IPv6

IPv6 Addresses

- An IPv6 address is 128 bits or 16 bytes (octets) long
- 2^{128} addresses =
  340,282,366,920,938,463,463,374,607,431,768,211,456
- Estimated number of grains of sand on the earth (npr.org) =
  7,500,000,000,000,000,000
- Estimated number of people on earth (wikipedia.org, 2019) =
  7,000,000,000
- Commonly displayed using colon-hexadecimal notation
- e.g., FEF6:BA98:7654:3210:ADEF:BBFF:2922:FF00

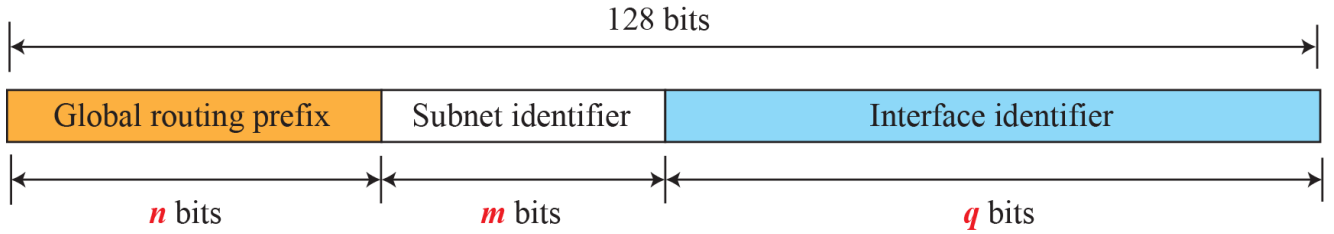
::

- Because IPv6 addresses are so long, the :: is used as a shorthand, to indicate one or more groups of 16 bits of zero (i.e., four hexadecimal digits of zero, or 0000_{16})
  - ::1 means
    0000:0000:0000:0000:0000:0000:0000:0001
  - 2607:f8b0:400a:0803::200e means
    2607:f8b0:400a:0803:0000:0000:0000:200e
- Leading 0s can be skipped, but trailing 0s must be listed
  - 2607:f8b0:400a:803::200e means
    2607:f8b0:400a:0803::200e but **not**
    ~~2607:f8b0:400a:8030::200e~~
- :: can only be used once per IP

IPv6 Addresses

- Addresses are classified based on their prefix
- Addresses starting with 0000 0000_2 are special, reserved addresses, e.g.,
  - :: is the unspecified address, like 0.0.0.0 in IPv4
  - ::1 is localhost

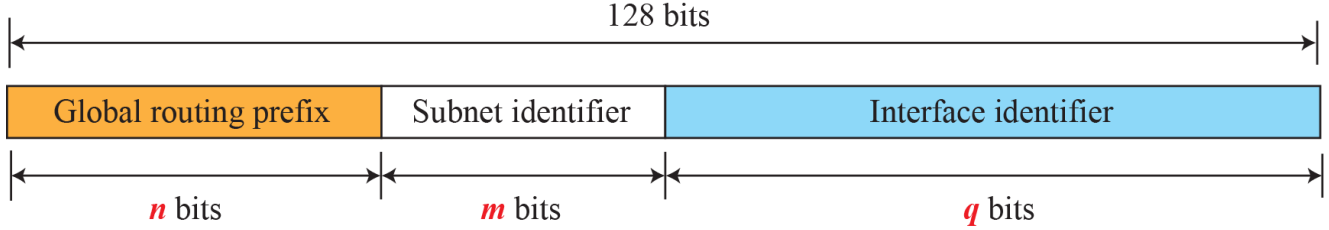
Block prefix	*CIDR*	*Block assignment*	*Fraction*
0000 0000	0000::/8	Special addresses	1/256
001	**2000::/3**	**Global unicast**	**1/8**
1111 110	FC00::/7	Unique local unicast	1/128
1111 1110 10	FE80::/10	Link local addresses	1/1024
1111 1111	FF00::/8	Multicast addresses	1/256



IPv6 Addresses

- Addresses starting with 001_2 are Internet-routable addresses (like IPv4 public addresses)
- **Generally** speaking:
  - The first 23 bits are unique to a registrar (e.g., many ARIN-administered addresses start with 2620::/23)
  - The first 32 bits are unique to an ISP
  - The first 48 bits are unique to a site (e.g., Camosun's IPv6 addresses start with 2620:78:C000::/48)
  - The first 64 bits are unique to a subnet (e.g., TEC 259's IPv6 addresses start with 2620:78:C000:2259::/64)

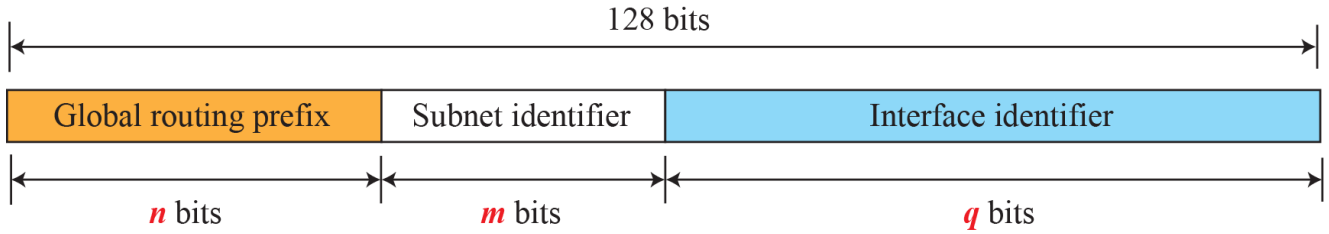
Block prefix	*CIDR*	*Block assignment*	*Fraction*
0000 0000	0000::/8	Special addresses	1/256
001	**2000::/3**	**Global unicast**	**1/8**
1111 110	FC00::/7	Unique local unicast	1/128
1111 1110 10	FE80::/10	Link local addresses	1/1024
1111 1111	FF00::/8	Multicast addresses	1/256



IPv6 Addresses

- Addresses starting with 1111110_2 are unique local addresses, similar to IPv4 local addresses like 10.0.0.0/8 and 192.168.0.0/16

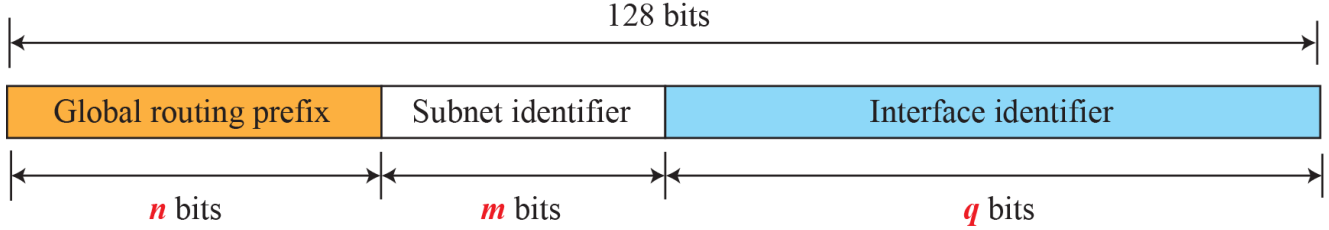
Block prefix	*CIDR*	*Block assignment*	*Fraction*
0000 0000	0000::/8	Special addresses	1/256
001	**2000::/3**	**Global unicast**	**1/8**
1111 110	FC00::/7	Unique local unicast	1/128
1111 1110 10	FE80::/10	Link local addresses	1/1024
1111 1111	FF00::/8	Multicast addresses	1/256



IPv6 Addresses

- Addresses starting with 1111111010_2 are link local addresses, which are only valid on the same link, and are therefore not routable beyond that link

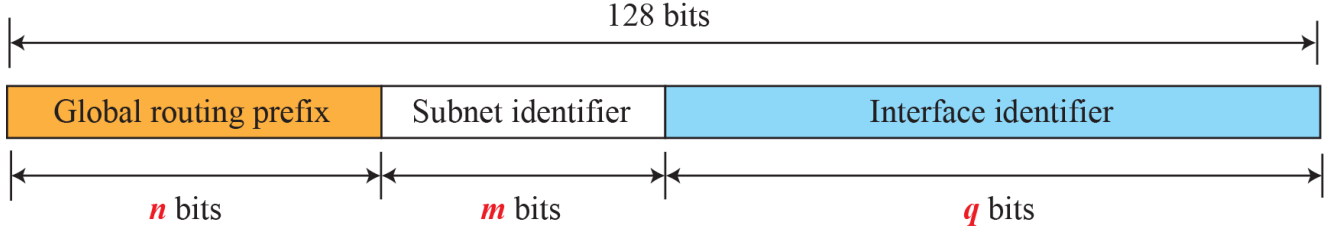
Block prefix	*CIDR*	*Block assignment*	*Fraction*
0000 0000	0000::/8	Special addresses	1/256
001	**2000::/3**	**Global unicast**	**1/8**
1111 110	FC00::/7	Unique local unicast	1/128
1111 1110 10	FE80::/10	Link local addresses	1/1024
1111 1111	FF00::/8	Multicast addresses	1/256



IPv6 Addresses

- Addresses starting with 11111111_2 are multicast addresses
- There is no broadcast; the address space is simply too big!

Block prefix	*CIDR*	*Block assignment*	*Fraction*
0000 0000	0000::/8	Special addresses	1/256
001	**2000::/3**	**Global unicast**	**1/8**
1111 110	FC00::/7	Unique local unicast	1/128
1111 1110 10	FE80::/10	Link local addresses	1/1024
1111 1111	FF00::/8	Multicast addresses	1/256



Autoconfiguration

- DHCP can still be used, but is not required
- When an IPv6 device *D* connects to a network, it sends out a Router Solicitation (RS) via the local network
- In response, an IPv6 router sends out a Router Advertisement (RA), to allow *D* to create its own unique IP based on the RA and *D*'s MAC address
- RAs can include DNS server information (e.g. Google DNS), as well as a DNS search list (e.g., *camosun.ca*)

IPv6 Thoughts

- /64 for a subnet is huge! From an address range perspective, we can have 18,446,744,073,709,551,616 connected devices in TEC259
- Using nmap to scan for hosts is not feasible (this can be a good thing!)
- Make sure your firewall blocks IPv6 traffic as well as IPv4 traffic as appropriate; some admins only think about IPv4 and forget about IPv6
- Because there are so many IPv6 addresses, we can use them to encode information (e.g., say 2620:0078:c000:2259::226:1 serves ICS 226 slides for week 1, 2620:0078:c000:2259::226:2 serves ICS 226 slides for week 2)

Lab 10

- Explore IPv6
- You must use a Pi connected to the white network cable in TEC 259; this lab cannot be done remotely from home

Acknowledgement

- Thank you to Craig Miller and Deid Reimer for contributing to this module

Key Skills

- Determine the type of IPv6 address based on its prefix
- Explain in general terms how autoconfiguration, stateless DHCPv6, and stateful DHCPv6 work
- Write network programs that function in an IPv6 environment