                Guidelines for Management of IP Address Space

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 has been reviewed by the Federal Engineering Planning
   Group (FEPG) on behalf of the Federal Networking Council (FNC), the
   co-chairs of the Intercontinental Engineering Planning Group (IEPG),
   and the Reseaux IP Europeens (RIPE). There was general consensus by
   those groups to support the recommendations proposed in this document
   for management of the IP address space.

1.0 Introduction

   With the growth of the Internet and its increasing globalization,
   much thought has been given to the evolution of the network number
   allocation and assignment process. RFC 1174, "Identifier Assignment
   and Connected Status", [1] dated August 1990 recommends that the
   Internet Registry (IR) continue as the principal registry for network
   numbers; however, the IR may allocate blocks of network numbers and
   the assignment of those numbers to qualified organizations. The IR
   will serve as the default registry in cases where no delegated
   registration authority has been identified.

   The distribution of the registration function is desirable, and in
   keeping with that goal, it is necessary to develop a plan which
   manages the distribution of the network number space. The demand for
   network numbers has grown significantly within the last two years and
   as a result the allocation of network numbers must be approached in a
   more systematic fashion.

   This document proposes a plan which will forward the implementation
   of RFC 1174 and which defines the allocation and assignment of the
   network number space. There are three major topics to be addressed:

   1) Qualifications for Distributed Regional Registries

   2) Allocation of the Network Number Space by the Internet Registry

   3) Assignment of the Network Numbers

2.0 Qualifications for Distributed Regional Registries

The major reason to distribute the registration function is that the
Internet serves a more diverse global population than it did at its
inception. This means that registries which are located in distinct
geographic areas may be better able to serve the local community in
terms of language and local customs. While there appears to be wide
support for the concept of distribution of the registration function,
it is important to define how the candidate delegated registries will
be chosen and from which geographic areas.

Based on the growth and the maturity of the Internet in Europe, North
America, Central/South America and the Pacific Rim areas, it is
desirable to consider delegating the registration function to an
organization in each of those geographic areas. Until an
organization is identified in those regions, the IR will continue to
serve as the default registry. The IR remains the root registry and
continues to provide the registration function to all those regions
not covered by distributed regional registries. And as other regions
of the world become more and more active in the Internet, the
Internet Assigned Numbers Authority (IANA) and the IR may choose to
look for candidate registries to serve the populations in those
geographic regions.

It is important that the regional registry is unbiased and and widely
recognized by network providers and subscribers within the geographic
region. It is also important that there is just a single regional
registry per geographical region at this level to provide for
efficient and fair sub-allocation of the address space. To be
selected as a distributed regional registry an organization should
meet the following criteria:

   a) networking authorities within the geographic area
      legitimize the organization,

   b) the organization is well-established and has
      legitimacy outside of the registry function,

   c) the organization will commit appropriate resources to
      provide stable, timely, and reliable service
      to the geographic region,

d) is committed to allocate IP numbers according to
the guidelines established by the IANA and the IR, and

e) is committed to coordinate with the IR to establish
qualifications and strategies for sub-allocations of
the regional allocation.

The distributed regional registry is empowered by the IANA and the IR
to provide the network number registration function to a geographic
area. It is possible for network applicants to contact the IR
directly. Depending on the circumstances the network subscriber may
be referred to the regional registry, but the IR will be prepared to
service any network subscriber if necessary.

3.0 Allocation of the Network Number Space by the Internet Registry

The Class A portion of the number space represents 50% of the total
IP host addresses; Class B is 25% of the total; Class C is
approximately 12% of the total. Table 1 shows the current allocation
of the IP network numbers.

	Total	Allocated	Allocated (%)
Class A	126	49	38%
Class B	16383	7354	45%
Class C	2097151	44014	2%

Table 1: Network Number Statistics (May 1992) [2]

Class A and B network numbers are a limited resource and therefore
allocations from this space will be restricted. The entire Class A
number space will be retained by the IANA and the IR. No allocations
from the Class A network numbers will be made to distributed regional
registries at this time. (See section 4.1.)

Allocations from the Class B network number space will be restricted
also. Small blocks of numbers may be allocated to regional
registries, which will be required to ensure that the allocation
guidelines are met. The IR will monitor those allocations. (See
section 4.2.)

It is proposed that the IR, and any designated regional registries,
allocate addresses in conformance with this overall scheme. Where
there are qualifying regional registries established, primary
responsibility for allocation within that block will be delegated to
that registry. It should be noted that the Reseaux IP Europeens
Network Coordination Center (RIPE NCC) had been allocated a block of
Class C addresses (193.0.0 - 193.255.255) prior to the adoption of
this proposal. The RIPE NCC has agreed to allocate the addresses

within that block according to the guidelines stated in this RFC.

The Class C network number space will be divided into allocatable
blocks which will be reserved by the IANA and IR for allocation to
distributed regional registries. In the absence of designated
regional registries in geographic areas, the IR will assign addresses
to networks within those geographic areas according to the Class C
allocation divisions.

Inspection of the Class C IP network numbers shows that the number
space with prefixes 192 and 193 are assigned. The remaining space
from prefix 194 through 223 is mostly unassigned.

The IANA and the IR will reserve the upper half of this space which
corresponds to the IP address range of 208.0.0.0 through
223.255.255.255. Network numbers from this portion of the Class C
space will remain unallocated and unassigned until further notice.

The remaining Class C network number space will be allocated in a
fashion which is compatible with potential address aggregation
techniques. It is intended to divide this address range into eight
equally sized address blocks.

```
    192.0.0.0 - 193.255.255.255
    194.0.0.0 - 195.255.255.255
    196.0.0.0 - 197.255.255.255
    198.0.0.0 - 199.255.255.255
    200.0.0.0 - 201.255.255.255
    202.0.0.0 - 203.255.255.255
    204.0.0.0 - 205.255.255.255
    206.0.0.0 - 207.255.255.255
```

Each block represents 131,072 addresses or approximately 6% of the
total Class C address space.

It is proposed that a broad geographic allocation be used for these
blocks. At present there are four major areas of address allocation:
Europe, North America, Pacific Rim, and South & Central America.

In particular, the top level block allocation be designated as
follows:

```
Multi-regional           192.0.0.0 - 193.255.255.255
Europe                   194.0.0.0 - 195.255.255.255
Others                   196.0.0.0 - 197.255.255.255
North America            198.0.0.0 - 199.255.255.255
Central/South
 America                 200.0.0.0 - 201.255.255.255
Pacific Rim              202.0.0.0 - 203.255.255.255
Others                   204.0.0.0 - 205.255.255.255
Others                   206.0.0.0 - 207.255.255.255
```

It is proposed that the IR, and any designated regional registries,
allocate addresses in conformance with this overall scheme. Where
there are qualifying regional registries established, primary
responsibility for allocation from within that block will be
delegated to that registry.

The ranges designated as "Others" permit flexibility in network
number assignments which are outside of the geographical regions
already allocated. The range listed as multi-regional represents
network numbers which have been assigned prior to the implementation
of this plan. It is proposed that the IANA and the IR will adopt
these divisions of the Class C network number space and will begin
assigning network numbers accordingly.

4.0 Assignment of the Network Number Space

   The exhaustion of the IP address space is a topic of concern for the
   entire Internet community. This plan for the assignment of Class A,
   B, or C IP numbers to network applicants has two major goals:

      1) to reserve a portion of the IP number space so that it may be
      available to transition to a new numbering plan

      2) to assign the Class C network number space in a fashion which
      is compatible with proposed address aggregation techniques

4.1 Class A

   The Class A number space can support the largest number of unique
   host identifier addresses and is also the class of network numbers
   most sparsely populated. There are only approximately 11 Class A
   network numbers which are unassigned or unreserved, and these 11
   network numbers represent about 9% of the total address space.

   The IANA and the IR will retain sole responsibility for the
   assignment of Class A network numbers. The upper half of the Class A
   number space will be reserved indefinitely (IP network addresses
   64.0.0.0 through 127.0.0.0). While it is expected that no new

assignments of Class A numbers will take place in the near future,
any organization petitioning the IR for a Class A network number will
be expected to provide a detailed technical justification documenting
network size and structure. Class A assignments are at the IANA's
discretion.

4.2 Class B

Previously, organizations were recommended to use a subnetted Class B
network number rather than multiple Class C network numbers. Due to
the scarcity of Class B network numbers and the underutilization of
the Class B number space by most organizations, the recommendation is
now to use multiple Class Cs where practical.

The restrictions in allocation of Class B network numbers may cause
some organizations to expend additional resources to utilize multiple
Class C numbers. This is unfortunate, but inevitable if we implement
strategies to control the assignment of Class B addresses. The
intent of these guidelines is to balance these costs for the greater
good of the Internet.

4.2.1

Organizations applying for a Class B network number should fulfill
the following criteria:

    1)   the organization presents a subnetting plan which documents
         more than 32 subnets within its organizational network

    AND

    2)   the organization has more than 4096 hosts

Organizations applying for a Class B network number must submit an
engineering plan that documents its need for a Class B network
number. This document must demonstrate that it is unreasonable to
engineer its network with a block of class C network numbers. The
engineering plan must include how many hosts the network will have
within the next 24 months and how many hosts per subnet within the
next 24 months.

The submitted engineering plans will be held in strict confidence by
the Internet registries and will only be used to judge whether an
application is justified. If it is deemed that the applicant's
engineering plan, including the number of hosts and subnets, does not
warrant a Class B assignment, the applicant will be allocated a block
of Class C addresses.

   There may be some circumstances where the organization is unable to
   utilize a block of Class C network numbers and does not meet the
   suggested criteria. In such cases, the engineering plan should
   clearly demonstrate their inability to utilize a block of Class C
   network numbers.

4.2.2

   The IR may allocate small blocks of Class B network numbers to
   regional registries if so doing will improve the service that is
   being provided to the community. The IR may issue more specific
   guidelines for the further assignment of the numbers which will be
   consistent with the stated guidelines. The IR may require accounting
   of the block assignment including receipt of the applicants'
   engineering plans. The IR may audit these engineering plans to
   confirm that the assignments are consistent with the guidelines.

4.3 Class C

   Section 3 of this document recommends a division of the Class C
   number space. That division is primarily an administrative division
   which lays the groundwork for distributed network number registries.
   This section addresses assignment of network numbers from within
   regional block assignments. Sub-allocations of the block to sub-
   registries is beyond the scope of this paper.

   By default, if an organization requires more than a single Class C,
   it will be assigned a bit-wise contiguous block from the Class C
   space allocated for its geographic region.

   For instance, an European organization which requires fewer than 2048
   unique IP addresses and more than 1024 would be assigned 8 contiguous
   class C network numbers from the number space reserved for European
   networks, 194.0.0.0 - 195.255.255.255. If an organization from
   Central America required fewer than 512 unique IP addresses and more
   than 256, it would receive 2 contiguous class C network numbers from
   the number space reserved for Central/South American networks,
   200.0.0.0 - 201.255.255.255.

   The IR or the registry to whom the IR has delegated the registration
   function will determine the number of Class C network numbers to
   assign to a network subscriber based on the subscriber's 24 month
   projection of required end system addresses according to the
   following criteria:

          Organization   Assignment

   1) requires fewer than 256 addresses   1 class C network
   2) requires fewer than 512 addresses   2 contiguous class C networks
   3) requires fewer than 1024 addresses   4 contiguous class C networks
   4) requires fewer than 2048 addresses   8 contiguous class C networks
   5) requires fewer than 4096 addresses 16 contiguous class C networks
   6) requires fewer than 8192 addresses 32 contiguous class C networks
   7) requires fewer than 16384 addresses 64 contiguous class C networks

   If the subscriber's network is divided into logically distinct LANs
   across which it would be difficult to use the given number of Class C
   network numbers, the above criteria may apply on a per-LAN basis.
   For example, if a subscriber has 600 hosts equally divided across ten
   Ethernets, the allocation to that subscriber could be ten Class C
   network numbers; one for each Ethernet. The subscriber would have to
   support the request with to deviate from the stated criteria with an
   engineering plan.

   These criteria are not intended to cause a subscriber to subnet Class
   C networks unneccessarily. Although, if a subscriber has a small
   number of hosts per subnet, the subscriber should investigate the
   feasibility of subnetting Class C network numbers rather than
   requesting one Class C network number for every subnet. In cases
   where the lack of Class C subnetting would result in an extravagant
   waste of address space, the registries may request an engineering
   plan detailing why subnetting is impossible.

   If a subscriber has a requirement for more than 4096 unique IP
   addresses it could conceivably receive a Class B network number.
   However, there are cases where a subscriber may request a larger
   block of Class C network numbers. For instance, if an organization
   requires fewer than 8192 addresses and requests 32 Class C network
   addresses, the regional registry may honor this request. The maximal
   block of Class C network numbers that should be assigned to a
   subscriber consists of 64 contiguous Class C networks. This would
   correspond to a single IP prefix of 18 bits.

   Exceptions from the above stated criteria will be determined on a
   case-by-case basis.

5.0 Conclusion

   This proliferation of class C network numbers may aid in retarding
   the dispersion of class A and B numbers, but it is sure to accelerate
   the explosion of routing information carried by Internet routers.
   Inherent in these recommendations is the assumption that there will
   be modifications in the technology to support the larger number of

network address assignments due to the decrease in assignments of
Class A and B numbers and the proliferation of Class C assignments.

Many proposals have been made to address the rapid growth of network
assignments and a discussion of those proposals is beyond the scope
and intent of this paper.

These recommendations for management of the current IP network number
space only profess to delay depletion of the IP address space, not to
postpone it indefinitely.

6.0 Acknowledgements

The author would like to acknowledge the substantial contributions
made by the members of the following two groups, the Federal
Engineering Planning Group (FEPG) and the Intercontinental
Engineering Planning Group (IEPG). This document also reflects many
concepts expressed at the IETF Addressing BOF which took place in
Cambridge, MA in July 1992. In addition, Dan Long (BBN), Jon Postel
(ISI), and Yakov Rekhter (T.J. Watson Research Center, IBM Corp.)
reviewed this document and contributed to its content. The author
thanks those groups and individuals who have been cited for their
comments.

7.0 References

[1] Cerf, V., "IAB Recommended Policy on Distributing Internet
    Identifier Assignment and IAB Recommended Policy Change to
    Internet 'Connected' Status", RFC 1174, CNRI, August 1990.

[2] Wang, Z., and J. Crowcroft, "A Two-Tier Address Structure for the
    Internet: A Solution to the Problem of Address Space Exhaustion",
    RFC 1335, University College London, May 1992.

Other related relevant work:

[3] "Internet Domain Survey", Network Information Systems Center, SRI
    International, July 1992.

[4] Solensky, F., and F. Kastenholz, "A Revision to IP Address
    Classifications", Work in Progress, March 1992.

[5] Fuller, V., Li, T., Yu, J., and K. Varadhan, "Supernetting: an
    Address Assignments and Aggregation Strategy", RFC 1338, BARRNet,
    cisco, Merit, OARnet, June 1992.

[6] Rekhter, Y., and Li, T., "Guidelines for IP Address Allocation",
    Work in Progress, August 1992.

    [7] Rekhter, Y. and Topolcic, C., "Exchanging Routing Information
        across Provider/Subscriber boundaries in CIDR environment", Work
        in Progress, February 1993.

8.0 Security Considerations

    Security issues are not discussed in this memo.

9.0 Author's Address

    Elise Gerich
    Merit Network, Inc.
    1071 Beal Avenue
    Ann Arbor, MI 48109-2112

    Phone: (313) 936-3335
    EMail: epg@MERIT.EDU