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Internet Address Space Management in Digital

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Abstract

IP/TCP network addressing affords many different schemes for dividing and using the address space in a network. This document describes Digital's IP/TCP address space and the policies and procedures for managing it. Because IP/TCP is an evolving and experimental technology, many of these policies and procedures are motivated more by technological considerations or by a desire to be compatible with the world outside Digital than by traditional Digital procedures.

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1. Introduction

This document describes Digital's IP/TCP address space and the policies and procedures for managing it. Because IP/TCP is an evolving and experimental technology, many of these policies and procedures are motivated more by technological considerations or by a desire to be compatible with the world outside Digital than by traditional Digital procedures.

1.1. Internet addresses

An IP address is 32 bits long. Each address encodes a network number as well as a host address.[1]. The network number identifies the administrative entity that owns the address space, and the host address identifies the specific node on that network. It is not possible to tell, just from looking at a 32-bit IP address, which bits of it stand for the network number and which bits of it stand for the host address. This is because many organizations that have large networks have further divided them into subnetworks, and the division of bits between subnetworks and host addresses can be quite arbitrary.

1.2. Networks and address classes

There are three classes of ordinary Internet addresses. They differ in terms of the number of bits that are used by each to identify the network number. Those using fewer bits to identify the network number have more bits available for host numbers. Thus, there is a small quantity of very large networks available, a moderate quantity of large networks, and a vast quantity of small networks available.

The IP address formats are explained in Table 1 and shown pictorially in Figure 2. The determination of address format is done by the leftmost bits (called the "high-order bits") of the binary form of the address.

High-order bits	address class	bits of network number	bits of host number	number of possible networks	number of possible nodes	range of network numbers
0	A	7	24	126	16,000,000	1 to 126
10	B	14	16	16,000	65,000	128.1 to 191.254
110	C	21	8	2,000,000	250	192.1.1 to 223.254.254

Figure 1: Internet address format information

Addresses whose first three bits are "111" are "extended mode" class D and class E addresses, used for multicast. They are not currently used in Digital, but may be used in the future; in particular, the OSPF routing protocol uses class-D multicast addresses to locate designated routers on a subnet.

[1]In the Internet world, a network node is called a *HOST*

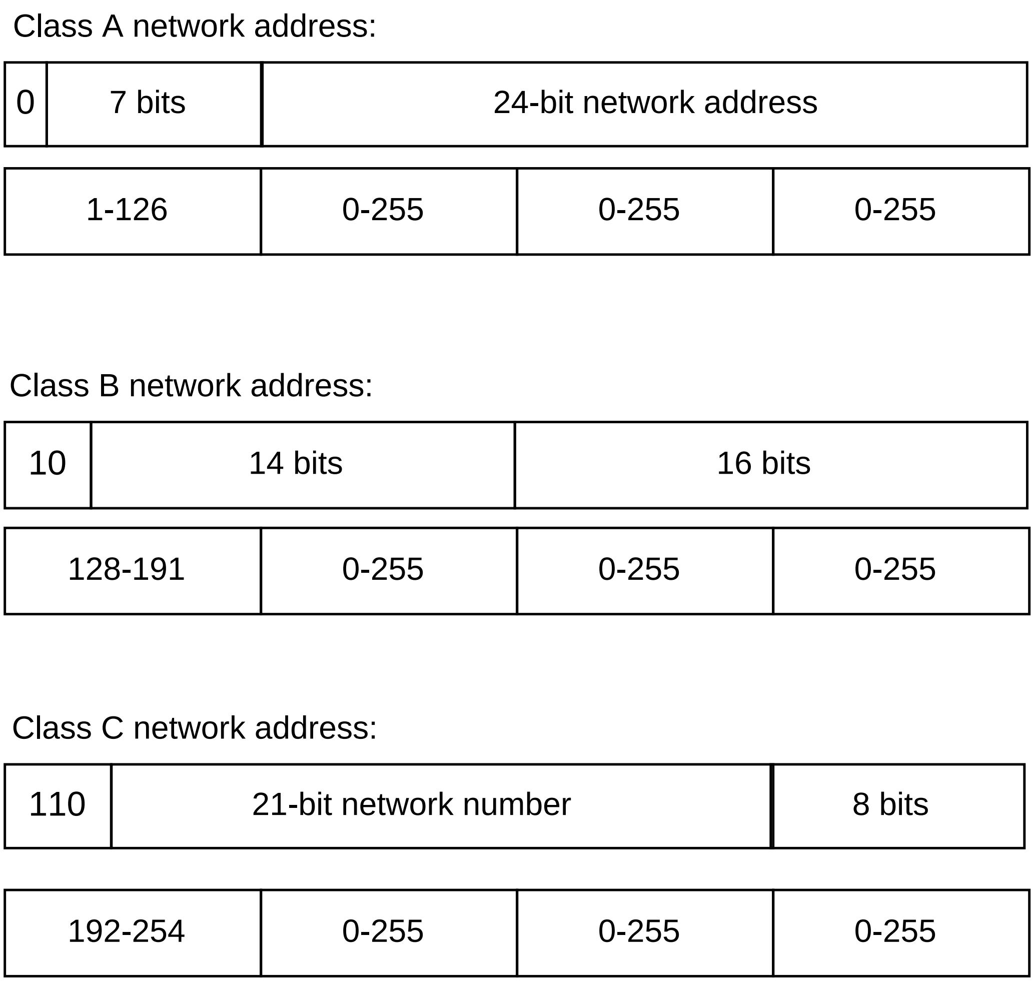

Figure 2: Internet address formats

More details of the Internet addressing scheme are contained in RFC791, *Internet Protocol*, by Jon Postel.

IP addresses are normally written down as four decimal numbers separated by periods:

```
128.45.33.18
16.1.32.14
193.44.133.1
```

Each of the decimal numbers stands for 8 bits of the address.

IP network numbers are normally written down as IP addresses with zeros in the "host number" portions. For example, the Class A network 36 is written as "`36.0.0.0`" and the Class B network 128.45 is written as "`128.45.0.0`".

1.3. Digital's Internet addressing scheme

As noted in Table 1, a Class A network potentially has 16 million nodes. This is far too many to manage as a single pool. Therefore Digital, like most other owners of Class A networks, has divided its network into subnetworks, each of which is administered separately.

Digital has been issued the Class A network number 16, (more properly written as "`16.0.0.0`"). It has been divided into subnets of 8 bits each, allowing 254 nodes per subnet (the use of host address 0 is not recommended, and host address 255 is reserved for broadcast).

Figure 3 shows, pictorially, the division of the 32 bits of the IP address into network number (always 16), subnet number (a 12-bit field), a reserved 4-bit guard zone (required to be zero), and an 8-bit node number.

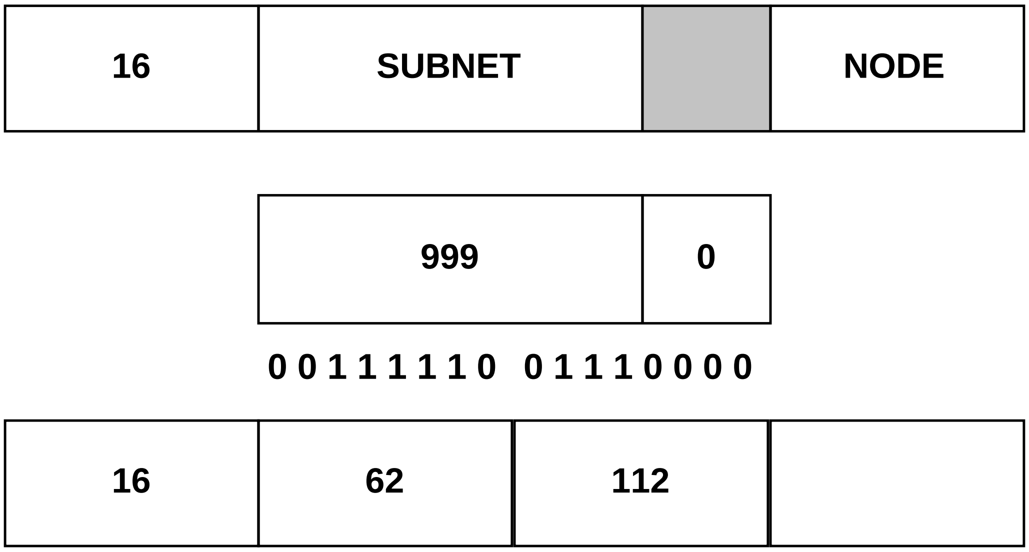

Figure 3: Division of Net 16 into subnets

This scheme immediately provides for 2^{12} (4096) subnets of 8 bits each, which can accommodate one million nodes. When that space becomes cramped, the 4 "reserved" bits can be used for additional subnet numbers, which will yield 2^{16} (65536) subnets of 8 bits each, giving the full 16 million nodes. The 4 bits are being held in reserve in case the Internet technology develops in some direction making it more practical for Digital to use them for some purpose other than subnet or node numbers.

The 4096 subnets are divided into 256 "subnet clusters", each of which has 16 subnets. Every subnet cluster belongs to some administrative organization within Digital; no cluster is split between organizations.

1.4. Subnet masks and broadcast addresses

When a computer or router is looking at an Internet address, it uses a "subnet mask" to decide how to interpret that address. This subnet mask is a 32-bit value, with a "1" bit in every position that is part of the network number, and a "0" bit in every position that is part of the host number.

Inside Digital, we use a subnet mask that consists of 24 bits of "1" followed by 8 bits of "0". This mask can be written down either in hexadecimal as "`0xffffff00`" or in quad decimal as "`255.255.255.0`". Under certain very special circumstances, with close cooperation with engineering, it is permissible to use other values, but in the overwhelming majority of cases the 24-bit netmask must be used. This 24-bit subnet mask is shown pictorially in Figure 4.

Associated with each subnet is its "broadcast address". The broadcast address for a subnet is the address to which a packet is sent if it is supposed to reach every node on the subnet. Normally the broadcast address can be computed by combining the subnet number with the subnet mask: take the subnet number, convert to binary, turn on every bit for which there is a "0" in the subnet mask, and then convert back to decimal. In the ordinary case of a 24-bit subnet mask, this can be accomplished by taking the subnet number and replacing its trailing "`.0`" with "`.255`". For example, the subnet "`16.87.128.0`" will have "`16.87.128.255`" as its broadcast address. This is because 255 is the decimal number whose binary equivalent is "11111111".

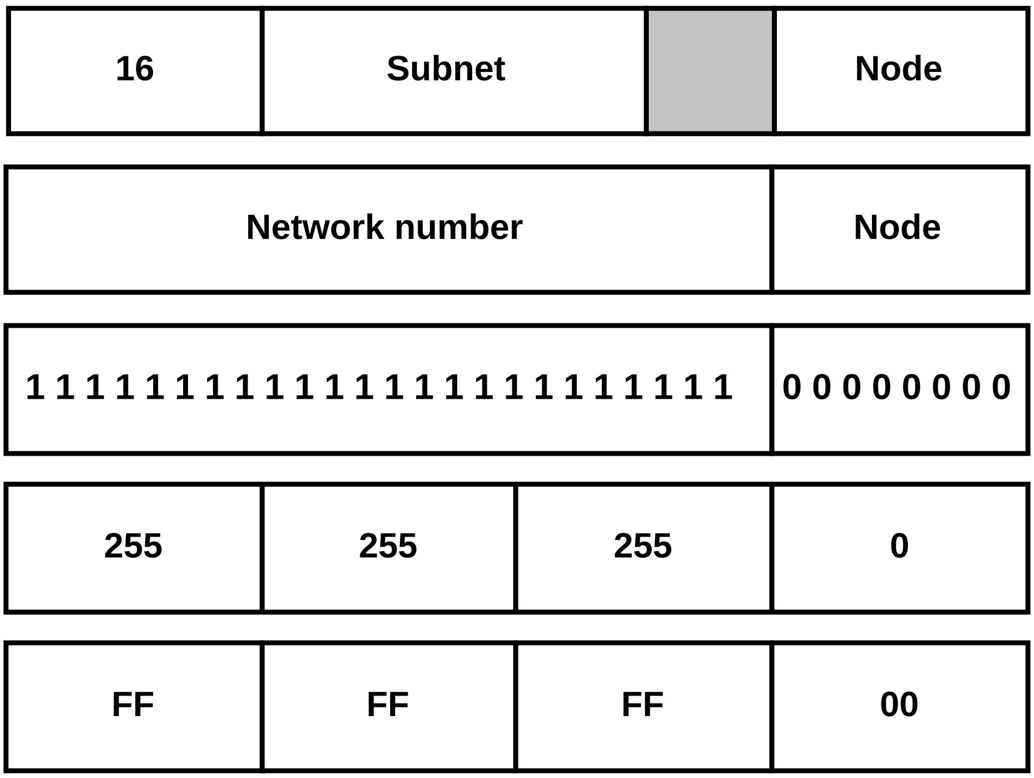

Figure 4: Pictorial representation of Digital's subnet mask

2. The IP/TCP address space database

2.1. Overall organization

The IP/TCP address space database is kept in a hierarchical ULTRIX directory structure whose leaves are ordinary text files. There is one text file for each address cluster.

The directory hierarchy currently (April 1991) is shown in Figure 5.

```
db/CRAnet:

    1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

db/DSN:
    41

db/EASYnet:
    db/EASYnet/CORP:

        50 51 52 53 54 55 56 57 58 59 200

    db/EASYnet/EUR:

        36 37 38 39 40 181 182 183 184 185 186 187 188 189 190 191 192
        193 194 195 196 197 198 199

    db/EASYnet/GIA:

        151 152 153 154 155 156 157 158 159 160 161 162 163 164 165
        166 167 168 169 170 171 172 173 174 175 176 177 178 179 180

    db/EASYnet/US:

        20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 45 46 47 48 49 60
        61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82
        83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102
        103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118
        119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134
        135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150


db/reserve:

    42 43 44 201 202 203 204 205 206 207 208 209 210 211 212 213 214
    215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230
    231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246
    247 248 249 250 251 252 253 254
```

Figure 5: Digital IP address space directory structure

2.2. Fields in the database

Each entry in the subnet database records certain information about the subnet. Figure 6 shows a sample entry, and Figure 7 (page 10) shows a summary of the field information.

The named fields in the database have the meanings and purpose shown below. Please refer to the example in Figure 6.

```
Subnet          16.5.176
Status          assigned
Usage           screened
Mask            255.255.255.0
Broadcast       16.5.176.255
Netname         nsl-zoo-net
Site            UCH
CostCenter      32Q
E-mail          peck@nsl.pa
E-mail          reilly@nsl.pa
Contact         Joe Peck
Contact         Mike Reilly
Badge           555555
Badge           000000
DTN             543-1341
MS              UCH-1
Purpose         NSL Zoo (other vendors' machines)
Remark          Not always online
ApproxSize      10
ConnectWith     NSL router with screen
Domains         pa.dec.com
Created         Mon Mar 11 16:33:22 PST 1991
Modified        Thu May  9 06:34:16 PDT 1991
Verified
End
```

Figure 6: Sample entry in subnet address database

- `Subnet`
  The subnet number without trailing zero bytes. This field should never be changed when editing the database. Required field.

- `Status`
  The "status" of a subnet is whether it belongs to somebody, is reserved for some facility, or is free and available. The field must contain one of the following values:
  - `assigned`
    This subnet has been registered and is in use. The rest of the database entry identifies the organization and person to which it has been assigned.
  - `free`
    This subnet is free and can be assigned.
  - `reserved`
    This subnet is not assigned, but has been reserved for the site identified by the "`Site`" field. Especially in Europe, the reserved subnets are quite likely to be in use without having been registered, so it is probably not be a good idea to change a reserve assignment without careful checking.

  Required field.

- `Usage`
  the "usage" of a subnet is whether or not it is connected to the greater network, isolated, or connected with a selective screen. The field must contain one of the following values:

  - `connected`
    This subnet is fully connected to Digital's internet.
  - `unconnected`
    This subnet is not connected to Digital's internet.
  - `screened`
    This subnet has a partial connection to Digital's internet, so that some packets pass and some do not. Typically a "screened" connection is connected with a screening router.

  Required field.

- `Mask`
  This is the subnet mask that is in use on the subnet. In all but extraordinary circumstances it must be equal to `255.255.255.0`". Required field.
- `Broadcast`
  This is the broadcast address that is in use on the subnet. In all but extraordinary circumstances it must be equal to the subnet number with "`.255`" appended as the node number. Required field.
- `Netname`
  This is the identifier that the owners of the net have chosen to use for it. These identifiers are used only by network diagnostic software in analyzing routing problems, and the details of the netnames do not matter very much. These names should be short, should typically end with the suffix "-net", and should, if possible, be different from one another. Recommended field; not required.
- `Site`
  This is the Digital site identifier for the site at which this subnet is located. If the subnet is a regional backbone and thus spans more than one site, then one of the sites that it connects must be listed. Examples are "`MRO4`" or "`NUO`". Required field.
- `CostCenter`
  The Digital cost center number of the cost center owning this subnet. Under rare circumstances a subnet will be shared between cost centers; in this case, the listed cost center should be the cost center in which the subnet manager is employed. Recommended field; not required.
- `E-mail`
  The electronic mail address, in Internet syntax[2] of the subnet manager. If there is more than one subnet manager or more than one contact address, then each should be listed on a separate line with a separate "`E-mail`" field. The "`E-mail`," "`Contact`," "`Badge`," and "`DTN`" fields should be in the same order, so that, for example, the second "`Badge`" field refers to the same person as the second "`E-mail`" field. The e-mail address of the primary contact should be listed first. One `E-mail` field is required; additional fields are optional.
- `Contact`
  The name of the subnet manager. If there is more than one subnet manager or more

[2]"Internet syntax" means that you have to use the "@" form and not the "::" form of an address, and that ALL-IN-1 addresses need an "@Internet" at the end of them.

than one responsible person, then each should be listed on a separate line with a separate "`Contact`" field. The "`E-mail`," "`Contact`," "`Badge`," and "`DTN`" fields should be in the same order, so that, for example, the second "`Contact`" field refers to the same person as the second "`E-mail`" field. One `Contact` field is required; additional fields are optional.

- `Badge`
  The badge number of the subnet manager. If there is more than one subnet manager or more than one responsible person, then the badge number of each should be listed on a separate line with a separate "`Badge`" field. The "`E-mail`," "`Contact`," "`Badge`," and "`DTN`" fields should be in the same order, so that, for example, the second "`Badge`" field refers to the same person as the second "`E-mail`" field. If the responsible person is a contractor, then put "none" for the badge number. A blank field means "don’t know". Recommended field; not required.

- `DTN`
  The Digital Telephone Network phone number of the subnet manager. If there is more than one subnet manager or more than one responsible person, then the DTN of each should be listed on a separate line with a separate "`DTN`" field. The "`E-mail`," "`Contact`," "`Badge`," and "`DTN`" fields should be in the same order, so that, for example, the second "`DTN`" field refers to the same person as the second "`E-mail`" field. Recommended field; not required.

- `MS`
  Mail stop. The ID mail location of the primary subnet manager. This is rarely used, and can normally be obtained from ELF unless the subnet manager is a contractor. Recommended field; not required.

- `Purpose`
  What this subnet is used for. Why it is needed. Normally this will not be very informative, but when there is more than one subnet per facility, the "`Purpose`" information is useful to be able to distinguish between them. Optional field.

- `Remark`
  Any additional information that might be useful. Optional field.

- `ApproxSize`
  Your best estimate as to the current size of the network, in number of nodes. Optional field.

- `ConnectWith`
  An explanation of how this network is connected, if at all, to the rest of Digital’s Internet. Optional field.

- `Domains`
  The subdomain or subdomains to which this subnet belongs. In all normal circumstances a subnet will belong to exactly one subdomain, though a subdomain can contain several different subnets. If this subnet belongs to a connected domain, then this is a required field.

- `Created`
  The date and time that this entry was first created. This is added automatically by the update software.

- `Modified`
  The date and time that this entry was last modified. This is added automatically by the update softwware.
- `Verified`
  The date and time that this entry was last verified. Not currently in use.

2.3. Address assignment strategy

IP subnet address assignment is not just the simple giving out of numbers. Although IP does not currently support true "area" routing, the job of the router can be greatly simplified if subnet addresses that are physically near each other are close together in binary difference. The more bits that two subnet addresses have in common, the more easily they can be routed or bundled together.

If subnet assignment is done "wrong", everything will still work. The routers will require more memory and the route management will be more complex, but nothing will malfunction. If subnet assignment is done "right", then current and future routing performance will be better, complexity will be lower, and there will be more options in future technologies.

The goal of the original subnet assignment strategy was to put the primary subnets for big sites into slots in the address space that had a lot of nearby subnets with a large number of bits in common, and to put little sites into "smaller" slots. This is a heuristic and not an algorithm, because "big" and "small" are relative terms, and not every large site will have a large number of IP nodes.

A simple procedure for assigning subnets within a cluster that tends to produce better assignments than most others is to sort the subnets in a cluster into decreasing order of expected maximum size, then assign the subnets in increasing order of binary entropy. This means that they are assigned in the order shown in Figure 8. The "relative size" column is an indication of how fully packed it is appropriate to make the cluster. If the first subnet in a cluster is for a facility that is ultimately expected to populate the entire cluster, then it should be given subnet 0 and no further assignments for other facilities should be made to that cluster. If the first facility is expected to use about half the cluster and the second about half the cluster, then they should be given subnets 0 and 128, and no further facility assignments made. And so forth.

When additional subnets for the same facility are assigned, they should be assigned to have the largest number of bits in common with the first or primary subnet in that facility. Naturally, as more and more subnets are assigned to a facility, the number of common bits that are possible will decrease.

3. Update procedures

In concept, the procedure to update the subnet database is very simple. You log on, locate the file that you need to edit, lock it, edit it, unlock it, and log out. The "lock" and "unlock" steps are kept separate from the "edit" step in order that the locking does not have to be built into the editing program; this permits users to use whatever editing program that they find most comfortable or convenient, without worrying about whether or not it knows how to participate in database locking.

Field name	Format or Description	Example	Usage
Subnet	Subnet number	16.5.176	Required
Status	Keyword: `free`, `reserved`, or `assigned`	assigned	Required
Usage	Keyword: `connected`, `unconnected`, `screened`	screened	Required
Mask	Numeric subnet mask value	255.255.255.0	Required
Broadcast	Numeric IP address	16.5.176.255	Required
Netname	Alphanumeric	nsl-zoo-net	Recommended
Site	Digital site code	UCH	Required
CostCenter	Digital Cost center	32Q	Recommended
E-mail	Internet-format electronic mail address	peck@nsl.pa	One required, others optional.
Contact	Person’s name	Joe Peck	One required, others optional.
Badge	Digital badge number	555555	Recommended; provide one for each "Contact"
DTN	Digital Telephone number	543-1341	Recommended
MS	Digital mail stop	UCH-1	Recommended
Purpose	Random text	"NSL Zoo (other vendors’ machines)"	Optional
Remark	Random text	Not always online	Optional
ApproxSize	A number	10	Optional
ConnectWith	Description of a router hookup	"NSL router with screen"	Optional
Domains	Name of subdomain(s) of `dec.com`	pa.dec.com	Required if the subdomains exist.
Created	Unix-format date		Added automatically
Modified	Unix-format date		Added automatically
Verified			Not currently used

Figure 7: Summary of fields in address database

Subnet number	allocation sequence	relative size
0	1	100
16	16	6
32	8	12
48	13	6
64	4	25
80	12	6
96	5	25
112	15	6
128	2	50
144	14	6
160	7	12
176	10	6
192	3	25
208	11	6
224	6	25
240	9	12

Figure 8: Allocation sequence for subnets in a new cluster

The command "`locks`" will tell you which files, if any, are currently locked. If you try to log out with a file still locked, you will be asked to unlock any locked files before you log out (though if you insist, you can log out even with locked files, by typing the `LOGOUT` command in upper case).

3.1. Locking and unlocking a database file

The commands "`checkout`" and "`checkin`" perform the lock and unlock functions, respectively. If you use "`checkout`" to check out a file, then it is locked, checked out in your name, until you use "`checkin`" to unlock it and return it. If you try to check out a file that somebody else has locked, the "`checkout`" request will fail.

The syntax for both commands is the same. Here is an example showing their use to check out, edit, and check in the file holding information for cluster 193.

```
checkout 193
edit 193
checkin 193
```

3.2. Update categories

There are several different kinds of database update that can be made. All of them basically amount to the same thing, namely changing the contents of a database entry for a subnet, but the procedure involved is slightly different.

3.2.1. Changing a field in an existing entry

Often a subnet manager will change, or a secondary subnet manager will be added. Sometimes a DTN or an E-mail address will change. These fields need to be kept up to date. Follow these steps:

1. Determine the subnet cluster number. This is the second number of the subnet address. For example, Subnet 16.123.32 is subnet cluster 123. If you don't know the subnet number, the database of subnet numbers is contained in the file "`reports/subnets.alpha`", i.e. in the file "`subnets.alpha`" in your subdirectory "`reports`".

2. Once you have determined the subnet number and are ready to update it, change to the "`db`" (database) subdirectory, using this command:

   ```
   cd db
   ```

3. Check out the file in that subdirectory whose name is the cluster number:

   ```
   checkout 123
   ```

4. Edit the file using the editor of your choice. If you are not sufficiently versed in the ways of ULTRIX to make that choice, use the "edit" command, which will give you the "`SEDT`" editor. Most VMS users are quite comfortable with it:

   ```
   edit 123
   ```

5. The cluster file contains the database entry for 16 subnets. Locate the correct entry, and edit it as needed. While you are in there, you should doublecheck the DTN and mail stop by using ELF to look up the contact person.

6. Write out the edited file and exit from the editor.

7. Check the file back in:

   ```
   checkin 123
   ```

   the "`checkin`" program will say this:

   ```
   RCS/123,v  <--  123
   new revision: 1.3; previous revision: 1.2
   enter log message:
   (terminate with ^D or single '.')
   >>
   ```

   In response to this, you should type a short note (just a line or two) about what change you have made, and why. The date and time and your identity will be recorded as part of the checking procedure.

8. Return to your top-level directory:

   ```
   cd
   ```

   (typing the "`cd`" command with no arguments returns you to your original login directory).

3.2.2. Assigning a new subnet

Always check existing assignments before making a new one. Sometimes the requestor does not actually need a new subnet, but can share an existing assignment. Sometimes there is a reservation for that facility, in which case you should normally assign the reserved subnet.

Once the particulars of the assignment have been made, the details are just the same as those for 3.2.1, "Changing a field in an existing entry," above. Just change the entry from being unassigned to being assigned, and fill in all of the relevant values.

3.2.3. Moving a subnet to a different facility

Moving a subnet to a different facility involves simply editing its "Site" code as stored in the database. There is no need to move the data entry from one cluster file to another.

3.2.4. Decommissioning a subnet

If it should become necessary to decommission a subnet, do this by changing its "`Status`" field to "`free`", and adding a note in its "`Remark`" field. Leave the other information alone. This will provide a record of the most recent use of that subnet, in case vestigial references persist after it has supposedly been decommissioned.

3.3. Special cases

Ordinary Internet addresses are assigned to fixed bus media such as Ethernet, CI, FDDI, or token rings. Movable or point-to-point addresses require some extra thought.

3.3.1. Point-to-point and link addresses

Internet devices have a separate IP address for each one of their communications interfaces. This means that each end of a wide-area IP link will have a separate address, because each end of the link connects to a communications interface.

While it is possible to configure most brands of IP router to operate wide-area links without addresses, and some brands (e.g. Vitalink) require that the link be run without addresses, it is good network management practice to assign addresses to all WAN links to enable network management software to locate all of the corners of the network.

Link addresses should be assigned out of a subnet to which there will never be any subnet routes published. Each administrative group that is responsible for the operation of a collection of subnets with internal point-to-point links should maintain its own unrouted subnet for this purpose. By way of example, CRA uses network 16.10.0 for this purpose.

3.3.2. Dialup and mobile addresses

Dialup and mobile connections have the property that they are not always connected to the same physical link. For example, a dialin connection using SLIP or PPP will be connected to a serial line router, but the exact interface on that router to which it is connected will vary depending on the connections that were existing at the time the call was made.

3.3.3. Off-premises addresses

In certain cases a Digital subnet is assigned to a location that is not a Digital facility. There are several situations in which this can arise:

- Demonstration IP networks at trade shows.
- Network segments at employee residences, typically used with dialup IP or point-to-point links.
- Digital-owned communications gear on the premises of network common carriers.

The assignment of a subnet for off-premises use does not imply approval for it to be connected; the External Access Review Committee (EXARC) must approve all requests for network connections between Digital's internal networks and off-premises networks.

3.3.4. Addresses not in Net 16

Under certain very rare circumstances it is useful or necessary to assign addresses that are not in Digital's Class A network, Net 16. Examples of appropriate circumstances:

- Connecting an approved external gateway.
- Testing of network hardware or software.
- Networks owned and operated by Digital but used by customers, such as field test or demonstration equipment.

Allocation of non-Net 16 network numbers is handled through the Corporate Research registrar and is sufficiently specialized that it is not documented here. If you have a valid business need for a network number outside Net 16, contact the CRA registrar.

3.3.5. Nonstandard subnet masks

The technology to use different subnet masks on different portions of Digital's IP network can be made to work in the hands of experts; the use of nonstandard masks is not forbidden, but it is not recommended.

When a subnet is assigned, it carries with it a requirement that the 4-bit "reserved" field always be zero. While current plans are that those four bits will be opened up to provide additional subnet capacity for current IP users, they are in fact being held in reserve, which means they are not to be used now. The Telecommunications and Networks group (TaN) in LKG and TAY is experimentally using IP subnet addresses in which the reserved bits are nonzero; all others are required to leave those bits turned off. To do otherwise will seriously jeopardize our ability to do effective wide-area routing.

4. Periodic housekeeping and report generation

Each night, a set of reports is produced that summarize the current contents of the address space database. Those reports are mailed to the Registrar list each week, and are made available in the "reports" subdirectory of each user who is authorized to update the database.

The reports are as follows:

`subnets.domains`
: A listing of all subnets that are registered and are properly recorded in the domain name servers (DNS). These subnets are "complete" according to current Digital operations procedures.

`subnets.connected`
: A listing of all subnets that are registered and which also have packet-level connectivity to the Corporate IP backbone. They do not necessarily have proper domain registration (see above).

`etc.networks` This file is distributed throughout Digital to be used for the list of network names, which on ULTRIX computers is `/etc/networks`. These names are used only by diagnostic software and are not necessary for the correct operation of a subnet or networked computer.

`subnets.16` A complete map of the Net 16 address space, showing subnet numbers, allocations, owners, and so forth. This is the only report that shows unused subnets that are available for assignment.

`subnets.report`
: The list of all assigned subnets and all reserved subnets. This is used to survey the database to locate missing contact information.

`subnets.registered`
: The list of all assigned (registered) subnets. This is produced primarily for the use of DNRS management and the central DECNET registrar.

`subnets.alpha` Allocated and reserved subnets, shown in alphabetical order by facility code. This is used for determining whether or not a facility has an assignment or a reservation.

5. Using Palo Alto Computers

All Palo Alto computers are connected to IP-EASYnet; some are also connected to the Phase-IV DECNET EASYnet.

The machine `NSL::` is a DECsystem 5500 running ULTRIX.

All ULTRIX machines in Palo Alto are in a single cluster. All logins are cluster-wide, though not every machine in the cluster will permit you to do anything once you have logged in.

5.1. Changing your password

Passwords for all Palo Alto cluster logins are controlled from a central password database. To change the password for your account you must connect to the database server machine, log on, change your password, and then wait for the change to propagate to the other machines in the cluster. You are also welcome to change your password on other cluster machines, to avoid having to wait for a new central password to propagate to them.

To change your password, follow this procedure:

1. Connect to the cluster center machine by typing this command:

```
rlogin palo-alto
```

2. Type the ULTRIX command to set a new password:

```
% passwd
Changing password for wade
Old password:

New password:
Retype new password:
```

3. Log out of the cluster center machine by typing this command:

```
logout
```

The new password will propagate to other machines in the cluster within 4 hours. If you need it changed more quickly than that on some machine, you can use the "`passwd`" command on the machine where the change is needed.