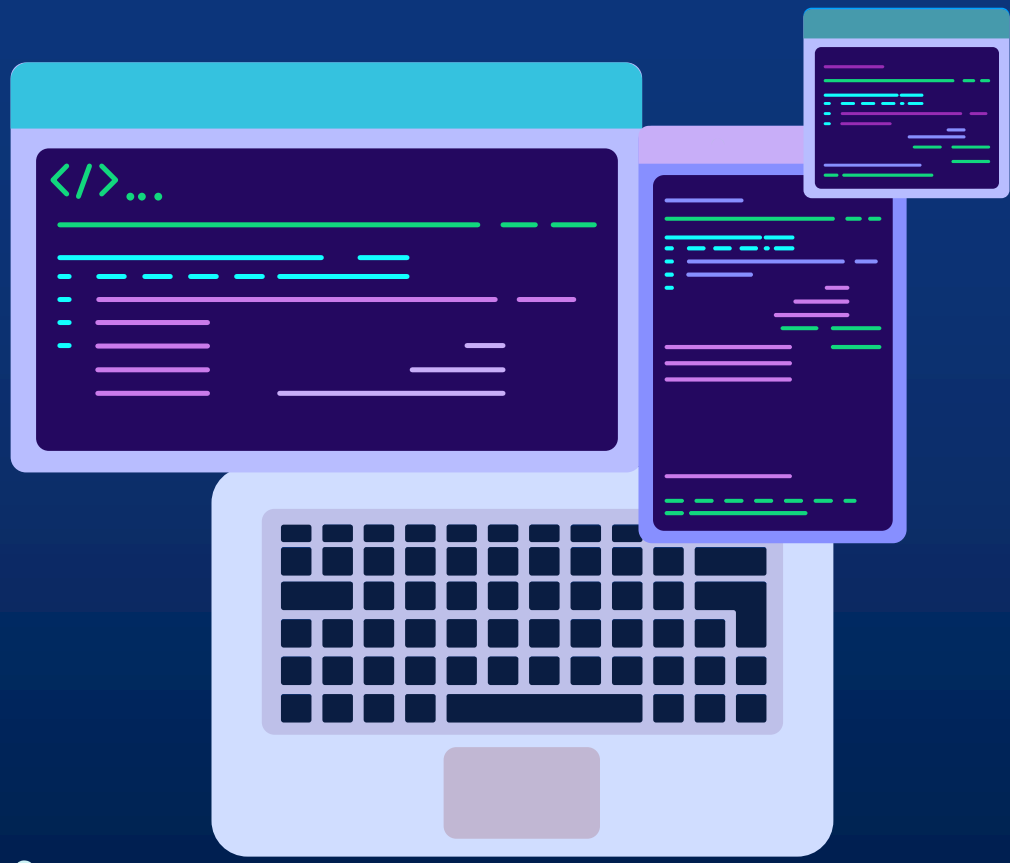
07-2
Networking Basics Module 10: IPv6 Addressing Formats and Rules



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1. About Today's Class

Module 10: IPv6 Addressing Formats and Rules

10.0. イントロダクション

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2. Today's Goal

Module Title: IPv6 Addressing Formats and Rules

Module Objective: Explain the features of IPv6 addressing.

- IPv4 Issue:

  Explain the need for IPv6 addressing.
- IPv6 Addressing:

  Explain how to represent IPv6 addresses.

2. Today’s Goal

Module Title: IPv6 Addressing Formats and Rules

モジュールの目的：IPv6アドレスの特徴を説明する。

IPv4の問題：IPv6アドレスの必要性を説明する。

IPv6アドレス表記：IPv6アドレスの表記方法を説明する。

10.1. IPv4 Issues

10.1.1 The Need for IPv6

IPv4 Address Depletion:

- Problem: IPv4 is running out of addresses due to global internet growth.
- Theoretical Maximum: 4.3 billion addresses.
- NAT Issues: Creates latency and hinders peer-to-peer communications.
- Insufficient for Global Growth: Cannot accommodate increasing internet usage.

IPv6 Introduction:

- Purpose: Succeed IPv4 with larger address space and enhanced features.
- Address Size: 128-bit, offering 340 undecillion possible addresses.
- ISPs and Content Providers: Major companies like YouTube, Facebook, and Netflix have transitioned to IPv6.
- Internal Transition: Companies like Microsoft, Facebook, and LinkedIn moving towards IPv6-only networks.
- ISP Deployment: Significant deployment rates by ISPs like Comcast and British Sky Broadcasting.
- Evolving Internet: Beyond traditional uses to include a vast array of internet-connected devices.

10.1. IPv4 Issues

10.1.1 The Need for IPv6

NAT:Network Address Translation

後の授業で勉強する。
インターネットで使われるグローバスIPアドレスをプライベートIPアドレスに変換する。

IPv4アドレスの不足：

- 問題点：世界的なインターネットの成長により、IPv4アドレスが不足している。
- 理論的最大数：4.3ビリオン(4,300,000,000)アドレス。
- NATの問題：アドレス不足の対応としてプライベートIPアドレスを導入したが、NAT（Network Address Translation)が必要となり、遅延が発生

IPv6の導入：

- 目的：IPv4の後継として、より大きなアドレス数と拡張機能を提供。
- アドレスサイズ：128ビットで、340デシリオン（340,000,000,000,000,000,000,000,000,000,000,000,000,000）のアドレスを提供。
- YouTube、Facebook、Netflixなどの大手企業がIPv6に移行済み。
- Microsoft、Facebook、LinkedInなどがIPv6専用ネットワークへの移行を進めている。

10.1. IPv4 Issues

10.1.1 The Need for IPv6

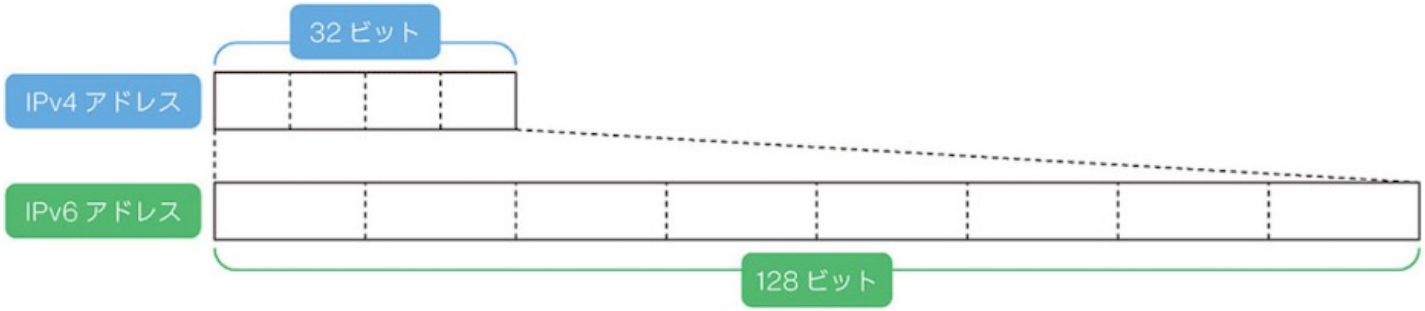


図4.2.3 • IPv4アドレスとIPv6アドレスの長さの違い

10.1. IPv4 Issues

10.1.2 IPv4 and IPv6 Coexistence

Both IPv4 and IPv6 will coexist in the near future and the transition will take several years.

The migration techniques can be divided into three categories:

1. Dual stack allows IPv4 and IPv6 to coexist on the same network segment. Dual stack devices run both IPv4 and IPv6 protocol stacks simultaneously. Known as native IPv6, this means the customer network has an IPv6 connection to their ISP and is able to access content found on the internet over IPv6.
2. Tunneling is a method of transporting an IPv6 packet over an IPv4 network. The IPv6 packet is encapsulated inside an IPv4 packet, similar to other types of data.
3. Network Address Translation 64 (NAT64) allows IPv6-enabled devices to communicate with IPv4-enabled devices using a translation technique similar to NAT for IPv4. An IPv6 packet is translated to an IPv4 packet and an IPv4 packet is translated to an IPv6 packet.

10.1. IPv4 Issues

10.1.2 IPv4とIPv6の共存

IPv4からIPv6に移行する期間は、両方のプロトコルが同時に使われます。

IPv4とIPv6の共存には3つの技術があります。

1. デュアルスタック：IPv4とIPv6を同じネットワークで同時に動かす方法
   - 1つのデバイスがIPv4とIPv6の両方をサポートする。
   - 同じネットワーク上でIPv4とIPv6を同時に使える。
   - インターネット上のIPv6コンテンツにアクセス可能。

2. トンネリング：IPv6のデータをIPv4のネットワークで送る方法
   - IPv6のデータを、IPv4のパケットの中に入れて送信する（カプセル化）。
   - IPv4しか対応していないネットワークでも、IPv6の通信が可能になる。

3. ネットワークアドレス変換64（NAT64）：IPv6のデバイスとIPv4のデバイスが通信できるようにする変換する方法
   - IPv6のパケットをIPv4のパケットに変換する。

10.1. IPv4 Issues

10.1.3 Check Your Understanding - IPv4 Issues

https://forms.gle/RrcY9mC8HoAfZVfNA

Question 1

What is the most important motivating factor for moving to IPv6?

- ❑ better security with IPv6
- ❑ depletion of IPv4 addresses
- ❑ IPv6 addresses that are easier to work with
- ❑ better performance with IPv6

10.1. IPv4 Issues

10.1.3 Check Your Understanding - IPv4 Issues

https://forms.gle/RrcY9mC8HoAfZVfNA

Question 2

True or False: 4 out of 5 RIRs no longer have enough IPv4 addresses to allocate to customers on a regular basis.

- ❑ True
- ❑ False

10.1. IPv4 Issues

10.1.3 Check Your Understanding - IPv4 Issues

https://forms.gle/RrcY9mC8HoAfZVfNA

Question 3

Which of the following techniques use native IPv6 connectivity?

- ❑ dual stack
- ❑ tunneling
- ❑ translation
- ❑ all of the above

10.2. IPv6 Addressing

10.2.1 Hexadecimal Number System
10.2.2 IPv6 Addressing Formats
10.2.3 Video - IPv6 Formatting Rules

Hexadecimal in IPv6:

- IPv6 addresses use hexadecimal numbers (base sixteen).
- Digits include 0-9 and letters A-F.

Hextets Representation:

- IPv6 uses hextets for readability, representing massive addresses more compactly.

IPv6 Addressing Formats:

- IPv6 addresses are 128 bits long, larger than IPv4.
- Address Representation: Written as a string of hexadecimal values.
- Format: 32 hexadecimal values, representing every four bits.
- Case Sensitivity: IPv6 addresses can be written in both lowercase and uppercase.

10.2. IPv6 Addressing

10.2.1 16進数の数値システム

IPv6における16進数:

- IPv6アドレスは16進数を使用します。
- ０１２３４５６７８９ＡＢＣＤＥＦ

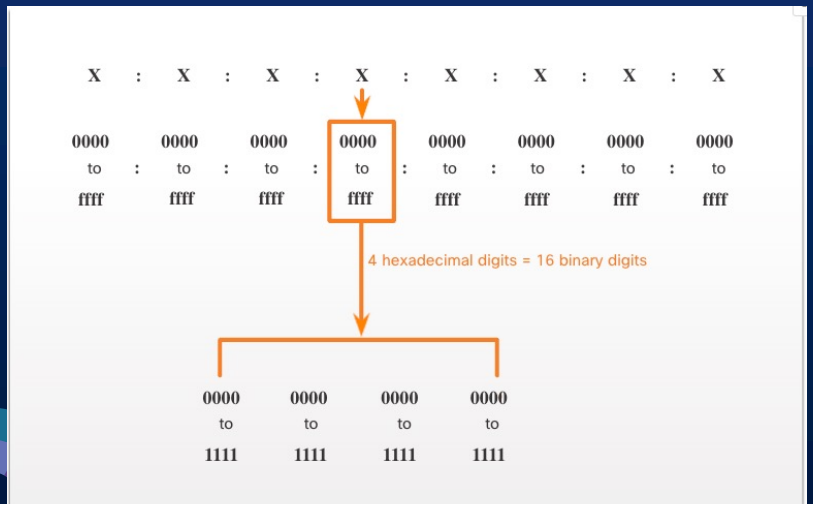
10.2. IPv6 Addressing

10.2.2 IPv6アドレスの形式

- IPv6アドレスは128ビットの長さで、16進数の文字列として書かれます。
- 4ビットごとに1つの16進数の数字で表され、合計で32の16進数値になります。
- IPv6アドレスは大文字・小文字を区別せず、どちらでも記述できます。
- IPv6において、「hextet: ヘクステット」は16ビット(4つの16進数)表す。
- 「x」は1つのヘクステットであり、16ビットまたは4桁の16進数です。

IPv４ Address
Octet： オクテット
8ビット

IPv6 Address
Hextet： ヘクステット
16ビット



IPv6アドレスフォーマット「x:x:x:x:x:x:x:x」

(ex)
fe80：ef80：307e：4378：b87d：8492：fe80：ef80
FE80：EF80：307E：4378：B87D：8492：FE80：EF80

10.2. IPv6 Addressing

10.2.3 Video - IPv6 Formatting Rules

このビデオではIPv6の記述方式について、以下の２つのルールを説明します。

1. 先頭のゼロを省略
   - すべての先頭のゼロを省略。（例：「01ab」は「1ab」）
   - 先頭のゼロのみが対象
     （例：「00ab」は「ab」になるが、「ab0」は「ab」にならない）。
2. ダブルコロン
   - ダブルコロン（::）は、連続する1つ以上のゼロの文字列を置き換えます。
   - 例：「2001:db8:cafe:1:0:0:0:1」は「2001:db8:cafe:1::1」になります。
   - ダブルコロンはアドレス内で1回しか使用できません。

これらのルールを組み合わせると、IPv6アドレスを大幅に短縮できます。

10.2. IPv6 Addressing

10.2.4 Rule 1 – Omit Leading Zeros
10.2.5 Rule 2- Double Colon

IPv6 Notation Rule 1 - Omit Leading Zeros:

- In any hextet, omit all leading zeros (e.g., "01ab" becomes "1ab").
- Only applies to leading zeros to avoid ambiguity (e.g., "00ab" becomes "ab", not "00ab").

IPv6 Notation Rule 2 - Double Colon:

- A double colon (::) replaces a contiguous string of one or more all-zero hextets.
- Example: "2001:db8:cafe:1:0:0:0:1" becomes "2001:db8:cafe:1::1".
- Restriction: Double colon can only be used once in an address to avoid multiple interpretations.

Compressed Format: Combining these rules can significantly shorten the IPv6 address.

Incorrect Use of Double Colon:

- Example of Error: Using double colon twice (e.g., "2001:db8::abcd::1234").
- Leads to multiple possible expansions, causing ambiguity.

10.2. IPv6 Addressing

10.2.4 Rule1 – 先頭のゼロを省略
10.2.5 Rule2- ダブルコロン

1. 先頭のゼロを省略
   - すべての先頭のゼロを省略。（例：「01ab」は「1ab」）
   - 先頭のゼロのみが対象
     （例：「00ab」は「ab」になるが、「ab0」は「ab」にならない）。
2. ダブルコロン
   - ダブルコロン（::）は、連続する1つ以上のゼロの文字列を置き換えます。
   - 例：「2001:db8:cafe:1:0:0:0:1」は「2001:db8:cafe:1::1」になります。
   - ダブルコロンはアドレス内で1回しか使用できません。

これらのルールを組み合わせると、IPv6アドレスを大幅に短縮できます。

10.3. IPv6 Addressing Formats and Rules Summary

IPv4 Issues

- The depletion of IPv4 address space has been the motivating factor for moving to IPv6. IPv6 has a larger 128-bit address space, providing 340 undecillion possible addresses. When the IETF began its development of a successor to IPv4, it used this opportunity to fix the limitations of IPv4 and include enhancements. One example is ICMPv6, which includes address resolution and address autoconfiguration not found in ICMPv4.

- Both IPv4 and IPv6 coexist and the transition to only IPv6 will take several years. The IETF has created various protocols and tools to help network administrators migrate their networks to IPv6. The migration techniques can be divided into three categories: Dual Stack, Tunneling, and Translation. Dual stack devices run both IPv4 and IPv6 protocol stacks simultaneously. Tunneling is a method of transporting an IPv6 packet over an IPv4 network. The IPv6 packet is encapsulated inside an IPv4 packet, similar to other types of data. NAT64 allows IPv6-enabled devices to communicate with IPv4-enabled devices using a translation technique similar to NAT for IPv4. An IPv6 packet is translated to an IPv4 packet and an IPv4 packet is translated to an IPv6 packet.

10.3. IPv6 Addressing Formats and Rules Summary

IPv6 Addressing

- IPv6 addresses are 128 bits in length and written as a string of hexadecimal values. Every four bits is represented by a single hexadecimal digit; for a total of 32 hexadecimal values. IPv6 addresses are not case-sensitive and can be written in either lowercase or uppercase. In IPv6, a hextet that refers to a segment of 16 bits, or four hexadecimal values. Each “x” is a single hextet, which is 16 bits or four hexadecimal digits. Preferred format means that you write IPv6 address using all 32 hexadecimal digits. Here is one example - fe80:0000:0000:0000:0123:4567:89ab:cdef.
- There are two rules that help to reduce the number of digits needed to represent an IPv6 address.

Rule 1 – Omit Leading Zeros. You can only omit leading zeros, not trailing zeros.

- 01ab can be represented as 1ab
- 09f0 can be represented as 9f0
- 0a00 can be represented as a00
- 00ab can be represented as ab

Rule 2 – Double Colon. A double colon (::) can replace any single, contiguous string of one or more 16-bit hextets consisting of all zeros. For example, 2001:db8:cafe:1:0:0:0:1 (leading 0s omitted) could be represented as 2001:db8:cafe:1::1. The double colon (::) is used in place of the three all-0 hextets (0:0:0). The double colon (::) can only be used once within an address, otherwise there would be more than one possible resulting address. If an address has more than one contiguous string of all-0 hextets, best practice is to use the double colon (::) on the longest string. If the strings are equal, the first string should use the double colon (::).

10.3. IPv6 Addressing Formats and Rules Summary

IPv4の問題

- IPv4アドレスの不足がIPv6への移行の要因。
- IPv6は128ビットの大容量アドレス空間で、340デシリオンのアドレスを提供。
- IPv4とIPv6の共存が続き、完全な移行には数年を要する。
- 移行技術はデュアルスタック、トンネリング、トランスレーションに分かれる。

IPv6アドレスの表記

- IPv6アドレスは128ビット
- 16進数で表記され、32桁の16進数で構成される。
- 2つの短縮ルールが存在：
  1. 先頭のゼロは省略可。
  2. ダブルコロン (::) で連続するゼロの文字列を1回だけ置き換える。

Questions and free discussion

Do you have any questions or anything you want to discuss?

Check Test 9

IPv6 Addressing Formats and Rules Quiz

https://forms.gle/1GVcVVGDHx7wTd3J6

Reference

- CISCO Network Academy
  Networking Basics - Module 10: IPv6 Addressing Formats and Rules

  https://skillsforall.com/launch?id=f393c38f-b410-4d2b-8275-70e144273519&tab=curriculum&view=2b467c2f-7024-5114-abc3-f904eeef5d36

  Textbook：
「図解入門　TCP/IP」みやたひろし