ADDRESSING ROUTING SCALABILITY OF FLOATING CLOUD INTERNETWORKING MODEL BY USING TIER BASED AGGREGATION

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Abstract: Scalability in inter-domain routing is becoming stressful as routing table sizes grow at very high rates. In this paper, we present a tiered addressing scheme to be implemented over a Floating Cloud Tiered internetworking model which uses tier based aggregation to address routing scalability.

Keywords: Internetworking model, Tiered architecture, Scalable inter-domain routing, tiered addressing scheme.

1 INTRODUCTION

The current Internet architecture has exhibited a remarkable capability for evolution and growth. However, this architecture was based on design decisions made in the 1970's resulting in the TCP/IP protocol suite which was intended to handle relatively fewer networks as compared to the huge networked system it is currently supporting. One attempt to accommodate for the increase in the number of computing devices that connect to the Internet resulted in the decisions to develop IPv6 and provide a transition path from IPv4 to IPv6. This may not solve the routing scalability problem faced by the current Internet routing protocols which has been of increasing concern over the last few decades, as the routing table sizes in the core routers experienced very high growth rates [1]. Over these years as the problem escalated, several research efforts have been directed to address the serious scalability issues. However these research efforts were constrained by the fact that they had to operate in the existing highly meshed internetwork architecture, the Internet Protocol, its logical addresses and its forwarding and routing mechanisms. The research outcomes thus resulted in incremental and point solutions which introduced new vulnerabilities in some cases in the evolving Internet [2].

The underlying premise of our solution is that the logical IP addresses and the address assignment process adopted in the Internet are mainly the reasons for the routing scalability problem. We need a flexible addressing scheme that is amenable to growth and provides better aggregation capabilities than that offered by IPv4 or IPv6. The fact that address aggregation is a key solution is vetted by interim solutions such as Classless Inter-Domain Routing and the hierarchical and geographical aggregation recommended in IPv6. Besides basing our solution on the above premise, our project followed the clean slate Future Internet Design (FIND) [3] initiatives by National Science Foundation (NSF) and hence the solution was designed with a greater degree of freedom in terms of consideration given to the current internetwork architecture and the Internet protocol. The Floating Cloud Tiered (FCT) internetwork model which is the outcome of this project is different from any prior work in this area as for the first time the tiered ISP topological structure is being leveraged to distribute the routing load across the routing domains and thus solve the routing scalability problem. This approach uses a tiered addressing scheme and a new and very efficient form of tier based address aggregation is now possible.

2 BACKGROUND AND RELATED WORK

In the Internet, the route discovery process is essential to establish communication links and maintain information flow between devices and networks. The discovery process uses the IP addresses as the location identifier. However, the process becomes difficult because the IP address is a logical address that is allocated dynamically to a node and does not have any relation to the actual location of the node. Further, the route itself is a path through a huge mesh of networks. In the event of failure of a network or device that connects networks, the connectivity information for thousands of networks and networked devices can be impacted which in turn may cause very long network convergence delays. The complex IP address allocation and the highly meshed topology has resulted in the huge routing table sizes leading to routing scalability problems. BGP routing table size at the core routers today have exceeded 304,500 entries [6]. This high load in the core routers is indicative of an imbalance in the 'routing information handling', which could adversely impact the advantages of the meshed structure, by making the routers a potential bottleneck. Management of IPv6 address space has been discussed in Internet Assigned Number Authority (IANA) and Regional Internet Registries (RIRs). It has been recommended that IPv6 address allocation should be done in a hierarchical manner to avoid fragmentation of address space and to better aggregate routing information.

However, at the same time, the IPv6 policy tries to avoid unnecessary and wasteful allocation[5]. It is difficult to achieve both fragmentation avoidance and wasteful address allocation at the same time because future address requirements from organizations and end sites are unpredictable [5].We will now look at some of the solutions that were proposed to address the routing scalability problem under the current Internet architecture. Hybrid Links State Protocol (HLP) used the AS structures to provide a solution to excessive route churning through route information aggregation within an AS hierarchy [7].

The New Intern-Domain Routing Architecture (NIRA) used a provider-rooted hierarchy and showed improvements in the number of forwarding entries and convergence times [8]. A routing research group at the Internet Engineering Task Force proposed 'coreedge separation' to temporarily solve the routing table size problem by 'address indirection' or 'Map-and-Encap' which keep the de-aggregated IP prefixes out of the global routing table [9]. Routing Architecture for Next Generation Internet uses locator/ identifier split ideas [10]. Routing on Flat Labels uses flat routing to separate location and identity for both inter and intra-domain routing [11]. Enhanced Mobility and Multi-homing Supporting Identifier Locator Split Architecture is a hybrid design of ID/locator split and core-edge separation [12].

3 THE FLOATING CLOUD TIERED INTERNETWORK MODEL

The Internet is comprised of more than 30,000 ASes and ISPs that operate the major flow of Internet communication and the current IP traffic represents in a way their business relationships. In general, ASes have either a customer-provider or a peer-to peer relationship with neighboring ASes. A customer pays its provider for transit and peers provide connectivity between their respective neighbor ASes. Based on the AS relationships, the tiered structure and the hierarchy in the AS topology becomes obvious when looking at the Internet.

In the US, there are several tier 1 ISPs, who connect several tier 2 ISPs, as their customers, and the tier 2 ISPs connect the tier 3 ISPs as their customers. Inside of an ISP, there are several Point of Presence (POPs) which form the backbone of that service provider. Each POP has several routers, some of which are backbone routers that are primarily meant to connect to other backbone routers in other POPs.

An interesting observation to be made at this point is the tiered structure that is also noticeable inside of an ISP POP. Inside an ISP POP there is a set of backbone routers that can be associated tier 1 within the POP. The BB routers connect to the distribution routers (DR), that can be associate at tier 2. The DRs provide redundancy and load-balancing between backbone and connect access routers (AR) that connect to customer or stub networks. The ARs and the stub network can thus be associated to tier 3. Note that each set of routers identified above is considered as a *network cloud*. Thus, in the FCT

Internetwork model, we define a network cloud as a set of routers that have a specific purpose. A cloud can also have several clouds within itself, such as the ISP cloud can have POP clouds. Thus the tiered internetwork model exhibits some very interesting ‘nesting’ and modularity properties.

3.1 Inter-cloud Communications

In Fig. 1, we show a simplified version of an ISP topological structure. ISPs A and B are tier 1 ISPs, while ISP C is a tier 2 ISP and ISP E is a tier 3 ISP. In the figure, we also show stub AS D. Note that each ISP or AS is presented as a network cloud. The broad arrows are indicative of multiple connections between any two ISPs or between ISPs and the AS. We use the ‘relative position’ among the ISP clouds across the tiers to introduce structured packet forwarding.

To achieve this, we associate a ‘tiered cloud address’ (CloudAddr) with each ISP or AS cloud, which will serve as an identifier for the cloud. Clouds can associate or disassociate from a tier via the acquisition or release of one or more CloudAddrs. A CloudAddr is thus a function of its tier, and the other clouds associated with it. For instance, ISP C has two addresses, address 2.1:1 based on its connection to ISP A and address 2.2:1 based on its connection to ISP B. This property allows a cloud to have more than one CloudAddr to be used for multi homing.

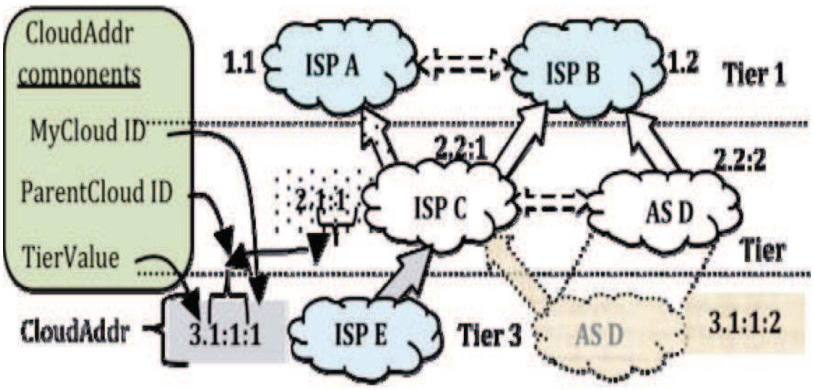

Fig 1: The Concept of Floating Clouds across Tiers

As noted in Fig. 1, the FCT model allows clouds to change their service providers by simply giving up one CloudAddr and acquiring another. Let us illustrate the movement with a further example. Assume AS D is first connected to ISP B with the address of 2.2:2 and then it desired to change its service provider to ISP C. It can then relinquish address 2.2:2 and acquire an address of 3.1:1:2 under ISP C. What changes is however, only the CloudAddr, and not the internal addressing of the cloud which will be explained in detail later. During the change in AS D's service provider and CloudAddr, ISP B and ISP C will both be informed of the change. However, the movement or address change is not required to be disseminated to all clouds in the network, as only those that are directly related to the moving cloud need to be informed. The TierValue, the first field in the CloudAddr is used to forward the packets across clouds. The decision to forward in a particular direction, up, down or sideways across the tiers, depends on the relative positions of the source (SRC) and destination (DST) clouds in the tier structure and the links between sibling clouds in a tier. To illustrate packet forwarding, we use another simple example from Fig. 1. Assuming the SRC cloud is 3.1:1:1 and DST cloud is 2.2:2. The source compares the two addresses to determine the tier of a common parent (or grandparent) cloud for the SRC and DST.

In this case, it will be tier '1' as there are no common address components after the TierValue, in the SRC and DST CloudAddrs. The remaining fields in the DST address (after the common part) are then appended to the TierValue to provide the forwarding address; in this case it will be 1.2:2. All intermediate clouds between 3.1:1:1 and 1.2 will forward the packet upwards, using the tier value until it reaches cloud 1.2. Cloud 1.2 then identifies that the destination is at tier 2 because of the two address fields following the tier value. Thus, it replaces the Tier Value with 2 and forwards the packet down to the DST cloud. However, if there were a link between ISP C and AS D (as shown by the dashed arrows), the border routers in ISP C could be made aware of the sibling cloud connection and then ISP C could forward the packet directly to the cloud 2.2:2. Packets will be forwarded to the

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appropriate cloud based on their CloudAddr, which has global visibility. The forwarding and routing within the cloud can adopt either the tiered approach, or any other mechanism such as OSPF and RIP based on IP (which could be useful during transition too). We thus decouple the inter- and intracloud dynamics, such that a change in CloudAddr will not impact the internal structure or addresses within a cloud. This decoupling will allow for easy movement (or floating) of network clouds across tiers.

4 THE NESTING CONCEPT

We use the AT&T topology to explain nesting with the tiered addresses. Let us assume that ISP A in Fig. 1 represents the AT&T cloud in the US. As part of our initial study, we abstracted the AT&T topology from the Rocketfuel database [15] using the Cytoscape tool [16]. We implemented the cloud concept on the AT&T topology using the following assumptions. Through the IP address information obtained from the Rocketfuel database, we identified routers that connect across POPs in the AT&T topology. These routers were designated as the backbone routers. The set of backbone routers belonging to a POP were then assigned to a 'backbone network cloud' (see Fig. 2). We then considered the edge routers to be access routers belonging to an 'access network cloud'. Routers that connected backbone and edge routers were the 'distribution routers' and each set of distribution routers connecting to a backbone router, was considered as a 'distribution network cloud'.

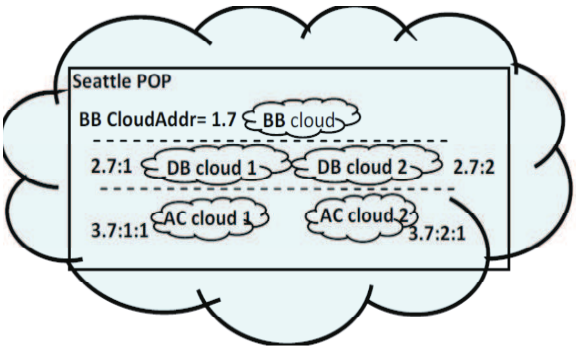

Fig 2: Tiered Addresses in an ISP POP; BB=Backbone,DB=Distribution,AC=Access

For the implementation of the tiered addresses, it is essential to have a delimeter field that identifies the boundaries of addresses is a given tier. For this purpose, we introduced a 2 bit type field before each of the MyCloudID. As per the preliminary studies based on the type field, the MyCloudID can be 4, 8 or 12 bits long. The pie chart. Due to the flexibility in address sizes, less than 1 percent of addresses would exceed 32 bits and 83.93% of addresses would be less than or equal to 28 bits. Moreover, current IPv4 and IPv6 based routers requires a different address on each of its routing interfaces. In contrast, the tiered address will use only one address per router similar to Network Service Access Point (NSAP) addresses in Intermediate System to Intermediate System (ISIS).

5. CONCLUSION

This paper introduced a new tiered addressing scheme which was invented to work with a new internetworking communications model based on the tiers in the ISP topological structures called the Floating Cloud Tiered internetworking model. The main goal was to address routing scalability and support for future growth in an unrestricted manner, whether it is in terms of address space or networks. We introduced a novel property of the tiered addresses in the form of 'nesting' and have explained its recursive use.

6. REFERENCES

1 Internet Usage Statistics, http://www.internetworldstats.com/stats.htm (retrieved on July 13, 2010)

2. Anderson, T., Blumenthal, D., Casey, D., Clark, D., Estrin, D.: GENI: Global environment for network innovations, Version 4.5 (April 23, 2007)

3. NSF NeTS Future Internet Design Initiative, http://www.nets-find.net

4. Grubesic, T.H., O'Kelly, M.E., Murray, A.T.: A Geographic Perspective on Commercial Internet Survivability. Telematics and Informatics (2002)

5. ARIN, Number Resource Polivy Manual (NRPM), Version 2010.1 (April 2010), http://www.arin.net/policy/

6. Oppenheimer, P.: Top-down Network Design. Cisco Press, Lebanon (1999)

7. Subramanian, L., Caesar, M., Ee, C.T., Handley, M., Mao, M., Shenker, S., Stoica, I.: HLP: A next generation inter-domain routing protocol. In: Proceedings of ACM SIGCOMM, pp. 13–24 (2005).

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