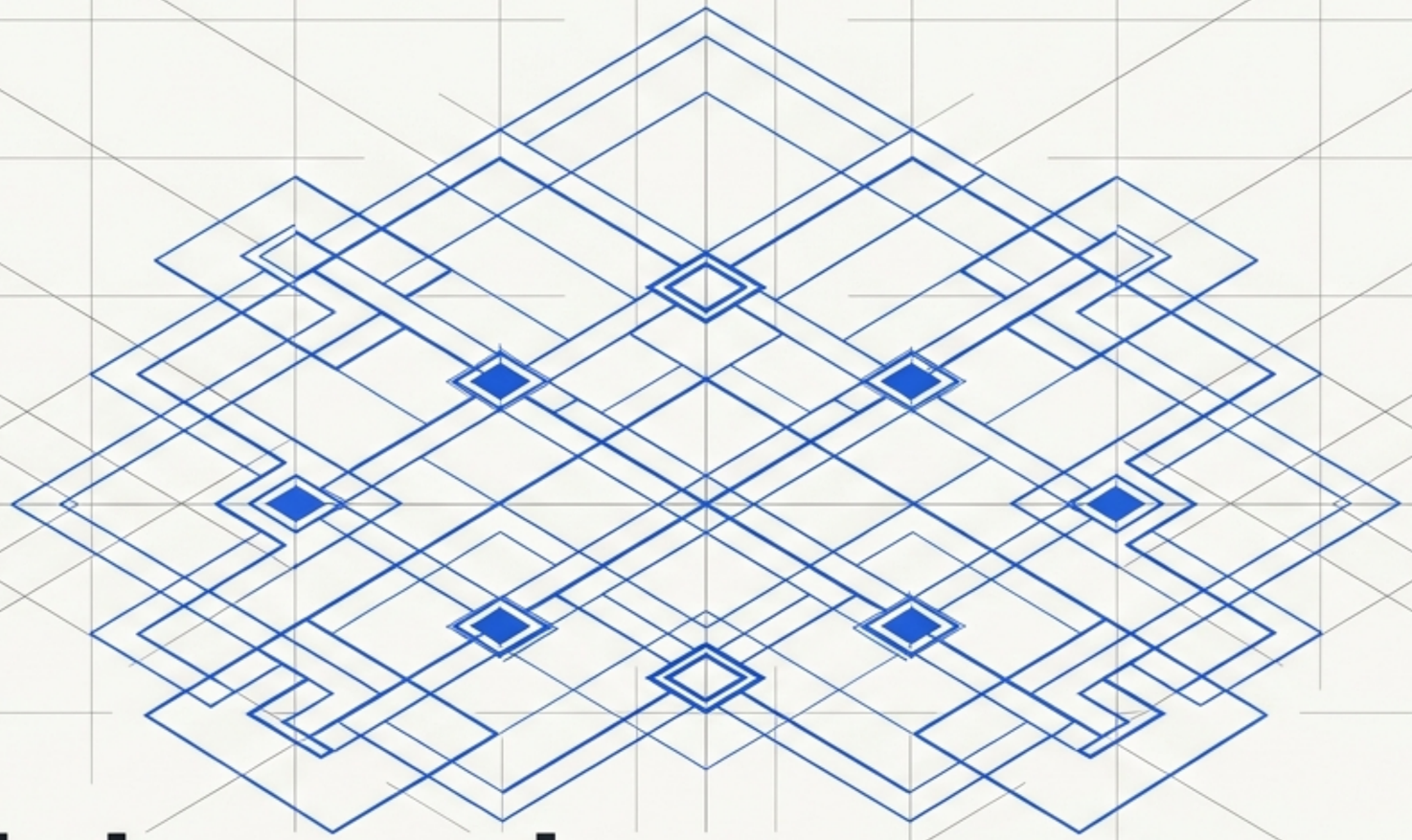
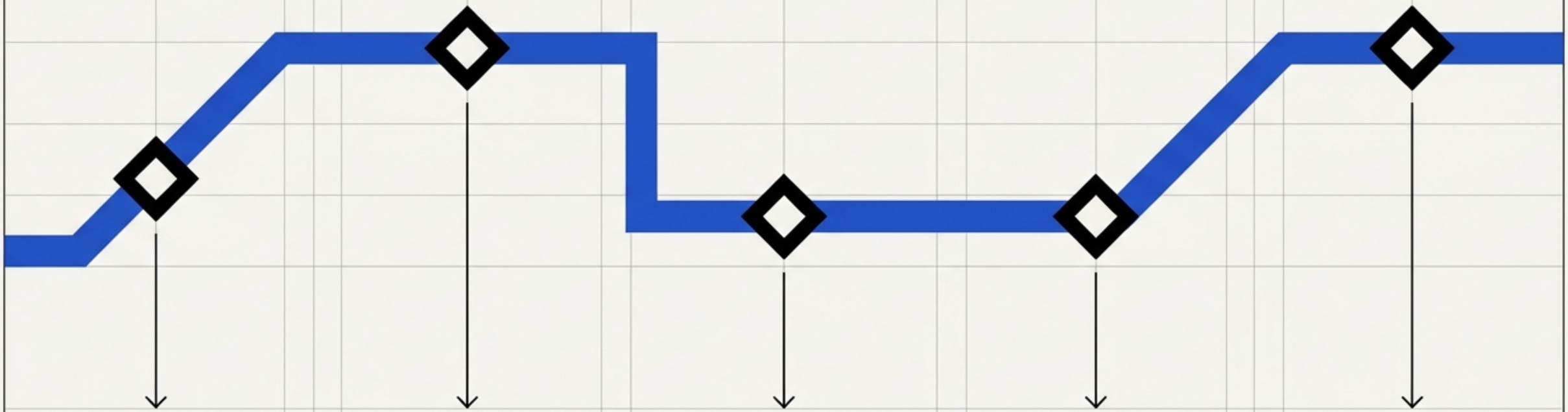


IP Addressing

The Blueprint of Computer Networking

Mapping the Route



Core Definition

What is an IP address?

IPv4 Anatomy

The mathematical 32-bit constraint.

Classful Architecture

The original system and its fatal flaw.

Subnetting & CIDR

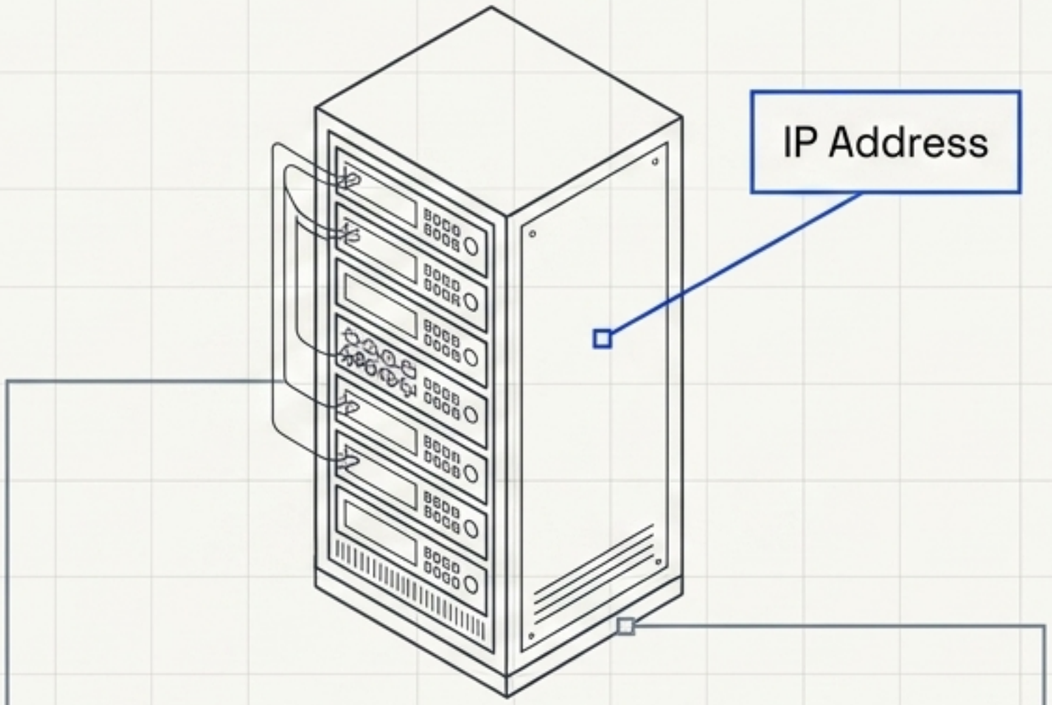
The engineering fix for network efficiency.

The IPv6 Protocol

The infinite 128-bit future.

The Digital Identity Problem

A logical, dynamic address used to route mail to your location. It changes if you move.

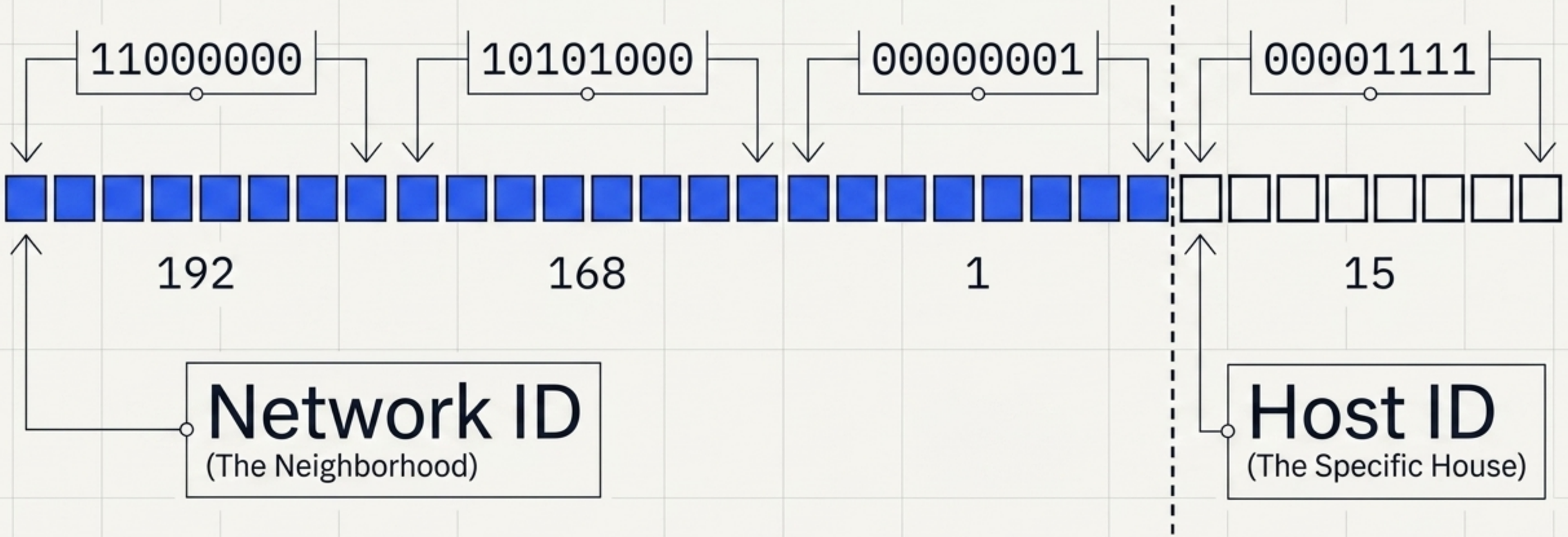


A logical, routable address used to locate a device on the global network. It changes based on the network you connect to.

MAC Address: A physical, permanent hardware address. It never changes (like a fingerprint). e.g., `00:1A:2B:3C:4D:5E`

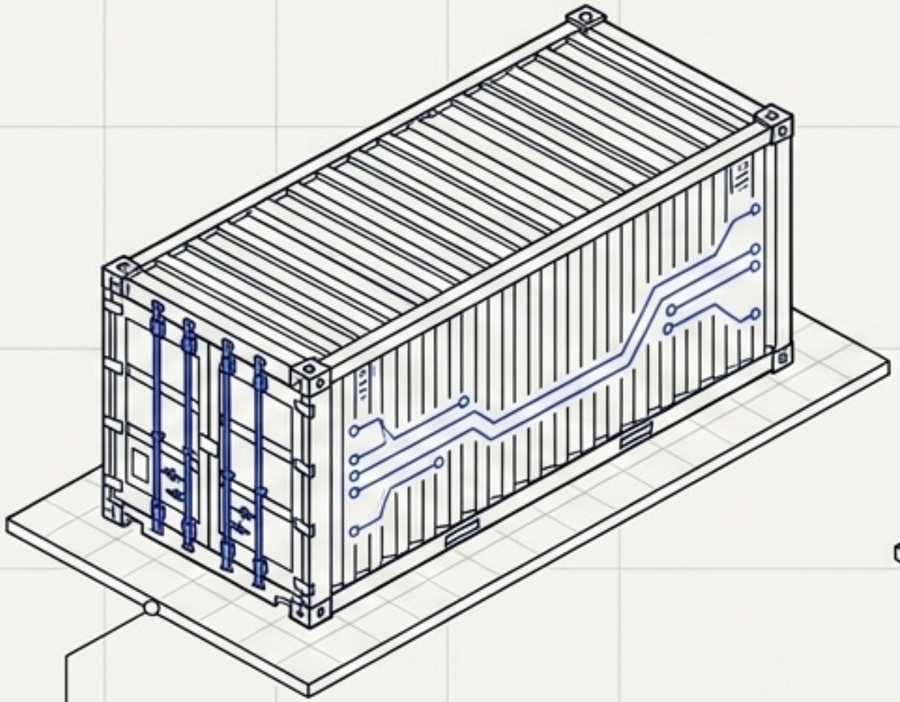
The Anatomy of IPv4

The fundamental truth of IPv4: It is exactly 32 bits long, resulting in ~4.3 billion possible unique addresses. Every IP is split into two logical zones.



The Original System: Classful Addressing

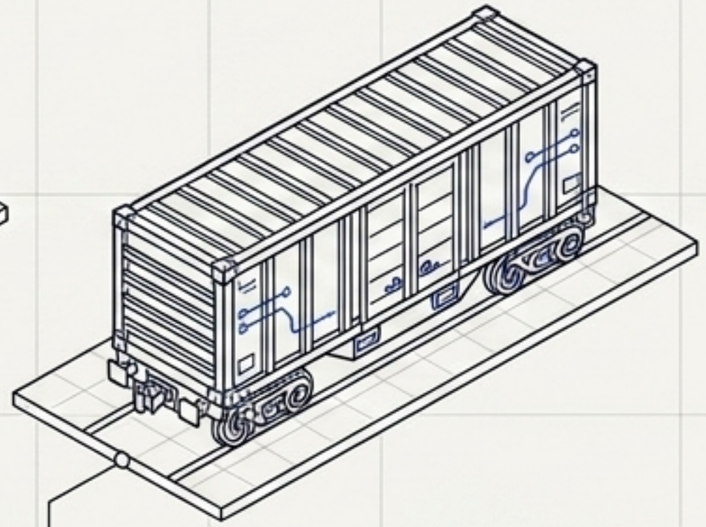
To manage the 4.3 billion addresses, early architects rigidly divided them into predetermined ‘classes’ to accommodate organizations of different sizes.



Class A

Massive Scale

Few networks globally, but millions of hosts per network.



Class B

Medium Scale

A balanced distribution of networks and hosts.

Class C

Small Scale

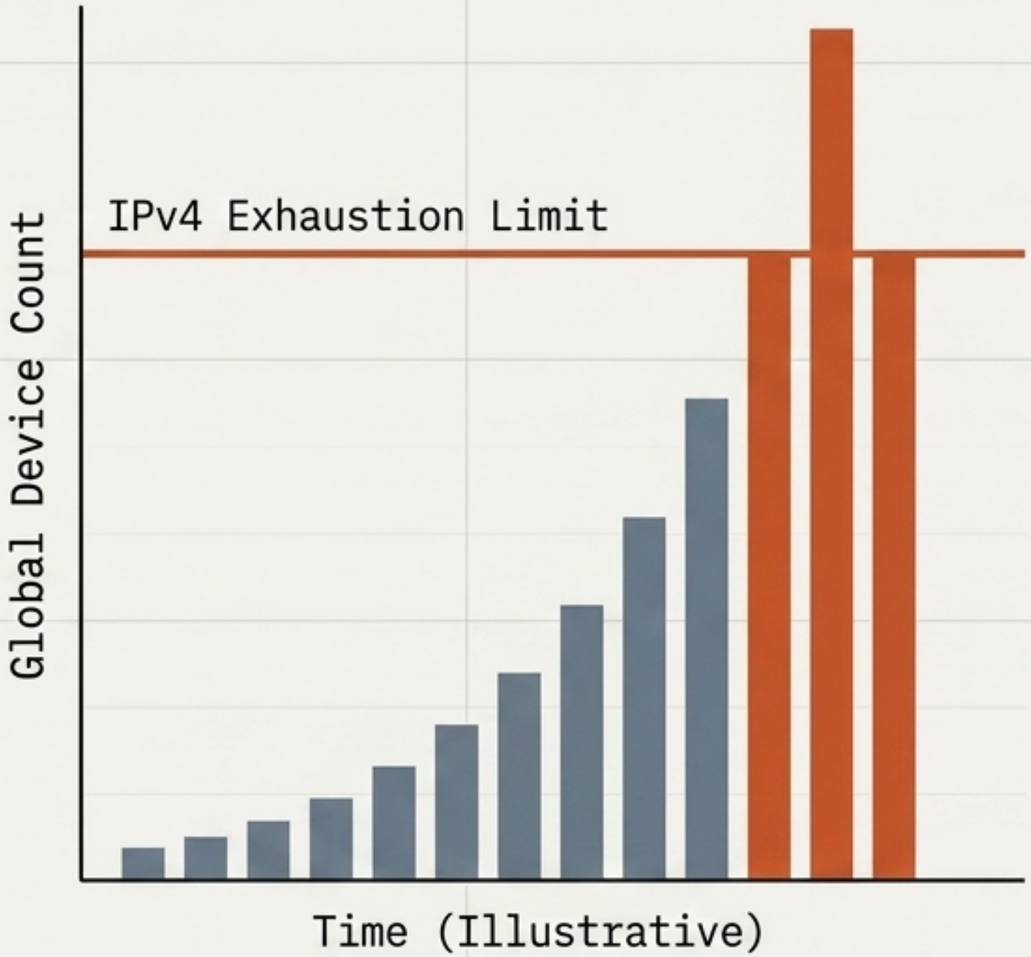
Millions of available networks, but limited to only 254 hosts each.

Classful Architecture Matrix

Class	Leading Bits	Default Subnet Mask	Structure	Max Hosts per Network
A	0	255.0.0.0	N.H.N.H	16,777,214
B	10	255.255.0.0	N.N.H.H	65,534
C	110	255.255.255.0	N.N.N.H	254
D	1110	Multicast	-	-
E	1111	Experimental	-	-

The Scaling Crisis

The fatal flaw of Classful addressing was catastrophic waste.



Waste Calculation

Requirement: A company needs exactly 300 IP addresses.

✕ Class C is too small (Only 254 available).

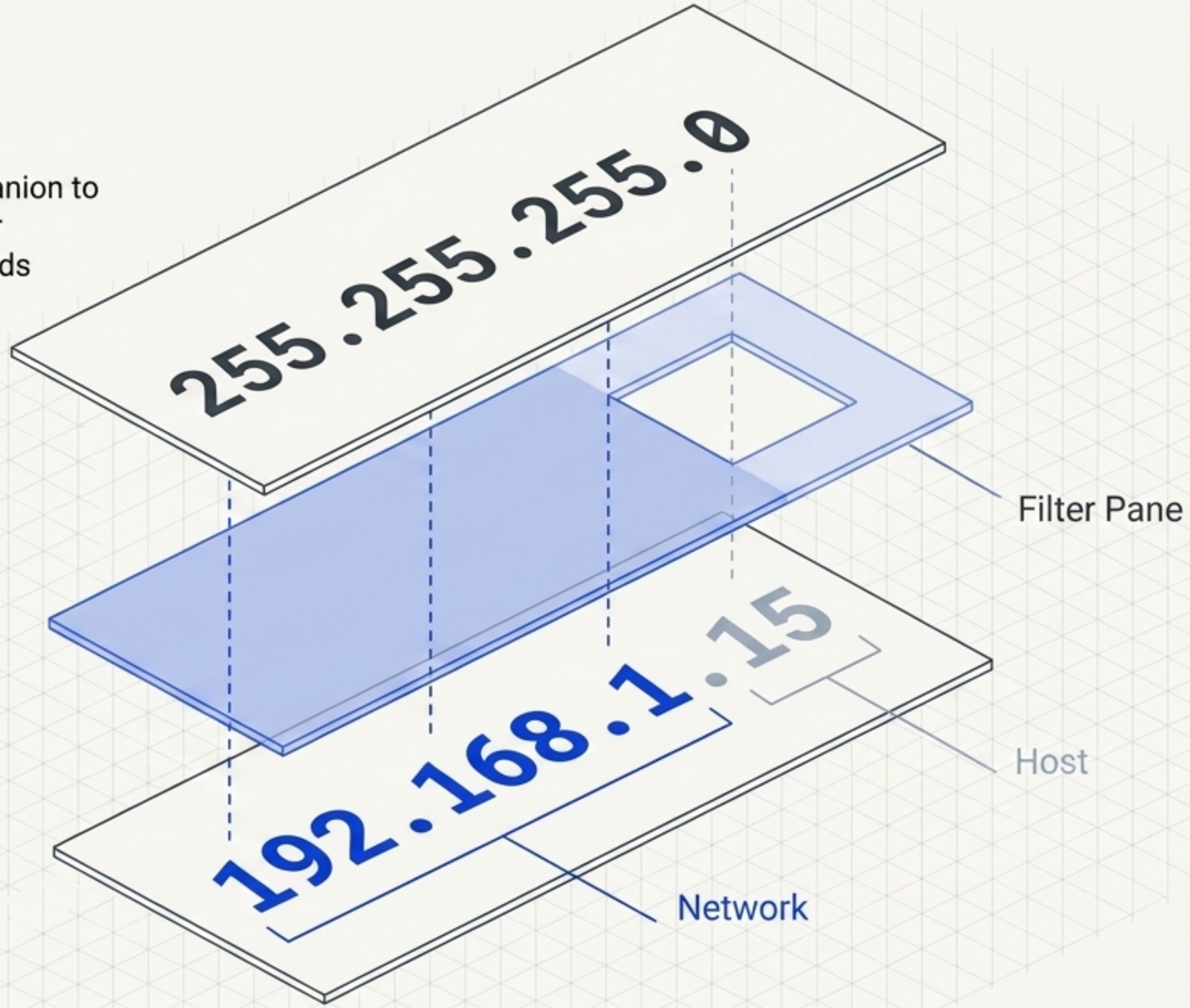
→ Forced to allocate a Class B network (65,534 available).

Result: 65,234 global addresses permanently stranded and wasted.

The internet needed a scalpel, not a cleaver.

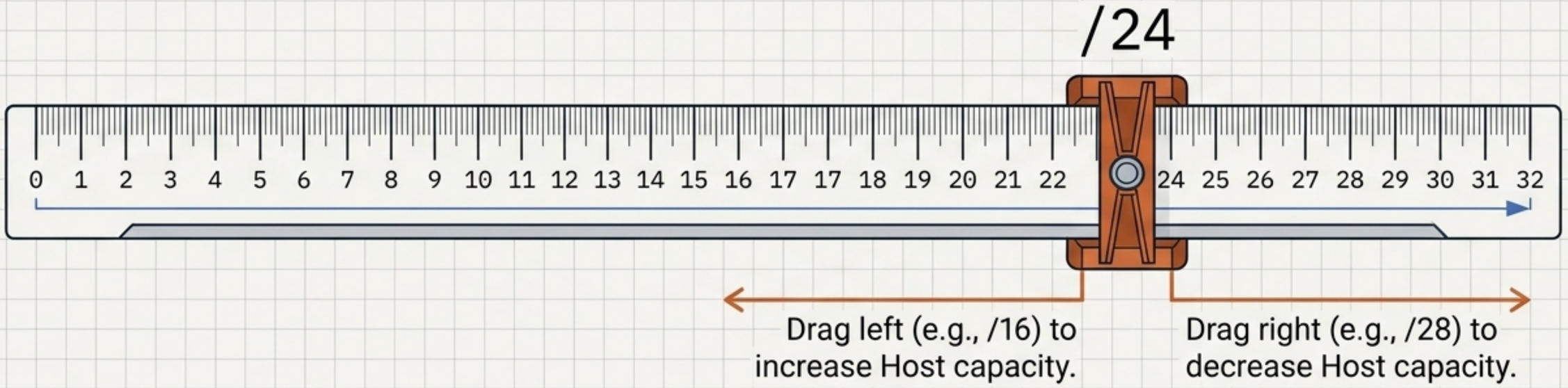
Subnet Masks: The Digital Filter

The Subnet Mask is the required companion to an IP. It acts as a filter, telling the router precisely where the Network identity ends and the Host identity begins.



CIDR Notation (Classless Routing)

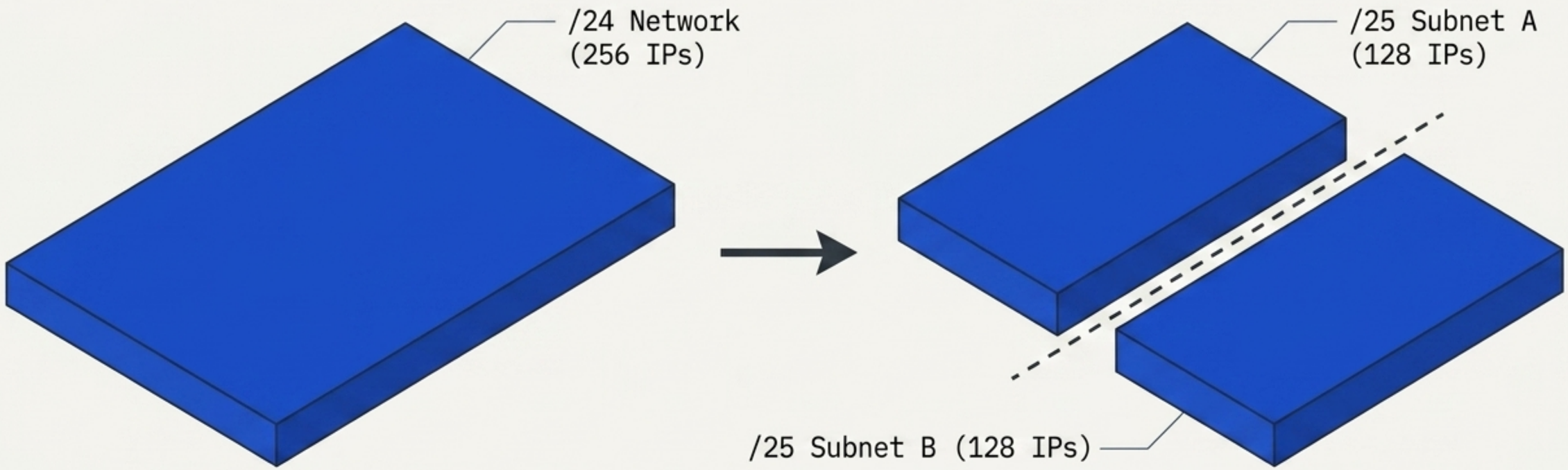
Classless Inter-Domain Routing (CIDR) abolished rigid classes. By specifying exactly how many bits are used for the network, engineers can custom-size boundaries and eliminate waste.



Example: /24 means exactly 24 bits are locked for the Network ID, leaving 8 bits for the Host ID (256 possible addresses).

The Mechanics of Subnetting

Subnetting is the mathematical art of borrowing bits from the Host portion to create more Networks.



Every single bit borrowed divides the available hosts in half, while doubling the number of available subnets.

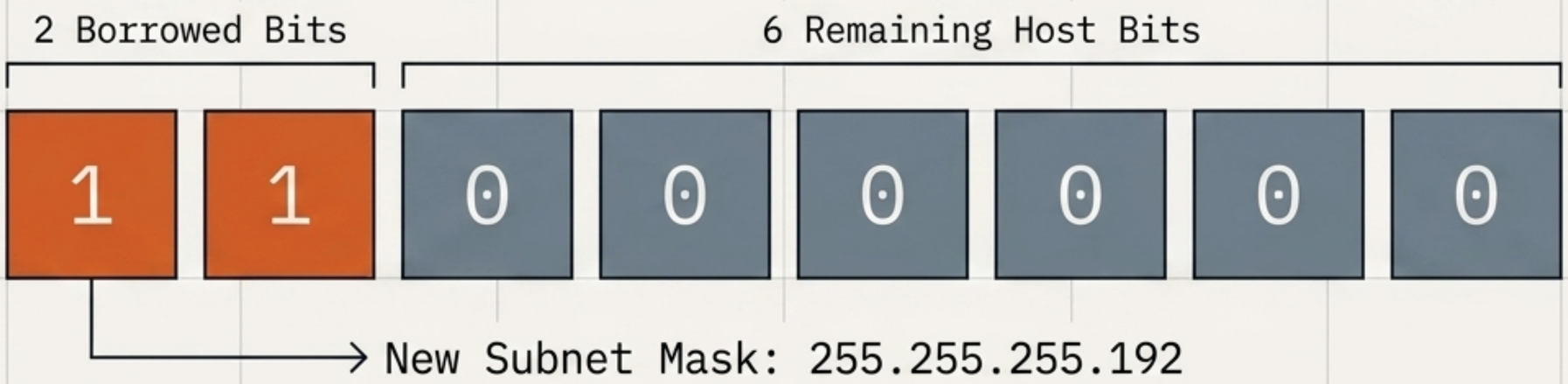
Subnetting in Action

1. The Base: Start with 192.168.1.0 /24

2. The Requirement: Company needs 4 separate secure departments.

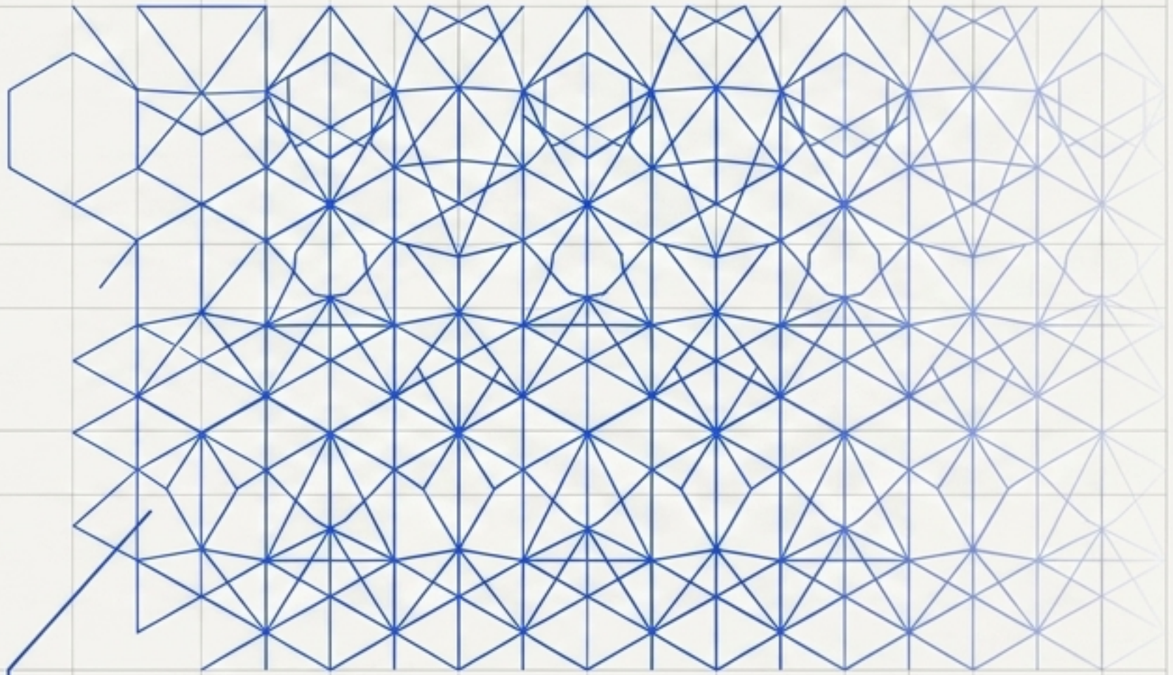
3. The Math: Borrow 2 bits (2^2 = 4 subnets).

4. The Result: The new mask becomes /26.



The Future: IPv6 Architecture

IPv4 (32-bit)
4.3 Billion Addresses



IPv6 (128-bit)
340 Undecillion Addresses

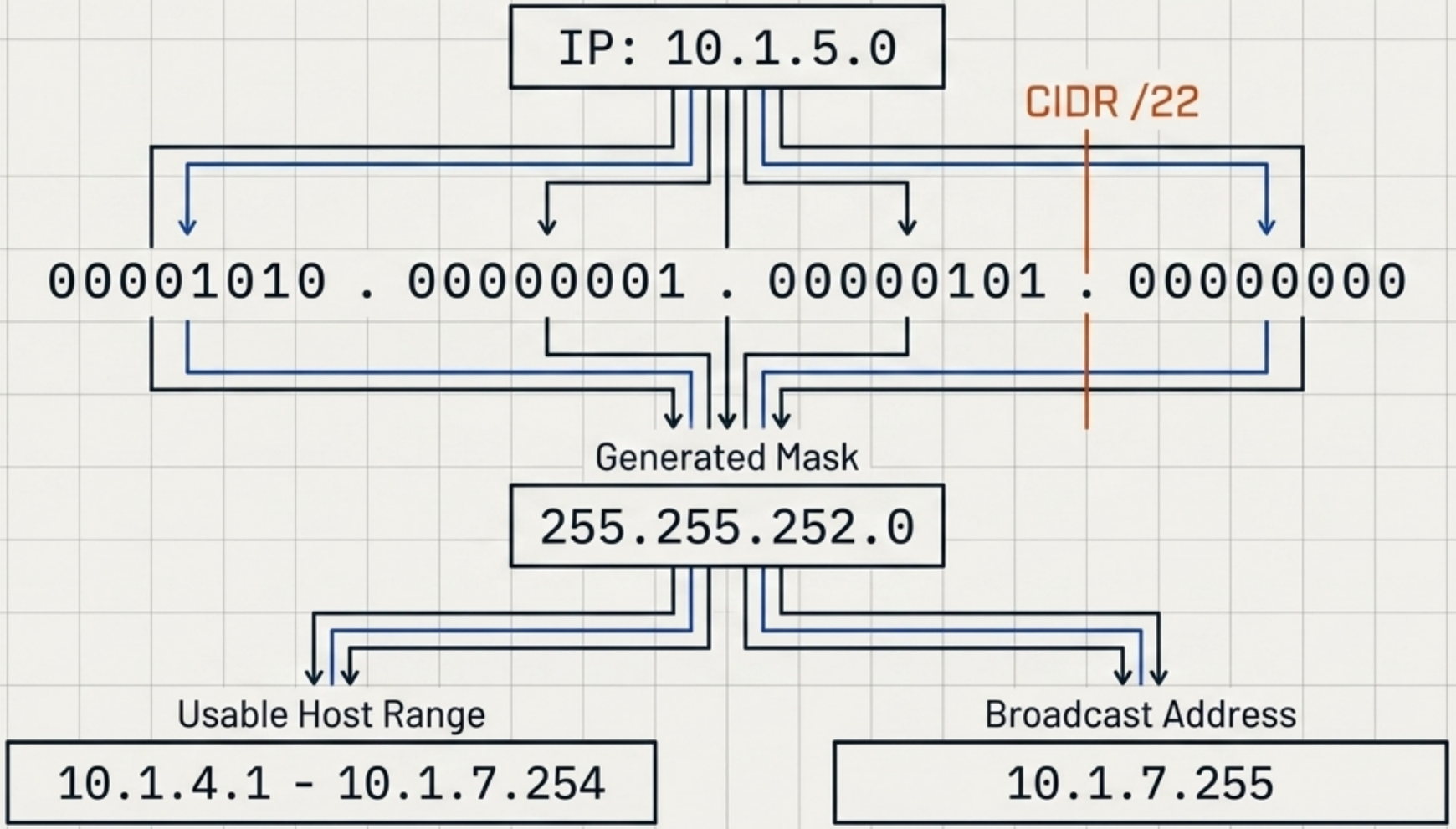
To permanently solve address exhaustion, IPv6 expands capacity so vastly that every single atom on the surface of the Earth could possess its own unique IP address.

The Grand Evolution: IPv4 vs. IPv6

	IPv4	IPv6
Address Length	32-bit (4.3 Billion)	128-bit (340 Undecillion)
Notation	Dotted Decimal `192.168.1.1`	Hexadecimal `2001:0db8:85a3::8a2e:0370:7334`
IPsec / Security	Optional / Add-on 	Mandatory / Built-in 
Configuration	Manual or DHCP required	Stateless Auto-configuration (SLAAC)

The Addressing Master Framework

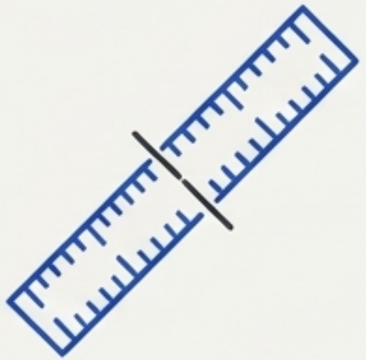
Everything connects. Classes, Masks, CIDR, and Subnets are simply different tools for drawing boundaries through 32 bits.



Core Architectural Tenets

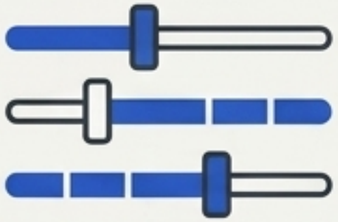
1. Logical Identity

IP addresses dictate routing location, entirely independent of physical hardware (MAC).



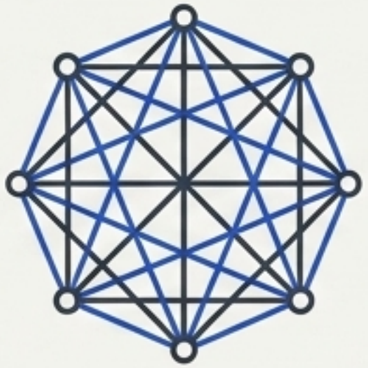
2. The 32-Bit Limit

IPv4 is bound by a fixed 32-bit structure, cleanly divided into Network and Host zones by the Subnet Mask.



3. Classless Precision

Subnetting and CIDR allow engineers to manipulate binary boundaries to custom-size networks and eliminate waste.



4. Infinite Scale

IPv6 abandons the 32-bit constraint, offering a 128-bit hexadecimal architecture to permanently secure the internet.