

## Internet Growth (1981-1991)

### Status of this Memo

This memo provides information for the Internet community. It does not specify an Internet standard. Distribution of this memo is unlimited.

### Abstract

This document illustrates the growth of the Internet by examination of entries in the Domain Name System (DNS) and pre-DNS host tables. DNS entries are collected by a program called ZONE, which searches the Internet and retrieves data from all known domains. Pre-DNS host table data were retrieved from system archive tapes. Various statistics are presented on the number of hosts and domains.

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### Introduction

This document provides statistics on the growth of the Internet by examining the number of Internet hosts and domains over a 10-year period. Before the Domain Name System was established, practically all hosts on the Internet were registered with the Network Information Center (SRI-NIC) and entries were placed in the Official Host Table for each one. Data on the number of hosts for pre-DNS

years comes from copies of the host table at selected times. The DNS system was introduced around 1984 but took almost 4 years before it was fully implemented on the Internet. However, by this time many hosts were no longer registered in the Host Table.

In 1986, the ZONE (Zealot Of Name Edification) program was written. ZONE was originally intended to be used during the host-table-to-DNS transition period. ZONE would "walk" the DNS tree and build a host table of all the information it collected. This host table could then be used by sites that had not yet made the DNS transition. However, ZONE was never used for this purpose. Instead, it was found to be useful for collecting statistics on the size of the domain system and the Internet.

ZONE could not collect complete data on the DNS until around 1988, because early versions of BIND (the popular Unix DNS implementation) had major problems with the zone transfer function of the DNS protocol. ZONE has been used in varying ways ever since to collect this information. In the first few years, it was used to produce a wall-size chart of the domain tree. However, the number of domains quickly outgrew the size of the wall and the charts were abandoned. In later years, statistics on the number of hosts and domains were extracted from the resulting host table, sometimes categorizing data based on top-level domain names or on computer system type or manufacturer.

The time to gather the data also grew from hours to a week, and the size of the host table produced soon reached 50 megabytes. In order to reduce the amount of data collected, ZONE is now run in a mode collecting only host names and IP addresses, ignoring protocol, host information and MX record data. The host table is then groveled over by some utilities (such as sort, uniq and grep) to produce the statistics required. ZONE is currently run every 3 months at SRI.

#### How ZONE Works

ZONE maintains a list of domains and their servers and a flag indicating whether information for a domain has been successfully loaded from one of the servers. Because of another bug in BIND, ZONE must be primed with a list of all the top-level domains and their name servers. It then cycles through the domain list, attempting to contact one of the servers for each domain not yet transferred. When a server is contacted (via TCP), a Start of Authority (SOA) query is first sent to make sure the server is authoritative for the domain being requested. If so, then a zone transfer query (AXFR) is sent to request all the resource records for the domain to be retrieved.

When a name server record (NS) is received, the referenced domain and

server are added to the list of domains to process. When host records (A, CNAME, HINFO, MX) are received, they are added to an in-core table of host information. The program ends when it has cycled through the entire list of domains without receiving any new information. It then dumps the table of host information to a HOSTS.TXT format file.

### Problems with Data Collection

For various reasons, some Internet sites do not allow zone transfers of their domain servers. ZONE also eventually gives up trying to transfer a domain after too many failures. The number of domains that could not be zone transferred during the 1-Jan-92 ZONE run was around 800 out of 17,000. Additionally, it is assumed that not all hosts on the Internet are registered in a domain server. These problems cause the statistics gathered by ZONE to be lower than the actual amounts.

Manual review of some of the data collected by ZONE also shows a lot of random entries in the DNS. Misformatted entries may cause bogus server or host records to appear. Many times a server is found to not be authoritative for the domain listed. Sometimes entire domains are renamed and their old entries left in place for a transition period, thus causing each host within that domain to be counted twice. These problems cause the results of ZONE to be higher than the actual amounts.

Manual scanning of the data indicates that the additional entries are insignificant compared to the missing entries discussed earlier. ZONE data can thus be viewed as the minimum number of Internet hosts, and not the actual figures.

A final problem with data collection is that of expense. Downloading domain information from every domain on the Internet generates a large amount of network traffic. It also puts an extra CPU load on each domain server it must contact. An organized effort might be considered to have only one such program doing this on the Internet at regularly scheduled intervals to keep the problem of multiple data collectors from occurring.

### Scope of the Study

A problem with counting hosts and domains on the Internet is defining what the Internet really is. Finding host entries in the DNS does not necessarily indicate that the host is reachable from the Internet. Many companies have mail gateways between the Internet and their local nets, thus disallowing direct access. However, some of these companies advertise all their hosts, and some advertise only

the gateway. Are these hosts on the Internet or not?

Furthermore, many domains in the DNS are just mail-forwarding (MX) entries for off-Internet (such as Usenet) sites. Are these domains really part of the Internet and should they be counted in an Internet size study?

For the purposes of this study, a host has been defined as a [name(s),IP-address(es)] grouping discovered from the DNS. This prevents us from counting a host with multiple names or addresses more than once. However, this does not consider whether the host is directly accessible or not. When ZONE counts the number of domains it includes all domains referenced by an NS record in the DNS, thus including MX-only domain sites in the final results.

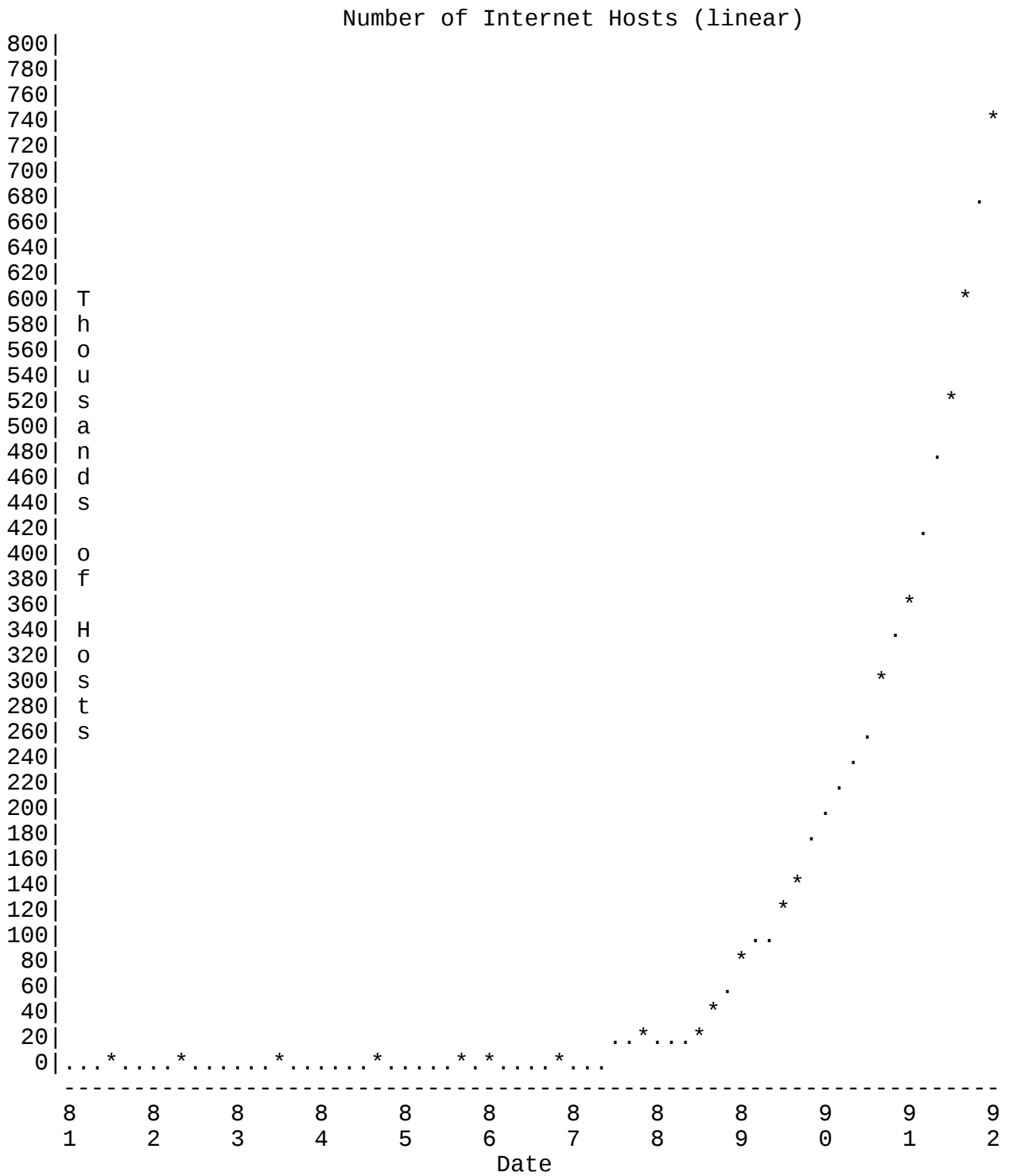
## N. Results

This section presents data from archive tapes of SRI-NIC from 1981 to 1986, and statistics gathered by runs of ZONE from 1986 to 1992.

### N.1 Number of Internet Hosts

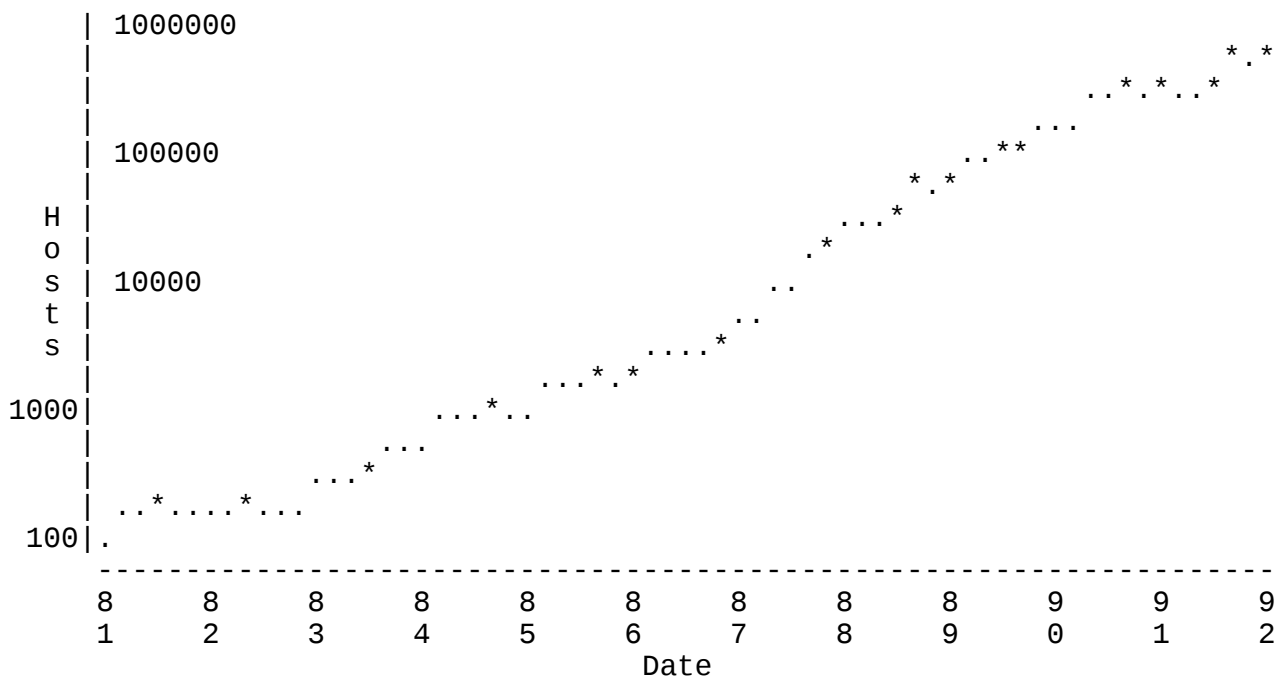
The chart below shows the number of IP hosts on the Internet. These are hosts with at least one IP address assigned. Data was collected by ZONE except where noted. The following two sections are graphs of the data in this chart.

| Date  | Hosts   |                 |
|-------|---------|-----------------|
| 08/81 | 213     | Host table #152 |
| 05/82 | 235     | Host table #166 |
| 08/83 | 562     | Host table #300 |
| 10/84 | 1,024   | Host table #392 |
| 10/85 | 1,961   | Host table #485 |
| 02/86 | 2,308   | Host table #515 |
| 11/86 | 5,089   |                 |
| 12/87 | 28,174  |                 |
| 07/88 | 33,000  |                 |
| 10/88 | 56,000  |                 |
| 01/89 | 80,000  |                 |
| 07/89 | 130,000 |                 |
| 10/89 | 159,000 |                 |
| 10/90 | 313,000 |                 |
| 01/91 | 376,000 |                 |
| 07/91 | 535,000 |                 |
| 10/91 | 617,000 |                 |
| 01/92 | 727,000 |                 |



"\*" = data point, "." = estimate  
This graph is a linear plot of the number of Internet hosts.

Number of Internet Hosts (logarithmic)



"\*" = data point, "." = estimate

This graph is a logarithmic plot of the number of Internet hosts.

## N.2 Number of Domains

This chart shows the number of domains existing in the Internet Domain Name System as collected by ZONE.

| Date  | Domains |
|-------|---------|
| 07/88 | 900     |
| 10/88 | 1,280   |
| 01/89 | 2,600   |
| 07/89 | 3,900   |
| 10/89 | 4,800   |
| 10/90 | 9,300   |
| 01/91 | 11,200  |
| 07/91 | 16,000  |
| 10/91 | 18,000  |
| 01/92 | 17,000  |

### N.3 Distribution of IP Addresses per Host

This chart shows how many hosts have how many IP addresses. This data was collected on 1-Jan-92 and only the first 10 entries are shown.

| Addresses | Hosts  |
|-----------|--------|
| 1         | 715143 |
| 2         | 9015   |
| 3         | 1027   |
| 4         | 556    |
| 5         | 314    |
| 6         | 213    |
| 7         | 100    |
| 8         | 85     |
| 9         | 58     |
| 10        | 71     |

### N.4 Distribution of Hosts by Top-level Domain

This chart shows the number of hosts per top-level domain (top 40 only) on 1-Jan-92. The percentage listed is the increase since 1-Oct-91. Large variations are probably due to problems and variations in the collection process; these figures are not meant to be authoritative, but serve as reasonable estimates.

|        |     |      |       |     |      |      |    |      |     |      |     |
|--------|-----|------|-------|-----|------|------|----|------|-----|------|-----|
| 243020 | edu | 13%  | 13011 | fr  | 4%   | 1791 | dk | 4%   | 357 | be   | -5% |
| 181361 | com | 12%  | 12770 | nl  | 21%  | 1662 | es | 15%  | 334 | gr   | 14% |
| 46463  | gov | 13%  | 12647 | ch  | 10%  | 1506 | kr | 9%   | 308 | br   | 26% |
| 31622  | au  | 19%  | 11994 | fi  | 15%  | 1111 | nz | -16% | 284 | mx   | -5% |
| 31016  | de  | 20%  | 10228 | no  | 9%   | 1016 | tw | n/a  | 207 | is   | 0%  |
| 27492  | mil | 26%  | 8579  | jp  | 6%   | 929  | za | n/a  | 146 | pl   | 97% |
| 27052  | ca  | 22%  | 4109  | net | -49% | 784  | pt | n/a  | 127 | us   | 25% |
| 19117  | org | 10%  | 3324  | at  | 19%  | 484  | sg | 251% | 25  | tn   | 0%  |
| 18984  | uk  | 139% | 2719  | it  | 197% | 448  | hk | 78%  | 24  | hu   | 71% |
| 18473  | se  | 34%  | 2020  | il  | 14%  | 374  | ie | -7%  | 6   | arpa | 0%  |

## N.5 Distribution of Hosts by Host Name

This chart shows the distribution of hosts by their host name on 1-Jan-92. The host name is defined to be the first part of a fully qualified domain name. Only the top 100 names are shown.

|             |            |             |             |            |
|-------------|------------|-------------|-------------|------------|
| 384 venus   | 204 mac4   | 172 mac9    | 155 pollux  | 138 chaos  |
| 356 pluto   | 201 hobbes | 172 mac11   | 155 frodo   | 136 bart   |
| 323 mars    | 201 hermes | 170 mac8    | 153 helios  | 135 pc5    |
| 288 jupiter | 198 thor   | 169 phoenix | 152 mac17   | 135 larry  |
| 286 saturn  | 198 sirius | 169 mac12   | 151 vega    | 135 cs     |
| 285 pc1     | 196 gw     | 169 hal     | 151 mac18   | 133 odin   |
| 282 zeus    | 195 calvin | 168 snoopy  | 150 falcon  | 131 tiger  |
| 262 iris    | 194 mac5   | 168 mac13   | 150 bach    | 131 sparky |
| 260 mercury | 191 mac10  | 167 mac15   | 146 castor  | 131 ariel  |
| 259 mac1    | 190 fred   | 167 mac14   | 145 sol     | 130 sneezy |
| 258 orion   | 189 titan  | 167 grumpy  | 145 dopey   | 128 mac    |
| 254 mac2    | 189 pc3    | 163 gandalf | 144 mac20   | 127 sun1   |
| 240 newton  | 186 opus   | 162 pc4     | 144 mac19   | 127 rocky  |
| 234 neptune | 186 mac6   | 160 uranus  | 142 spock   | 126 pc6    |
| 233 pc2     | 185 charon | 159 mac16   | 142 euler   | 125 hydra  |
| 224 gauss   | 185 apollo | 158 sleepy  | 141 mickey  | 125 homer  |
| 222 eagle   | 179 mac7   | 158 io      | 141 atlas   | 124 isis   |
| 213 mac3    | 179 athena | 157 earth   | 140 maxwell | 123 moe    |
| 209 merlin  | 177 alpha  | 156 europa  | 140 happy   | 123 delta  |
| 207 cisco   | 172 mozart | 155 rigel   | 140 doc     | 122 pc10   |

## Future Issues

ZONE currently runs on a DECsystem-20 and is written in assembler. The amount of data is quickly reaching the limits of the DEC-20 section address space, and the hardware's ability to survive gets slimmer each day. ZONE assembles all its data in core before dumping it to disk. The implementation does this in order to be able to match host nicknames with official names before dumping complete host records. Sometimes a nickname can be in a different domain than the official name, complicating simpler methods.

A new version of ZONE needs to be written to run on a modern computer system. A completely new architecture should be designed to handle the enormous amount of data collected and expected in the future. Data should be kept on disk so that a system crash will not wipe out days of collection. Multiple zone transfers could be occurring in parallel to reduce the time needed for data gathering. A new ZONE might run continuously, cycling through the domain system on a cycle lasting weeks to a month, updating a local database with statistics collected for each domain. In this way, current statistics on the size of the Internet would always be known. The resulting database

may also be useful for other network information services.

#### RFC References

Libes, D., "Choosing a Name for Your Computer", RFC 1178, Integrated Systems Group/NIST, August 1990. (Also FYI 5.)

Mockapetris, P., "Domain Names - Implementation and Specification", RFC 1035, USC/Information Sciences Institute, November 1987.

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Lazear, W., "MILNET Name Domain Transition", RFC 1031, Mitre, November 1987.

Harrenstien, K. Stahl, M., and J. Feinler, "DoD Internet Host Table Specification", SRI, October 1985.

Postel, J., "Domain Name System Implementation Schedule - Revised", RFC 921, USC/Information Sciences Institute, October 1984.

#### Security Considerations

Security issues are not discussed in this memo.

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