Classful network

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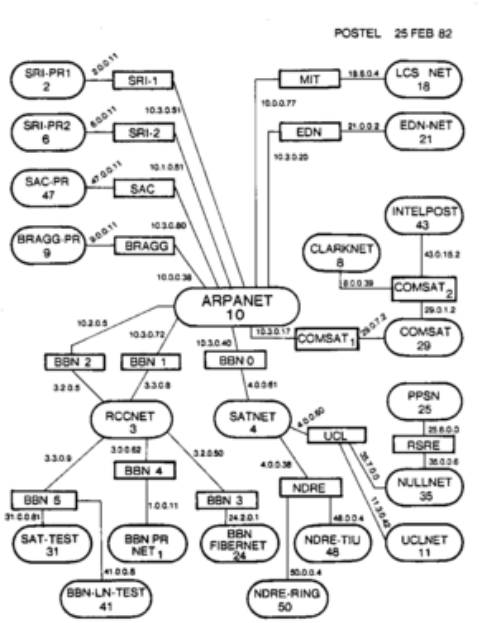
A **classful network** is a network addressing architecture used in the Internet from 1981 until the introduction of Classless Inter-Domain Routing in 1993. The method divides the address space for Internet Protocol Version 4 (IPv4) into five address classes by address range. Classes A, B, C are networks of three different network sizes, i.e. number of hosts for unicast addresses. Class D is for multicast. The class E address range is reserved for future or experimental purposes. Under classful networking, the subnet mask was implied by which address range (class) the address occupied and did not need to be specified separately.

Since its discontinuation, remnants of classful network concepts remain in practice only in limited scope in the default configuration parameters of some network software and hardware components, most notably in the default configuration of subnet masks.



Map of the prototype Internet in 1982, showing 8-bit-numbered networks (ovals) only interconnected by routers (rectangles).

Contents

Background

Originally, the most significant 8 bits of the 32-bit IPv4 address was the *network number* field which specified the particular network a host was attached to. The remaining 24 bits specified the local address, also called *rest field* (the rest of the address), which uniquely identified a host connected to that network.[1] This format was sufficient at a time when only a few large networks existed, such as the ARPANET, which was assigned the network number 10, and before the wide proliferation of local area networks (LANs). As a consequence of this architecture, the address space supported only a low number (254) of independent networks, and it became clear very early on that this would not be enough.

Introduction of address classes

Expansion of the network had to ensure compatibility with the existing address space and the Internet Protocol (IP) packet structure, and avoid the renumbering of the existing networks. The solution was to expand the definition of the network number field to include more bits, allowing more networks to be designated, each potentially having fewer hosts. Since all existing network numbers at the time were smaller than 64, they had only used the 6 least-significant bits of the network number field. Thus it was possible to use the most-significant bits of an address to introduce a set of address classes while preserving the existing network numbers in the first of these classes.

The new addressing architecture was introduced by RFC 791 in 1981 as a part of the specification of the Internet Protocol.[2] It divided the address space into primarily three address formats, henceforth called address *classes*, and left a fourth range reserved to be defined later.

The first class, designated as *Class A*, contained all addresses in which the most significant bit is zero. The network number for this class is given by the next 7 bits, therefore accommodating 128 networks in total, including the zero network, and including the existing IP networks already allocated. A *Class B* network was a network in which all addresses had the two most-significant bits set to 1 and 0. For these networks, the network address was given by the next 14 bits of the address, thus leaving 16 bits for numbering host on the network for a total of 65 536 addresses per network. *Class C* was defined with the 3 high-order bits set to 1, 1, and 0, and designating the next 21 bits to number the networks, leaving each network with 256 local addresses.

The leading bit sequence *111* designated an "*escape to extended addressing mode*",[2] and was later subdivided as Class D (*1110*) for multicast addressing,[3] while leaving as reserved for future use the *1111* block designated as Class E.

Classful addressing definition

Class	Leading bits	Size of *network number* bit field	Size of *rest* bit field	Number of networks	Addresses per network	Total addresses in class	Start address	End address	Default subnet mask in dot-decimal notation	CIDR notation
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})	2,147,483,648 (2^{31})	0.0.0.0	127.255.255.255[a]	255.0.0.0	/8
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})	1,073,741,824 (2^{30})	128.0.0.0	191.255.255.255	255.255.0.0	/16
Class C	110	24	8	2,097,152 (2^{21})	256 (2^8)	536,870,912 (2^{29})	192.0.0.0	223.255.255.255	255.255.255.0	/24
Class D (multicast)	1110	not defined	not defined	not defined	not defined	268,435,456 (2^{28})	224.0.0.0	239.255.255.255	not defined	not defined
Class E (reserved)	1111	not defined	not defined	not defined	not defined	268,435,456 (2^{28})	240.0.0.0	255.255.255.255	not defined	not defined

The number of addresses usable for addressing specific hosts in each network is always $2^N - 2$, where N is the number of rest field bits, and the subtraction of 2 adjusts for the use of the all-bits-zero host portion for network address and the all-bits-one host portion as a broadcast address. Thus, for a Class C address with 8 bits available in the host field, the number of hosts is 254.

Today, IP addresses are associated with a subnet mask. This was not required in a classful network because the mask was implicitly derived from the IP address itself. Any network device would inspect the first few bits of the IP address to determine the class of the address.

The blocks numerically at the start and end of classes A, B and C were originally reserved for special addressing or future features, i.e., 0.0.0.0/8 and 127.0.0.0/8 are reserved in former class A; 128.0.0.0/16 and 191.255.0.0/16 were reserved in former class B but are now available for assignment; 192.0.0.0/24 and 223.255.255.0/24 are reserved in former class C.

While the 127.0.0.0/8 network is a Class A network, it is designated for loopback and cannot be assigned to a network.[4]

Class D is reserved for multicast and cannot be used for regular unicast traffic. Class E is reserved and cannot be used on the public Internet (and many older routers will not accept using it).

Not all sizes of prefix announcement may be routable on the public Internet: see routing, peering.

Bit-wise representation

In the following table:

- *n* indicates a bit used for the network ID.
- *H* indicates a bit used for the host ID.
- *X* indicates a bit without a specified purpose.

```
Class A
  0.  0.  0.  0 = 00000000.00000000.00000000.00000000
127.255.255.255 = 01111111.11111111.11111111.11111111
                  0nnnnnnn.HHHHHHHH.HHHHHHHH.HHHHHHHH

Class B
128.  0.  0.  0 = 10000000.00000000.00000000.00000000
191.255.255.255 = 10111111.11111111.11111111.11111111
                  10nnnnnn.nnnnnnnn.HHHHHHHH.HHHHHHHH

Class C
192.  0.  0.  0 = 11000000.00000000.00000000.00000000
223.255.255.255 = 11011111.11111111.11111111.11111111
                  110nnnnn.nnnnnnnn.nnnnnnnn.HHHHHHHH

Class D
224.  0.  0.  0 = 11100000.00000000.00000000.00000000
239.255.255.255 = 11101111.11111111.11111111.11111111
                  1110XXXX.XXXXXXXX.XXXXXXXX.XXXXXXXX

Class E
240.  0.  0.  0 = 11110000.00000000.00000000.00000000
255.255.255.255 = 11111111.11111111.11111111.11111111
                  1111XXXX.XXXXXXXX.XXXXXXXX.XXXXXXXX
```

Replacement methods

The first architecture change extended the addressing capability in the Internet, but did not prevent IP address exhaustion. The problem was that many sites needed larger address blocks than a Class C network provided, and therefore they received a Class B block, which was in most cases much larger than required. In the rapid growth of the Internet, the pool of unassigned Class B addresses (2^{14}, or

about 16,000) was rapidly being depleted. Classful networking was replaced by Classless Inter-Domain Routing (CIDR), starting in 1993 with the specification of RFC 1518 and RFC 1519, to attempt to solve this problem.

Before the introduction of address classes, the only address blocks available were what later became known as Class A networks.[5] As a result, some organizations involved in the early development of the Internet received address space allocations far larger than they would ever need.

Notes

a. 127.0.0.0 through 127.255.255.255 are reserved for loopback addresses. Though reserved, they are still part of the class A address group.

See also

- IPv4 subnetting reference
- List of assigned /8 IPv4 address blocks
- Private network - common use of classful networks

References

1. Postel, J., ed. (January 1980). "Internet Header Format" (https://tools.ietf.org/html/rfc760#section-3.1). *DoD standard Internet Protocol* (https://tools.ietf.org/html/rfc760). IETF. sec. 3.1. RFC 760. https://tools.ietf.org/html/rfc760#section-3.1. Retrieved November 8, 2013.
2. RFC 791, *Internet Protocol*, Information Sciences Institute (September 1981)
3. Deering, S., ed. (August 1989). "Host Group Addresses" (https://tools.ietf.org/html/rfc1112#section-4). *Host Extensions for IP Multicasting* (https://tools.ietf.org/html/rfc1112). IETF. sec. 4. RFC 1112. https://tools.ietf.org/html/rfc1112#section-4. Retrieved January 21, 2015.
4. RFC 5735
5. Clark, David D. (June 1978). *A proposal for addressing and routing in the Internet* (https://tools.ietf.org/rfcmarkup?url=https://www.ietf.org/rfc/ien/ien46.txt). IETF. IEN 46. https://tools.ietf.org/rfcmarkup?url=https://www.ietf.org/rfc/ien/ien46.txt. Retrieved January 8, 2014.

External links

- IANA, Current IPv4 /8 delegations
- Overview of IP addressing, both classless and classful (404)
- Postel, Jon, RFC 790 "Assigned Numbers", September 1981, which includes a list of Class A networks as of that date.