

Classless Inter-Domain Routing

Classless Inter-Domain Routing (**CIDR** /ˈsaɪdər, ˈsɪ-/) is a method for allocating [IP addresses](#) and for [IP routing](#). The [Internet Engineering Task Force](#) introduced CIDR in 1993 to replace the previous [classful network addressing architecture](#) on the [Internet](#). Its goal was to slow the growth of [routing tables](#) on [routers](#) across the Internet, and to help slow the rapid [exhaustion of IPv4 addresses](#).^{[1][2]}

IP addresses are described as consisting of two groups of [bits](#) in the address: the [most significant bits](#) are the [network prefix](#), which identifies a whole network or [subnet](#), and the [least significant](#) set forms the *host identifier*, which specifies a particular interface of a host on that network. This division is used as the basis of traffic routing between IP networks and for address allocation policies.

Whereas classful network design for IPv4 sized the network prefix as one or more 8-bit groups, resulting in the blocks of Class A, B, or C addresses, under CIDR address space is allocated to [Internet service providers](#) and end users on any address-bit boundary. In IPv6, however, the interface identifier has a fixed size of 64 bits by convention, and smaller subnets are never allocated to end users.

CIDR encompasses several concepts. It is based on **variable-length subnet masking (VLSM)** which allows the specification of arbitrary-length prefixes. CIDR introduced a new method of representation for IP addresses, now commonly known as **CIDR notation**, in which an address or routing prefix is written with a suffix indicating the number of bits of the prefix, such as *192.0.2.0/24* for IPv4, and *2001:db8::/32* for IPv6. CIDR introduced an administrative process of allocating address blocks to organizations based on their actual and short-term projected needs. The aggregation of multiple contiguous prefixes resulted in [supernets](#) in the larger Internet, which whenever possible are advertised as aggregates, thus reducing the number of entries in the global routing table.

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Background

An IP address is interpreted as composed of two parts: a network-identifying prefix followed by a [host identifier](#) within that network. In the previous [classful network](#) architecture, IP address allocations were based on the bit boundaries of the four [octets](#) of an IP address. An address was considered to be the combination of an 8, 16, or 24-bit network prefix along with a 24, 16, or 8-bit host identifier respectively. Thus, the smallest allocation and routing block contained only 256 addresses—too small for most enterprises, and the next larger block contained 65 536 addresses—too large to be used efficiently even by large organizations. This led to inefficiencies in address use as well as inefficiencies in routing, because it required a large number of allocated class-C networks with individual route announcements, being geographically dispersed with little opportunity for [route aggregation](#).

During the first decade of the Internet after the invention of the [Domain Name System](#) (DNS) it became apparent that the devised system based on the classful network scheme of allocating the IP address space and the routing of IP packets was not [scalable](#).^[3] This led to the successive development of [subnetting](#) and CIDR. The network class distinctions were removed, and the new

system was described as being *classless*, with respect to the old system, which became known as *classful*. In 1993, the Internet Engineering Task Force published a new set of standards, RFC 1518 (<https://tools.ietf.org/html/rfc1518>) and RFC 1519 (<https://tools.ietf.org/html/rfc1519>), to define this new concept of allocation of IP address blocks and new methods of routing IPv4 packets. An updated version of the specification was published as RFC 4632 (<https://tools.ietf.org/html/rfc4632>) in 2006.^[4]

Classless Inter-Domain Routing is based on variable-length subnet masking (VLSM), which allows a network to be divided into variously sized subnets, providing the opportunity to size a network more appropriately for local needs. Variable-length subnet masks are mentioned in RFC 950 (<https://tools.ietf.org/html/rfc950>).^[5] Accordingly, techniques for grouping addresses for common operations were based on the concept of cluster addressing, first proposed by Carl-Herbert Rokitsky.^{[6][7]}

CIDR notation

CIDR notation is a compact representation of an IP address and its associated routing prefix. The notation is constructed from an IP address, a slash (/) character, and a decimal number. The trailing number is the count of leading 1 bits in the routing mask, traditionally called the network mask. The IP address in the notation is always represented according to the standards for IPv4 or IPv6.

The address may denote a single, distinct interface address, or it may be the beginning address of an entire network. When expressing a network, its size is given by the number of addresses that are possible with the number of remaining, least-significant bits below the prefix, i.e. the host identifier.

For example:

- `192.168.100.14/24` represents the IPv4 address `192.168.100.14` and its associated routing prefix `192.168.100.0`, or equivalently, its subnet mask `255.255.255.0`, which has 24 leading 1-bits.
- the IPv4 block `192.168.100.0/22` represents the 1024 IPv4 addresses from `192.168.100.0` to `192.168.103.255`.
- the IPv6 block `2001:db8::/48` represents the block of IPv6 addresses from `2001:db8:0:0:0:0:0:0` to `2001:db8:0:ffff:ffff:ffff:ffff:ffff`.
- `::1/128` represents the IPv6 loopback address. Its prefix length is 128 which is the number of bits in the address.

For IPv4, CIDR notation is an alternative to the older system of representing networks by their starting address and the subnet mask, both written in dot-decimal notation. `192.168.100.0/24` is equivalent to `192.168.100.0/255.255.255.0`.

The number of addresses of a subnet may be calculated as $2^{\text{address length} - \text{prefix length}}$, where *address length* is 128 for IPv6 and 32 for IPv4. For example, in IPv4, the prefix length /29 gives: $2^{32 - 29} = 2^3 = 8$ addresses.

Subnet masks

A subnet mask is a bitmask that encodes the prefix length associated with an IPv4 address or network in quad-dotted notation: 32 bits, starting with a number of 1 bits equal to the prefix length, ending with 0 bits, and encoded in four-part dotted-decimal format: `255.255.255.0`. A subnet mask encodes the same information as a prefix length but predates the advent of CIDR. In CIDR notation, the prefix bits are always contiguous. Subnet masks were allowed by RFC 950 (<https://tools.ietf.org/html/rfc950>)^[5] to specify non-contiguous bits until RFC 4632 (<https://tools.ietf.org/html/rfc4632>)^[4]:Section 5.1 stated that the mask must be left contiguous. Given this constraint, a subnet mask and CIDR notation serve exactly the same function.

CIDR blocks

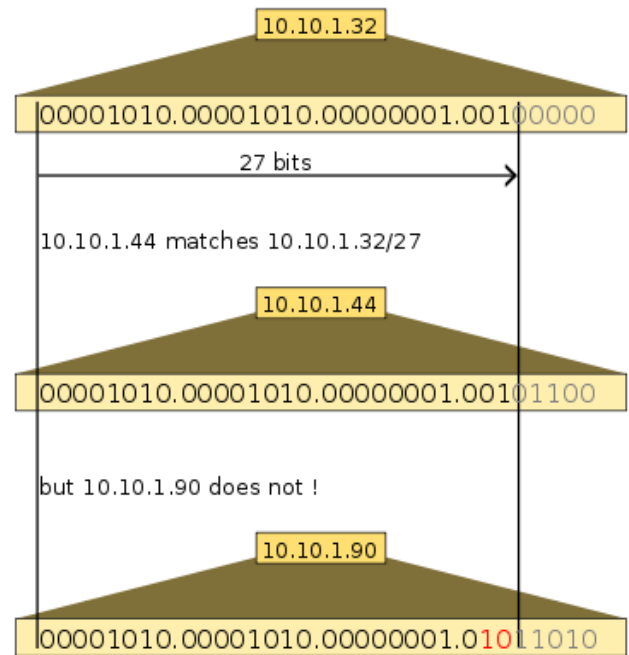
CIDR is principally a bitwise, prefix-based standard for the representation of IP addresses and their routing properties. It facilitates routing by allowing blocks of addresses to be grouped into single routing table entries. These groups, commonly called CIDR blocks, share an initial sequence of bits in the binary representation of their IP addresses. IPv4 CIDR blocks are identified using a syntax similar to that of IPv4 addresses: a dotted-decimal address, followed by a slash, then a number from 0 to 32, i.e., `a.b.c.d/n`. The dotted decimal portion is the IPv4 address. The number following the slash is the prefix length, the number of shared initial bits, counting from the most-significant bit of the address. When emphasizing only the size of a network, the address portion of the notation is usually omitted. Thus, a /20 block is a CIDR block with an unspecified 20-bit prefix.

An IP address is part of a CIDR block and is said to match the CIDR prefix if the initial *n* bits of the address and the CIDR prefix are the same. An IPv4 address is 32 bits so an *n*-bit CIDR prefix leaves $32 - n$ bits unmatched, meaning that $2^{32 - n}$ IPv4 addresses match a given *n*-bit CIDR prefix. Shorter CIDR prefixes match more addresses, while longer prefixes match fewer. In the case of overlaid CIDR blocks, an address can match multiple CIDR prefixes of different lengths.

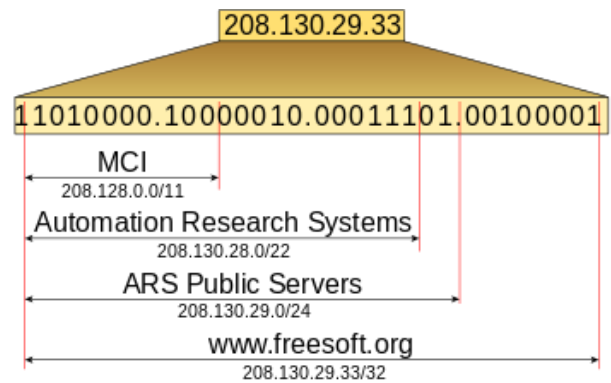
CIDR is also used for IPv6 addresses and the syntax semantic is identical. The prefix length can range from 0 to 128, due to the larger number of bits in the address. However, by convention, a subnet on broadcast MAC layer networks always has 64-bit host identifiers. Larger prefixes are rarely used even on point-to-point links.

Assignment of CIDR blocks

The Internet Assigned Numbers Authority (IANA) issues to regional Internet registries (RIRs) large, short-prefix CIDR blocks. For example, 62.0.0.0/8 (with over sixteen million addresses) is administered by RIPE NCC, the European RIR. The RIRs, each responsible for a single, large, geographic area, such as Europe or North America, subdivide these blocks and allocate subnets to local Internet registries (LIRs). Similar subdividing may be repeated several times at lower levels of delegation. End-user networks receive subnets sized according to their projected short-term need. Networks served by a single ISP are encouraged by IETF recommendations to obtain IP address space directly from their ISP. Networks served by multiple ISPs, on the other hand, may obtain provider-independent address space directly from the appropriate RIR.



For example, in the late 1990s, the IP address 208.130.29.33 (since reassigned) was used by www.freessoft.org. An analysis of this address identified three CIDR prefixes. 208.128.0.0/11, a large CIDR block containing over 2 million addresses, had been assigned by ARIN (the North American RIR) to MCI. Automation Research Systems, a Virginia VAR, leased an Internet connection from MCI and was assigned the 208.130.28.0/22 block, capable of addressing just over 1000 devices. ARS used a /24 block for its publicly accessible servers, of which 208.130.29.33 was one. All of these CIDR prefixes would be used, at different locations in the network. Outside MCI's network, the 208.128.0.0/11 prefix would be used to direct to MCI traffic bound not only for 208.130.29.33, but also for any of the roughly two million IP addresses with the same initial 11 bits. Within MCI's network, 208.130.28.0/22 would become visible, directing traffic to the leased line serving ARS. Only within the ARS corporate network would the 208.130.29.0/24 prefix have been used.



IPv4 CIDR blocks

IPv4 CIDR

Address format	Difference to last address	Mask	Addresses		Relative to class A, B, C	Restrictions on a, b, c and d (0..255 unless noted)	Typical use
			Decimal	2^n			
<i>a.b.c.d/32</i>	+0.0.0.0	255.255.255.255	1	2^0	$\frac{1}{256}$ C		Host route
<i>a.b.c.d/31</i>	+0.0.0.1	255.255.255.254	2	2^1	$\frac{1}{128}$ C	$d = 0 \dots (2n) \dots 254$	Point-to-point links (RFC 3021 (https://tools.ietf.org/html/rfc3021))
<i>a.b.c.d/30</i>	+0.0.0.3	255.255.255.252	4	2^2	$\frac{1}{64}$ C	$d = 0 \dots (4n) \dots 252$	Point-to-point links (glue network)
<i>a.b.c.d/29</i>	+0.0.0.7	255.255.255.248	8	2^3	$\frac{1}{32}$ C	$d = 0 \dots (8n) \dots 248$	Smallest multi-host network
<i>a.b.c.d/28</i>	+0.0.0.15	255.255.255.240	16	2^4	$\frac{1}{16}$ C	$d = 0 \dots (16n) \dots 240$	Small <u>LAN</u>
<i>a.b.c.d/27</i>	+0.0.0.31	255.255.255.224	32	2^5	$\frac{1}{8}$ C	$d = 0 \dots (32n) \dots 224$	
<i>a.b.c.d/26</i>	+0.0.0.63	255.255.255.192	64	2^6	$\frac{1}{4}$ C	$d = 0, 64, 128, 192$	
<i>a.b.c.d/25</i>	+0.0.0.127	255.255.255.128	128	2^7	$\frac{1}{2}$ C	$d = 0, 128$	Large <u>LAN</u>
<i>a.b.c.0/24</i>	+0.0.0.255	255.255.255.0	256	2^8	1 C		
<i>a.b.c.0/23</i>	+0.0.1.255	255.255.254.0	512	2^9	2 C	$c = 0 \dots (2n) \dots 254$	
<i>a.b.c.0/22</i>	+0.0.3.255	255.255.252.0	1,024	2^{10}	4 C	$c = 0 \dots (4n) \dots 252$	Small business
<i>a.b.c.0/21</i>	+0.0.7.255	255.255.248.0	2,048	2^{11}	8 C	$c = 0 \dots (8n) \dots 248$	Small <u>ISP</u> / large business
<i>a.b.c.0/20</i>	+0.0.15.255	255.255.240.0	4,096	2^{12}	16 C	$c = 0 \dots (16n) \dots 240$	
<i>a.b.c.0/19</i>	+0.0.31.255	255.255.224.0	8,192	2^{13}	32 C	$c = 0 \dots (32n) \dots 224$	<u>ISP</u> / large business
<i>a.b.c.0/18</i>	+0.0.63.255	255.255.192.0	16,384	2^{14}	64 C	$c = 0, 64, 128, 192$	
<i>a.b.c.0/17</i>	+0.0.127.255	255.255.128.0	32,768	2^{15}	128 C	$c = 0, 128$	
<i>a.b.0.0/16</i>	+0.0.255.255	255.255.0.0	65,536	2^{16}	$256 \text{ C} = \text{B}$		
<i>a.b.0.0/15</i>	+0.1.255.255	255.254.0.0	131,072	2^{17}	2 B	$b = 0 \dots (2n) \dots 254$	
<i>a.b.0.0/14</i>	+0.3.255.255	255.252.0.0	262,144	2^{18}	4 B	$b = 0 \dots (4n) \dots 252$	
<i>a.b.0.0/13</i>	+0.7.255.255	255.248.0.0	524,288	2^{19}	8 B	$b = 0 \dots (8n) \dots 248$	
<i>a.b.0.0/12</i>	+0.15.255.255	255.240.0.0	1,048,576	2^{20}	16 B	$b = 0 \dots (16n) \dots 240$	
<i>a.b.0.0/11</i>	+0.31.255.255	255.224.0.0	2,097,152	2^{21}	32 B	$b = 0 \dots (32n) \dots 224$	
<i>a.b.0.0/10</i>	+0.63.255.255	255.192.0.0	4,194,304	2^{22}	64 B	$b = 0, 64, 128, 192$	
<i>a.b.0.0/9</i>	+0.127.255.255	255.128.0.0	8,388,608	2^{23}	128 B	$b = 0, 128$	
<i>a.0.0.0/8</i>	+0.255.255.255	255.0.0.0	16,777,216	2^{24}	$256 \text{ B} = \text{A}$		Largest <u>IANA</u> block allocation
<i>a.0.0.0/7</i>	+1.255.255.255	254.0.0.0	33,554,432	2^{25}	2 A	$a = 0 \dots (2n) \dots 254$	
<i>a.0.0.0/6</i>	+3.255.255.255	252.0.0.0	67,108,864	2^{26}	4 A	$a = 0 \dots (4n) \dots 252$	

a.0.0.0/5	+7.255.255.255	248.0.0.0	134,217,728	2 ²⁷	8 A	a = 0 ... (8n) ... 248	
a.0.0.0/4	+15.255.255.255	240.0.0.0	268,435,456	2 ²⁸	16 A	a = 0 ... (16n) ... 240	
a.0.0.0/3	+31.255.255.255	224.0.0.0	536,870,912	2 ²⁹	32 A	a = 0 ... (32n) ... 224	
a.0.0.0/2	+63.255.255.255	192.0.0.0	1,073,741,824	2 ³⁰	64 A	a = 0, 64, 128, 192	
a.0.0.0/1	+127.255.255.255	128.0.0.0	2,147,483,648	2 ³¹	128 A	a = 0, 128	
0.0.0.0/0	+255.255.255.255	0.0.0.0	4,294,967,296	2 ³²	256 A		

In common usage, the first address in a subnet, all binary zero in the host identifier, is reserved for referring to the network itself, while the last address, all binary one in the host identifier, is used as a broadcast address for the network; this reduces the number of addresses available for hosts by 2. As a result, a /31 network, with one binary digit in the host identifier, would be unusable, as such a subnet would provide no available host addresses after this reduction. RFC 3021 (<https://tools.ietf.org/html/rfc3021>) creates an exception to the "host all ones" and "host all zeros" rules to make /31 networks usable for point-to-point links. /32 addresses (single-host network) must be accessed by explicit routing rules, as there is no room in such a network for a gateway.

In routed subnets larger than /31 or /32, the number of available host addresses is usually reduced by two, namely the largest address, which is reserved as the broadcast address, and the smallest address, which identifies the network itself.^{[8][9]}

IPv6 CIDR blocks

The large address size used in IPv6 permitted implementation of worldwide route summarization and guaranteed sufficient address pools at each site. The standard subnet size for IPv6 networks is a /64 block, which is required for the operation of stateless address autoconfiguration.^[10] At first, the IETF recommended in RFC 3177 (<https://tools.ietf.org/html/rfc3177>) as a best practice that all end sites receive a /48 address allocation,^[11] however, criticism and reevaluation of actual needs and practices has led to more flexible allocation recommendations in RFC 6177 (<https://tools.ietf.org/html/rfc6177>)^[12] suggesting a significantly smaller allocation for some sites, such as a /56 block for home networks.

This **IPv6 subnetting reference** lists the sizes for IPv6 subnetworks. Different types of network links may require different subnet sizes.^[13] The subnet mask separates the bits of the network identifier prefix from the bits of the interface identifier. Selecting a smaller prefix size results in fewer number of networks covered, but with more addresses within each network.^[14]

2001:0db8:0123:4567:89ab:cdef:1234:5678	
	128 Single end-points
and loopback	
	127 Point-to-point links
(inter-router)	
	124
	120
	116
	112
	108
	104
	100
	96
	92
	88
	84
	80
	76
	72
	68
	64 Single LAN; default prefix size for SLAAC
	60 Some (very limited) 6rd deployments (760 =
16 /64 blocks)	
	56 Minimal end sites assignment ^[12] ; e.g. home
network (/56 = 256 /64 blocks)	
	52 /52 block = 4096 /64 blocks
	48 Typical assignment for larger sites (/48 =
65536 /64 blocks)	

Prefix	Number of equivalent subnets			Interface ID bits
	/48	/56	/64	
/24	16M	4G	1T	104
/25	8M	2G	512G	103
/26	4M	1G	256G	102
/27	2M	512M	128G	101
/28	1M	256M	64G	100
/29	512K	128M	32G	99
/30	256K	64M	16G	98
/31	128K	32M	8G	97
/32	64K	16M	4G	96
/33	32	8M	2G	95
/34	16K	4M	1G	94
/35	8K	2M	512M	93
/36	4K	1M	256M	92
/37	2K	512K	128M	91
/38	1K	256K	64M	90
/39	512	128K	32M	89
/40	256	64K	16M	88
/41	128	32	8M	87
/42	64	16K	4M	86
/43	32	8K	2M	85
/44	16	4K	1M	84
/45	8	2K	512K	83
/46	4	1K	256K	82
/47	2	512	128K	81
/48	1	256	64K	80
/49		128	32	79
/50		64	16K	78
/51		32	8K	77
/52		16	4K	76
/53		8	2K	75
/54		4	1K	74
/55		2	512	73
/56		1	256	72
/57			128	71
/58			64	70
/59			32	69
/60			16	68
/61			8	67
/62			4	66
/63			2	65
/64			1	64

K = 1,024	G = 1,073,741,824
M = 1,048,576	T = 1,099,511,627,776

A Table of CIDR prefixes for IPv6, it shows the number of corresponding equivalent subnets for each prefix, as well as the number of the host identifier bits.

```

||||| ||||| ||44
||||| ||||| ||40
||||| ||||| 36 possible future local Internet registry (LIR)
extra-small allocations
||||| ||||| 32 LIR minimum allocations
||||| ||||| 28 LIR medium allocations
||||| ||||| 24 LIR large allocations
||||| ||||| 20 LIR extra large allocations
||||| 16
||12 Regional Internet registry (RIR) allocations from IANA[15]
|8
4

```

Prefix aggregation

CIDR provides fine-grained routing prefix aggregation. For example, if the first 20 bits of their network prefixes match, sixteen contiguous /24 networks can be aggregated and advertised to a larger network as a single /20 routing table entry. This reduces the number of routes that have to be advertised.

See also

- Internet protocol suite

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Further reading

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External links

- CIDR Report (<https://www.cidr-report.org/as2.0/>) (updated daily)

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