Networking Basics

03a - IP: Addresses, Prefixes and Routing

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Networking Basics
DE-CIX Academy

01 - Networks, Packets, and Protocols
02 - Ethernet, 02a - VLANs
03 - IP: the Internet Protocol
  03a - IP addresses, prefixe, and routing
  03b - Global IP routing
04a - UDP, 04b - TCP, 04c - ICMP
05 - Uni-, Broad-, Multi-, and Anycast
06a - DNS
IP - the Internet Protocol
Internet Model
IP / Internet Layer

- Data units are called "Packets"
- Provides source to destination (end-to-end) transport
- Needs addresses for entities
IPv4 Addresses
32 bit long

- 32 bit in length
- 4,294,967,296 possible addresses
- written as 4 decimal numbers separated by dots "."
- some addresses are reserved / not usable
- all usable IPv4 addresses have been assigned to users

IPv6
Development started: 1994
First published: 1995
IPv6 Addresses
128 bit long

• 128 bit in length - possible addresses:
  340282366920938463463374607431768211456

• there are lots of IPv6 addresses available

• written as hexadecimal numbers separated by colons ":";
  • double-colon "::" means fill up with zeros here

• some addresses are reserved / not usable

IPv6 Addresses
Internet Model
IP / Internet Layer

- Data units are called "Packets"
- Needs **addresses** for entities
- Provides source to destination transport
  - End-to-End Transport
End-to-End Transport
To: 2001:db8:10::5
Routing
Routing

Intermission: Language
Routing

"A method of finding paths from origins to destinations in a network such as the Internet, along which information can be passed."

https://en.wiktionary.org/wiki/routing

UK /ˈrjuːtɪŋ/

US /ˈrʊtɪŋ/

/ˈraʊtɪŋ/
Routing

"A method of finding paths from origins to destinations in a network such as the Internet, along which information can be passed."

https://en.wiktionary.org/wiki/routing

routing /ˈrɔʊtɪŋ/

root

rooting "A hole formed by a pig when it roots in the ground"

https://en.wiktionary.org/wiki/rooting
Routing

How a router works

- All IP packets have a destination IP address
- Depending on the destination IP address a next hop is chosen
- For this, each router has a large lookup-table
  - This is called the routing table
- It contains not single IP addresses, but Prefixes
IP Prefixes
IPv6 - Addresses

2003:de:274f:400:226:b0ff:fed8:3d8a
IPv6 - Addresses

2003:de:274f:400:206:b0ff:fed8:3d8a

IPv6 - Prefixes

2003:de:274f:400::/64

Notation:
- 4 digit hex numbers (0-9,a-f)
- Separated by "::"
- "::" = fill up with zeros

128 Bits long
IPv6 - Prefixes

2003:de:274f:400::/64

Prefix-Length: 0-128

Notation:
- 4 digit hex numbers (0-9,a-f)
- Separated by ":"
- "::" = fill up with zeros

Host-part all zero

128 Bits long
IPv4 - Addresses

10.3.8.17
IPv4 - Addresses

10.3.8.17

IPv4 - Prefixes

10.3.8.0/22

Notation:
- 4 numbers (0-255)
- Separated by "."

32 Bits long
IPv4 - Prefixes

10.3.8.0/22

Prefix-Length: 0-32

Notation:
- 4 numbers (0-255)
- Separated by "."

Host-part all zero

32 Bits long
# IP Addresses and Prefixes

Prefix or not?

<table>
<thead>
<tr>
<th></th>
<th>IPv4</th>
<th>IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>32 Bit</td>
<td>128 Bit</td>
</tr>
<tr>
<td><strong>0-32 Prefix Length</strong></td>
<td>0-128 Prefix Length</td>
<td></td>
</tr>
<tr>
<td><strong>Notation</strong></td>
<td>4 Numbers, 0-255</td>
<td>8 Numbers, 0-ffffff</td>
</tr>
<tr>
<td><strong>Separator</strong></td>
<td>.</td>
<td>:</td>
</tr>
<tr>
<td><strong>Prefix: Host part</strong></td>
<td>all zero</td>
<td></td>
</tr>
<tr>
<td><strong>Address: Host part</strong></td>
<td>not all zero / not all one</td>
<td></td>
</tr>
<tr>
<td><strong>Example (Prefix)</strong></td>
<td>198.51.100.0/24</td>
<td>2001:db8:4f30::/48</td>
</tr>
</tbody>
</table>
IP Routing
To: 198.51.100.17
198.51.100.0/24
198.51.0.0/16
IP Routing
IP Routing

To: 198.51.100.17

192.51.0.0/16
192.51.100.0/24
IP Routing

To: 198.51.100.17
IP Routing

To: 198.51.100.17
IP Routing

To: 198.51.100.17

Apply the netmask: /24

/24 = 24 bits in network part
11111111 11111111 11111111 00000000

255.255.255.0
"bitwise logical and" with IP address

198.051.100.017
255.255.255.000
= 198.051.100.000 ≠
IP Routing

To: 198.51.100.17

Apply the netmask: /24

/24 = 24 bits in network part

255.255.255.0

"bitwise logical and" with IP address

198.051.100.017
255.255.255.000

= 198.051.100.000 =

Prefix | Destination
--- | ---
192.0.2.0/24 | up
198.51.100.0/24 | left
203.0.113.0/24 | right
198.51.0.0/16 | right
44.0.0.0/8 | right
IP Routing

- You now know how routing works
  - The router has a routing table with IP prefixes
  - The destination address is used to select a best matching prefix
  - The routing table tells the router the "next hop"

But how does the information get into the routing table?
IP Routing
But how does the information get into the routing table?

- Someone types it in
  - This is called "static routing"
  - Simple, often used, but does not scale
- Routers "talk" to each other
  - This is called "dynamic routing"
  - And the protocols used are called "routing protocols"
- Examples of such protocols are BGP, OSPF, IS-IS, RIP, EIGRP
Conclusion
Conclusion

We introduced a lot of new terms in this webinar

- "Routing"
  - "A method of finding paths from origins to destinations in a network such as the Internet, along which information can be passed."
    https://en.wiktionary.org/wiki/routing

- "Router"
  - A device which routes

- "IP Prefix"
  - A network address and a prefix length

- "Routing Table"
  - A table of IP prefixes and a next hop addresses
Thank you!

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Links and further reading
Links and further reading

- IP Version Numbers [https://www.iana.org/assignments/version-numbers/version-numbers.xhtml#version-numbers-1](https://www.iana.org/assignments/version-numbers/version-numbers.xhtml#version-numbers-1)
- IPv4
  - IPv4 address exhaustion - [https://en.wikipedia.org/wiki/IPv4_address_exhaustion](https://en.wikipedia.org/wiki/IPv4_address_exhaustion)
- IPv6
  - First standard: RFC1884, current standard: RFC8200
- Routing

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Internet RFCs (Standards)

- There are too many RFCs dealing with IPv4, IPv6, and routing to be listed here
- Just go to https://tools.ietf.org/html/ and use the search field
- The IETF - Internet Engineering Task Force
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