What is IP Address?

IP Address (Internet Protocol Address) is a unique numerical identifier assigned to every device connected to a network that uses the Internet Protocol for communication.

Think of it like a **postal address** for your house - just like how postal service needs your home address to deliver mail, networks need IP addresses to deliver data packets to the correct device.

Why Do We Use IP Addresses?

1. Unique Identification

- Every device on internet needs a unique identifier
- Prevents data from going to wrong device
- Like phone numbers - each device has its own "number"

2. Routing Purpose

- Routers use IP addresses to forward data packets
- Helps find the path from source to destination
- Without IP, internet wouldn't know where to send data

3. Network Communication

- Enables device-to-device communication
- Allows services like web browsing, email, file sharing
- Foundation of all internet communication

How IP Address Works?

Basic Working Process:

```
Device A (IP: 192.168.1.10) wants to send data to Device B (IP: 192.168.1.20)

1. Device A creates packet with:
   - Source IP: 192.168.1.10
   - Destination IP: 192.168.1.20
   - Data payload

2. Router reads destination IP
3. Router forwards packet toward destination
4. Packet reaches Device B
5. Device B processes packet
```

Packet Structure:

```
[IP Header] [Data]
- Source IP
- Destination IP
- Protocol info
- Other routing info
```

Types of IP Addresses

1. Based on Version:

IPv4 (Internet Protocol Version 4)

- **Format:** 32-bit address (4 bytes)
- **Example:** 192.168.1.1
- **Structure:** Four octets separated by dots
- **Range:** Each octet: 0-255
- **Total addresses:** ~4.3 billion
- **Problem:** Running out of addresses

IPv6 (Internet Protocol Version 6)

- **Format:** 128-bit address (16 bytes)
- **Example:** 2001:0db8:85a3:0000:0000:8a2e:0370:7334
- **Structure:** Eight groups of 4 hexadecimal digits
- **Total addresses:** 340 undecillion (virtually unlimited)
- **Purpose:** Solve IPv4 shortage

2. Based on Scope:

Public IP Address

- **Definition:** Globally unique across entire internet
- **Assignment:** Given by ISP (Internet Service Provider)
- **Accessibility:** Can be reached from anywhere on internet

e DNS)

- **Use:** Web servers, public services

Private IP Address

- **Definition:** Used within local networks only
- **Not routable:** Cannot be accessed directly from internet
- **RFC 1918 Ranges:**
  - Class A: 10.0.0.0 to 10.255.255.255
  - Class B: 172.16.0.0 to 172.31.255.255
  - Class C: 192.168.0.0 to 192.168.255.255
- **Use:** Home networks, office networks

Browser IP Process with Example

Single Website Request Example:

```
You type: www.google.com in browser

1. DNS Resolution:
   - Browser cache check → Not found
   - OS cache check → Not found
   - DNS query: google.com → IP: 142.250.185.78

2. Packet Creation:
   Source IP: 192.168.1.15 (Your laptop)
   Destination IP: 142.250.185.78 (Google server)
   Port: 80 (HTTP) or 443 (HTTPS)

3. Request Flow:
   Your Laptop → Router → ISP → Internet → Google Server

4. Response Flow:
   Google Server → Internet → ISP → Router → Your Laptop
```

Multiple Tabs/Websites - How Requests are Handled

Port-Based Differentiation:

```
Your Computer IP: 192.168.1.15

Tab 1: google.com
- Source: 192.168.1.15:3001 → Destination: 142.250.185.78:443

Tab 2: facebook.com
- Source: 192.168.1.15:3002 → Destination: 157.240.241.35:443

Tab 3: youtube.com
- Source: 192.168.1.15:3003 → Destination: 142.251.42.110:443
```

How Browser Manages Multiple Requests:

1. Different Source Ports:

- Each tab/connection gets unique source port number
- Browser tracks: Port 3001 = Google, Port 3002 = Facebook
- When response comes back, browser knows which tab to update

2. Connection Management:

```
Browser maintains connection table:
```

Local Port	Remote IP	Remote Port	Tab ID
3001	142.250.185.78	443	Tab 1
3002	157.240.241.35	443	Tab 2
3003	142.251.42.110	443	Tab 3

3. Request Handling Process:

```
Step 1: User clicks link in Tab 1
↓
Step 2: Browser creates request packet:
- Source: 192.168.1.15:3001
- Destination: 142.250.185.78:443
- Data: HTTP GET request
↓
Step 3: OS sends packet through network stack
↓
Step 4: Router forwards to internet using NAT
↓
Step 5: Response comes back to port 3001
↓
Step 6: Browser receives response on port 3001
↓
Step 7: Browser updates Tab 1 (matches port 3001)
```

4. Simultaneous Requests Example:

```
Time: 10:00:01 - Tab 1 requests Google (Port 3001)
Time: 10:00:02 - Tab 2 requests Facebook (Port 3002)
Time: 10:00:03 - Tab 3 requests YouTube (Port 3003)

All three requests travel simultaneously:
- Same source IP (your computer)
- Different destination IPs (different servers)
- Different source ports (browser tracking)

Responses come back independently:
- Facebook responds first → Updates Tab 2
- Google responds second → Updates Tab 1
- YouTube responds last → Updates Tab 3
```

5. Key Points:

- **One IP address** for your device (assigned by router/ISP)
- **Multiple ports** for different connections/tabs
- **Browser tracks** which port belongs to which tab
- **Parallel processing** - multiple requests can happen simultaneously
- **Independent responses** - each tab updates independently

This is how your single IP address can handle multiple websites simultaneously - through port multiplexing and browser connection management!