



# CIDR – VLISM – AS

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# Outline

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



# IP Addresses Revisited

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- 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



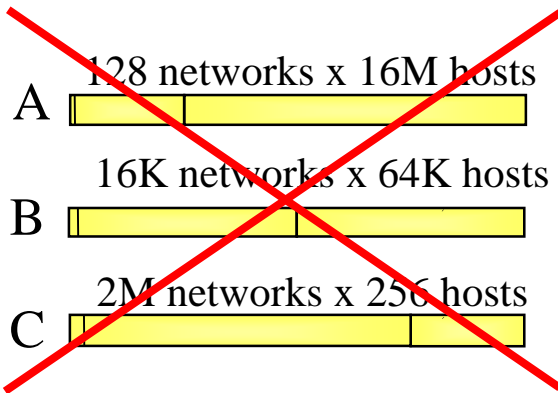
# Classless InterDomain Routing (CIDR)

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- 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

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<i>/n</i>	<i>Mask</i>	<i>/n</i>	<i>Mask</i>	<i>/n</i>	<i>Mask</i>	<i>/n</i>	<i>Mask</i>
/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

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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

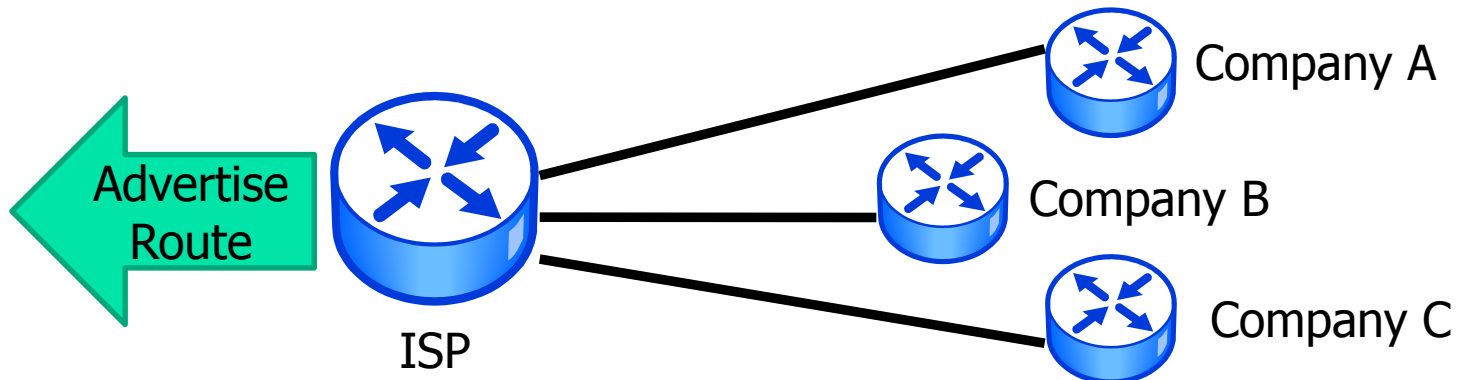
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- Enable network number to be any length (No Class)
- Collapse multiple addresses assigned to a single AS to one address
- All routers must understand CIDR addressing
  - Need both Address and Mask (prefix and suffix)
  - Slash notation (123.10.16.0 /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

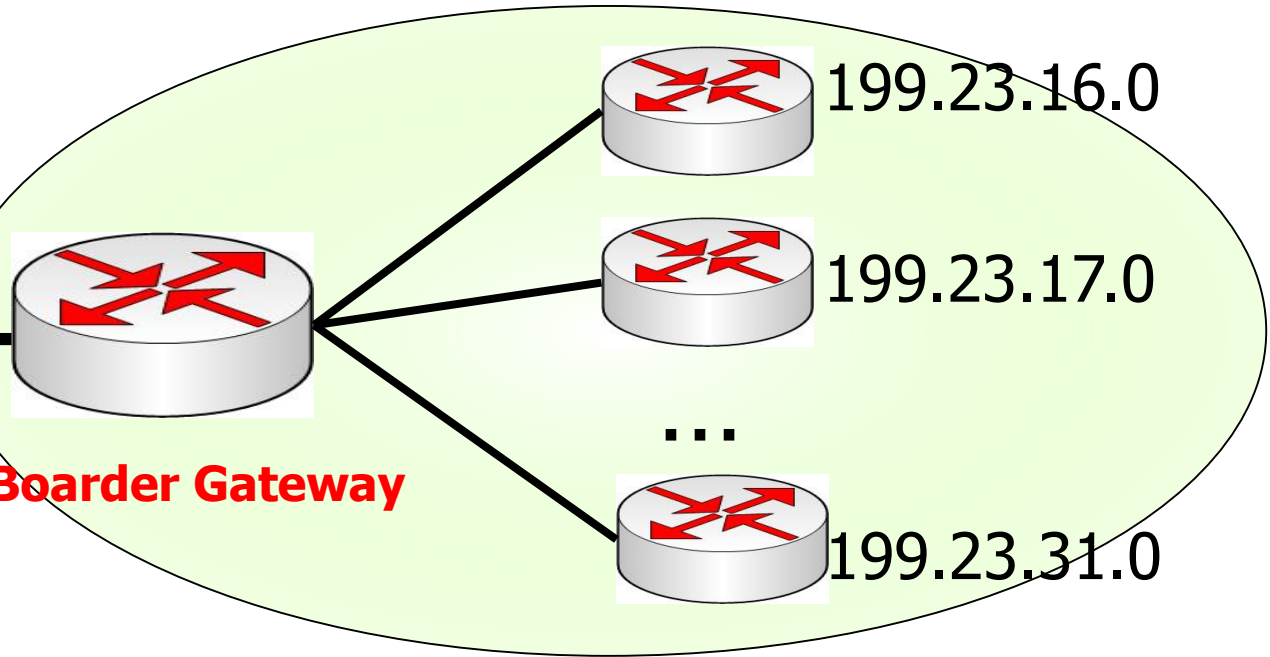
...

199.23.31.0

## With CIDR

199.23.16.0/20

**Border Gateway**



# Aggregation

- Some pairs of consecutive prefixes
- Example: routes within the same AS:  
AS has 2 address blocks:

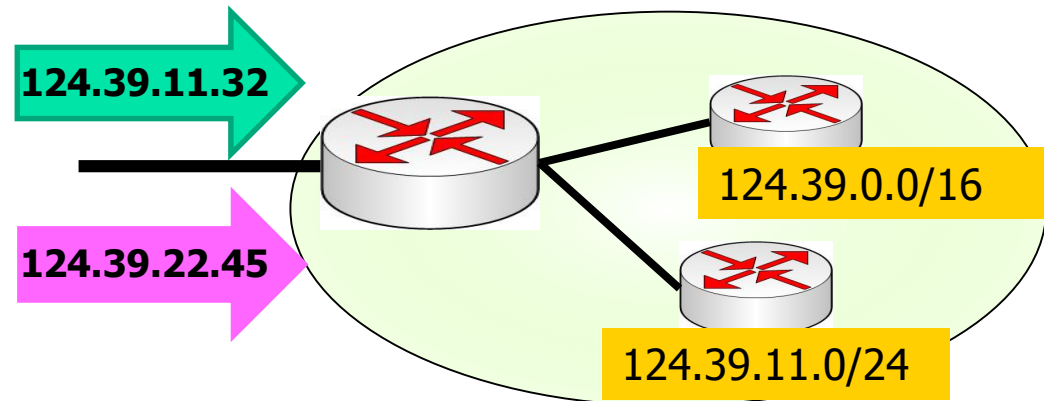
1.2.2.0/24 = 0000001.00000010.**00000010**.00000000/24  
1.2.3.0/24 = 0000001.00000010.**00000011**.00000000/24

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

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- 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

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# VLSM

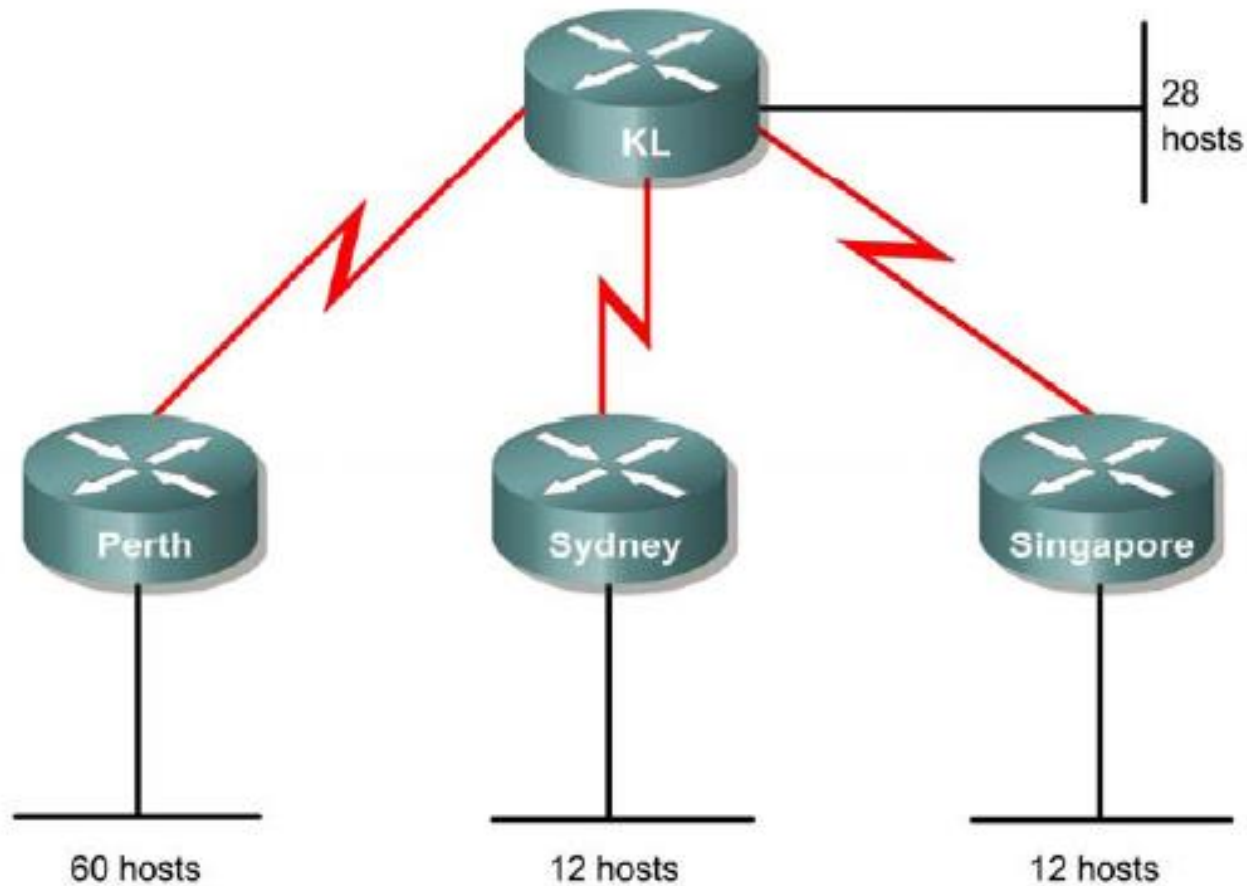
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- Variable-length subnet mask
- Classful allows only one subnet in a network
  - > one subnet in an autonomous system
- Maximizing the use of address (Subnet Zero)
- “Subnetting a Subnet”
- Routing Protocol that supports VLSM
  - OSPF, Integrated IS-IS,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

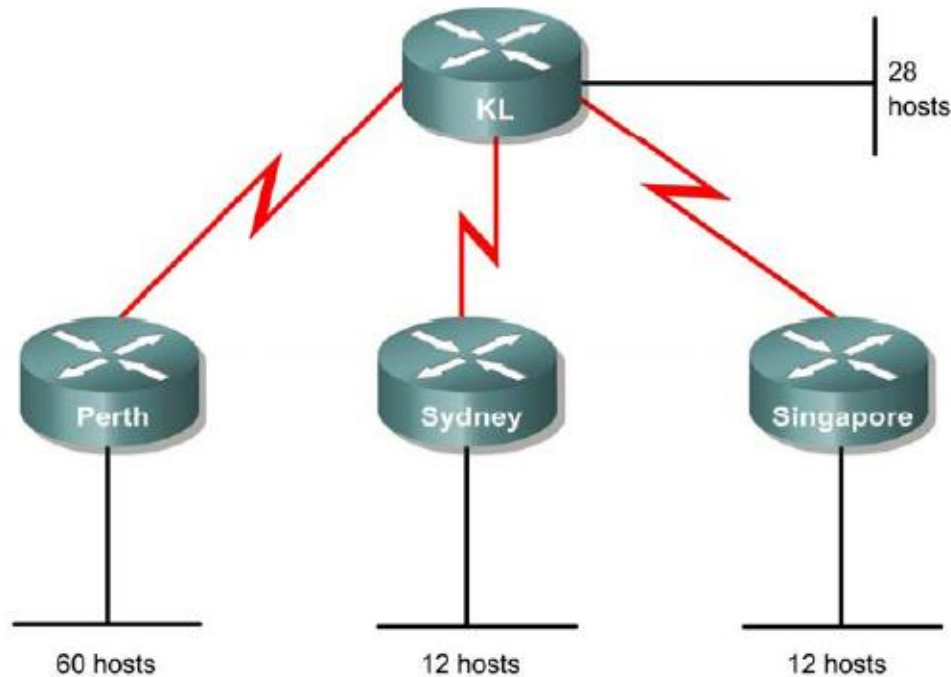


# Subnet with VLSM

192.168.10.0/24



# Regular Subnet



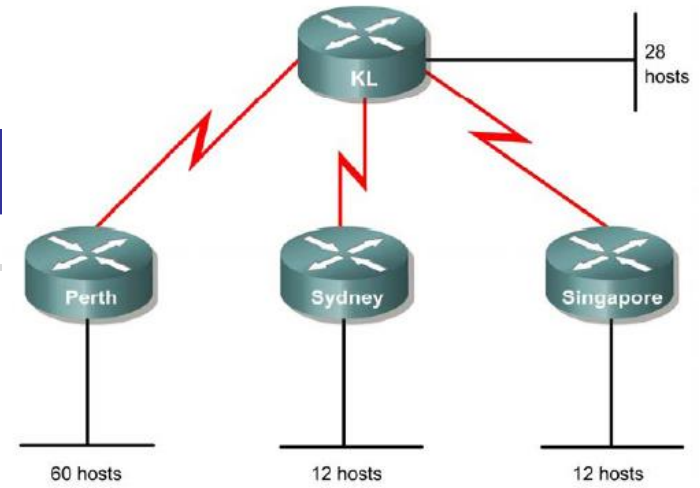
**192.168.10.0/24**

**7** subnets; The largest subnet needs **60+1** 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

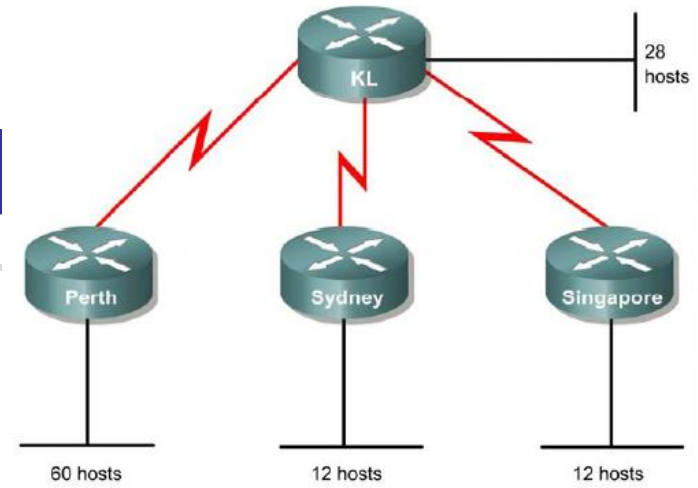
192.168.10.64/26

- 192.168.10.64/27

← KL

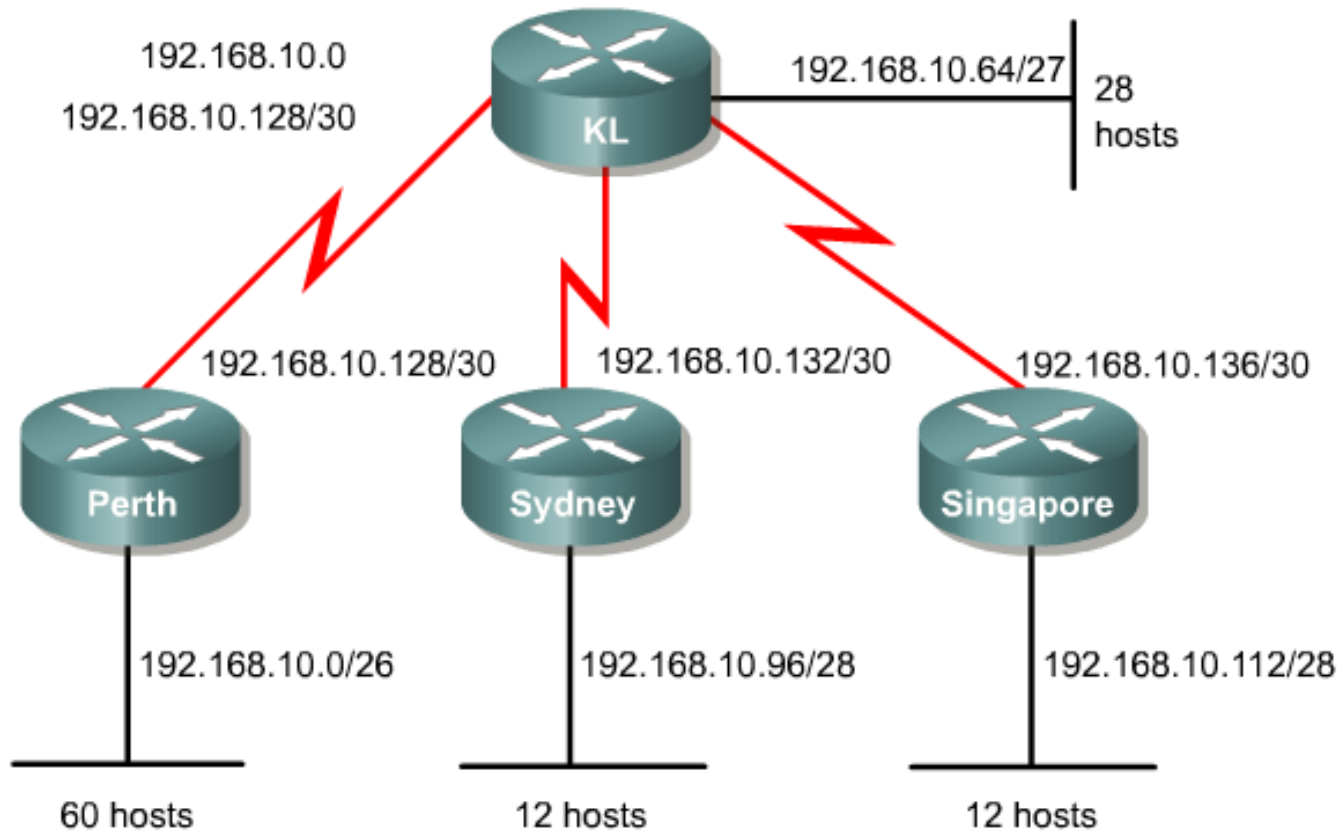
- 192.168.10.96/27

# Subnet with VLSM

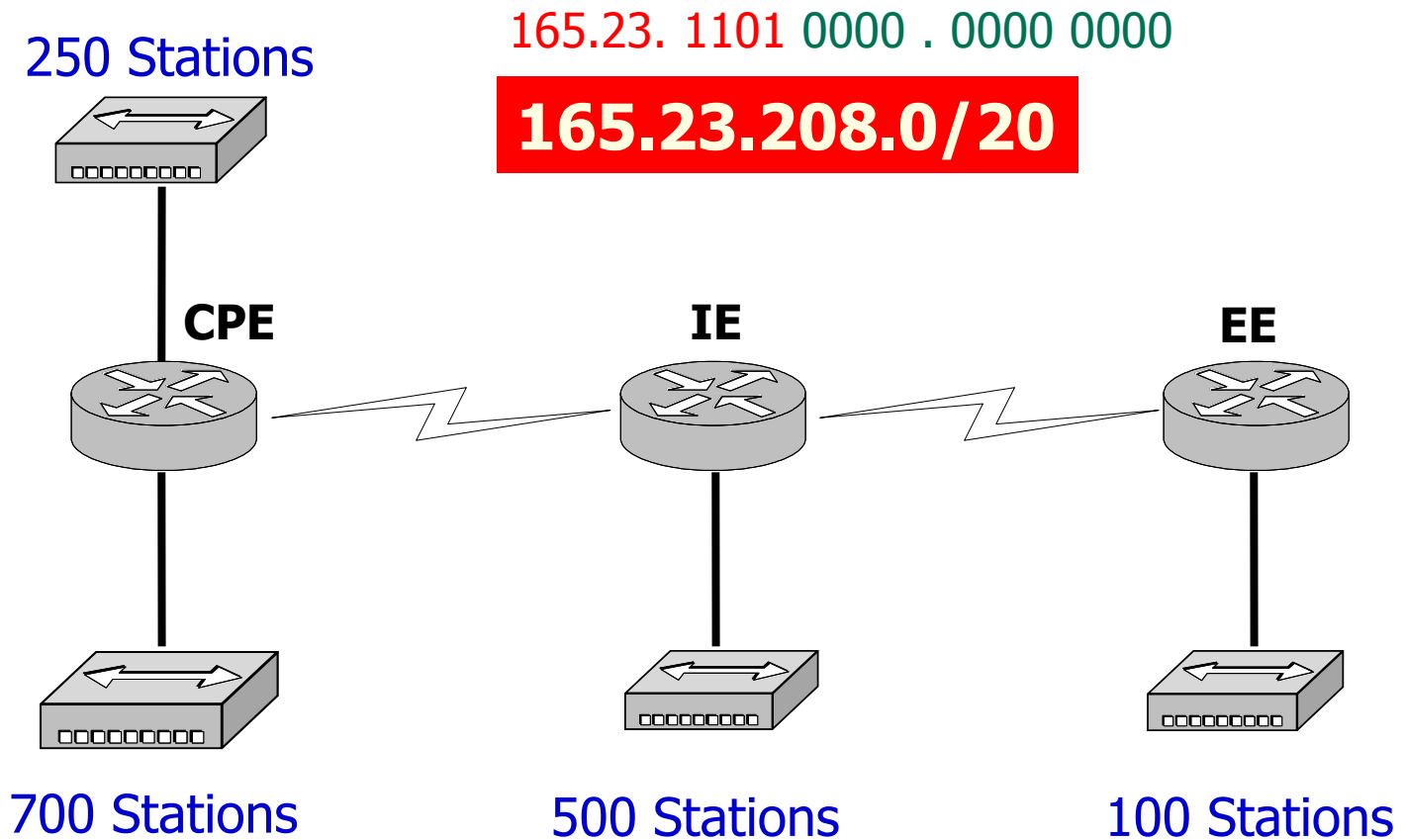


- 192.168.10.96/27
  - 192.168.10.96/28 ← Sydney
  - 192.168.10.112/28 ← Singapore
  
- 192.168.10.128/26
  - 192.168.10.128/30 ← Perth – KL
  - 192.168.10.132/30 ← Sydney – KL
  - 192.168.10.136/30 ← Singapore – KL
  - 192.168.10.140/30
  - ...

# Final: Subnet with VLSM

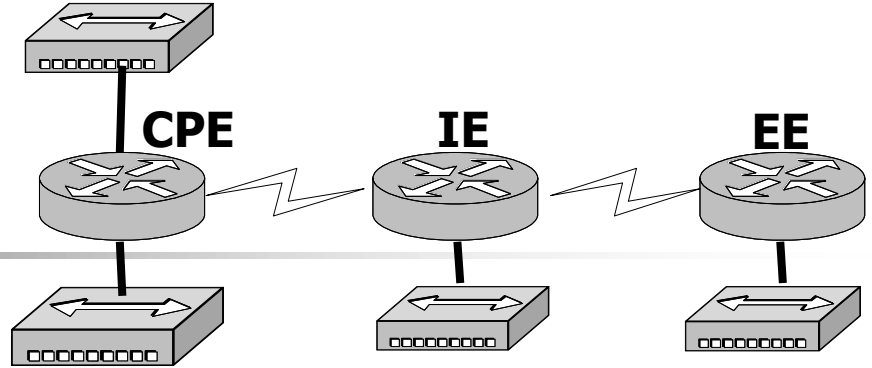


# Example II



# Solution

250 Stations



700 Stations

500 Stations

100 Stations

•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

•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**

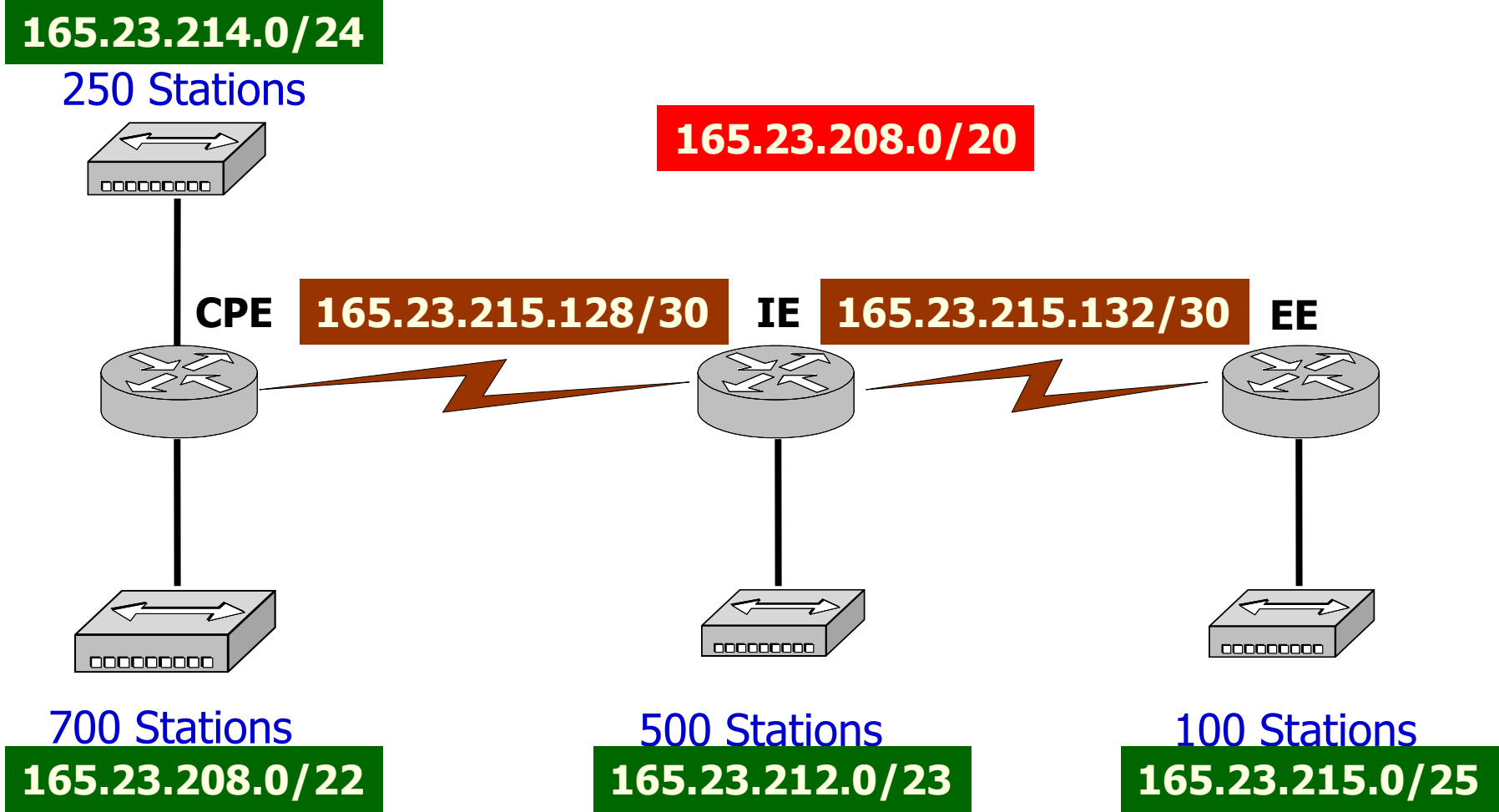
•**165.23.215.132/30**

•165.23.215.136/30

•...

The largest subnet needs **701** hosts  
→ **10** bits for host (1024 hosts)

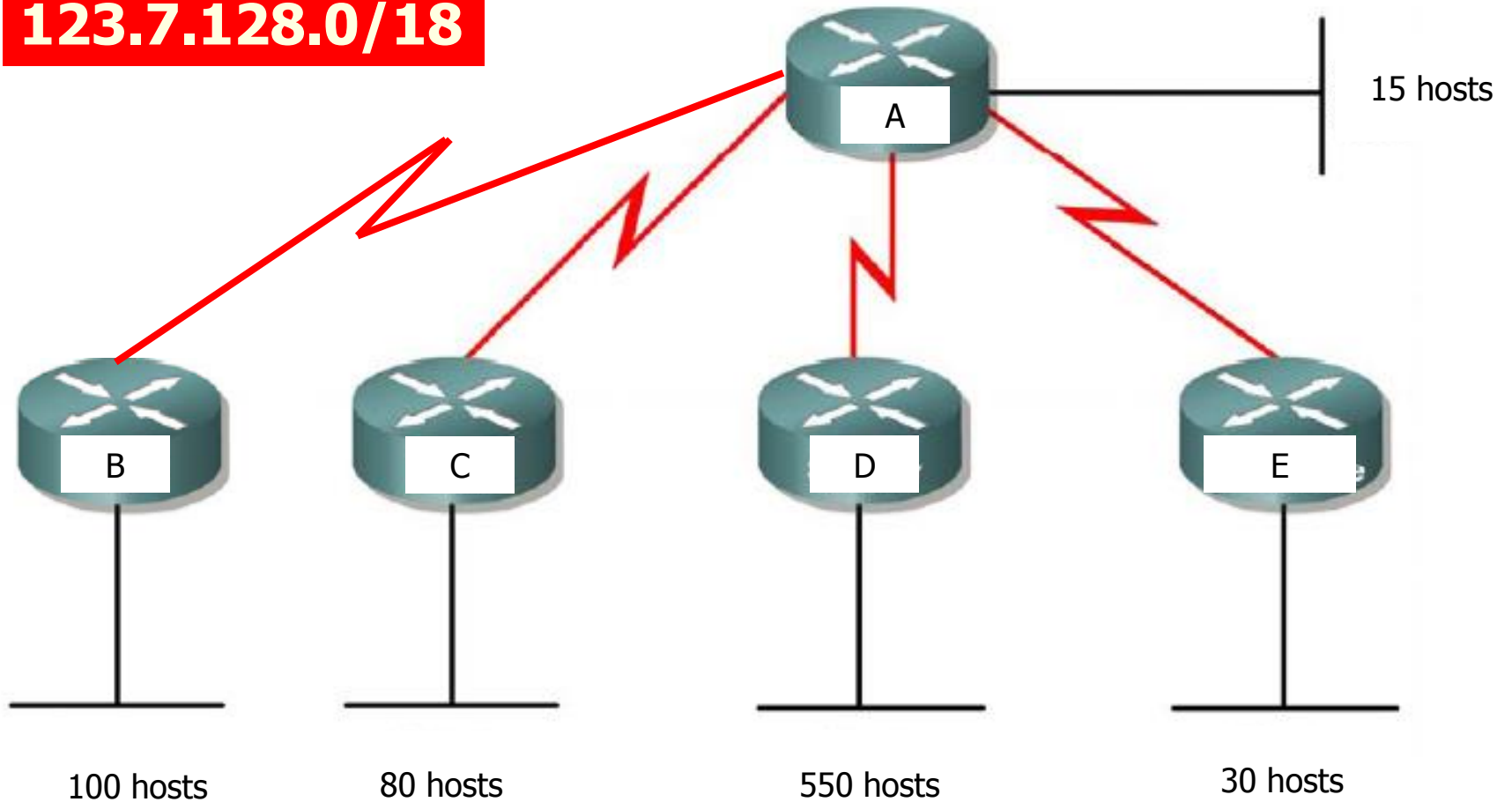
# Final Solution





# Quiz

**123.7.128.0/18**



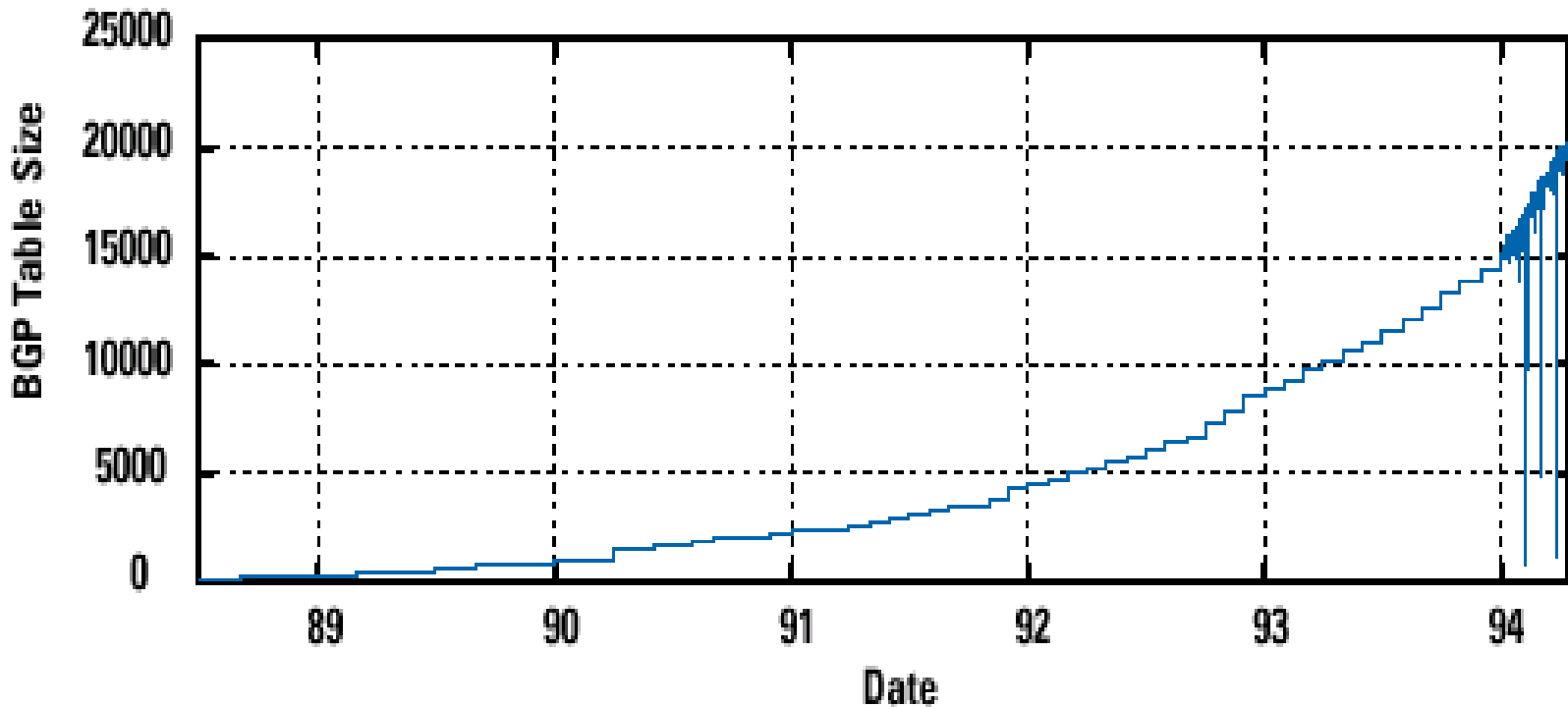


# Notes for CIDR

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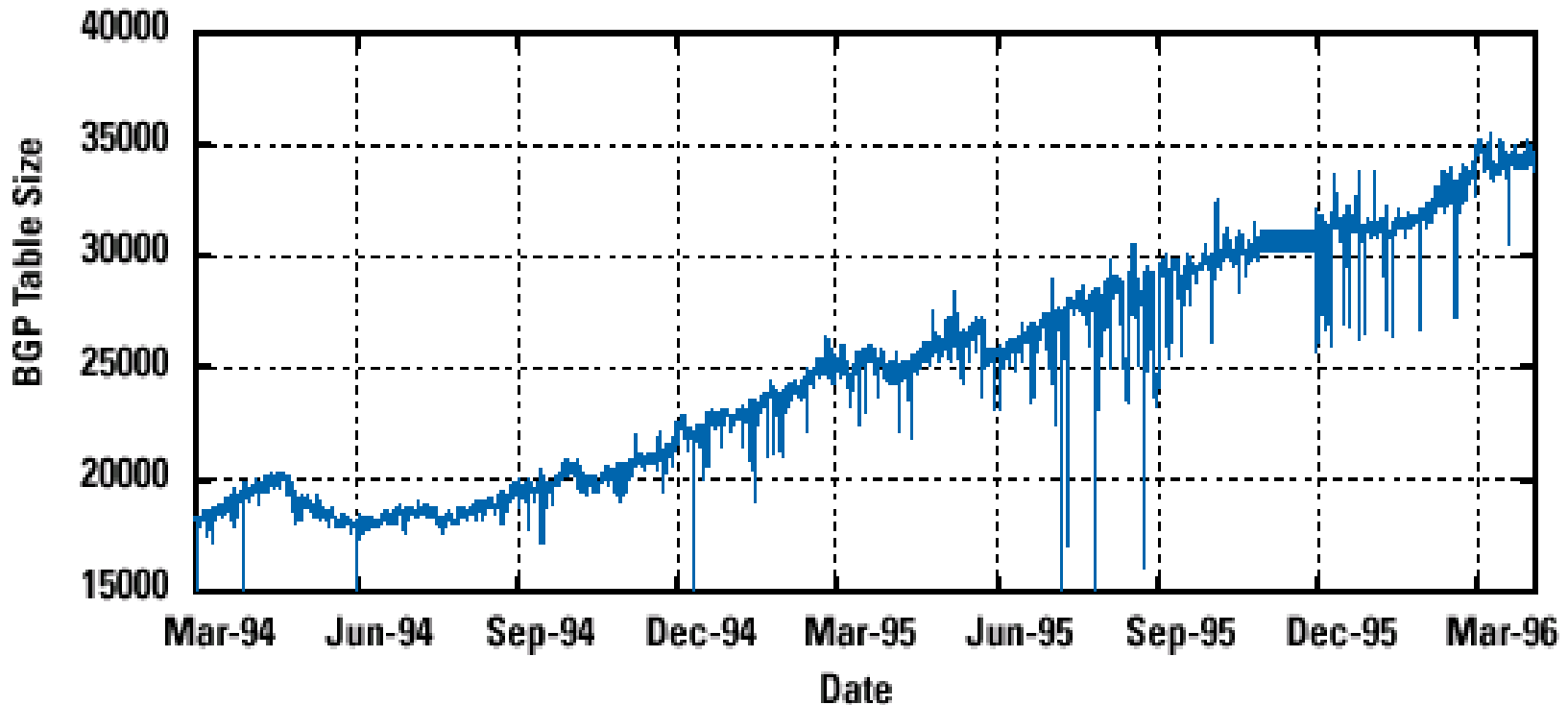
- CIDR was actually intended as a **quick fix**
  - Solve addressing crisis until IPv6 was deployed
- Unfortunately, CIDR has been **widely adopted**
  - IPv6 deployment has proven to be very, very slow
- CIDR is **currently** deployed
  - However, IPv6 is not compatible with IPv4
  - Generates a big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

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

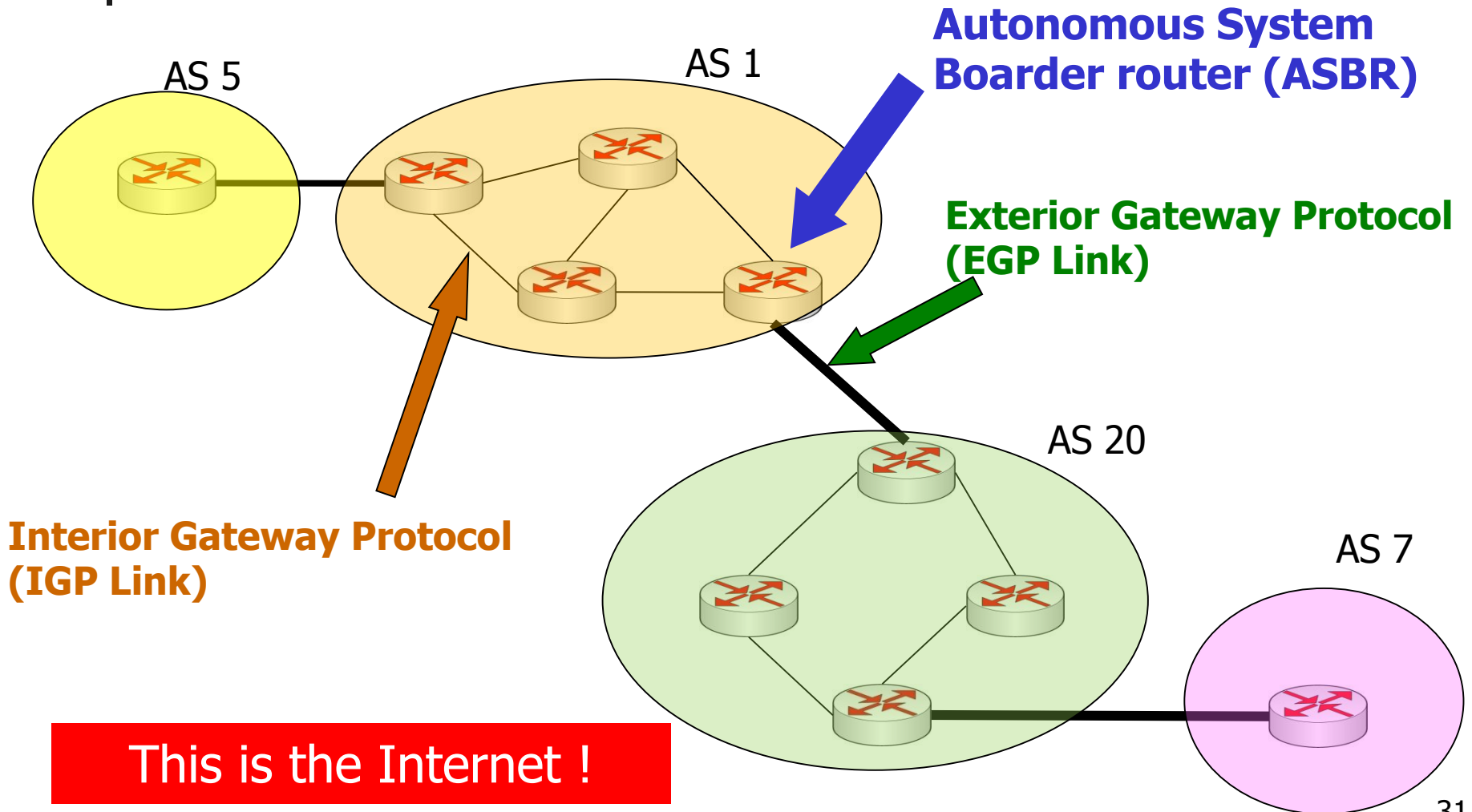


# Autonomous System (AS)

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- 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)





# Types of AS

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- **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*

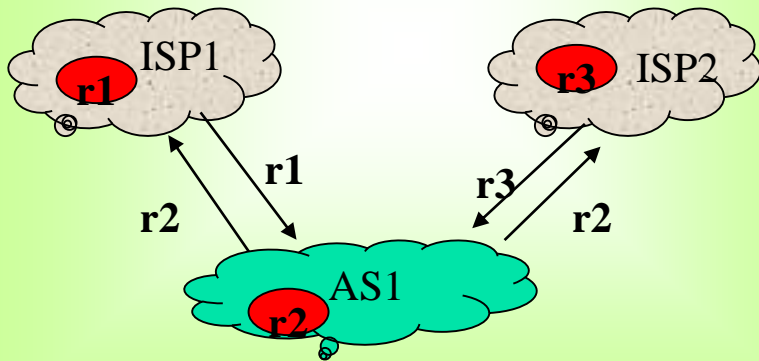


# Transit vs. Nontransit AS

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

