

# Address Space Utilization

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# Recap

- Hierarchical addressing based on classes (A,B,C) to handle scalability and different network sizes
  - IP address has a network part and a host part
  - Routers maintain entries corresponding to network portion
- What can potentially go wrong now?

# Problem Statement

- Network part uniquely identifies a physical network
- Network with just 2 hosts needs Class C address
  - Efficiency:  $2/2^8 = 0.7\%$
- Network with 256 hosts needs a Class B address
  - Efficiency:  $256/2^{16} = 0.4 \%$

# Problem Statement

- Class B addresses in high demand (keeping future needs in mind)
  - Host addresses  $\sim 4$  billion ( $2^{32}$ )
  - Class B networks:  $2^{14}$  ( $\sim 16000$ )
  - Out of class B addresses, out of addresses to hand out
- Need to solve “Address assignment inefficiency”
  - Challenge: Within IP framework (using 32-bits)

“The gem cannot be polished without friction,  
nor man perfected without trials.”

**---Chinese proverb**

“You see a mousetrap; I see free cheese and a  
\*\*\*\*\* challenge!”

**---Scroobius Pip**

# Specific Scenario –1

- An organization has 30 different physical networks, each network has about 2000 hosts
- Current Allocation: Allocate 30 class B addresses
  - Efficiency =  $2000/2^{16} = 3\%$
- Will one class B address suffice?
  - Can support  $2^{16} = 65536$  hosts  $> 30 \times 2000$

# Solution: Subnetting

- Introduce another level of hierarchy
  - Divide host part into subnet id and host id

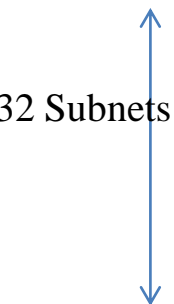
Network Number	Host Number	
Network Number	Subnet ID	Host ID

- 16 host bits divided into 5 subnet bits (32 physical networks ) and 11 host bits (2048 hosts)

- Address format: a.b.c.d/x, where x is # bits in net portion of address
  - Example: 190.23.12.17, mask is 255.255.248.0 (/21)
- `ifconfig eth0 190.23.12.17 netmask 255.255.255.240`
- The bit-wise end of the IP address and the subnet mask give the subnet number of the host
- All hosts on a given physical network have the same subnet number and mask



Class B Address: 10111110. 00010111. \*. \*; 190.23.0.0/16



Subnet ID	Subnet No	Hosts
00000	190.23.0.0	190.23.0.1 – 190.23.7.254
00001	190.23.8.0	190.23.8.1 – 190.23.15.254
.....		
11111	190.23.248.0	190.23.248.1 – 190.23.255.254

- All routers outside organization have one entry (190.23.0.0/16)
- Routers within organization have more detailed entries corresponding to different subnets

# Forwarding at a Router

D = Destination IP Address

For each forwarding table entry

$T = D \ \& \ \text{SubnetMask}$

If  $T == \text{SubnetNum}$

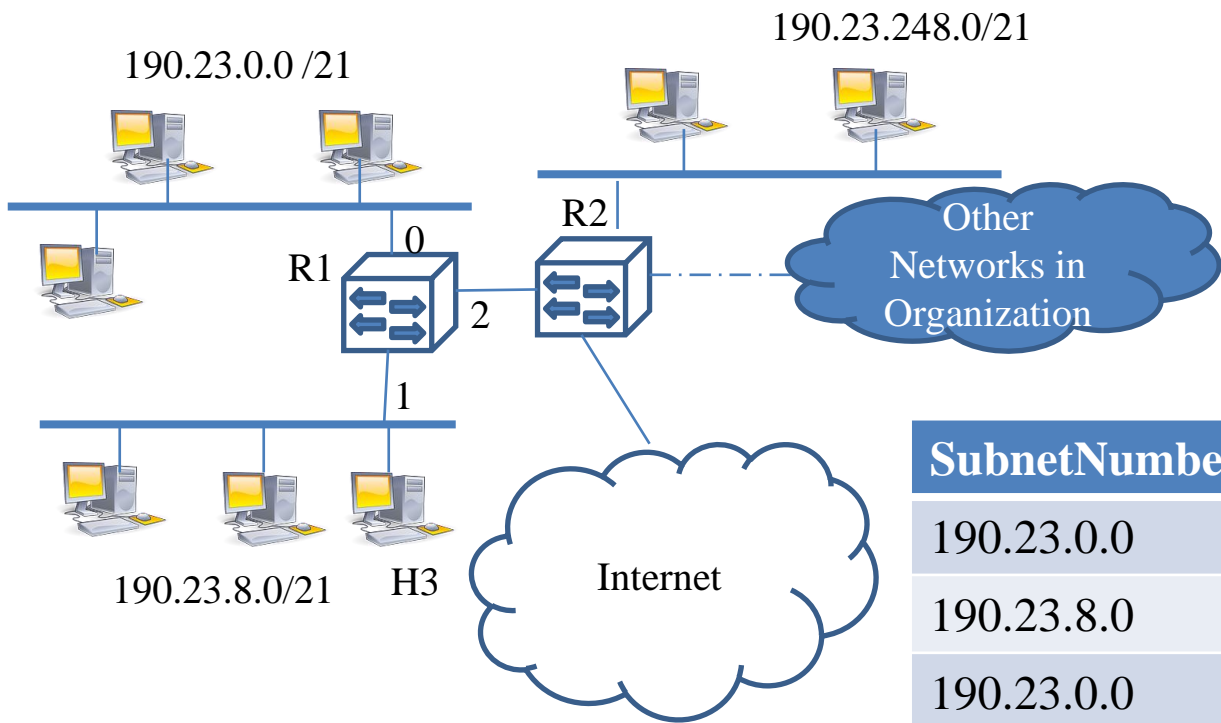
    If Nexthop is an interface

        deliver datagram directly to destination

    Else

        deliver datagram to NextHop (router)

# Example



Routing Table at R1

SubnetNumber	Mask	Nexthop
190.23.0.0	255.255.248.0	Inf0
190.23.8.0	255.255.248.0	Inf1
190.23.0.0	255.255.0.0	R2
Default	0.0.0.0	R2

```

kameswari@asterix:~$ route
Kernel IP routing table
Destination      Gateway          Genmask          Flags  Metric  Ref    Use  Iface
10.129.0.0        *                255.255.0.0      U        1        0        0  eth0
link-local        *                255.255.0.0      U       1000        0        0  eth0
default          router.it.iitb.  0.0.0.0          UG         0        0        0  eth0
kameswari@asterix:~$
kameswari@asterix:~$
kameswari@asterix:~$ route -n
Kernel IP routing table
Destination      Gateway          Genmask          Flags  Metric  Ref    Use  Iface
10.129.0.0        0.0.0.0          255.255.0.0      U        1        0        0  eth0
169.254.0.0       0.0.0.0          255.255.0.0      U       1000        0        0  eth0
0.0.0.0          10.129.250.1    0.0.0.0          UG         0        0        0  eth0
kameswari@asterix:~$ |

```

A deep red velvet curtain with a prominent vertical pleated texture, filling the entire frame. The lighting creates subtle gradients of red, with darker tones in the folds and lighter tones on the raised sections.

INTERMISSION

## Specific Scenario -- 2

- An organization has a physical network with 4000 hosts
- Current Solution: Give a class B address
  - Efficiency:  $4000/2^{16} = 6\%$
- How about assigning multiple class C addresses?
- Problem: 16 entries for same organization in the routing table

## Solution--2

- Assign multiple contiguous class C addresses & aggregate
- 222.7.16.\* through 222.7.31.\*, top 20 bits in this range are the same (0001 bits, 20-bit network number)
- Advertise 222.7.16/20 as the organization's network address
- Goes by the name supernetting

# Conclusions

- Subnetting: One class address shared among many physical networks
- Supernetting: Multiple class addresses shared among one physical network (Autonomous system -- AS)
- Network portion can take on any length



# Classless Interdomain Routing (CIDR)

- Use a new notation to represent network numbers (also called IP prefixes)
- Address block represented as A/X, where A is the address prefix and X is the prefix length
  - X can range from 2 till 32
  - X is represented as a network mask as well
- E.g. 222.7.16/20 (Mask 255.255.240.0) represents addresses in the range 222.7.16.0 to 222.7.31.255

# Longest Prefix Match

- Routers do a prefix match.
  - Does destination address fall in the range of addresses captured by prefix?
- Prefix match works if Internet topology is a tree
  - Shortest path between networks is unique
- Internet is a graph
  - Many networks multi-home
  - Many matching prefixes

# Example

- Two prefixes in a forwarding table 190.23.8.0/21 and 190.23.0.0/16
  - Address 190.23.8.1 matches both
- Go with the longest prefix match (e.g 190.23.8.0/21)
- Challenge: Longest match between destination IP address and variable length prefixes in forwarding table
  - Lot of research in this space

# Summary

- Class based addressing was found not to be scalable
- Subnetting: Share a single class address among multiple networks
- Supernetting: Share multiple class addresses on a single network
- Lead to CIDR (classless addressing) and Longest prefix match --- widely used now