NBONE

Experimental Internet Simulation Environment

Abstract

The Internet is a global, worldwide network of networks, also known as the information superhighway. Each component network in this "network of networks" known as the Internet is called an Autonomous System (AS). Each major AS interconnects with another to maintain a global convergence of worldwide connectivity. The underlying protocol which distributes routing information across the AS interconnections is called the Border Gateway Protocol, or BGP.

BGP is a highly resilient protocol in distributing inter-AS routing information. The features of BGP and the underlying interior routing protocols such as OSPF and IS-IS provide tools for a network engineer to build a highly redundant and resilient network infrastructure, designed to withstand an outage or a force majeure event, such as an act of god, war, civil disorder or a major accident.

However, these potentials for high resiliency and redundancy offered by BGP are often misunderstood by many inexperienced network engineers. Even engineers with extensive knowledge in BGP protocol itself often get confused when it comes to the practical usage of BGP in inter-AS routing of the Internet. This is clearly outlined in some of the postings made to NANOG and equivalent forums during the recent controversial Level3-Cogent depeering event, where some posters were questioning the Internet's ability to withstand disasters when a dispute between two carriers disconnected thousands of networks worldwide.

The misunderstanding and delusions in practical use of BGP do not stop in posting by some individuals in public forums. The 6Bone project, which pioneered the global IPv6 development since its infancy, suffers from many network operators who simply do not understand the core inter-AS routing, thus practical use of BGP. This is often seen by certain 6Bone based IPv6 networks swapping full routing table to each other without any control of quality, thereby creating a widely known condition of "tunneling mess." Should such event ever occur in the production IPv4 Internet, the critical routing of information between thousands of users will be severely degraded.

NBONE Goals

The goal of the NBONE is to provide the most accurate simulation of the Inter-AS Internet routing for new and experienced network engineers to learn more about the practical usage of BGP in the real world environment. As such, because the NBONE platform aims to simulate the practical, real world usage of BGP, participants are expected to already have experienced the TCP/IP protocols, IP routing and dynamic routing protocols, most specifically, including BGP. NBONE will not provide any support relating to the understanding and troubleshooting of routing between the participant networks; as such basic knowledge should be already possessed by each participant prior to joining the community. Extensive study materials provided by Cisco Press and many publishers throughout major bookstores provide these basic set of knowledge at a significantly low cost.

Having stated the above, network engineers and researchers are welcomed to participate in the community to learn more about the practical usage of BGP, whether it is for fun or profit. It is also important to understand that NBONE will provide a very challenging environment for its participants in simulating the real world Internet, and almost no assistance for troubleshooting and lack-of-understanding will be given. Building upon this model of providing a challenging environment, because inter-AS routing at core of the Internet is pervasive, none

of the practical rules of BGP change whether one is using IPv4 or IPv6. Thus, IPv6 is the official protocol in use under the NBONE simulation environment. Everyone participating in NBONE's simulated Internet environment must use IPv6 protocol to interconnect and participate.

The NBONE Model

1. Definitions

Experimental Internet – The simulated Internet created solely between the participating NBONE members. Routes inside the Experimental Internet only provide connectivity between the participating NBONE members which have connected to the Experimental Internet world.

Commodity Internet – The commercial, real-world IPv6 Internet, operated between commercial backbone operators for production use.

Transit – A business or similar relationship where one party provides access to all of the routes in its routing table to another. Purchasing an upstream Internet bandwidth in real-world is a simple form of IP transit.

Peering – A business or similar relationship, bilaterally between two parties, where both agree to exchange their own internal and customer routes. This gives both parties access to their own network and downstream users (the "customers"), but not to the whole Internet.

> **Note:** It is important to understand that there is no official standard definition for tier levels of network carriers in the industry, such as the "Tier-1" terminology. The explanations given in this document are "widely accepted" definition by most network operators, however should not be construed as perfectly accurate or otherwise scientific.

Tier-1 Backbone – By definition, a Tier-1 backbone is a network which is transit-less, where it purchases or acquires no transit from any other party to maintain connectivity to rest of the world. Tier-1 backbones are typically largest backbones on the Internet, and all of the Tier-1s peer between each other to maintain connectivity. Note that despite the typical marketing materials, Tier-1s are not always the best providers in quality, and are sometimes susceptible to loss of connectivity during an event known as "depeering", since they do not have any transit service from another party.

Tier-2 Backbone – By definition, a Tier-2 backbone is a network which acquires transit from another party (such as a Tier-1 backbone), but also peers with other networks to reduce its reliance on transit provider routes. Largest Tier-2 backbones that are close to achieving Tier-1 status are also sometimes susceptible to loss of connectivity during a depeering event, as such networks only receive partial transit service to reach networks it does not peer with.

Tier-3 Backbone – By definition, a Tier-3 backbone is a network which relies on transit providers to reach the world, such as small ISP or an end-user network. To increase redundancy not only during a circuit or connection outage, but also during a depeering event by largest networks, Tier-3s often become multihomed, by acquiring transit from more than one carrier.

Commercial Internet Gateway Network (IGN) – IGNs are networks in the experimental internet, which provides commodity internet transit service to the NBONE community. The IGNs act as the official form of border between the experimental internet operated by NBONE and the commodity internet. Having this border cleanly separates the experimental activities away from the production real world for obvious safety reasons.

Private Network Interconnect (PNI) – A private connection built by bilateral parties for the purpose of peering and thereby exchanging customer/internal traffic.

Internet Exchange Point (IXP) – A Layer-2 apparatus, such as an Ethernet switch which provides a single broadcast domain between the participant networks to permit cost-efficient peering. Traditionally, peering is conducted using private connections (i.e. PNI, private tunnel) installed under expense and time of both parties. Thus, when a network peers with 10 different networks, it must build separate interconnects for each and every network which it peers with. However, by connecting to an IXP, the network only needs to run a single circuit to the IXP to peer with other participants of the exchange, over a publicly shared infrastructure.

NBIX (also known as NBONE-IX) – An Internet Exchange Point in NBONE, which permits peering between its participating members over a publicly shared Layer-2 broadcast domain.

2. NBONE Connection Procedure

Each new participant is assigned an AS number (ASN) that is unique within the experimental internet. The ASN will be assigned from a pool of private ranges, which is between AS64512 and AS65535, as defined by IETF for the purpose of private and limited utilization of BGP.

NBONE will also allocate a /48 IPv6 address space to the participant, so that it can be used to address participant's network infrastructure and its end-users (aka, customers). These /48 allocations are made from a public IPv6 addressing pool, not a private range such as RFC1918 for IPv4 Internet.

The NBONE community itself does not provide commodity internet transit, thus by default, the participant will not gain access to the real world IPv6 internet. However, the participant may ask, on a bilateral basis, any of the Commercial Internet Gateway Networks (IGNs) for commodity internet transit. However, provisioning of commodity internet transit is governed individually by each IGN and NBONE community has no binding authority in each IGN's decision to serve the user. But the NBONE community will regularly elect new IGN's to the community, in order to provide more equitable options to every participant in acquiring commodity internet transit service.

3. NBONE Hierarchy and General Apparatus

Having joined NBONE community, the participant will need to decide connecting with another participant AS. The participant may setup peering with another participant AS over a private tunnel, a PNI or through the NBIX exchange point. However, peering is governed bilaterally between the two parties, and any participant network may reject peering application at their sole will. Additionally, once peering is established, both parties will be able to reach each other's network only. Only end-user/customer and internal routes are exchanged over peering.

For this reason, a participant may wish to acquire experimental internet transit from any NBONE networks that maintain full connectivity to rest of the experimental internet. Having acquired transit, the user effectively becomes a downstream "customer" of the provider AS that is providing the transit service.

When a user's network becomes larger as time passes, the user may wish to peer with more NBONE networks to reduce its reliance on experimental internet transit providers, thus becoming a Tier-2 experimental backbone. However, while the user may be able to easily acquire peering with another NBONE network of similar size, largest NBONE networks may refuse to peer simply because they are Tier-1 experimental backbones, and already reach the user's network through an existing peering partner. The user may then wish to connect more people to its network, and provide transit to new set of downstream networks, and also expand its network coverage to cover more user-base. These activities typically increase the significance of user's network, increasing its chance of acquiring peering with Tier-1

experimental backbones. Other creative activities are available for the participant to implement, as these events regularly happen across the real world internet's IP carrier industries.

4. NBIX Experimental Internet Exchange

NBIX IXPs will be operated in Ashburn, VA in United States (node code: ASH) and London in United Kingdom (node code: LON). NBIX IXPs simulate a real world distributed internet exchange, and permit exchange participants to join the layer-2 domain through use of MPLS VPN tunnels (Martini) and OpenVPN tunnels (open-source for Linux and *BSD). However, to ensure better quality in routing, prospective participants joining NBIX must maintain less than or equal to 50 miliseconds round-trip latency from the NBIX tunneling end-point. Users who are unfortunate to have greater latency from NBIX exchange should acquire experimental internet transit from a larger network which maintains coverage in user's country or a nearby area. More NBIX IXPs will be established in additional locations later as demand rises.

Native interconnects to NBIX are also available on case-by-case basis for serious experimental internet operators only.

5. NBONE Regulations and Policy Framework

The general regulations and policies will be applied to all participants of the NBONE community and every participant must abide to these policies.

At this point in time, these policies are being ratified by the NBONE Steering Committee; however there is one common sense rule that should immediately apply to everyone participating in NBONE, below.

"All participants in NBONE should NEVER conduct BGP to reach commodity internet from any network that is not approved to operate as an IGN. This is to ensure that commercial real world internet is completely oblivious and never affected by the activities happening within the borders of experimental internet. Failure to abide to this policy shall result in termination from NBONE community."

Funding and Schedule

NBONE will be an OCCAID funded program for educational and scientific purposes. The ratification of NBONE policy framework and election of its Steering Committee is scheduled to occur in January of 2006. After completion of framework and election, the Steering Committee will discuss with the OCCAID Program Committee regarding acquisition of funding and sponsorship opportunities to kick-off the project.

NBONE is planned to go online for public service in spring of 2006.