largest ISPs, which are usually referred to as Tier-1 ISPs. There are about 20 Tier-1s at present [5], which represents less than 0.1 percent of the total number of ASes in the Internet [4]. These Tier-1s are directly interconnected in almost a full mesh and compose the Internet core. In the core all relationships between Tier-1s are peer-to-peer, so a Tier-1 is any ISP lacking an upstream provider.

The second level of the hierarchy is composed of Tier-2 ISPs. A Tier-2 is any transit AS that is a customer of one or more Tier-1 ISPs. A representative example of a Tier-2 ISP is the national service provider(NIXI-The National Internet Exchange of India). Tier-2 ISPs tend to establish peer-to-peer relationships with other neighbouring Tier-2s for both economical and performance reasons. This is typically the case for geographically close Tier-2 ISPs that exchange large amounts of traffic. There are also Tier-3 ISPs, which are those transit ASes in the hierarchy that are customers of one or more Tier-2 ISP, such as regional ISPs within a country.

Stub ASes are non-transit ASes that are customers of any ISP (Tier-1, Tier-2, or Tier-3). In Fig. 1 ISPs such as AS11, AS12, AS21, AS23, and AS31 would be classified as Tier-2 ISPs, while AS22 represents a Tier-3 ISP. An important outcome of this hierarchical structure is that the diameter of the Internet is very small in terms of AS hops.

In AS1 the reachability information R11 learns from AS11 is received over eBGP. This information is passed from R11 to the routers inside AS1(i.e., R12 and R13) so that they are able to reach the routes advertised by AS11. This exchange of reachability information between R11 and the internal routers in AS1 is done by means of iBGP. The same occurs for the external routes R12 learns from AS12.

For scalability reasons, BGP does not try to keep track of the entire Internet's topology. Instead, it only manages the end-to-end AS path of one route in the form of an ordered sequence of AS numbers. For this reason BGP is known as a path vector routing protocol, to reflect the fact that it is essentially a modified distance vector protocol. While a typical distance vector protocol like RIP chooses a route according to the least number of routers traversed (router hops), BGP generally chooses the route that traverses the least number of ASes (AS hops).The BGP process running in router R21 will typically choose to reach AS1 via the ASes AS21 and AS12. Thus, the AS path chosen by R21 is {AS21, AS12, AS1}.

5. BGP DECISION PROCESS

The term generally mentioned before is due to the fact that the AS path length is one of the steps of the BGP decision process, but not the only one. This decision process is used for route selection each time a BGP router has at least two different routes for the same destination. Thus, BGP routing is more complex than simply minimizing the number of AS hops. BGP routers have built-in features to override the AS hop count, and to tiebreak if two or more routes have the same AS path length. The sequence of steps in Figure 2 represents a simplified version of the BGP decision process.

Choose the route with the highest local preference (LOCAL_PREF).

1. If the LOCAL_PREFs are equal choose the route with the shortest AS-path
2. If the AS-path lengths are equal choose the route with the lowest MED
3. If the MEDs are equal prefer external routes over internal routes(eBGP over iBGP)
4. If the routes are still equal prefer the one with the lowest IGP metric to the next-hop router
5. If more than one route is still available run tie-breaking rules

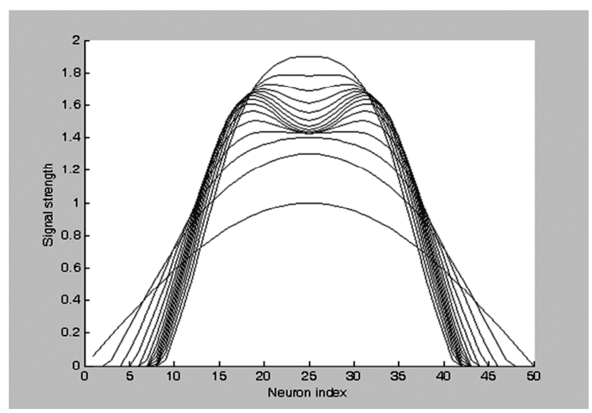

Figure 2: Signal Strength Vs. Neuron Index

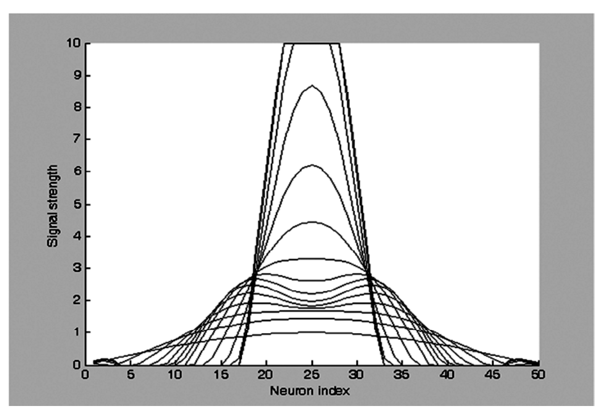

Figure 3: Signal Strength Vs. Neuron Index

Figure 2 A simplified version of the BGP route selection process

In this process each subsequent step is used to break ties when the routes being compared were equally good in the previous step. The local preference (LOCAL_PREF) in step 1 and the multi-exit discriminator (MED) in step 3 are two BGP attributes that are used by BGP routers for controlling how traffic flows from and into an AS, respectively.

6. ECHO ALGORITHM

The echo algorithms [6] consists of two phases or waves: A forward wave of explorer messages which spread through a net, and a backward wave of echo messages which is created if the explorer wave front hits the border of the net. The explorer wave travels from the initiator to the border of the distributed system and can be used to disseminate information, the echo wave travels from the border of system back to the initiator and can be used to collect information from the system. During the propagation of the first explorer wave, a spanning tree is constructed which consists of all the predecessor nodes stored in the parameter "pred" at each node. The echo wave travels back along this spanning tree to the initiator. If it reaches the initiator, the algorithm is terminated.

All nodes or processes are initiated with:

1. Initiator = false;
2. Engaged = false;
3. $N = 0$;

The parameter "Engaged" shows if the explorer wave has already visited the node, and the echo counter N contains the number of echoes the node has received. The initiator starts with :

1. Initiator = true;
2. Engaged = true;
3. Send Explorer-Msg to all Neighbors;

If a process receives a Message from process p it reacts like the following piece of code: Each node which is visited for the first time by an explorer message will propagate itself explorer messages to all its neighbors and waits for responses ("echoes") from the neighbours. If all neighbors have responded, the node sends itself an echo-message to its predecessor.

```
IF NOT Engaged THEN
 Engaged = TRUE;
 N = 0;
 Pred = p;
 Send Explorer-Msg to all Neighbors except p;
N = N + 1;
IF N == #Neighbors THEN
 Engaged = FALSE;
 IF NOT Initiator
  THEN Send Echo-Msg to Pred
  ELSE finished;
```

The **message extinction principle** says that if two explorer messages hit each other on a single link, then both extinguish each other. They are received, but have no effect, because both sender nodes are already marked as "engaged".

7. NUMERICAL SIMULATIONS OF ECHO ALGORITHM

Numerical Simulations are performed using the Echo Algorithm. We assume that a neuron receives a constant lateral excitation from 2L neighbours and a constant lateral inhibition is received from 2M neighbours. A SCILAB program is used to perform the simulations.

The width and the height of the maximum signal strength of any neuron is a function of the feedback factor.

Figure 4.3 indicates the simulation results obtained for 15 snapshots of neuron field updates with the feedback value of 1.0 Figure 4.4 indicates the simulation results obtained for 15 snapshots of neuron field updates with the feedback value of 1.5

8. CONCLUSION

The echolocation method is useful to find the shortest path in the inter-domain routing system. By slightly modifying the value of the feedback parameter we get different values of the signal strengths for the given neuron indices. The highest value of the signal strength indicates the shortest path between the two autonomous systems.

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