Number System

A number system is a writing system for expressing numbers. **I**n computing and networking, three number systems are most commonly used: **Binary**, **Decimal**, and **Hexadecimal**. Understanding these systems is essential, particularly in the context of IP addressing (IPv4 and IPv6).

1. **Binary Number System**

- **Base**: 2
- **Symbols**: 0, 1

The binary system is used extensively in computing because it is the simplest system for electronic circuits, representing two states: on (1) and off (0). In networking, binary is fundamental for understanding IP addresses, subnet masks, and network configurations.

Example: The IPv4 address **`192.168.1.1`** in binary is:

- 192 = **`11000000`**
- 168 = **`10101000`**
- 1 = **`00000001`**
- 1 = **`00000001`**

So, **`192.168.1.1`** in binary becomes **`11000000.10101000.00000001.00000001`**.

2. **Decimal Number System**

- **Base**: 10
- **Symbols**: 0-9

The decimal system is the standard system used in daily life. In networking, IP addresses are typically represented in decimal form, making them easier to read. Each octet in an IPv4 address is an 8-bit binary number converted to decimal.

Example: The binary IP address **`11000000.10101000.00000001.00000001`** converts to:

- **`11000000`** = 192
- **`10101000`** = 168
- **`00000001`** = 1
- **`00000001`** = 1

Thus, the decimal equivalent is **`192.168.1.1`**.

3. **Hexadecimal Number System**

- **Base**: 16
- **Symbols**: 0-9, A-F (where A=10, B=11, C=12, D=13, E=14, F=15)

The hexadecimal system is used in networking, especially for representing IPv6 addresses. It provides a more compact way of expressing binary data, making it easier to read and manage.

Example: An IPv6 address like `2001:0db8:85a3:0000:0000:8a2e:0370:7334` is expressed in hexadecimal form. Each block represents 16 bits (4 hexadecimal digits per block).

Converting Binary to Decimal and Decimal to Binary Using an 8-Bits Chart

To convert between binary and decimal numbers, we use an 8-bit chart that represents the value of each binary digit in a byte (8 bits).

8-Bit Chart:

- Position: 7 6 5 4 3 2 1 0
- Value: 128 64 32 16 8 4 2 1

Method 1: Converting Binary to Decimal

To convert a binary number to decimal, sum the values corresponding to the positions where there is a 1.

Example: Convert `11001100` to decimal.

- Start with the binary number: `1 1 0 0 1 1 0 0`
- Assign positional values: `128, 64, 32, 16, 8, 4, 2, 1`
- Multiply each binary digit by its positional value:
  - `1 * 128 = 128`
  - `1 * 64 = 64`
  - `0 * 32 = 0`
  - `0 * 16 = 0`
  - `1 * 8 = 8`
  - `1 * 4 = 4`
  - `0 * 2 = 0`
  - `0 * 1 = 0`
- Add up the results: `128 + 64 + 8 + 4 = 204`
- So, `11001100` in binary equals `204` in decimal.

Method 2: Converting Decimal to Binary Using an 8-Bit Chart

To convert a decimal number to binary using the 8-bit chart, start with the largest value in the chart and subtract it from the decimal number if possible. Continue this process with the next largest value until you reach zero. Place a 1 where the value was subtracted and a 0 where it wasn't.

Example: Convert `204` to binary.

1. Start with the 8-bit chart: `128 64 32 16 8 4 2 1`
2. Subtract the largest possible value from `204`:
   - `204 - 128 = 76` → 1 in the 128 position.
   - `76 - 64 = 12` → 1 in the 64 position.
   - `12 - 32 = cannot subtract` → 0 in the 32 position.
   - `12 - 16 = cannot subtract` → 0 in the 16 position.
   - `12 - 8 = 4` → 1 in the 8 position.
   - `4 - 4 = 0` → 1 in the 4 position.
   - `0 - 2 = cannot subtract` → 0 in the 2 position.
   - `0 - 1 = cannot subtract` → 0 in the 1 position.
3. The binary representation is `11001100`.

So, `204` in decimal equals `11001100` in binary.

Application in IP Addressing

- **IPv4**: IPv4 addresses are expressed in decimal form but are inherently binary. Each octet (e.g., 192 in `192.168.1.1`) represents an 8-bit binary number. Understanding binary conversion is crucial for tasks like subnetting and network calculations.
- **IPv6**: IPv6 addresses are written in hexadecimal, simplifying the representation of long binary numbers (128 bits). Knowing how to convert between binary and hexadecimal is vital for configuring and managing IPv6 networks.

Conclusion

The Binary, Decimal, and Hexadecimal number systems are essential for understanding and working with IP addresses in networking. Mastering the conversion methods between these systems using tools like the 8-bit chart is key to tasks such as IP address allocation, subnetting, and network configuration.