CIDR – VLSM – AS

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Outline

- Classless Interdomain Routing (CIDR)
- Variable Length Subnet Mask (VLSM)
- Autonomous System (AS)

IP Addresses Revisited

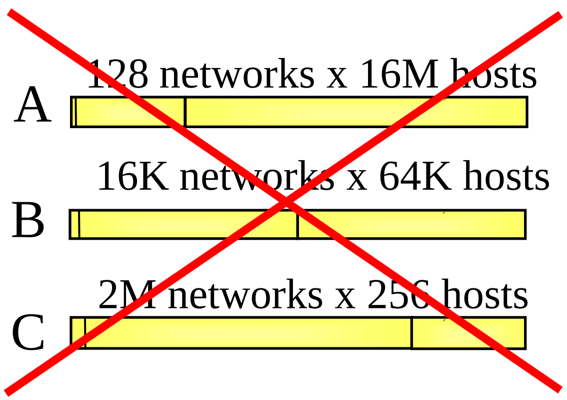
- Potential exhaustion of IPv4 address space (due to inefficiency)
  - Class B is too big
  - Class C is too small (many are available)
- Growth of back bone routing tables
  - Lots of small networks causes large routing tables
  - Route calculation and management requires high computational overhead

Classless InterDomain Routing (CIDR)

- Try to balance two competing effects
  - Address utilization
  - Router complexity
- CIDR allows routers to break the rigid interpretation of IP address structures
- Also called “Supernet”
  - Opposite of “Subnet”

Classful & Classless addressing

Classful



Obsolete

- *inefficient*
- *depletion of B space*
- *too many routes from C space*

Classless

Hosts	Prefix	Classful
2	/31	
4	/30	
8	/29	
16	/28	
32	/27	
64	/26	
128	/25	
256	/24	1 C
...	...	...
4096	/20	16 C
8192	/19	32 C
16384	/18	64 C
32768	/17	128 C
65536	/16	1 B
...	...	...

Best Current Practice

Prefix Length

/n	Mask	/n	Mask	/n	Mask	/n	Mask
/1	128.0.0.0	/9	255.128.0.0	/17	255.255.128.0	/25	255.255.255.128
/2	192.0.0.0	/10	255.192.0.0	/18	255.255.192.0	/26	255.255.255.192
/3	224.0.0.0	/11	255.224.0.0	/19	255.255.224.0	/27	255.255.255.224
/4	240.0.0.0	/12	255.240.0.0	/20	255.255.240.0	/28	255.255.255.240
/5	248.0.0.0	/13	255.248.0.0	/21	255.255.248.0	/29	255.255.255.248
/6	252.0.0.0	/14	255.252.0.0	/22	255.255.252.0	/30	255.255.255.252
/7	254.0.0.0	/15	255.254.0.0	/23	255.255.254.0	/31	255.255.255.254
/8	255.0.0.0	/16	255.255.0.0	/24	255.255.255.0	/32	255.255.255.255

CIDR Example

What is the first address in the block if one of the addresses is 167.199.170.82/27?

Solution

Address in binary: 10100111 11000111 10101010 01010010
Keep the left 27 bits: 10100111 11000111 10101010 01000000

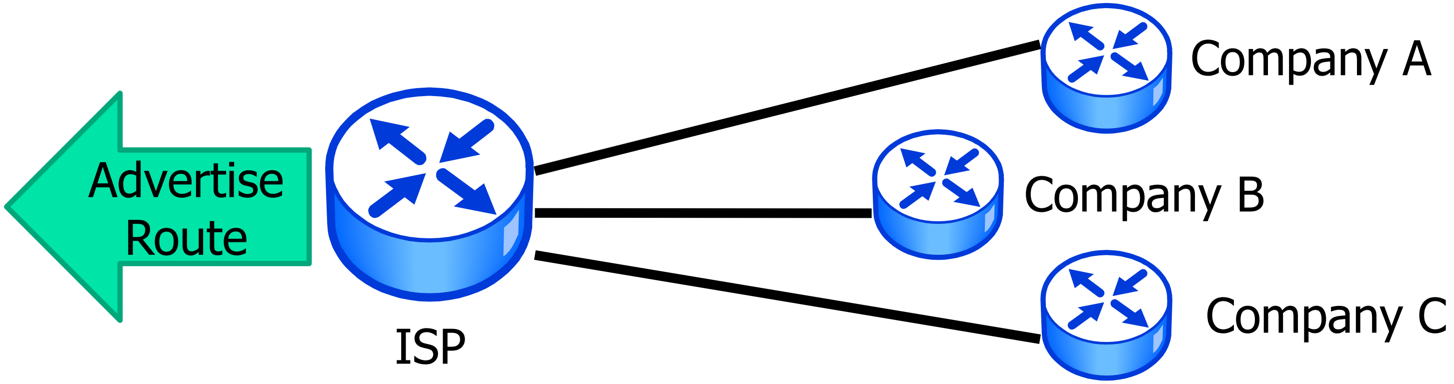
Result in CIDR notation: 167.199.170.64/27

Supernetting: CIDR

- Enable network number to be any length (No Class)
- Collapse multiple addresses assigned to a single AS to one address
- All routers must understand CIDR addressing
  - Need both Address and Mask (prefix and suffix)
  - Slash notation (123.10.16.0 /20)
- Some prefixes are reserved for private add.
  - 10/8, 172.16/12, 192.168/16, 169.254/16
  - These are not routable in the Internet

Example of CIDR

- Consider an ISP providing IP connection to a number of private companies
- If IP addresses for companies are carefully selected
  - a border router needs only advertise one "aggregated" route for all companies



Example of CIDR (Supernetting)

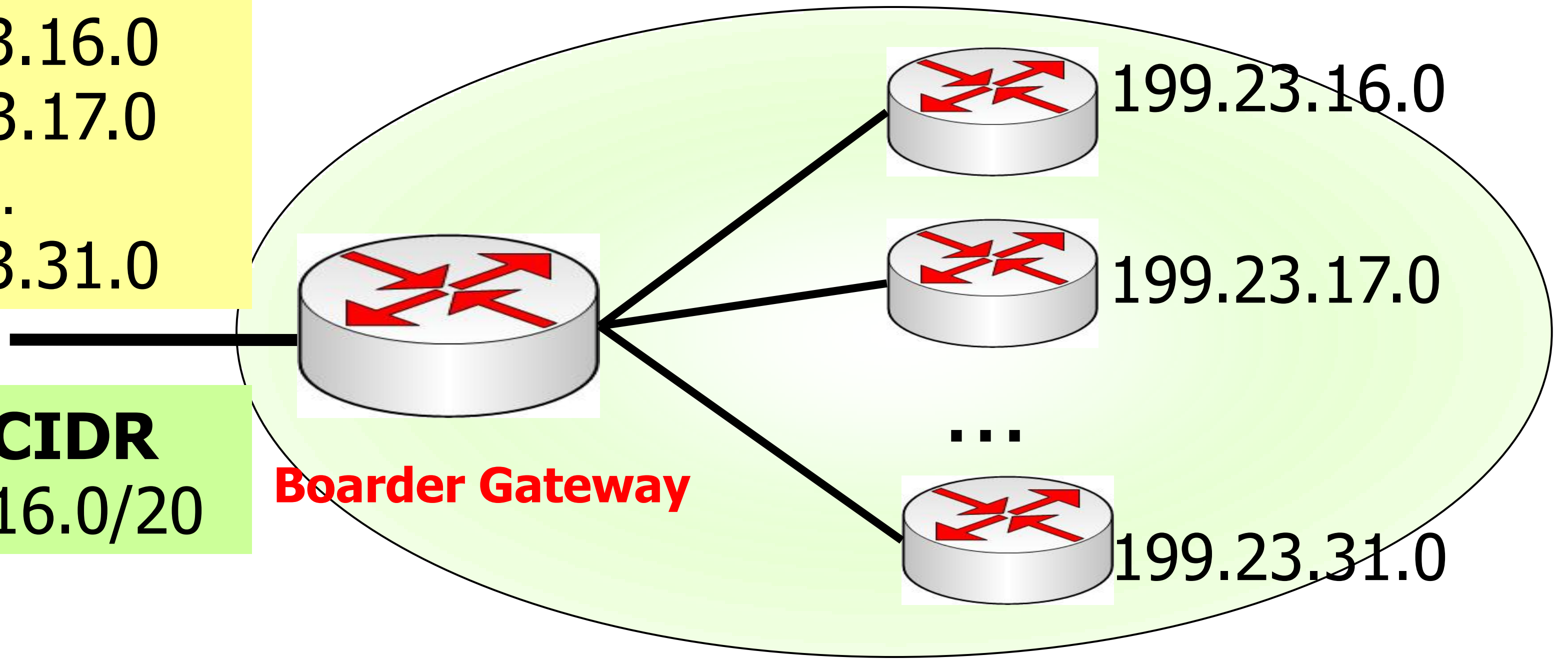
- If ISP needs 16 class C addresses
  - make them contiguous
- Eg. 199.23.16.0 to 199.23.31.0
  - enables a 20-bit network number

199.23.0001 0000.0 → 199.23.16.0
199.23.0001 0001.0 → 199.23.17.0
199.23.0001 0010.0 → 199.23.18.0
199.23.0001 0011.0 → 199.23.19.0
…
199.23.0001 1111.0 → 199.23.31.0

Example of CIDR

Without CIDR
199.23.16.0
199.23.17.0
...
199.23.31.0

With CIDR
199.23.16.0/20



Aggregation

- Some pairs of consecutive prefixes
- Example: routes within the same AS:

  AS has 2 address blocks:

1.2.2.0/24 = 0000001.00000010.**00000010**.00000000/24
1.2.3.0/24 = 0000001.00000010.**00000011**.00000000/24

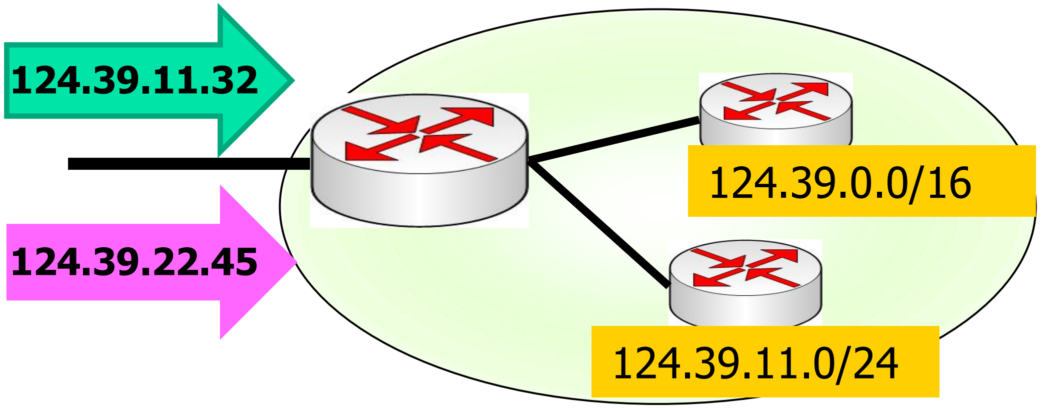
Can announce 1.2.2.0/23

CIDR: Longest prefix match

- Because prefixes of arbitrary length allowed, overlapping prefixes can exist.
- Example:

  router hears 124.39.0.0/16 from one neighbor

  and 124.39.11.0/24 from another neighbor



- Router forwards packet according to most specific forwarding information, called longest prefix match
  - Packet with destination **124.39.11.32** will be forwarded using /24 entry.
  - Packet with destination **124.39.22.45** will be forwarded using /16 entry

CIDR: Longest prefix match

- Implicit ordering in the routing table
  - longer prefixes higher up the table
  - So, the first match is the right one
- Explicit route to directly attached host
  - a netmask of 0.0.0.0

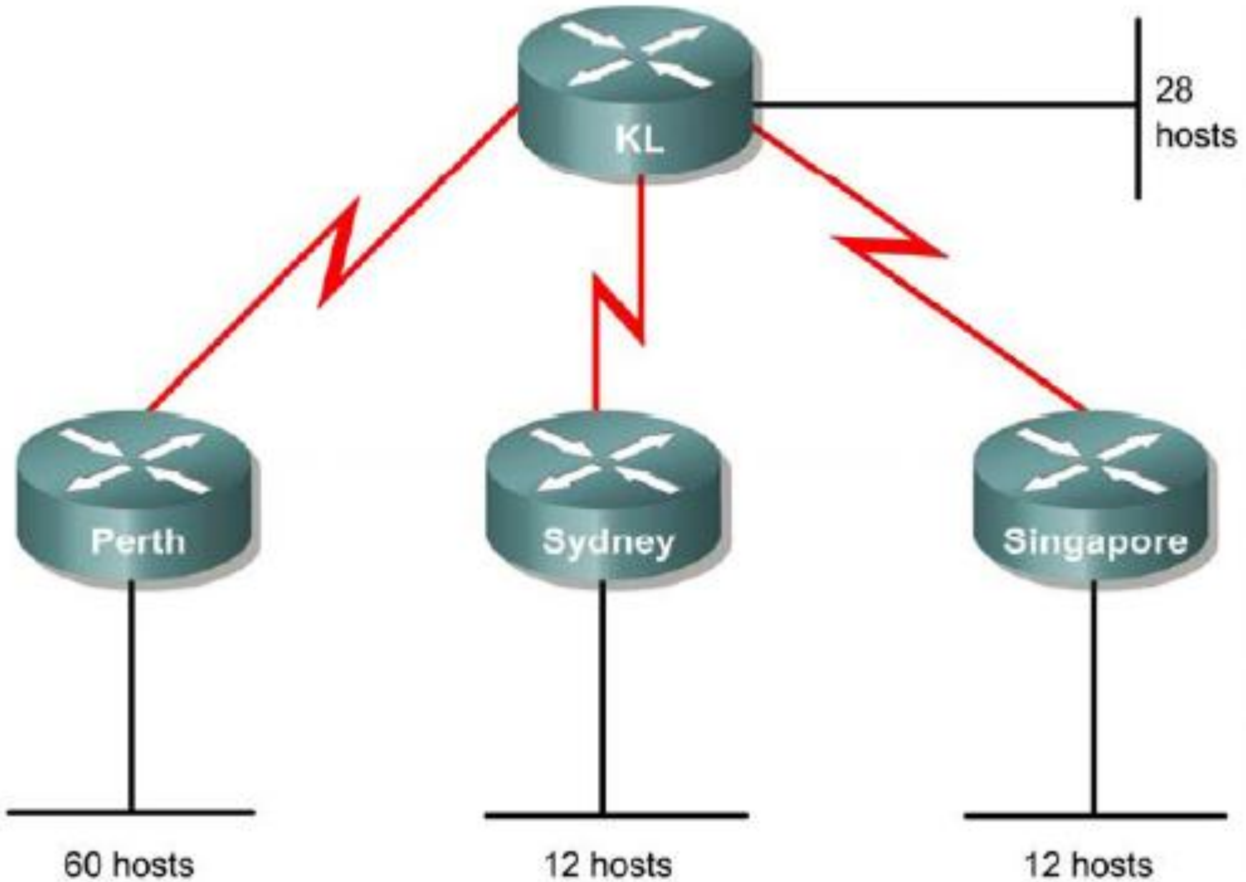
VLSM

VLSM

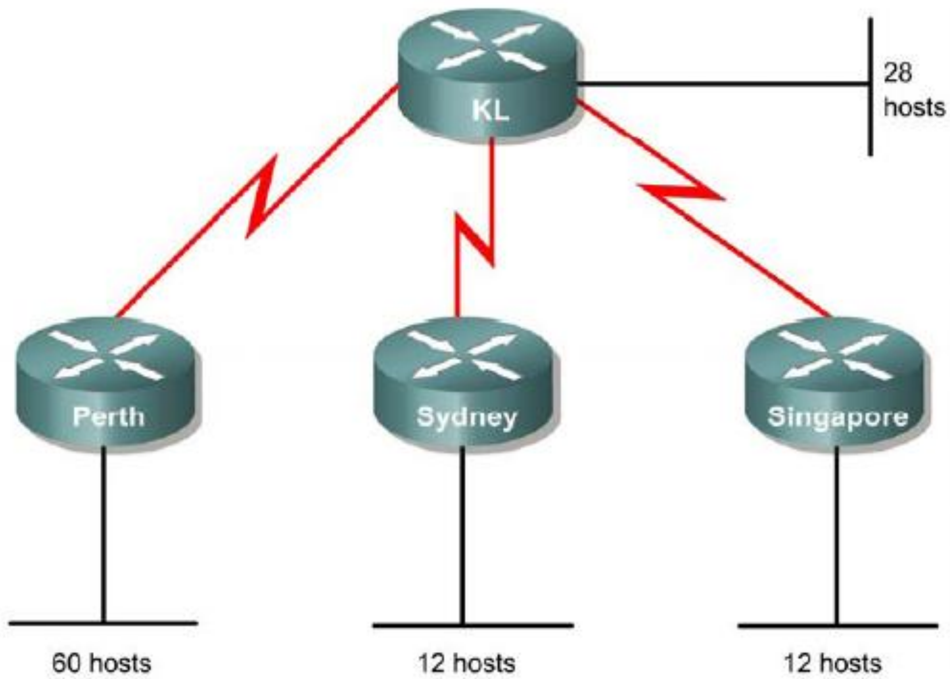
- Variable-length subnet mask
- Classful allows only one subnet in a network
  - > one subnet in an autonomous system
- Maximizing the use of address (Subnet Zero)
- “Subnetting a Subnet”
- Routing that supports VLSM
  - OSPF, Integrated IS-IS, EIGRP, RIPv2, and static routing

Subnet with VLSM

192.168.10.0/24



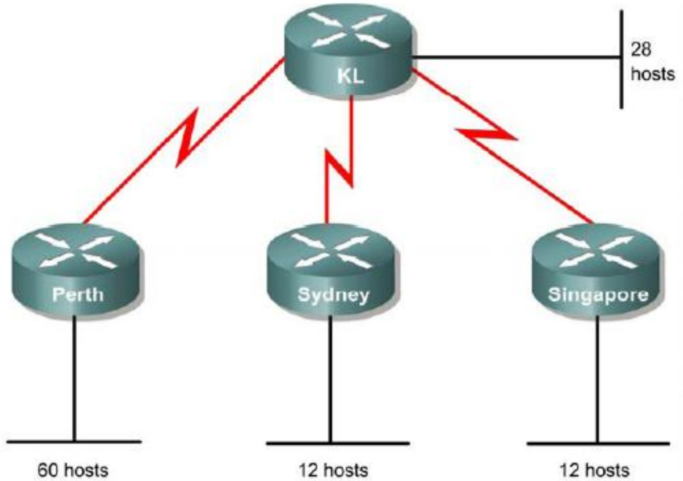
Regular Subnet



192.168.10.0/24

7 subnets; The largest subnet needs **60** hosts
If 3 bits for subnet (8 subnets) ➔ 5 bits for host (32 hosts)
If 6 bits for host (64 hosts) ➔ 2 bits for subnet (4 subnets)

Subnet with VLSM

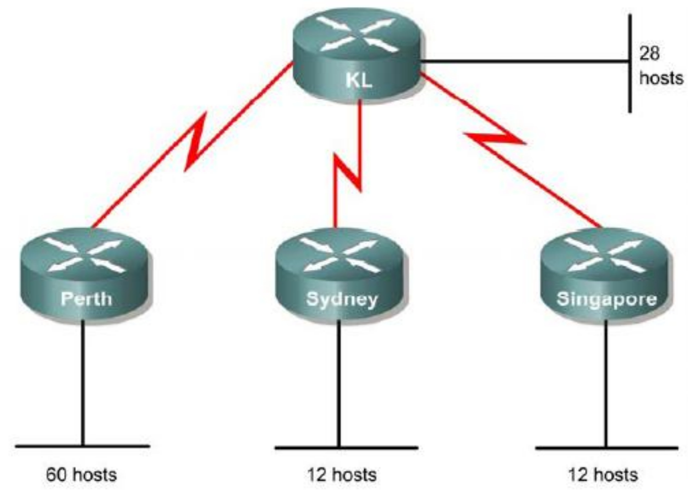


- Select the biggest first
- 192.168.10.0/24
  - 192.168.10.0/26 ← **Perth**
  - 192.168.10.64/26
  - 192.168.10.128/26
  - 192.168.10.192/26

192.168.10.64/26

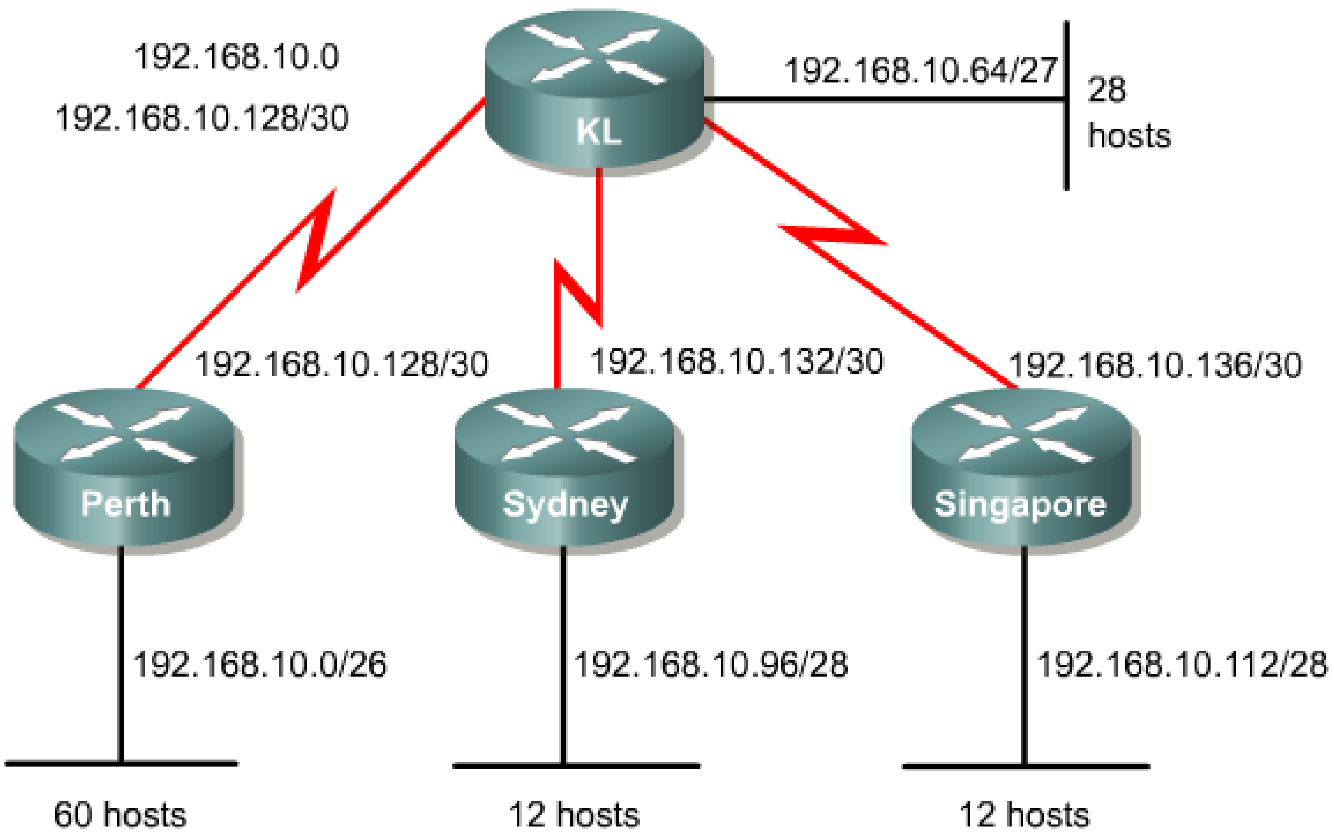
  - 192.168.10.64/27 ← **KL**
  - 192.168.10.96/27

Subnet with VLSM



- 192.168.10.96/27
  - 192.168.10.96/28 ← **Sydney**
  - 192.168.10.112/28 ← **Singapore**
- 192.168.10.128/**26**
  - 192.168.10.128/30 ← **Perth – KL**
  - 192.168.10.132/30 ← **Sydney – KL**
  - 192.168.10.136/30 ← **Singapore – KL**
  - 192.168.10.140/30
  - …

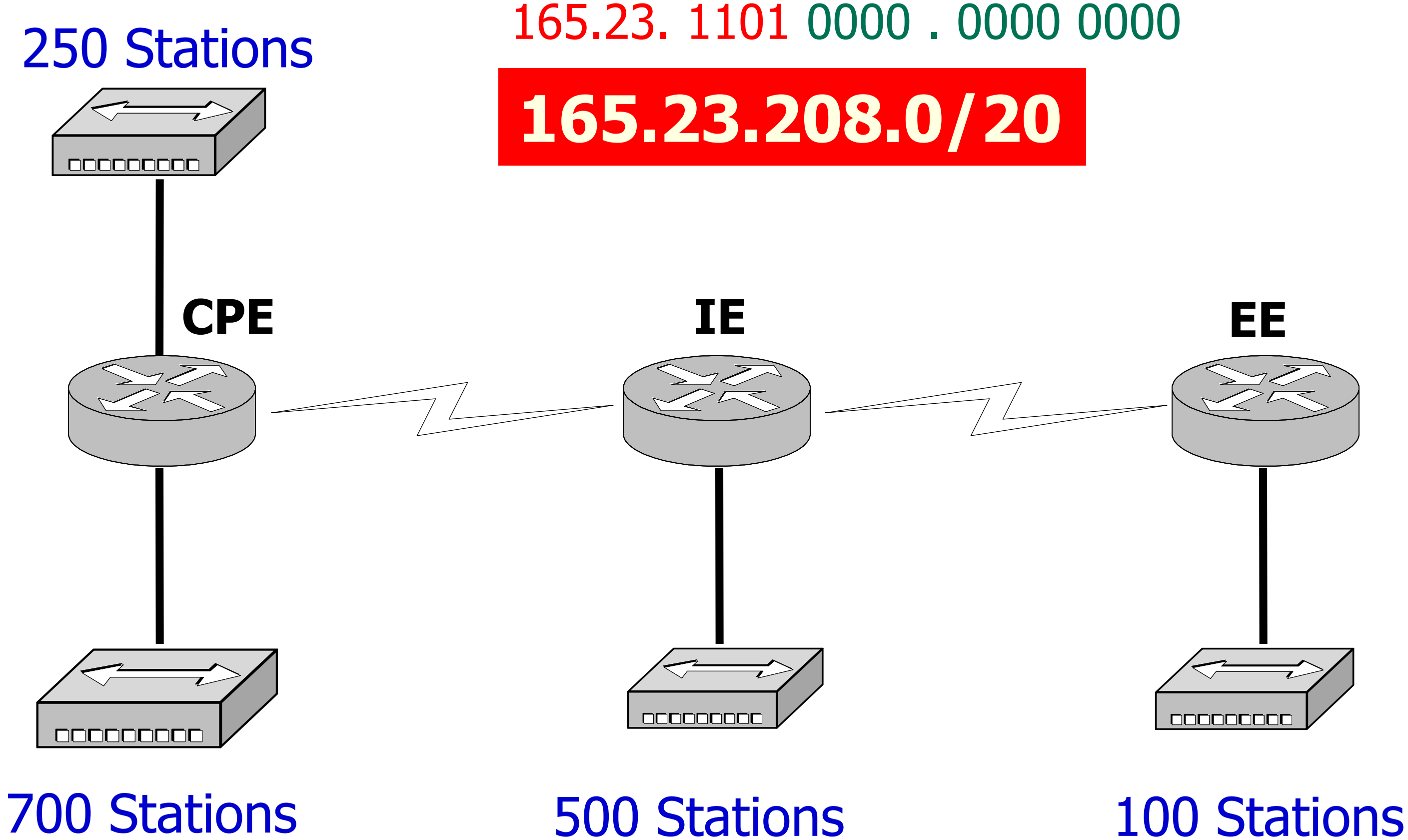
Final: Subnet with VLSM



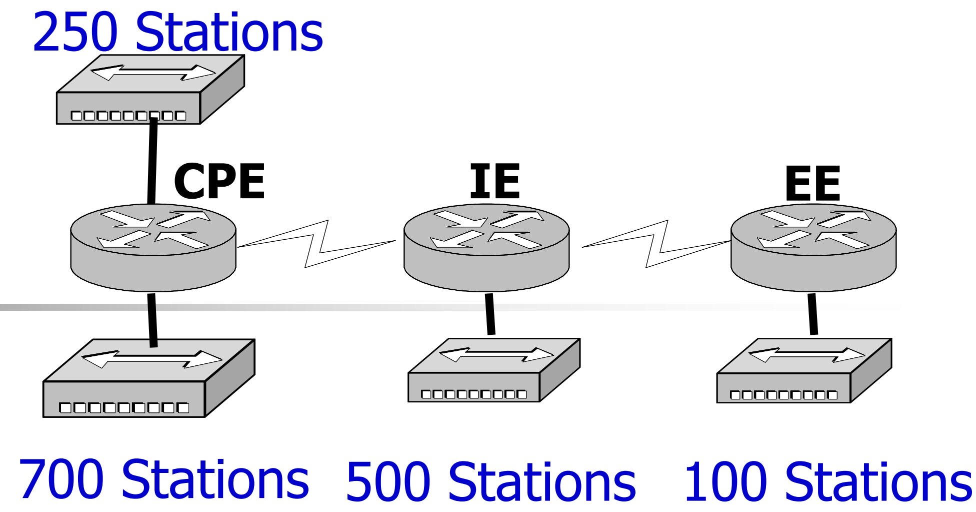
Example II

165.23. 1101 0000 . 0000 0000

165.23.208.0/20



Solution



- 165.23.208.0/20
  - **165.23.208.0/22** 1022 Hosts
  - 165.23.212.0/22
  - 165.23.216.0/22
  - 165.23.220.0/22

The largest subnet needs **700** hosts
➔10 bits for host (1024 hosts)

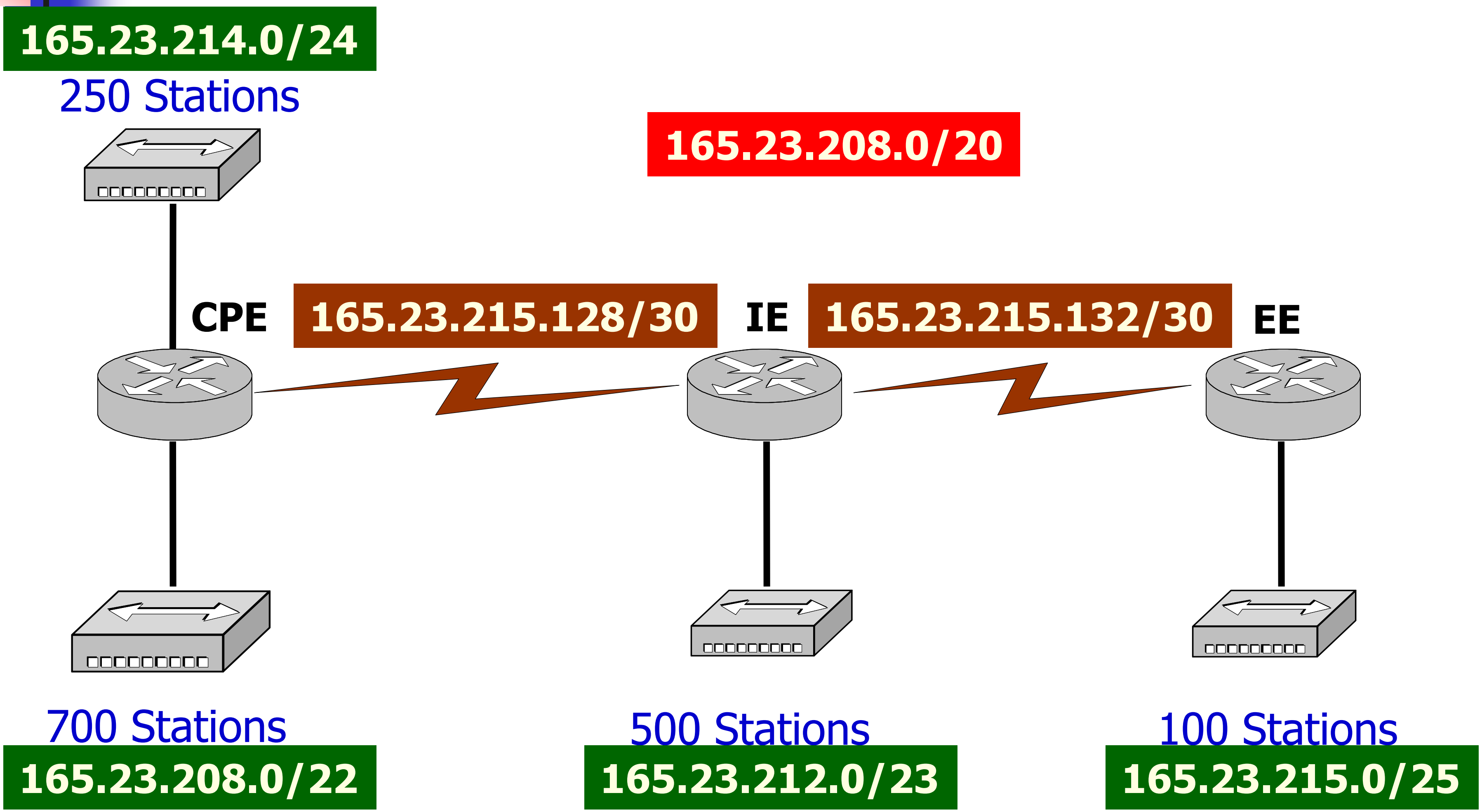
- 165.23.212.0/22
  - **165.23.212.0/23** 510 Hosts
  - 165.23.214.0/23

- 165.23.214.0/23
  - **165.23.214.0/24** 254 Hosts
  - 165.23.215.0/24

- 165.23.215.0/24
  - **165.23.215.0/25** 126 Hosts
  - 165.23.215.128/25

- 165.23.215.128/25 2 Hosts
  - **165.23.215.128/30**
  - **165.23.215.132/30**
  - 165.23.215.136/30
  - …

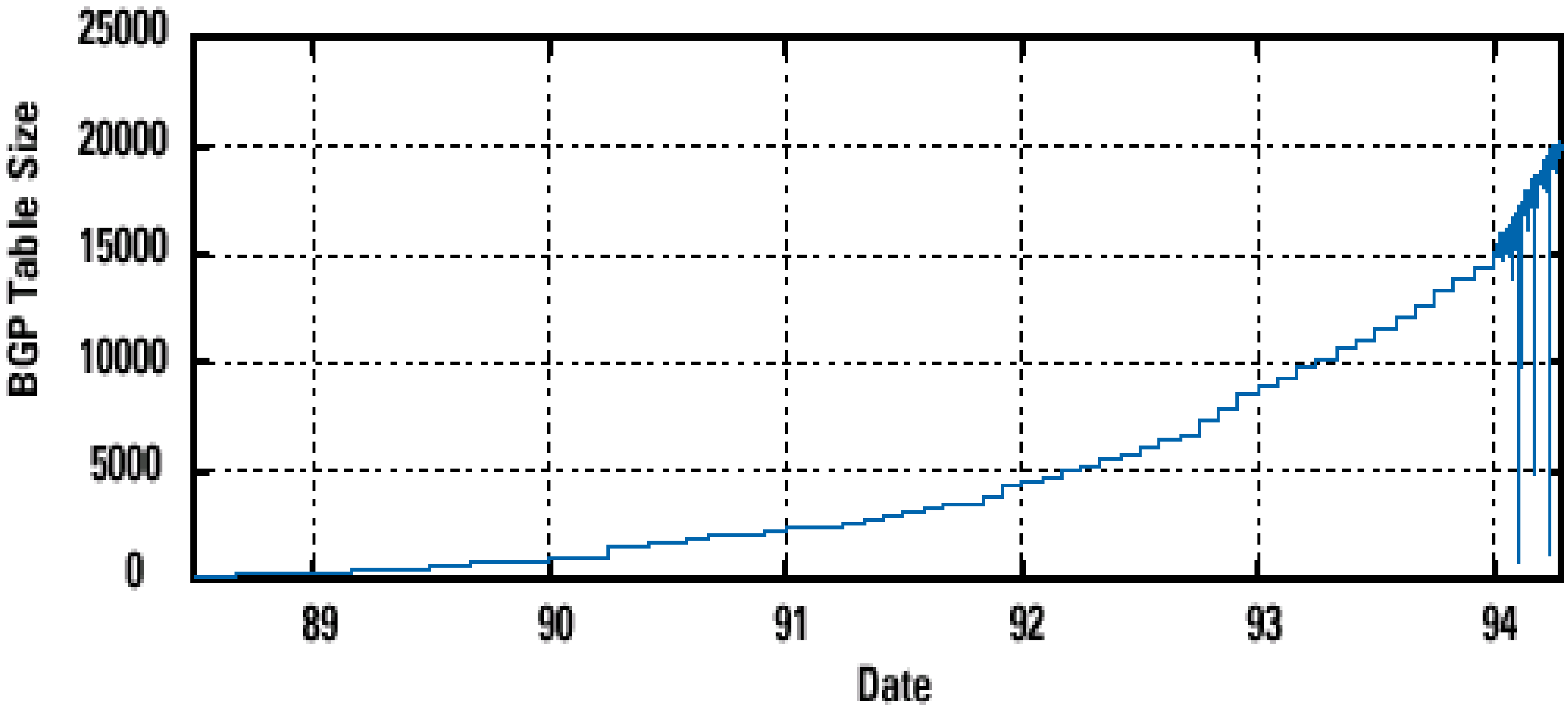
Final Solution



Notes for CIDR

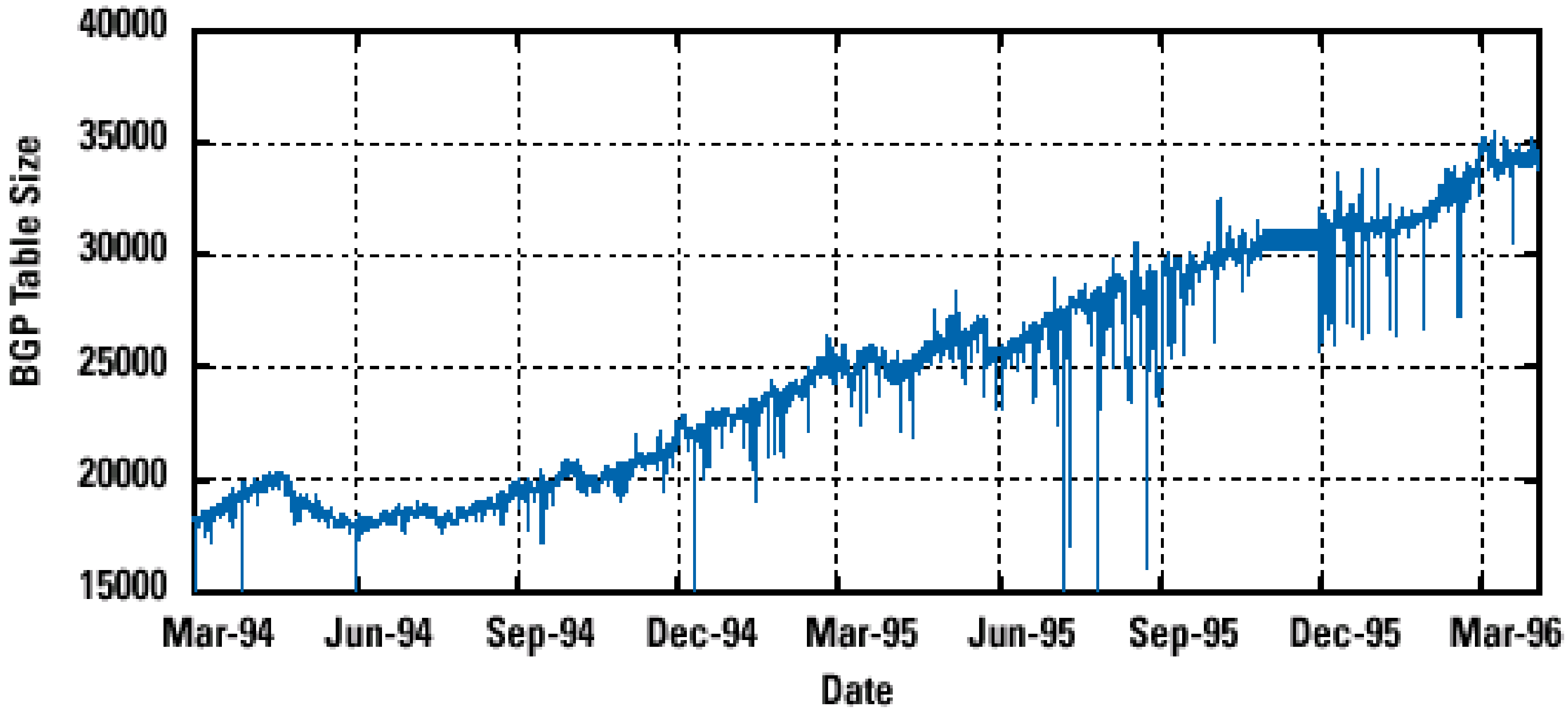
- CIDR was actually intended as a quick fix
  - Solve addressing crisis until IPv6 was deployed
- Unfortunately, CIDR has been widely adopted
  - IPv6 deployment has proven to be very, very slow
- CIDR is currently deployed
  - However, IPv6 is not compatible with IPv4
  - Generates a big migration problem

Growth in Routing Table Size



Pre-CIDR (1988-1994): Steep Growth Rate

Growth in Routing Table Size



CIDR Deployment (1994-1996): Much Flatter

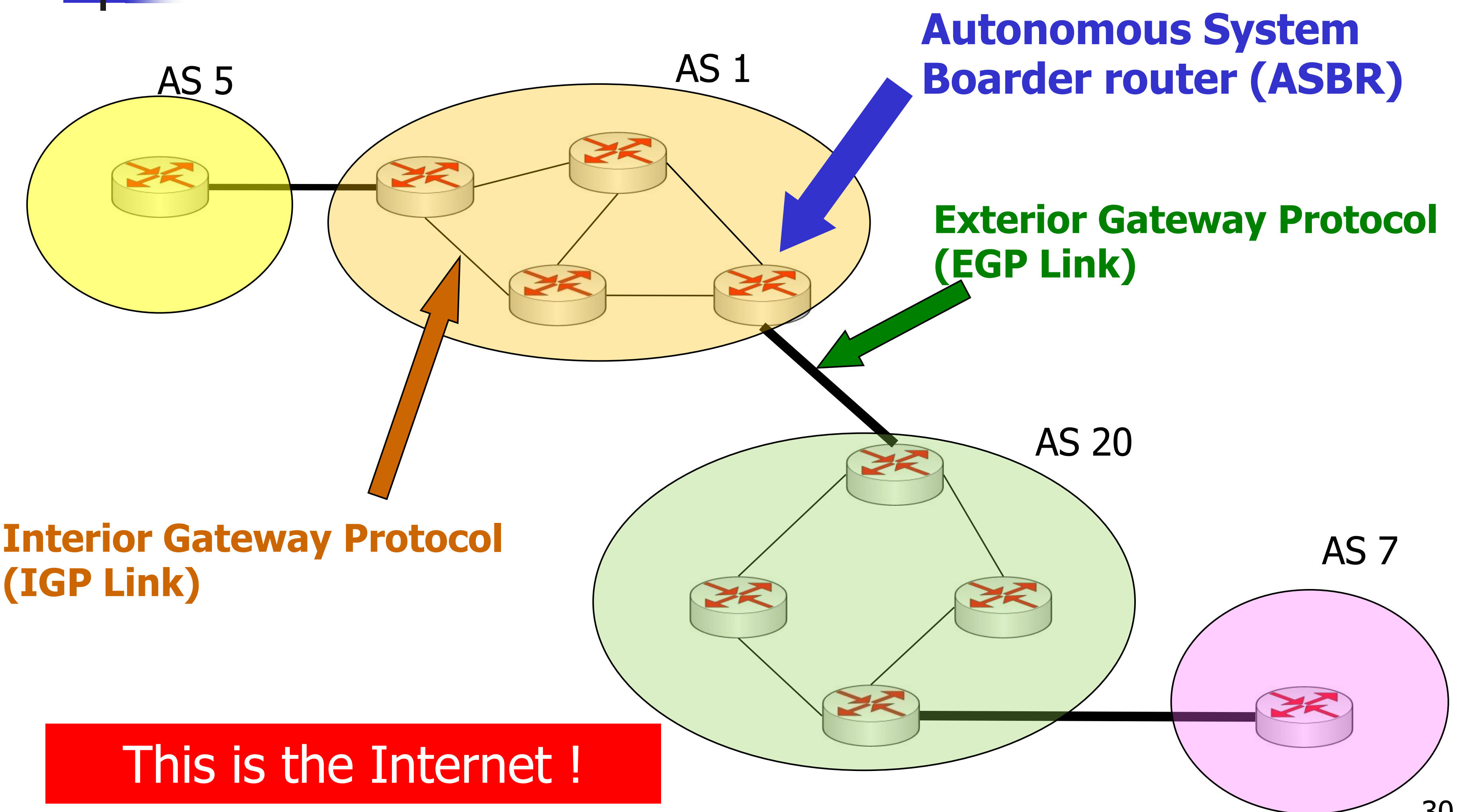
Autonomous System (AS)

- A single network domain
- Grouping of computers/routers
- Operate in isolation from other groups
- A single network administrative entity

Autonomous System (AS)

- Need protocols for distribute routing information in the AS
  - Interior Gateway Protocols (IGPs)
  - Intradomain routing algorithms
- Between AS
  - Need interdomain routing algorithms
  - Exterior Gateway Protocols (EGPs)
  - More complex task

Autonomous System (AS)



This is the Internet !

Types of AS

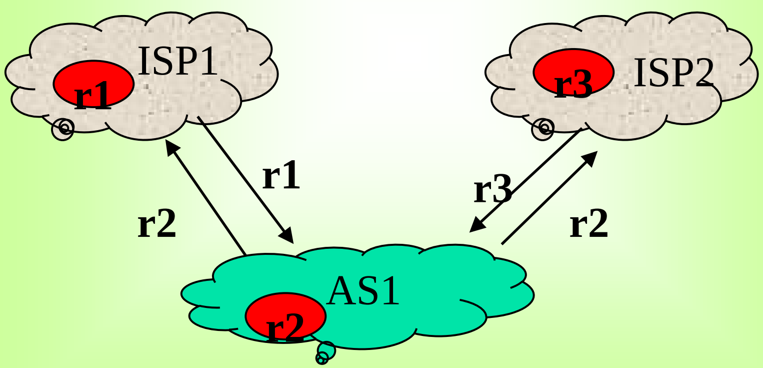
- **Stub AS**
  - Only has a single connection to one other AS
  - only carries *local traffic*
- **Multihomed AS**
  - Connect to more than one other AS
  - But will not carry *transit traffic*
- **Transit AS**
  - Connect to more than one other AS
  - Can carry both *local* and *transit* traffic

Transit vs. Nontransit AS

Transit traffic = traffic whose source and destination are outside the AS

Nontransit AS: does not carry transit traffic

- Advertise own routes only
- Do not propagate routes learned from other AS's



Transit AS: does carry transit traffic

- Advertises its own routes PLUS routes learned from other AS's