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On characterizing BGP routing table growth

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Abstract

The sizes of the BGP routing tables have increased by an order of magnitude over the last six years. This dramatic growth of the routing table can decrease the packet forwarding speed and demand more router memory space. In this paper, we explore the extent that various factors contribute to the routing table size and characterize the growth of each contribution. We begin with measurement study using routing tables of Oregon Route Views server to determine the contributions of multi-homing, load balancing, address fragmentation, and failure to aggregate to routing table size. We find that the contribution of address fragmentation is the greatest and is three times that of multi-homing or load balancing. The contribution of failure to aggregate is the least. Although multi-homing and load balancing contribute less to routing table size than address fragmentation does, we observe that the contribution of multi-homing and that of load balancing grow faster than the routing table does and that the load balancing has surpassed multi-homing becoming the fastest growing contributor. Moreover, we find that both load balancing and multi-homing contribute to routing table growth by introducing more prefixes of length greater than 17 but less than 25, which is the fastest growing class of prefixes. Next, we compare the growth of the routing table to the expanding of IP addresses that can be routed and conclude that the growth of routable IP addresses is much slower than that of routing table size. Last, we demonstrate that our findings based on the view derived from the Oregon server are accurate through evaluation using additional 15 routing tables collected from different locations in the Internet.

Keywords: Internet routing; BGP

1. Introduction

The Internet has experienced explosive growth since its commercialization. The Internet is divided into thousands of autonomous systems (ASes), each of which consists of networks of hosts or routers administrated by a single organization. Hosts and routers are identified with 32-bit IP addresses. To ensure the scalability of the Internet routing infrastructure, IP addresses are aggregated into contiguous blocks, called *prefixes* that consist of 32-bit IP address and mask lengths (e.g., 1.2.3.0/24 represents IP block 1.2.3.0–1.2.3.255). Routers exchange reachability information for each prefix using the Border Gateway Protocol (BGP). As a consequence, each BGP routing table entry contains reachability information for a single prefix.

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The size of a BGP routing table, i.e., the number of prefixes contained in the routing table, has risen from 10,000 to 100,000 over the past six years [1,2]. This dramatic growth of the routing table can decrease the packet forwarding speed and demand more router memory space.

The introduction of Classless Inter-domain Routing (CIDR) [3] reduces the routing table size by enabling more aggressive *route aggregation* in which a single prefix is used to announce the routes to multiple prefixes. Route aggregation, however, might not always be performed. First, an AS can aggregate its prefix with its provider's only when the AS is *single-homed*, i.e., the AS has only one provider. For a *multi-homed* AS, which has multiple providers, its prefix(es) cannot be aggregated by all of its providers. Second, an AS may have to announce several prefixes. One reason is *address fragmentation* due to the fact that a set of prefixes originated by the same AS cannot be summarized by one prefix. Another reason is *load balancing* where an AS originates several prefixes so as to perform load balancing by announcing different prefixes via different AS paths. The last reason is that an AS may *fail to aggregate* aggregatable prefixes.

We explore the contribution of multi-homing, failure to aggregate, load balancing, and address fragmentation to routing table size. We examine the BGP routing tables of the Oregon route server [4], and present techniques to quantify and perform measurement study on these factors. We find that multi-homing introduces around 20–30% extra prefixes and load balancing introduces around 20–25% extra prefixes. However, multi-homing and load balancing are necessary trends and cannot be eliminated. This leads us to consider contribution of failure-to-aggregate and find that failure-to-aggregate increases the routing table size by only 15–20%. Finally, we explore the extent that address fragmentation contributes to the routing table size and find that address fragmentation contributes to more than 75% of routing table size. Clearly, address fragmentation contributes to the routing table size the most.

Besides identifying and quantifying each contributor, we also compare the growth rate of each contributor to that of the routing table. Our results show that, although the routing table entries contributed by multi-homing and load balancing are not as significant as that contributed by address fragmentation, both the contribution of multi-homing and the contribution of load balancing grow faster than the routing table size does whereas the routing table entries contributed by address fragmentation grow slower than the routing table size does. Moreover, load balancing has surpassed multi-homing, becoming the fastest growing contributor. Our further measurement study suggests that both load balancing and multi-homing contribute to the routing table growth by introducing more prefixes of length greater than 17 but less than 25, which is the fastest growing class of prefixes.

The demand of routing more IP address can contribute to routing table growth as well. As we evaluate the contribution of the increase on routable IP addresses to routing table growth, we find that, over the last four years, the size of the routing table has increased by more than 100% whereas address space covered by the routing table has expanded by only 25%. This suggests that the major contributor of the routing table growth is not the increase on routable IP addresses.

We choose to use routing tables of the Oregon route server because the Oregon route server archives routing tables over a longer period of time than any other route servers do. This is necessary to our study on the trend of routing table growth. Although Oregon route server peers with many ISPs and collects routing information from these routers, it only provides a partial view of the Internet. In order to evaluate our findings based on the partial view, we investigate how routing tables collected from 15 other route servers may affect our findings and conclude that the additional routing tables do not change our results drawn from Oregon routing tables much.

Our paper makes several contributions. First, it identifies various factors contributing to routing table size. Second, it quantifies the contribution of each factor through the measurement study using the routing table of the Oregon route server. Third, it demonstrates how each contribution changes over time. Fourth, it relates the contributors to the growth of prefix of different mask lengths. Last, it evaluates the effect of incomplete view derived from the Oregon routing table on the findings by including additional routing tables of 15 route servers residing at different locations in the Internet.

Our work differs from the important work of Huston [2] on analyzing BGP routing tables in two ways. First, we not only demonstrate the growth of the routing table, but also identify and quantify various contributors to the growth. Second, we use the routing tables obtained from the Oregon server that collects route announcements from many ISPs. In addition, we evaluate our findings using additional routing tables obtained from other 15 route servers. Studies by Broido et al. [5], developing framework for analyzing BGP connectivity, have a different goal from ours. Bates [6] and Mccreary [7] have plotted the routing table growth using routing tables collected from different locations in the Internet. However, none of them characterizes the contributors to the growth.

The remainder of the paper is structured as follows. Section 2 presents the background on the Internet routing. In Section 3, we identify and quantify various factors that contribute to the routing table growth. Section 4 evaluates the completeness of the views of the Oregon Route View server for the purpose of our studies. We conclude the paper in Section 5 with a summary.

2. Internet routing

In this section, we first describe the Internet architecture. We then present how IP addresses are allocated and route aggregations are performed to ensure the scalability of the Internet routing architecture. We finally describe the content of BGP routing tables.

(a) *Internet architecture:* The Internet is divided into thousands of autonomous systems (AS). An AS has its own routers and routing policies, and connects to other ASes to exchange traffic with remote hosts. A router typically has very detailed knowledge of the topology within its AS, and limited reachability information about other ASes. ASes interconnect at dedicated point-to-point links or public Internet exchange points (IXPs) such as MAE-EAST or MAE-WEST. Public exchange points typically consist of a shared medium, such as a Gigabit Ethernet or an ATM switch, that interconnects routers from several different ASes. Physical connectivity at the IXP does not necessarily imply that every pair of ASes exchanges traffic with every other.

The relationships between ASes arise from contracts that define the pricing model and the exchange of traffic between two ASes [8]. In a customer-provider relationship, the customer is typically a smaller AS that pays a larger AS for access to the rest of the Internet. The provider may, in turn, be a customer of an even larger AS. In a peering relationship, the two peers are typically of comparable sizes and find it mutually advantageous to exchange traffic between their respective customers. We denote by $\text{Provider}(u)$ the set of AS u's providers. and $|\text{Provider}(u)|$ is the number of direct providers of AS u. Throughout this paper, we use the AS relationships derived from the inference algorithm in [9].

(b) *Route aggregation:* An AS employs an *inter-domain* routing protocol, e.g., BGP, to advertise the reachability of prefixes to neighboring ASes. The scalability of the Internet routing infrastructure depends on *route aggregation*, i.e., the aggregation of prefixes. We use $\text{addr}(p)$ and $\text{len}(p)$ to denote the *IP address* and the *mask length* of prefix p respectively. In addition, we denote by $\text{Prefix}(u)$ the set of prefixes originated by AS u. An AS performs route aggregation by using the minimum number of prefixes to summarize all of its IP addresses. A set of prefixes are *aggregatable iff* the union of IP blocks represented by the set of prefixes can be summarized by one prefix.

Route aggregation, however, cannot be performed all the time. First, an AS may not be able to aggregate its prefixes with its provider's. One reason that an AS does not aggregate with its provider is multi-homing. An AS is *multi-homed* if it has multiple providers to ensure connectivity even under the failure of some providers. That is, AS u is *multi-homed* iff $|\text{Provider}(u)| > 1$. Note that we do not classify an AS that is multi-homed to a single provider as a multi-homed AS in this paper. A multi-homed AS gets its address blocks from either some or all of its providers, or the

Routing Registry directly. In any case, a multi-homed AS cannot aggregate its prefix(es) with those of its providers'. Second, prefixes originated by the same AS might not be aggregated. One reason is due to the desire to perform load balancing. In order to balance the traffic coming into a multi-homed AS, the AS originates several prefixes and announces them via different paths. For example, suppose that an AS originates prefix 1.2.2.0/23 and has two providers. To load balance incoming traffic, the AS announces prefix 1.2.2.0/24 to Provider 1 and prefix 1.2.3.0/24 to Provider 2. In addition, the AS announces prefix 1.2.2.0/23 to both providers to ensure that all addresses are reachable in the case that one provider link fails. In this case, although prefixes 1.2.2.0/23, 1.2.2.0/24, and 1.2.3.0/24 can be aggregated into a single prefix, all of them are announced since the AS needs to announce them in different ways. An AS may also fail to aggregate due to the artifact of pre-CIDR practice, where only 8, 16 or 24 bit prefixes are announced, fails to aggregate. For example, an AS might originate prefixes 1.2.0.0/16 and 1.3.0.0/16 and announce them identically to others. Another reason that an AS originates several prefixes is address fragmentation where non-aggregatable IP blocks prevent an AS from performing route aggregation for routes originated by it. For example, an ISP might expand to have more customers and thus have insufficient IP addresses. The ISP has to request additional IP address blocks which might not be aggregatable with its previously acquired IP address block.

(c) *Routing tables:* Each BGP-speaking router maintains a *BGP routing table*, which stores routes received from its neighbors. There is one entry for each destination prefix, which contains a set of candidate routes to reach the prefix. Formally, let $\mathrm{RouteEntry}_u(p)$ denote the set of routes for prefix p announced to AS u. An AS path is an ordered sequence of ASes that must be traversed in order to reach the destination prefix. We show a router's BGP routing table entries for destination prefix 4.2.24.0/21 below. The AS has five candidate routes to 4.2.24.0/21: AS path (1740 1) via next_hop 134.24.127.3, AS path (5459 5413 1) via next_hop 194.68.130.254, etc. Note that the third candidate route has AS path (1849 702 702 701 1), where AS 702 appears twice consecutively. This is due to AS prepending; AS 702 prepends its AS number twice before exporting to AS 1849 so as to discourage AS 1849 to use it to reach prefix 4.2.24.0/21 by inflating the AS path length.

Network	Next Hop	Path
*> i4.2.24.0/21	134.24.127.3	0 1740 1 i
*	194.68.130.254	0 5459 5413 1 i
*	158.43.133.48	0 1849 702 702 701 1 i
*	193.0.0.242	0 3333 286 1 i
*	144.228.240.93	0 1239 1 i

The size of the routing table is the number of entries in the table. Since each routing table entry represents a single prefix, the routing table size is the number of prefixes appearing in the routing table. Therefore, the extent that route aggregations are performed directly affects the routing table size.

3. Measuring BGP routing table growth

In Section 2, we described Internet architecture and various contributors to the BGP routing table size. We begin this section with quantifying the contribution of each factor. In particular, we investigate to what extent the routing table has inflated due to multi-homing, failure to aggregate, load balancing and address fragmentation. We then relate these contributors to the growth of prefixes at different mask lengths. Last, we demonstrate that the demand on routing more IP addresses does not contribute much to the growth of routing table.

The study of routing table growth needs many routing tables over a period of time. The Oregon route servers and the Ripe route server [10] are the only two sites that have archived routing tables publicly available. The Oregon route server started to collect routing table from November 1997 whereas the Ripe route server started from September 1999. We choose to use routing tables of the Oregon route server in this section not only because it has routing tables over a longer period but it also peers with more ISPs. By the end of year 2001, the Oregon peered with up to 57 ASs. We analyze a total of 51 routing tables starting at November, 1997 and ending at March 2002, spanning over more than four years. The top curve in Fig. 1 plots the growth of routing table size (number of prefixes) during this period. We observe that the size of routing table has doubled over the last four years. Moreover, We also observe that the growth slows down during the last six months due to the fact that ISPs have started to react by adopting some short term solutions. However, long term solutions to the problem need a better understanding of various contributors to the growth.

There are also a few commercial ISPs (Internet Service Provider) that allow public access to their route servers providing full BGP table dumps. However, they do not keep historical routing tables needed for routing table growth study. In the next section, we will use the routing tables from these route servers to evaluate the completeness of the view derived from Oregon routing tables.

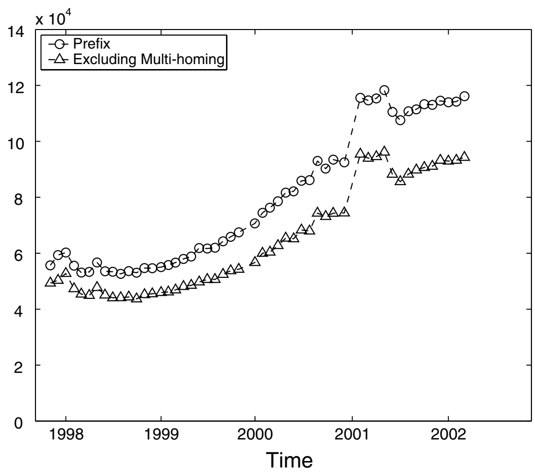

Fig. 1. Contribution of multi-homing to routing table size.

3.1. Quantifying contributions to BGP routing table growth

We first describe our technique on quantifying the contributions to BGP routing table's growth in this section. We then report the results as we apply the techniques to the routing tables of the Oregon route server.

(a) *Multi-homing:* Many ASes connect to more than one provider for the purpose of fault tolerance. Multi-homing may create "holes" in the routing table. A hole is an address block that is contained in another announced address block but is announced separately. If a multi-homed AS originates a prefix, p, that is contained in a prefix announced from one of its providers, then p has to be announced to the Internet by one of the multi-homed AS' providers for the purpose of fault tolerance as explained in Section 2. On the other hand, if an AS is single-homed, it is not necessary that the AS announces the prefix beyond its providers. Therefore, we can evaluate the extent that multi-homing contributes to the routing table size by identifying *multi-homed prefixes*, i.e., prefixes that are originated by a multi-homed AS and contained in the prefixes originated by one of its providers. Formally, prefix p_1 contains prefix p_2 iff $\mathrm{len}(p_2) > \mathrm{len}(p_1)$ and $\mathrm{addr}(p_2)/2^{32-\mathrm{len}(p_1)} = \mathrm{addr}(p_1)/2^{32-\mathrm{len}(p_1)}$. Prefix p is a multi-homed prefix if and only if $p \in \mathrm{Prefix}(u)$, u is a multi-homed AS, and $\exists$ prefix q, AS v such that $q \in \mathrm{Prefix}(v)$ and $v \in \mathrm{Provider}(u)$ and q contains p. Fig. 1 plots the total number of prefixes and the number of prefixes that are not multi-homed prefixes over the last four years. The difference suggests that the number of multi-homed prefixes is on the rise and multi-homing introduces approximately 20–30% more prefixes.

(b) *Failure to aggregate:* In order to understand to what extent that failure to aggregate contributes to the routing table size, we aggregate all aggregatable prefixes that are originated by the same AS and are announced identically. First, we classify prefixes into prefix clusters, in each of which prefixes are originated by the same AS and announced identically. Formally, a *prefix cluster* is a maximal set of prefixes whose routing table entries are the same in every BGP routing table in the Internet.

In this section, we approximate a prefix cluster by a maximal set of prefixes whose routing table entries are the same in the Oregon route server's routing table. That is, two prefixes, p_1 and p_2, belong to the same prefix cluster if and only if $\text{RouteEntry}_v \times (p_1) = \text{RouteEntry}_v(p_2)$ for Oregon route server v. In the next section, we will show that the classification of prefix clusters does not change much after we include routing tables of other 15 routing servers. Second, we perform aggregation for prefixes from the same prefix cluster iteratively as follows. Initially, we remove all prefixes that are contained in another prefix. That is, all prefixes contained in a prefix, p, are aggregated by prefix p. In each iteration, we first sort all prefixes in an increasing order on their addresses. We then aggregate each pair of consecutive prefixes that are aggregatable. A pair of consecutive prefixes, p_1 and p_2, are aggregatable if and only if $\text{len}(p_1) = \text{len}(p_2)$, $\text{addr}(p_1)/2^{32-\text{len}(p_1)} + 1 = \text{addr}(p_2)/2^{32-\text{len}(p_2)}$, and $\text{addr}(p_1)\%2^{33-\text{len}(p_1)} = 0$. The aggregated prefix has the address of p_1 and the length of $p_1 - 1$. We repeat the iteration until no aggregation can be performed. The total number of prefixes after the aggregation is the number of prefixes excluding those are introduced by failure to aggregate. The number of prefixes and the number of prefixes excluding those that are introduced by failure to aggregate are plotted in Fig. 2. We observe that approximately 15–20% prefixes could be aggregated beyond what network operators have done.

(c) *Load balancing:* Another reason that route aggregation cannot be performed for prefixes originated by the same AS is load balancing where a set of aggregatable prefixes cannot be aggregated since they are announced differently. To quantify the effect of load balancing on the routing table size, we first compute the number of prefixes resulting from aggregating all aggregatable prefixes originated by the same AS independent of whether those prefixes are announced identically or not. The prefixes after the aggregation exclude the contribution of both failure to aggregate and load balancing. We compare the total number of prefixes after the aggregation with the number of prefixes excluding those introduced by failure to aggregate in Fig. 2. The difference between the two numbers quantifies the contribution of load balancing to routing table size. We observe from Fig. 2 that load balancing introducing an additional 20–25% more prefixes.

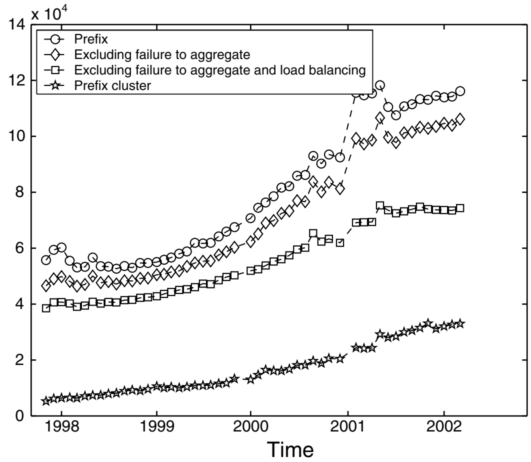

Fig. 2. Contributions to routing table growth.

(d) *Address fragmentation:* Since all of the prefixes within the same prefix cluster are announced identically, a single routing table entry would be sufficient for them if these prefixes could be represented by one prefix. However, the Internet addresses covered by these prefixes may not be summarized by one prefix due to either failure to aggregate or address fragmentation. We evaluate the effect of address fragmentation by comparing the number of prefixes excluding those contributed by failure to aggregate with the number of prefix clusters. We plot the number of prefix clusters in Fig. 2. The number of prefix clusters is only about 1/5 of the size of current routing table. The contribution of the address fragmentation to the routing table size is the difference between the number of prefixes excluding those introduced by failure to aggregate and the number of prefix clusters. The plot suggests that address fragmentation contributes to more than 75% of the routing table size and is the most significant contributor.

3.2. Growth rate of each contributors

We have demonstrated the contribution of each factor to the routing table in Figs. 1 and 2. However, the growth trend of each contributor is not obvious in both figures. In order to characterize the growth rate of each contributor, we plot the growth of routing table versus that of each contribution in Fig. 3. The growths are calculated by normalizing the number of prefix and the contributions of each factor with their values measured from the earliest routing table we use respectively. A marker over, under, or on the dashed line indicates that the contributor it represents grows faster than, slower than, or equal to the overall routing table growth. We observe from Fig. 3 that both load balancing and multi-homing contributions grow faster than the overall routing table, and load balancing has surpassed multi-homing becoming the fastest growing contributor. On the other hand, both failure to aggregation and address fragmentation grow slower than the overall routing table. In addition, the failure to aggregate contribution fluctuates a lot over time.

3.3. Routing table size versus routable IP addresses

The demand of routing more IP addresses can potentially require more prefixes. We explore the impact of increasing address space on routing table growth by investigating the correlation between the routable IP addresses and the advertised prefixes. For each BGP routing table, we count the number of prefixes and the number of IP addresses that are covered by at least one prefix in

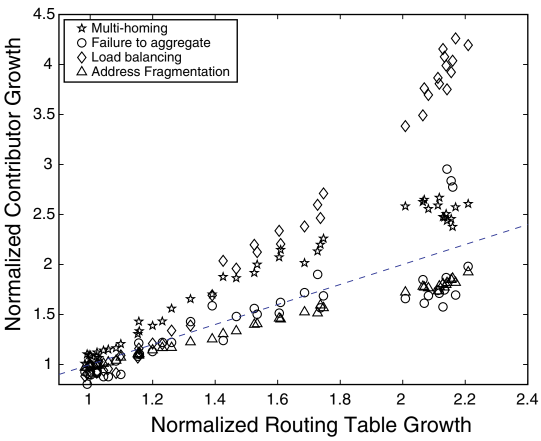

Fig. 3. Growth rate of contributors.

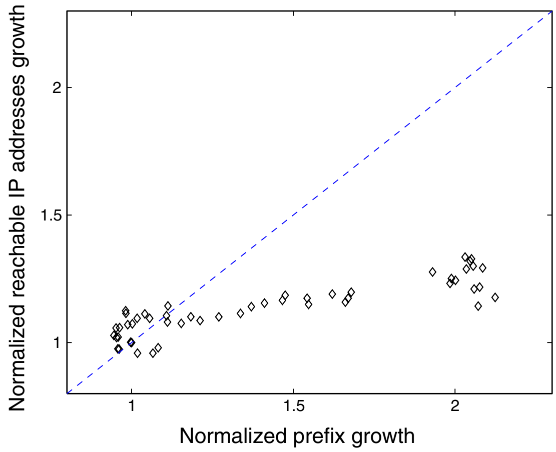

Fig. 4. Prefix growth versus reachable IP addresses growth.

the routing table. Fig. 4 plots the growth on the number of routable IP addresses as the number of prefixes increase over a period of more than four years. Both the number of prefixes and the number of IP addresses are normalized by the values obtained from the earliest routing table respectively. We observe that the number of prefixes has increased more than 100% over the past four years whereas the number of routable IP addresses has increased only about 25%. This suggests that expanding of reachable IP address space contributes little to the rapid growth of routing table size.

3.4. Prefix growth at different mask lengths

We have shown multi-homing and load balancing are two contributors to the routing table size that grow the fastest. We now explore how this is related to the growth of the prefix of different mask lengths. Fig. 5 plots the rate at which prefixes of different length grow. We do not include prefixes of length equal to 17 or prefixes of length greater than 24 because the number of these prefixes are very small. [1] We observe that the number of prefixes of length greater than 17 and less than 24 has tripled and grown the fastest. The number of prefixes of length 24 has doubled whereas the

[1] Despite rapid growth of the prefixes of length greater than 24, their contribution to routing table size is small.

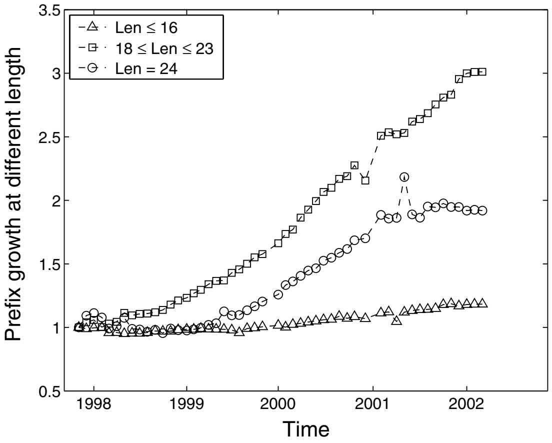

Fig. 5. Prefix growth at different mask lengths.

number of prefixes of length 16 does not change much during the last four years. For those fast growing prefixes of length greater than 17 and less than 25, we plot the fraction of them introduced by multi-homing and load balancing in Fig. 6 and observe that the contribution of multi-homing and load balancing has almost doubled. We conclude that multi-homing and load balancing contribute to the routing table growth by introducing more prefixes of length greater than 17 and less than 25, which are the fastest growing prefixes.

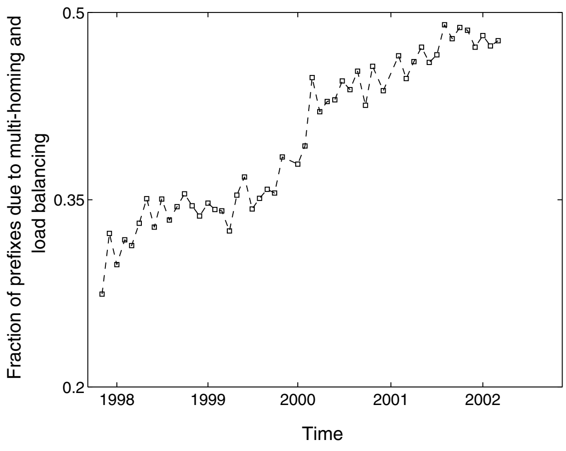

Fig. 6. The fraction of prefixes due to multi-homing and load balancing at different lengths.

4. On the completeness of Oregon Route View

Our study on routing table growth in Section 3 uses the BGP routing tables obtained from Oregon route server. In addition to the Oregon route server, we record in Table 1 other route servers located at different ASs that allow public access and provide full routing table dumps. The use of these routing tables and Oregon routing table together provide a more complete view of the Internet that may improve the accuracy of our results in Section 3. However, the growth study relies on the routing tables archived over a period of time whereas all route servers in Table 1 except RIPE do not keep historical routing tables and the RIPE route server started to archive routing tables two years after the Oregon route server. We choose to use the Oregon routing tables because they allow us to study the growth trend over a longer period of time. On the other hand, we can collect one routing table from each route server in Table 1 at approximately the same time and use them to evaluate the impact of the partial view derived from Oregon routing tables on our results in Section 3.

We focus on the impact of partial views on the classification of multi-homing prefixes and prefix clusters. It relies on the customer–provider relationship to identify multi-homing prefixes. Since the relationships used in Section 3 are inferred

Table 1
Route servers and their impact on prefix cluster classification

AS num.	Name	Add. PC	Incr. (%)
1	Genuity	36	0.11
1838	CerfNet	1407	4.17
3549	Global Crossing	32	0.09
3741	Internet Solution	0	0
3967	Exodus USA	213	0.63
4197	Exodus Asia	59	0.17
5388	Planet Online	170	0.5
5511	Opentransit	23	0.06
7018	AT&T	12	0.03
8200	Colt	187	0.55
8709	Exodus Europe	61	0.18
9328	Exodus Australia	112	0.33
12654	RIPE NCC	1763	5.23
15290	AT&T Canada	122	0.03
65500	SwiNOG	3673	10.89

solely from Oregon route tables, some customer–provider relationships may be missed due to the incomplete view derived from the Oregon routing table. Therefore, we may underestimate the multi-homing contribution. In Section 3, we approximate prefix clusters by a maximum set of prefixes that share identical entries in the Oregon BGP routing tables. However, two prefixes may be announced differently by some routers in the Internet even though they share identical entries in an Oregon routing table. As a result, we may under-estimate the number of prefix clusters, which leads to over-estimate contributions of failure to aggregate and address fragmentation but under-estimate the load balancing contribution.

We have collected the routing tables for several different days over a period of a month. Since the results obtained from routing tables collected on other days are similar, we only report the results using the routing tables collected on February 26, 2002.

Once we have the routing tables of every route server, we first apply the inference technique solely on the Oregon table and use the derived customer–provider relationship to identify the set of multi-homing prefixes, S_1. There are 22,441 multi-homing prefixes out of a total of 128,711 prefixes. We then apply the inference technique on the combination of all routing tables and use the derived customer–provider relationships to identify the set of multi-homing prefixes, S_2, from the same set of prefixes. There are 22870 multi-homing prefixes in S_2 out of a total of 128711 prefixes. The sets S_1 and S_2 only differ by at less than 2%. Therefore, Oregon routing tables provide a reasonably complete view for the purpose of identifying multi-homing prefixes.

In order to investigate how the additional routing tables affect the prefix cluster classification. We first identify a total of 33,721 prefix clusters using only Oregon routing tables. We then check each of these prefix clusters with every additional routing table collected from route servers in Table 1. For a routing table, if there are prefixes within the same cluster but having different entries in the table, we divide them into more clusters such that the prefixes in every cluster have the same entry in the additional routing table. The third column and fourth column in Table 1 record the number of and the percentage of additional prefix clusters respectively. We observe that including any one among 12 routing tables out of a total of 15 routing tables of route servers in Table 1 add only very few prefix clusters (less than 0.6%). By including either the CerfNet or RIPE routing table, we add only about 5% more prefix clusters. The number of prefix clusters increases 10.88% after we include SwiNOG routing table. The SwiNOG (Swiss Network Operators Group) route server collect route announcements mostly from ISPs local to Switzerland. We conjecture that some ISPs that SwiNOG peers with practice some very distinctive routing policies. We would like to investigate this in the future study. To conclude, the Oregon routing table agrees with all views except SwiNOG reasonably well on prefix cluster classification.

5. Conclusion

In this paper, we characterize the factors contributing to BGP routing table growth. Among multi-homing, load balancing, address fragmentation, and failure to aggregate, address fragmentation contributes most of the routing table size whereas the contribution of multi-homing and load balancing grow the fastest. Moreover, load balancing has surpassed multi-homing becoming the fastest growing contributor. We also find that load balancing and multi-homing contribute to routing table growth by introducing more prefixes of length greater than 17 but less than 25 and those prefixes grow the fastest in the routing tables. We observe that the increase on routable IP addresses contributes little to routing table growth. Although our findings are based only on the view derived from BGP routing tables of the Oregon server, the evaluation through using additional fifteen routing tables collected from ASs residing at other locations in the Internet suggests that our results are reasonably accurate.

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