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Lecture 1

IPv6 Addressing

Part 1

OBJECTIVES:

- To introduce the IPv6 addressing scheme and different notations used to represent an address in this version.
- To explain the **three types of addressing** used in IPv6: unicast, anycast, and multicast.
- To show the **address space** in this version and how it is divided **into several blocks.**
- To discuss some **reserved blocks** in the address space and their applications.
- To define the **global unicast address block** and how it is used for unicast communication.
- To discuss **how three levels of hierarchy** in addressing are used in IPv6 deploying the global unicast block.
- To discuss **autoconfiguration** and **renumbering** of IPv6 addresses.

General Outline For IP_{V6} Addressing

1 Introduction

2 Address Space Allocation

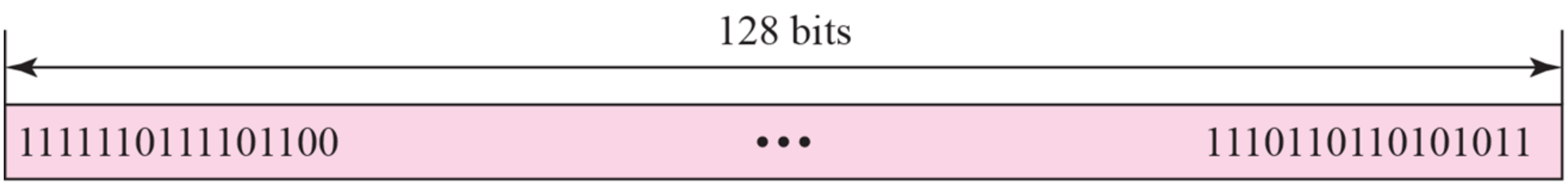
3 Global Unicast Addresses

4 Autoconfiguration

5 Renumbering

1. INTRODUCTION

- An IPv6 address is 128 bits or 16 bytes (octet) long as shown in the following Figure.
- The address length in IPv6 is four times of the length address in IPv4.



Topics Discussed in the Section

- ✓ **Notations**
- ✓ **Address Space**
- ✓ **Three Address Types**
- ✓ **Broadcasting and Multicasting**

1. Notations

- Computer normally stores the address in **binary**, but is clear that 128 bits cannot easily be handled by humans.

- **Several notations** have been proposed to represent IPv6 addresses when they are handled by humans:

Dotted-Decimal Notation

This notation is rarely used, it seems too long for 16-byte IPv6 addresses as shown below:

221.14.65.11.105.45.170.34.12.234.18.0.14.0.115.255

Colon hexadecimal Notation

- To make addresses more readable, IPv6 specifies **colon hexadecimal notation** (or *colon hex* for short).

- In this notation, 128 bits are divided into eight sections, each 2 bytes in length. Two bytes in hexadecimal notation require four hexadecimal digits. Therefore, the address consists of 32 hexadecimal digits, with every four digits separated by a colon.

FDEC : BA98 : 7654 : 3210 : ADBF : BBFF : 2922 : FFFF

Colon hexadecimal Notations

- **Although** the IP address, even in hexadecimal format, is very long, many of the digits are zeros. In this case, we can abbreviate the address. **The leading zeros** of a section can be omitted. Using this form of abbreviation, 0074 can be written as 74, 000F as F, and 0000 as 0. **Note** that 3210 cannot be abbreviated.

- **Further abbreviation,** often called **zero compression,** can be applied to colon hex notation if there are consecutive sections consisting of zeros only. We can remove all the zeros altogether and replace them with a double colon. **Note that** this type of abbreviation is allowed only once per address.

FDEC : 0 : 0 : 0 : 0 : BBFF : 0 : FFFF → FDEC : : BBFF : 0 : FFFF

Original address → Zero compressed

Mixed Representation

- Sometimes we see a mixed representation of an IPv6 address: **colon hex** and **dotted decimal** notation. This is appropriate during the **transition period** in which an IPv4 address is embedded in an IPv6 address (as the rightmost 32 bits).

FDEC:14AB:2311:BBFE:AAAA:BBBB:130.24.24.18

- However, this happens when all or most of the rightmost sections of the IPv6 address are **0**s. For example, the following is a legitimate address in IPv6, in which the zero compression shows that all 96 leftmost bits of the address are all zeros:

::130.24.24.18

CIDR Notation

- IPv6 uses hierarchical addressing. For this reason, IPv6 allows classless addressing and **CIDR** notation.

CIDR: Classless **I**nter**D**omain **R**outing

- The following address shows how we can define a prefix of **60** bits using **CIDR**.

FDEC : : BBFF : 0 : FFFF/60

Example 1

Show the unabbreviated colon hex notation for the following IPv6 addresses:

a. An address with 64 0s followed by 64 1s.
b. An address with 128 0s.
c. An address with 128 1s.
d. An address with 128 alternative 1s and 0s.

Solution

a. 0000:0000:0000:0000:FFFF:FFFF:FFFF:FFFF
b. 0000:0000:0000:0000:0000:0000:0000:0000
c. FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF
d. AAAA:AAAA:AAAA:AAAA:AAAA:AAAA:AAAA:AAAA

Example 2

The following shows the zero contraction version of addresses in Example 1 (part c and d cannot be abbreviated)

a. :: FFFF:FFFF:FFFF:FFFF
b. ::
c. FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF
d. AAAA:AAAA:AAAA:AAAA:AAAA:AAAA:AAAA:AAAA

Example 3

Show abbreviations for the following addresses:

a. 0000:0000:FFFF:0000:0000:0000:0000:0000

b. 1234:2346:0000:0000:0000:0000:0000:1111

c. 0000:0001:0000:0000:0000:0000:1200:1000

d. 0000:0000:0000:0000:0000:FFFF:24.123.12.6

Solution

a. 0:0:FFFF::

b. 1234:2346::1111

c. 0:1::1200:1000

d. ::FFFF:24.123.12.6

Example 4

Decompress the following addresses and show the complete unabbreviated IPv6 address:

a. 1111::2222
b. ::
c. 0:1::
d. AAAA:A:AA::1234

Solution

a. 1111:0000:0000:0000:0000:0000:0000:2222
b. 0000:0000:0000:0000:0000:0000:0000:0000
c. 0000:0001:0000:0000:0000:0000:0000:0000
d. AAAA:000A:00AA:0000:0000:0000:0000:1234

2. Address Space

- The address space of IPv6 contains 2^{128} addresses as shown below.

340,282,366,920,938,463,463,374,607,431,768,211,456

- This address space is 2^{96} times of the IPv4 address - definitely no address depletion.:

Example 5

To give some idea about the number of addresses:

- let us assume that the number of people on the planet earth is soon to be 2^{34} (more than 16 billion). Each person can have 2^{94} addresses to use.

2^{94} : 19,807,040,628,566,084,398,385,987,584

- If we assign 2^{60} addresses to the users each year (almost one billion each second), it takes 2^{68} years to deplete addresses.

2^{68} : 295,147,905,179,352,825,856

- If we can build a high-rise building over the land and sea to accommodate 2^{68} computers in each square meter of the earth, still there are enough addresses to connect all computers to the Internet (the planet earth is approximately 2^{60} square meters).

3. Three Address Types

In IPv6, a destination address can belong to one of **three categories**: **Unicast, Anycast and multicast**.

- **Unicast Address:** A unicast address defines a single interface (computer or router).
- **Anycast Address:** An anycast address defines a group of computers that all share a single address. A packet with an anycast address is delivered to only one member of the group, the most reachable one.
- **multicast Address:** A multicast address also defines a group of computers. However, there is a difference between anycasting and multicasting. In multicasting, each member of the group receives a copy.

4. Broadcasting and Multicasting

- It is interesting that IPv6 **does not define broadcasting.**
- IPv6 considers broadcasting **as a special case of multicasting.**