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1.0 : Understanding CIDR Notation

Before we begin, let's cover the basics of CIDR (Classless Inter-Domain Routing) notation. CIDR is a way to represent IP addresses and their associated routing information.

A CIDR block is represented as `a.b.c.d/n`, where:

- `a.b.c.d` is the IP address
- `n` is the number of bits (or "prefix length") that are fixed and used for routing

For example, `10.0.0.0/16` represents an IP address range from `10.0.0.0` to `10.0.255.255`. The `/16` means that the first 16 bits (or "prefix length") are fixed used for network portion, and the remaining bits are available for host addressing.

Network Portion:

- Determined by the first `n` bits of the IP address.

Host Portion:

- The remaining bits after the network portion.

VPC CIDR calculations :

1. VPC CIDR Block: `10.0.0.0/16`

- **Total IP Addresses:**
  - The `/16` CIDR block provides `2^(32-16)` IP addresses.
  - `2^16 = 65,536` IP addresses.
  - This range is from `10.0.0.0` to `10.0.255.255`.

2. Public Subnet 1: `10.0.1.0/24`

- **Total IP Addresses:**
  - The `/24` CIDR block provides `2^(32-24)` IP addresses.
  - `2^8 = 256` IP addresses.
  - This range is from `10.0.1.0` to `10.0.1.255`.
- **Usable IP Addresses:**
  - AWS reserves 5 IP addresses in each subnet for its own use:
    - Network address: `10.0.1.0`
    - VPC router: `10.0.1.1`
    - Reserved for AWS DNS: `10.0.1.2`
    - Reserved for future use: `10.0.1.3`
    - Broadcast address: `10.0.1.255`
  - Usable IP addresses: `256 - 5 = 251` IP addresses.

3. Public Subnet 2: `10.0.2.0/24`

- **Total IP Addresses:**
  - The `/24` CIDR block provides `2^8 = 256` IP addresses.
  - This range is from `10.0.2.0` to `10.0.2.255`.

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- **Usable IP Addresses:**
  - Usable IP addresses: `256 - 5 = 251` IP addresses.

4. Private Subnet: `10.0.3.0/24`

- **Total IP Addresses:**
  - The `/24` CIDR block provides `2^8 = 256` IP addresses.
  - This range is from `10.0.3.0` to `10.0.3.255`.
- **Usable IP Addresses:**
  - Usable IP addresses: `256 - 5 = 251` IP addresses.

Summary

- **VPC**: `10.0.0.0/16` provides 65,536 IP addresses.
- **Public Subnet 1**: `10.0.1.0/24` provides 256 IP addresses, with 251 usable.
- **Public Subnet 2**: `10.0.2.0/24` provides 256 IP addresses, with 251 usable.
- **Private Subnet**: `10.0.3.0/24` provides 256 IP addresses, with 251 usable.

Each subnet has been allocated 256 IP addresses (`/24`), which is generally sufficient for small to medium-sized deployments. The usable IPs (251 per subnet) are those available for EC2 instances, load balancers, etc.

2.0: Where did this come from 2^ ??

Explanation of the Expression

1. **IPv4 Addresses:**
   - An IPv4 address is 32 bits long, represented in dotted decimal format like `192.168.0.1`.
   - Each part of the IP address (e.g., `192`) is 8 bits, so four parts make up the 32 bits.
2. **CIDR Notation:**
   - CIDR notation (like `/16`) indicates how many bits are used for the network portion of the IP address.
   - The remaining bits are used for host addresses within that network.
3. **Calculating the Number of IP Addresses:**
   - If you have a `/16` CIDR block, it means the first 16 bits are used for the network portion, and the remaining 16 bits are for host addresses.
   - The number of host addresses available is determined by the number of bits left for the hosts.
4. **Formula:**

   To calculate the number of possible IP addresses for a given CIDR block, use the formula:

   Number of IP addresses = 2^(32 - network bits)

   For a /16 CIDR block:

   Number of IP addresses = 2^(32 - 16) = 2^16 = 65,536

   This means a /16 block can have 65,536 unique IP addresses.

Why 2^?

- **Binary System:**
  - IP addresses are represented in binary (base 2), so each bit can be either 0 or 1.
  - If you have `n` bits, you can represent `2^n` different combinations.

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Applying It:

- **/24 CIDR Block:**
  - For a `/24` CIDR block, the calculation would be: 2^32−24=28=256 IP addresses

So, the `2^` in `2^(32-16)` refers to the binary nature of IP addresses and the total number of possible addresses that can be generated with the remaining bits after the network portion is specified.

3.0: Calculate a subnet that provides exactly 25 usable IP addresses :

Step 1: Determine the Total IPs Needed

- **Total IPs Required:** 25 usable IPs.

Step 2: Calculate the Minimum Subnet Size

- **Subnet Size Formula:** 2^n, where n is the number of bits in the host portion.
- **Subtract Reserved IPs:** AWS reserves 5 IP addresses in each subnet, so you'll need at least 30 IP addresses in total to get 25 usable ones.
    - **Minimum Total IPs:** 25 + 5 = 30 IP addresses.

Step 3: Find the Closest Power of 2 Greater Than 30

- The closest power of 2 that is greater than 30 is **32**.
- **Number of Bits for Host Portion:** 2^5=32 IP addresses.
    - So, 5 bits are required for the host portion.

Step 4: Determine the CIDR Notation

- An IPv4 address is 32 bits long.
- If 5 bits are used for the host portion, then 32−5=27 bits are used for the network portion.
- **CIDR Notation:** `/27` provides 2^5 = 32 total IPs, with 25 usable.

Summary

- **CIDR Block:** `/27`
- **Total IP Addresses:** 32
- **Usable IP Addresses:** 25 (after accounting for AWS-reserved IPs).

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Example

If your VPC CIDR block is `10.0.0.0/16`:

- **Subnet CIDR:** `10.0.0.0/27`
  - IP Range: `10.0.0.0` to `10.0.0.31`
  - Usable IPs: `10.0.0.1` to `10.0.0.30` (after excluding the network address `10.0.0.0` and broadcast address `10.0.0.31`).