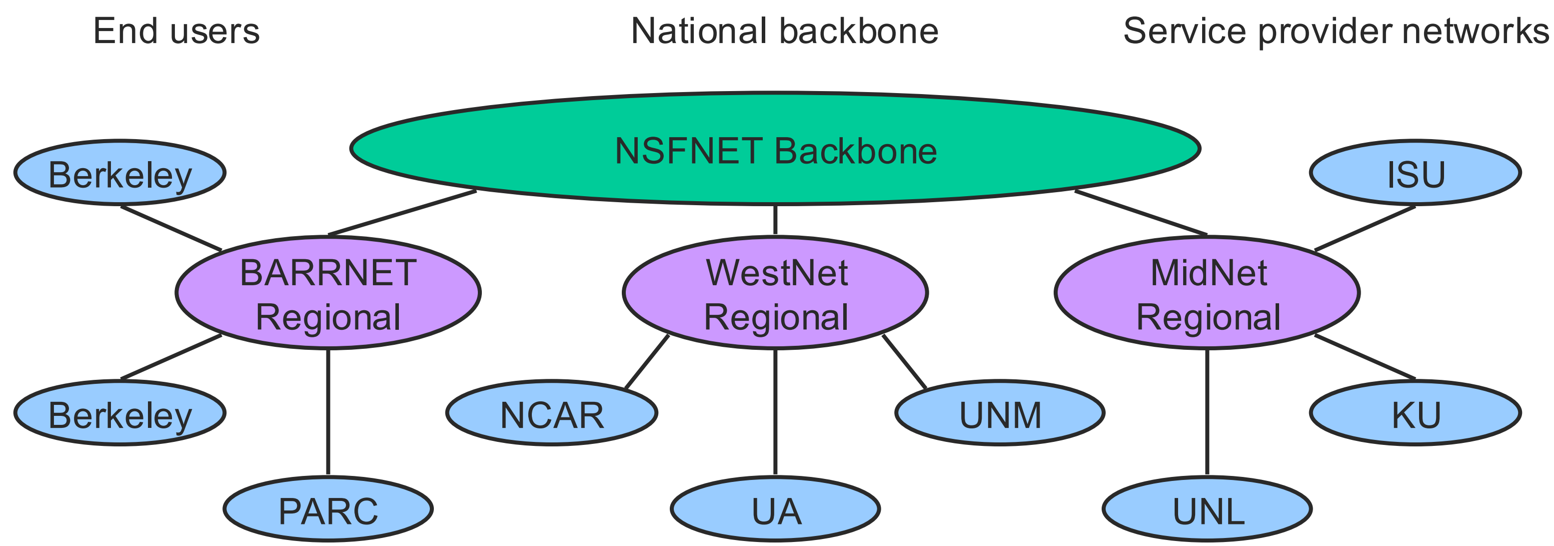
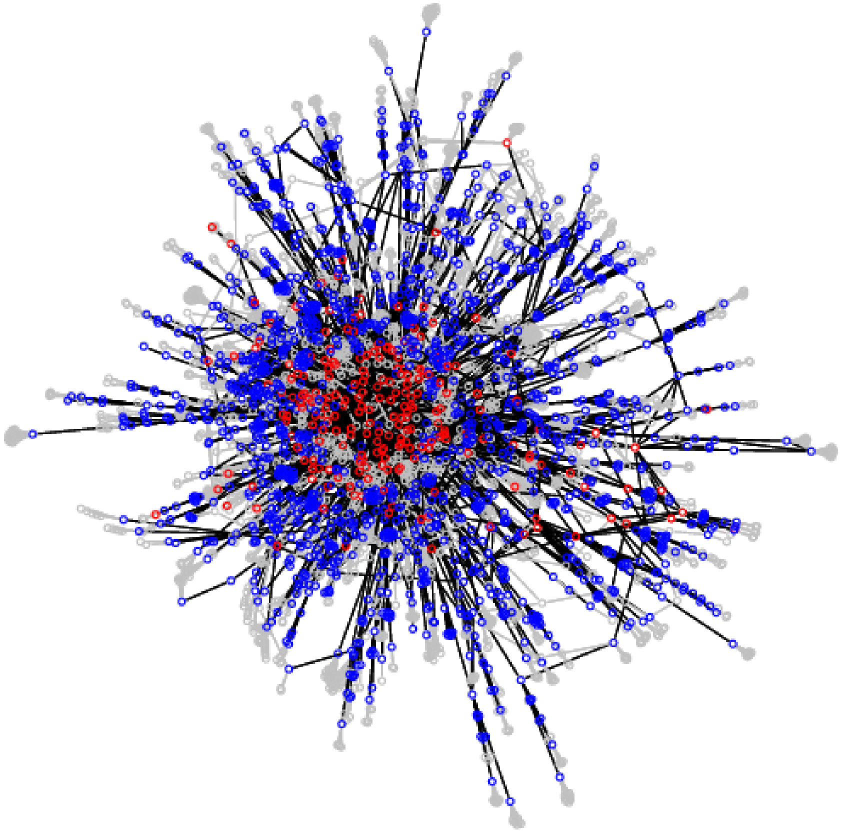
IP Addressing

Evolution of Internet Structure

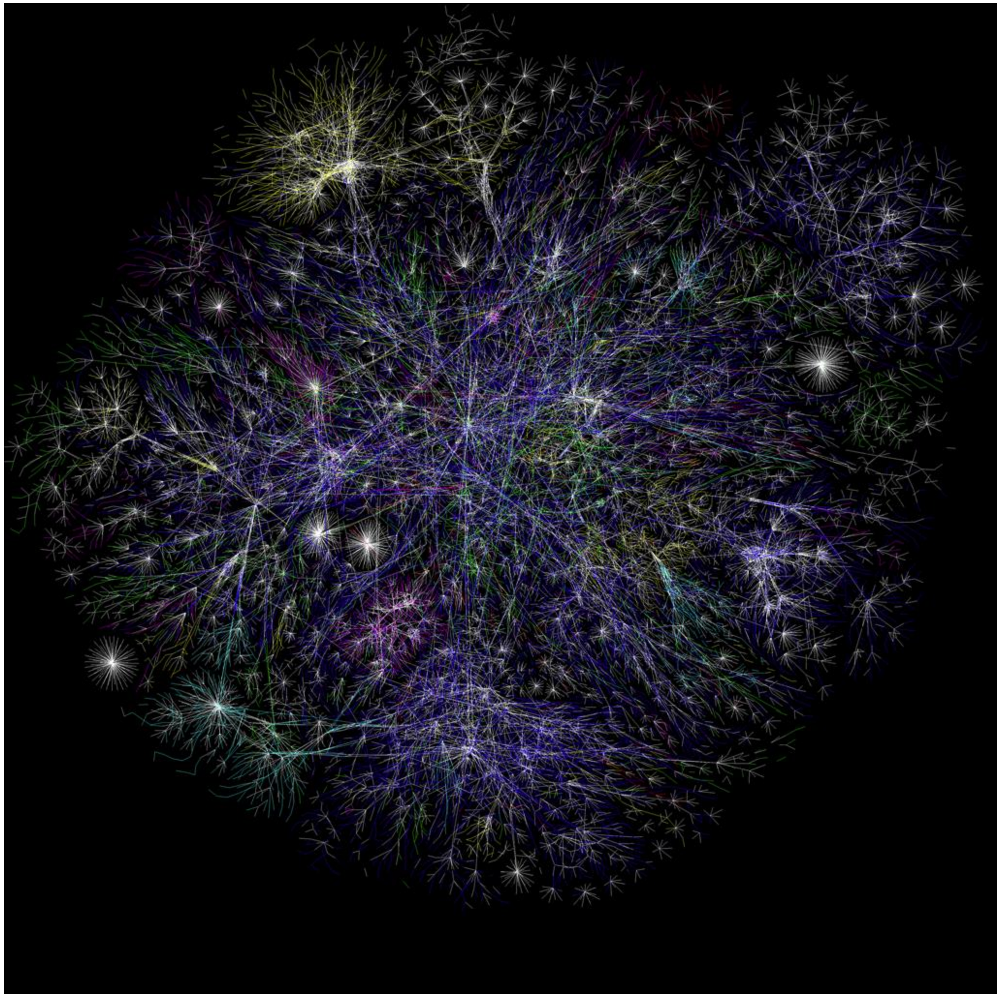
- Internet c. 1990
  - Tree structure, centered around one backbone
  - National Science Foundation (NSF) funded



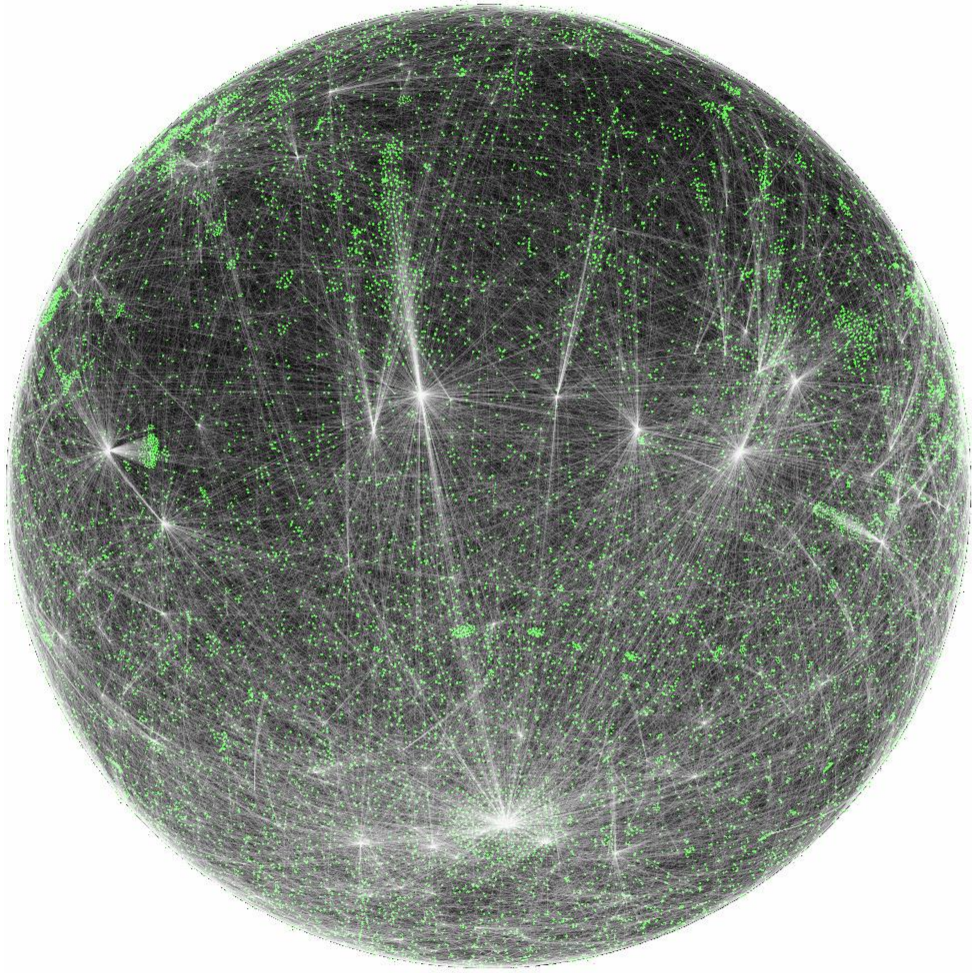
An Old Internet ISP Map



A New Internet Map

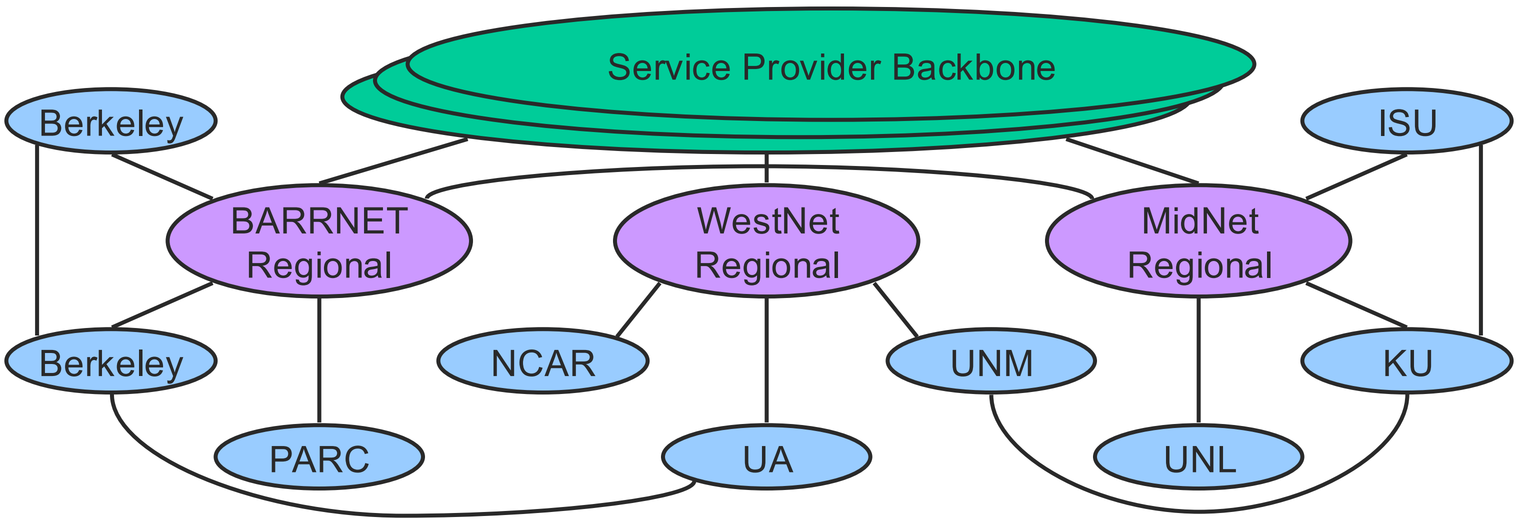


Another Internet Map



Evolution of Internet Structure

- Today
  - Multiple backbone service providers
  - Arbitrary graph structure

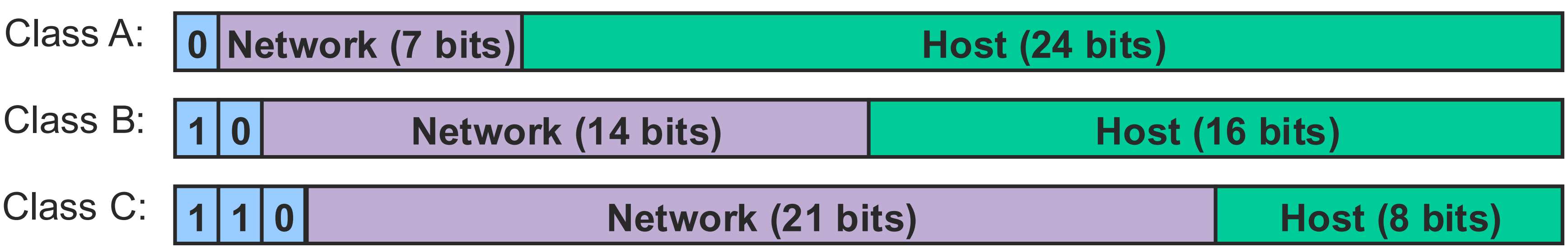


Problems of Scale

- Main problems
  - Inefficient address allocation
  - Too many networks for routing

IPv4 Address Model

- Properties
  - 32-bit address
  - Hierarchical
    - Network, subnet, host hierarchy
  - Maps to logically unique network adaptor
    - Exceptions: service request splitting for large web servers
- Three Class Model



IPv4 Address Model

- IP addresses
  - Host in class A network
    - 1.0.0.0 to 126.255.255.255
  - Host in class B network
    - 128.0.0.0 to 191.255.255.255
  - Host in class C network
    - 192.0.0.0 to 223.255.255.255

IPv4 Address Model

Class	Network ID	Host ID	# of Addresses	# of Networks
A	0 + 7 bit	24 bit	2^{24}-2	126
B	10 + 14 bit	16 bit	65,536 - 2	2^{14}
C	110 + 21 bit	8 bit	256 - 2	2^{21}
D	1110 + Multicast Address		IP Multicast	
E	Future Use			

Basic Datagram Forwarding with IP

- Hosts and routers maintain forwarding tables
  - List of <prefix, next hop> pairs
    - IP = 69.2.1.2 = 01000101 00000010 00000001 00000010
    - 24-bit prefix = 69.2.1.0/24
      = 01000101 00000010 00000001 ********
  - Often contains a default route
    - Pass unknown destination to provider ISP
  - Simple and static on hosts, edge routers
    - Complex and dynamic on core routers

Basic Datagram Forwarding with IP

- Packet forwarding
  - Compare network portion of address with <network/host, next hop> pairs in table
    - Send directly to host on same network
    - Send to indirectly (via router on same network) to host on different network
  - Use ARP to get hardware address of host/router

IPv4 Address Model

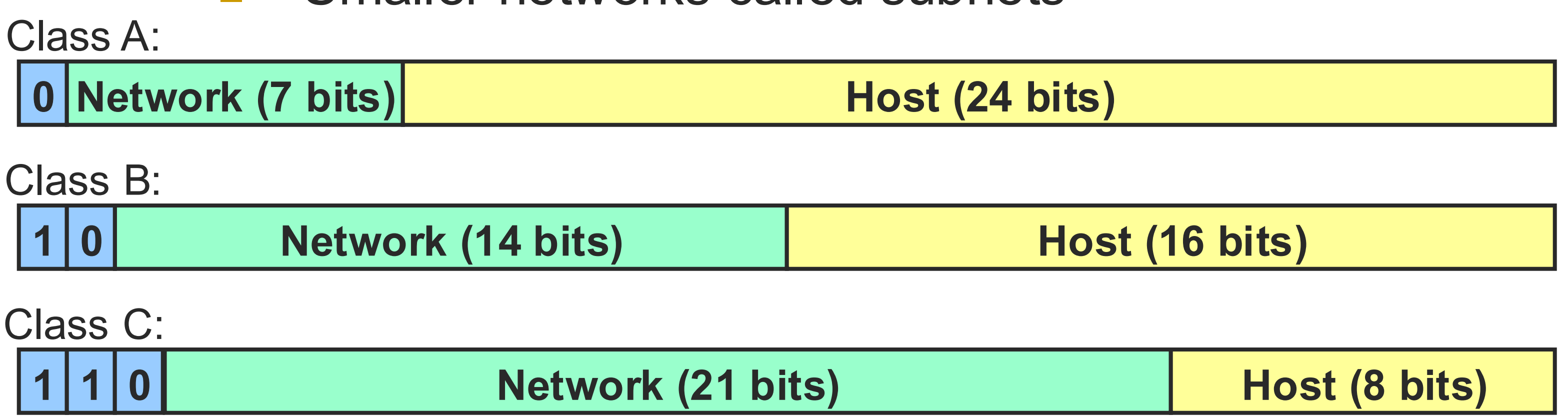
- IP addresses
  - Number of hosts in class A network
    - Approximately 16.7 million
  - Number of hosts in class B network
    - Approximately 65 thousand
  - Number of hosts in class C network
    - 254
- Questions
  - What networks should be allocated to a company with 1000 machines?
  - What about a company with 100 machines?
  - What about a company with 2 machines that plans to grow rapidly?

Problems of Scale

- Pressure mostly on class B networks
  - Most companies plan to grow beyond 255 machines
  - Renumbering is time consuming and can interrupt service
  - Approximately 16,000 class B networks available
- Class B networks aren't very efficient
  - Few organizations have O(10,000) machines
  - More likely use O(1,000) of the 65,000 addresses
- Scaling problems with alternatives
  - Multiple class C networks
    - Routing tables don't scale
  - Protocols do not scale beyond O(10,000) networks

IP Address Hierarchy Evolution

- Began with class-based system
  - Subnetting within an organization
    - Network can be broken into smaller networks
    - Recognized only within the organization
    - Implemented by packet switching
    - Smaller networks called subnets



Subnetting

- Simple IP
  - All hosts on the same network must have the same network number
- Assumptions
  - Subnets are close together
    - Look like one network to distant routers
- Idea
  - Take a single IP network number
  - Allocate the IP addresses to several physical networks (subnets)
- Subnetting
  - All hosts on the same network must have the same subnet number

Subnetting

- Enables a domain to further partition address space into smaller networks
  - Subdivide host id into subnet ID + host ID
  - Subnet mask
- Only routers in the domain interpret subnet mask
  - Other routers treat IP address as normal class A, B or C address

Subnet Example

- Consider
  - A domain with a class B address
  - 135.104.*.*
- Without subnetting
  - Every router in the domain needs to know how to route to every host
- However
  - the domain itself is likely organized as a hierarchy of physical networks

Subnet Example

- Solution
  - Partition the 65K address in the class B network
    - 256 subnets each with 256 addresses
    - Subnet mask: 255.255.255.0
  - If 135.104.5.{1,2,3} are all on the same physical network reachable from router 135.105.4.1
    - There only needs to be one routing entry for 135.104.5.* pointing to 135.105.4.1 as next hop

Subnetting

- Normal IP

Class B:

1	0	Network (14 bits)	Host (16 bits)

- Typical subnetting example
  - Use first byte of host as subnet number

Class B:

1	0	Network (14 bits)	Subnet (8 bits)	Host (8 bits)

- Atypical example
  - Non-contiguous 6-bit subnet number

Class B:

1	0	Network (14 bits)								

Subnetting

- The subnet mask specifies the bits of network and subnet addresses
- Routing table entries carry both addresses and subnet masks

Class B:

1	0	Network (14 bits)	Host (16 bits)

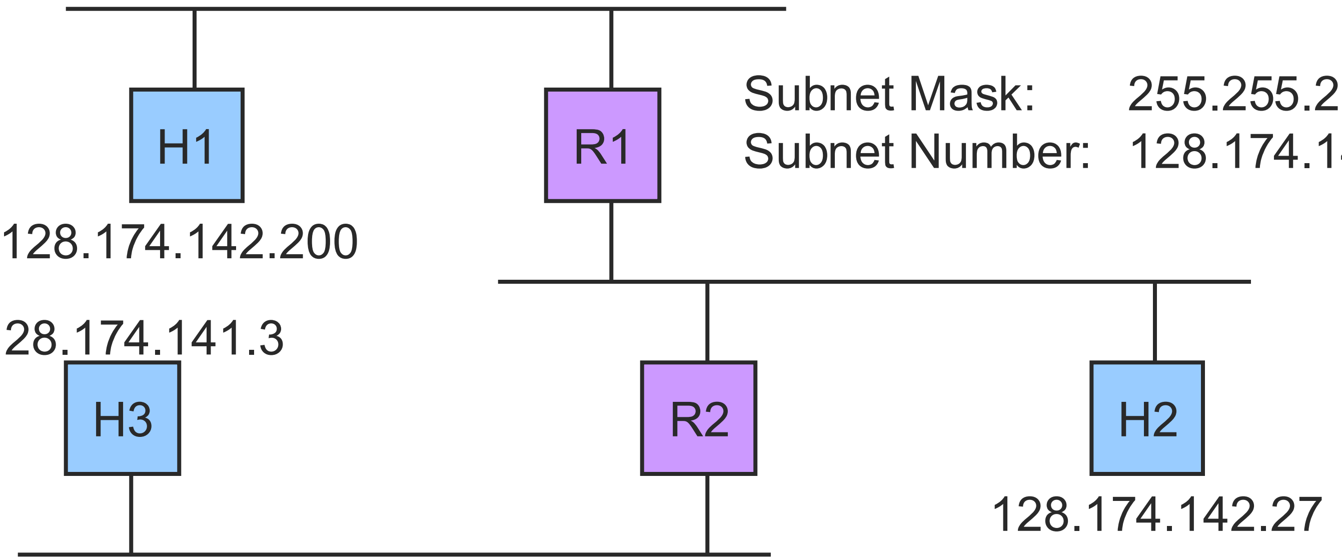
Class B:

1	0	Network (14 bits)	Subnet (8 bits)	Host (8 bits)

Subnet Mask:

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Subnetting – Host 1



Subnet Mask: 255.255.255.128
Subnet Number: 128.174.142.128

Host 1: 128.174.142.200

1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0	0	0	1	1	1	0	1	1	0	0	1	0	0	0

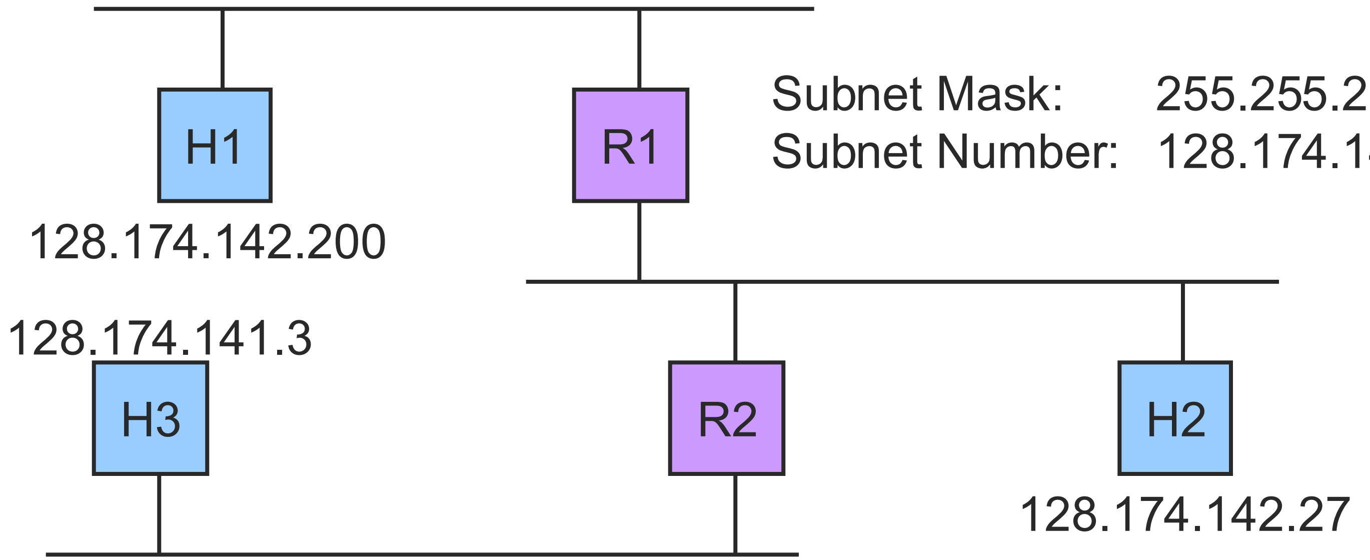
Subnet Mask 255.255.255.128

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Subnet # 128.174.142.128

1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0

Subnetting – Host 3



Subnet Mask: 255.255.255.0
Subnet Number: 128.174.141.0

Host 3: 128.174.141.3

1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	1

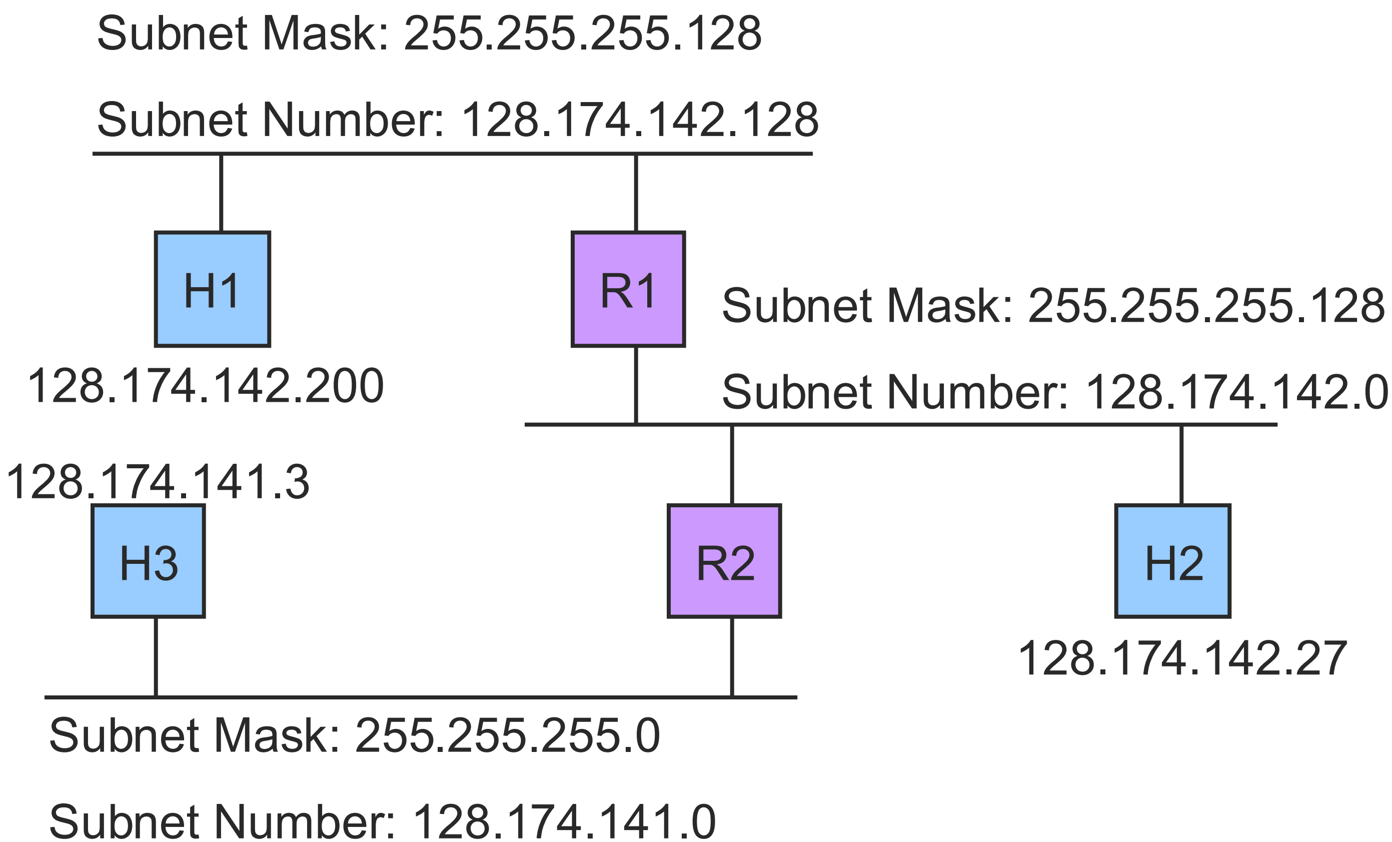
Subnet Mask 255.255.255.0

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Subnet # 128.174.141.0

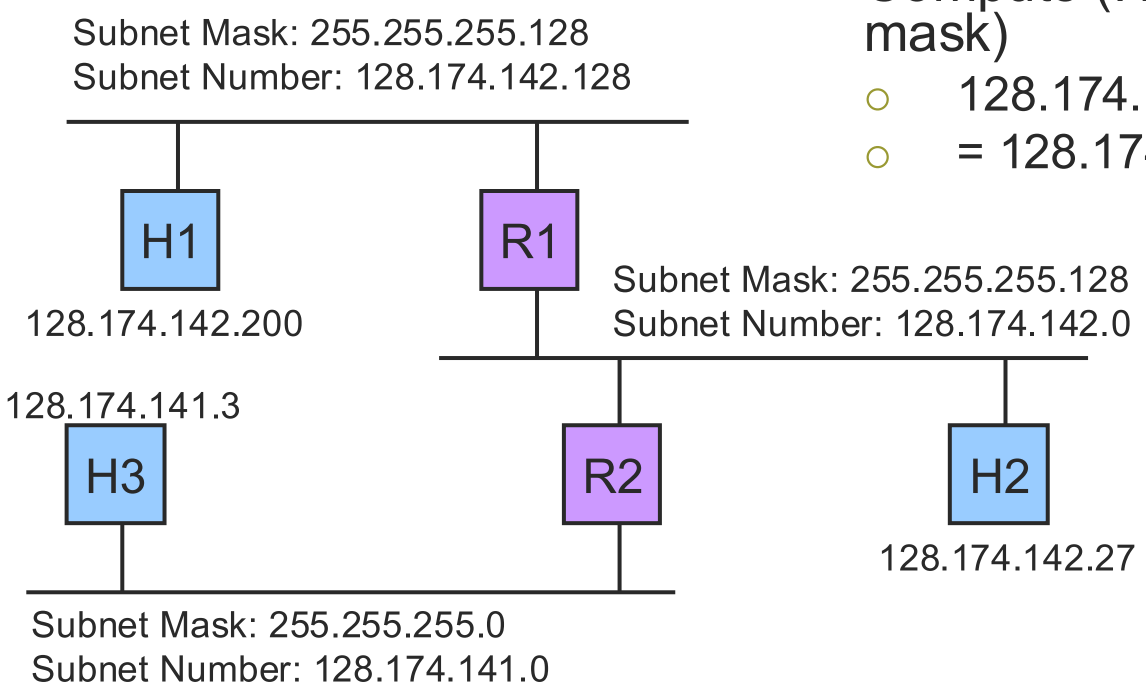
1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0

Subnetting - Example



Subnetting

Send from H1 to H3



- At H1:
- Compute (H3 AND H1's subnet mask)
  - 128.174.141.3 **AND** 255.255.255.128
  - = 128.174.141.0 (≠ 128.174.142.128)
- If result == H1's subnet number
  - H3 and H1 are on the same subnet
- else
  - route through appropriate router

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

196 = 1100 0100

128 = 1000 0000

141 = 1000 1101

142 = 1000 1110

145 = 1001 0001

196 = 1100 0100

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

196 = 1100 0100 ≠

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

=

`196 = 1100 0100`

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

```
196 = 1100 0100
```

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

=

196 = 1100 0100

128 = 1000 0000

141 = 1000 1101

142 = 1000 1110

145 = 1001 0001

196 = 1100 0100

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196 to R1
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

`196 = 1100 0100`

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

?

- Example Table from R2
  - Next hop
    - 128.174.142.196 to R1
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

`196 = 1100 0100`

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

```
95 = 0101 1111
```

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

```
95 = 0101 1111
```

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

`95 = 0101 1111` ≠ `128 = 1000 0000`

```
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

95 = 0101 1111

to Interface 1

128 = 1000 0000

141 = 1000 1101

142 = 1000 1110

145 = 1001 0001

196 = 1100 0100

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

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  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

`137 = 1000 1001`

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

137 = 1000 1001 ≠

128 = 1000 0000

141 = 1000 1101

142 = 1000 1110

145 = 1001 0001

196 = 1100 0100

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137 to Interface 0
    - 128.174.145.18
    - 131.126.244.15

```
137 = 1000 1001
```

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

```
18 = 0001 0010   ≠
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

18 = 0001 0010 ≠

128 = 1000 0000

141 = 1000 1101

142 = 1000 1110

145 = 1001 0001

196 = 1100 0100

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

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  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

```
18 = 0001 0010
```

```
128 = 1000 0000
141 = 1000 1101
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```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18 to R3
    - 131.126.244.15

```
18 = 0001 0010
```

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
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128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15

```
15 = 0000 1111
```

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
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128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196
    - 128.174.142.95
    - 128.174.141.137
    - 128.174.145.18
    - 131.126.244.15 to R3

```
15 = 0000 1111
```

```
128 = 1000 0000
141 = 1000 1101
142 = 1000 1110
145 = 1001 0001
196 = 1100 0100
```

Routing with Subnetting

Subnet #	Subnet Mask	Next Hop
128.174.141.0	255.255.255.0	Interface 0
128.174.142.0	255.255.255.128	Interface 1
128.174.142.128	255.255.255.128	R1
128.174.0.0	255.255.0.0	R3
Default	0.0.0.0	R3

- Example Table from R2
  - Next hop
    - 128.174.142.196 to R1
    - 128.174.142.95 to Interface 1
    - 128.174.141.137 to Interface 0
    - 128.174.145.18 to R3
    - 131.126.244.15 to R3

Subnetting

- Notes
  - Non-contiguous subnets are difficult to administer
  - Multiple subnets on one physical network
    - Must be routed through router
- Pros
  - Helps address consumption
  - Helps reduce routing table size

The Crisis

- Fixed 32-bit address space for IPv4
- Network allocation based on Classic A, B, C Model
- Central allocation authority
  - Randomly assigning addresses
- Problems
  - Router table explosion
  - Address space exhaustion

Classless Interdomain Routing (CIDR)

- CIDR/Supernetting
  - Problem with subnetting
    - Allows hierarchy within organizations
    - Does not reduce class B address space pressure
  - Solution
    - Aggregate routes in routing tables
    - Eliminate class notation
    - Generalize subnet notion
    - Allow only contiguous subnet masks
    - Specify network by <network #, # of bits in subnet mask>
    - Equivalent to <network #, # of hosts>
    - Blocks of class C networks can now be treated as one network

CIDR

- Route aggregation
  - Use contiguous blocks of Class C addresses
    - Example:
      - 192.4.16 – 192.4.31
      - 20 bit subnet mask
    - Block size must be a power of 2
  - Network number may be any length

192.4.16.0

1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

192.4.31.0

1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0

Subnet Mask

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0

CIDR

Subnet # / length	Next Hop
128.174.141.0 / 24	Interface 0
128.174.142.192 / 27	Interface 1
128.174.142.128 / 25	R1
128.174.0.0 / 16	R3
Default	R3

- CIDR is similar to subnetting
  - Trend is for increasing amounts of overlap in routing table entries
  - Example: 128.174.142.200
    - Matches second, third and fourth lines
    - Route to entry with longest match

CIDR

Subnet: 128.174.141.0

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0

Subnet Mask length = 24 (255.255.255.0)

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0

Host: 128.174.142.200

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 1 1 0 0 1 0 0 0

Resulting Subnet Number: 128.174.142.0 (≠ 128.174.141.0)

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0

Subnet: 128.174.142.192

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 1 1 0 0 0 0 0 0

Subnet Mask length = 27 (255.255.255.224)

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0

Host: 128.174.142.200

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 1 1 0 0 1 0 0 0

Resulting Subnet Number: 128.174.142.192 (= 128.174.142.192)

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 1 1 0 0 0 0 0 0

CIDR

Subnet: 128.174.142.128

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 1 0 0 0 0 0 0 0

Subnet Mask length = 25 255.255.255.192

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0

Host: 128.174.142.200

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 1 1 0 0 1 0 0 0

Resulting Subnet Number: 128.174.142.128 (= 128.174.142.128)

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 1 0 0 0 0 0 0 0

Subnet: 128.174.0.0

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Subnet Mask length = 16 255.255.0.0

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Host: 128.174.142.200

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 1 0 0 0 1 1 1 0 1 1 0 0 1 0 0 0

Resulting Subnet Number: 128.174.0.0 (= 128.174.0.0)

1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

CIDR

- Subnetting
  - Share one address (network number) across multiple physical networks
- Supernetting
  - Aggregate multiple addresses (network numbers) for one physical network

CIDR

- Allows hierarchical development
  - Assign a block of addresses to a regional provider
    - Ex: 128.0.0.0/9 to provider
  - Regional provider subdivides address and hands out block to sub-regional providers
    - Ex: 128.132.0.0/16 to sub-provider
  - Sub-regional providers can divide further for smaller organizations
    - Ex: 128.132.32.0/1 to organization

Pros and Cons

- Provides a fast easy solution
- Was not intended to be permanent
- Multihomed sites cannot benefit from aggregation
- Not backward compatible

IPv6

- History
  - Next generation IP (AKA IPng)
  - Intended to extend address space and routing limitations of IPv4
    - Requires header change
    - Attempted to include everything new in one change
  - IETF moderated
    - Based on Simple Internet Protocol Plus (SIPP)

IPv6

- Wish list
  - 128-bit addresses
  - Multicast traffic
  - Mobility
  - Real-time traffic/quality of service guarantees
  - Authentication and security
  - Autoconfiguration for local IP addresses
  - End-to-end fragmentation
  - Protocol extensions
- Smooth transition!
- Note
  - Many of these functionalities have been retrofit into IPv4