VLSM and Supernetting

Internetworking

Lecture 4

IP Addresses & Subnets

- Overview from last week
  - Subnetting
- Variable Length Subnet Mask – VLSM
- Supernetting

Classful Subnetting

- IPv4 provides 2^32 IP addresses
  - 4.294.967.296 (theoretical) maximum

- A class C network provides 2^8 (256) addresses – only 254 are usable

- A class B network provides 2^{16} (65536) addresses – only 65534 are usable

- A class A network provides 2^{24} (16.777.216) addresses – only 16.777.214 are usable

- As a result, Class B addresses were mostly preferred! Even Class B networks could prove too big!

Subnetting – Example

- Class B without subnetting

1	0	NET ID (14bit)	HOST ID (16 bit)

- Class B with subnetting

1	0	NET ID (14bit)	SUBNET ID (n bit)	HOST ID (16-n bit)

- You reserve host ID bits for subnet ID!

Subnet Address and Mask

- Host IP address
  - 148.197.9.18 -> 10010100.11000101.00001001.00010010
- Class B network with network mask:
  - 255.255.0.0 -> 11111111.11111111.00000000.00000000
- Subnet mask (when subnetting)
  - Longer than default class mask. Set by admin.
  - Tells where the boundary network-host really is
- Example: class B address with a 5 bit subnet ID
  - Subnet mask = /21 ->
  - 255.255.248.0 -> 11111111.11111111.11111000.00000000
  - Network ID = 148.197.0.0 (B class)
  - New (sub)network ID = 10010100.11000101.00001000.00000000 -> 148.197.8.0/21

Class C subnetting – example

- You have been assigned a Class C network.
  - 193.1.1.0/24
    - Network ID = 24 bits & Host ID = 8 bits
- You need 8 subnets for your organisation
  - 8 subnets means you need 3 bits for subnet ID -> 2^3
  - You reserve 3 bits from the Host ID -> Host ID = 5 bits
  - **All subnets have an equal number of addresses**

Subnet # 0	11000001.00000001.00000001.**000**00000	**193.1.1.0/27**
Subnet # 1	11000001.00000001.00000001.**001**00000	**193.1.1.32/27**
Subnet # 2	11000001.00000001.00000001.**010**00000	**193.1.1.64/27**
Subnet # 3	11000001.00000001.00000001.**011**00000	**193.1.1.96/27**
Subnet # 4	11000001.00000001.00000001.**100**00000	**193.1.1.128/27**
Subnet # 5	11000001.00000001.00000001.**101**00000	**193.1.1.160/27**
Subnet # 6	11000001.00000001.00000001.**110**00000	**193.1.1.192/27**
Subnet # 7	11000001.00000001.00000001.**111**00000	**193.1.1.224/27**

Custom Subnet mask values

128	64	32	16	8	4	2	1	
1	0	0	0	0	0	0	0	= 128
1	1	0	0	0	0	0	0	= 192
1	1	1	0	0	0	0	0	= 224
1	1	1	1	0	0	0	0	= 240
1	1	1	1	1	0	0	0	= 248
1	1	1	1	1	1	0	0	= 252
1	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*= 254*
1	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*= 255*

Variable Length Subnet Mask

- Allows more than one subnet mask in the same network
  - Efficient use of an organisation's IP address space
    - Create subnets significantly different in size
    - Consider a 4 host network with mask 255.255.255.0 → it wastes 250 IP addresses
  - Allows route aggregation → less routing information

Benefits of VLSM

- Allows efficient use of available address space.

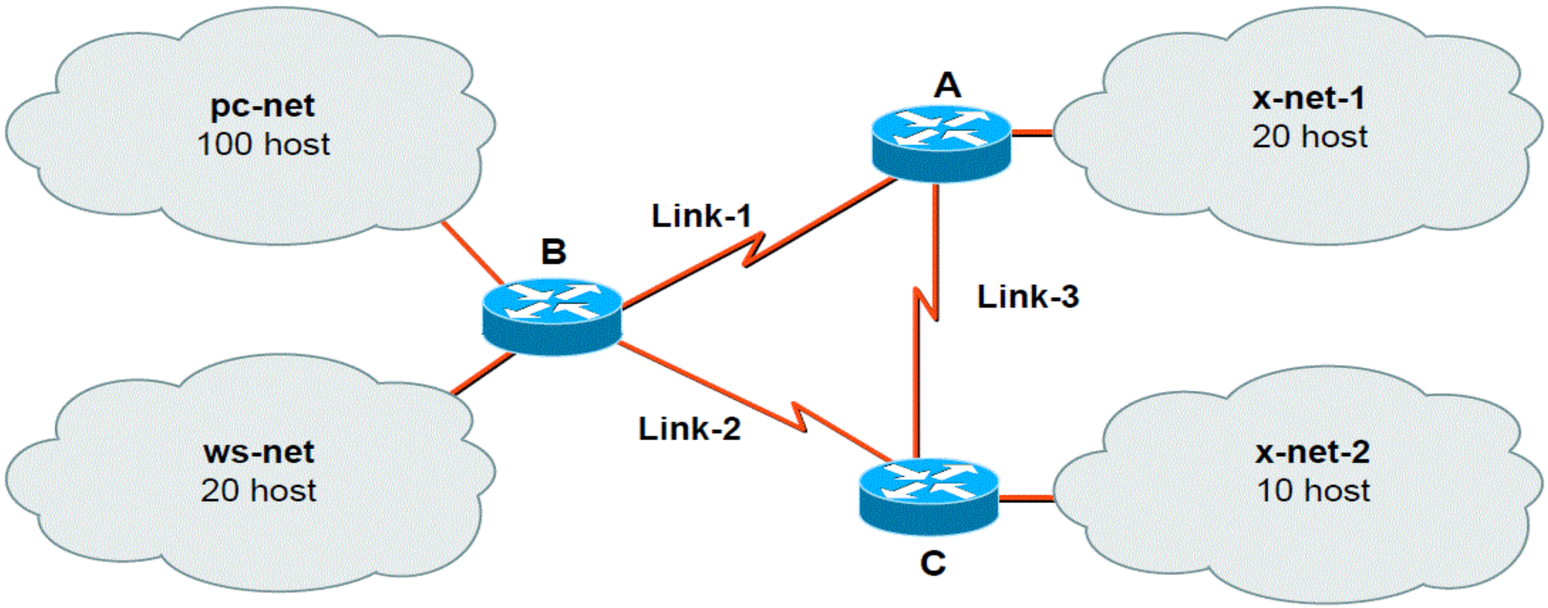
- Allows the use of variable subnet mask lengths

- Breaks up the address space into blocks of variable size
  - Provides more flexibility in network design

- Allows for route summarisation ->
  - CIDR, next week

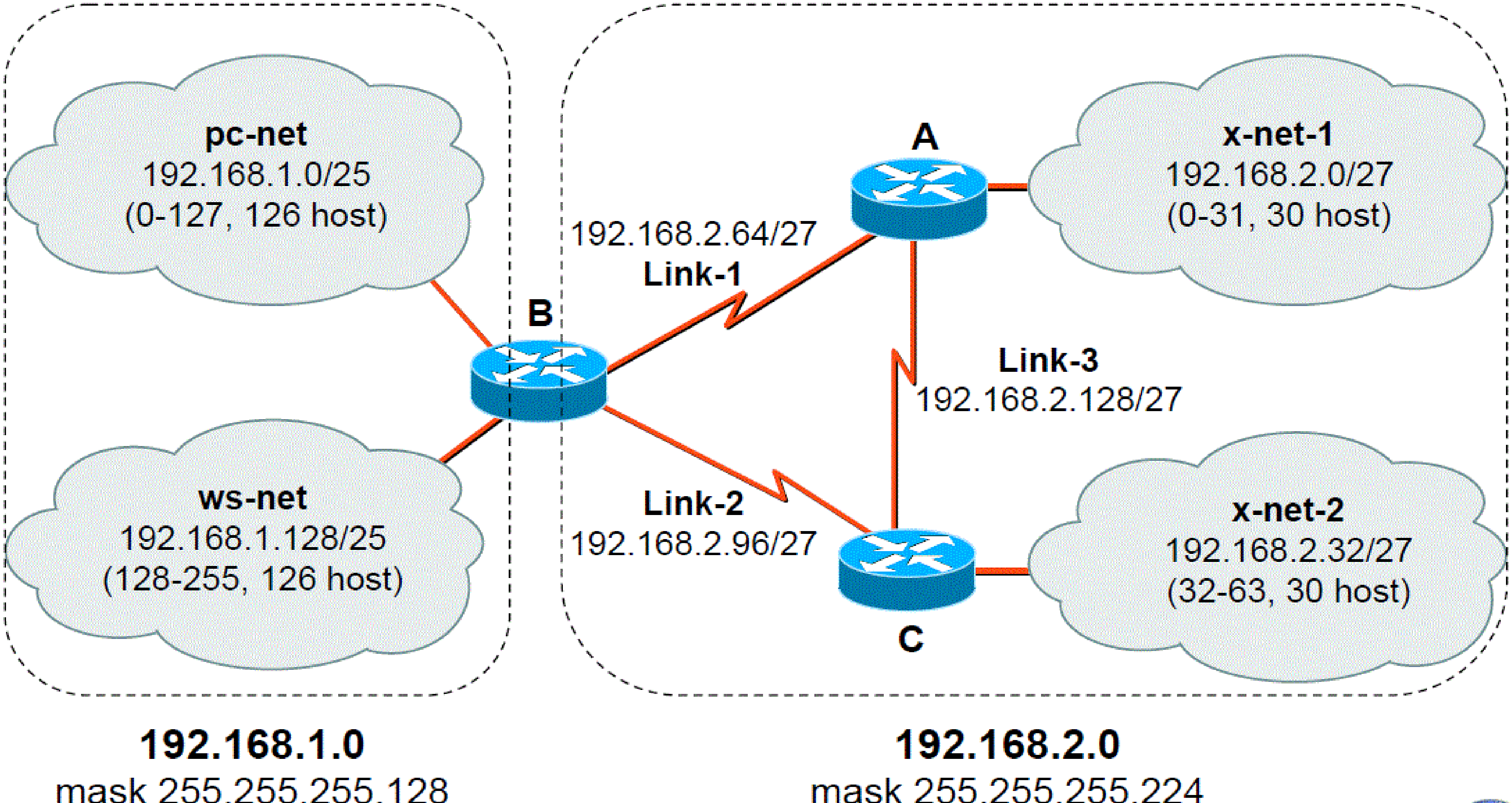
- Supports hierarchical enterprise networks

A typical problem



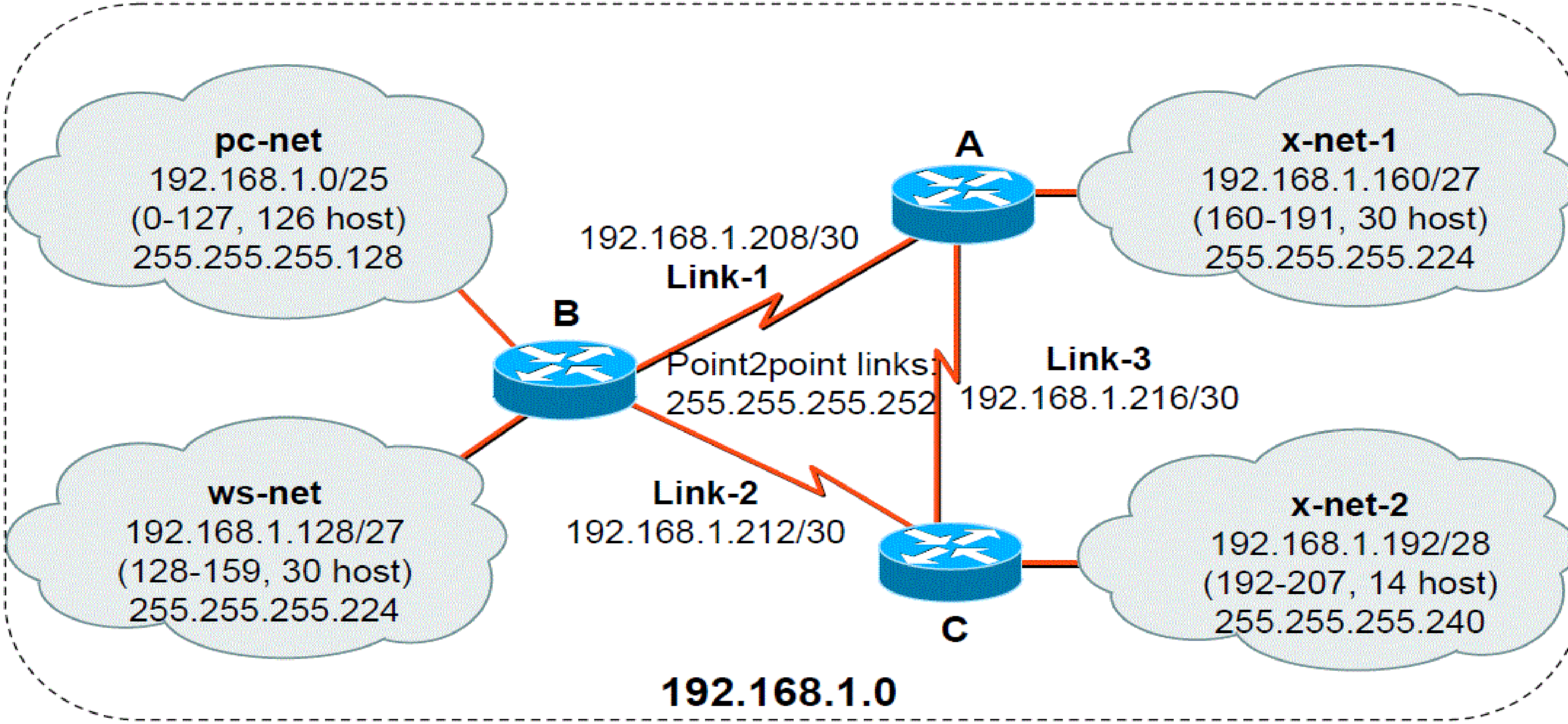
- You own <u>one Class C</u> address
- How many subnets are needed?
- Want to accommodate 150 hosts within 7 subnets (4 LANs + 3 links) →3 bit subnet ID (8 subnets) and 30 hosts per subnet
- What is the problem?
  - Subnets are not big enough to meet the requirements! – Exercise 1d anyone?

Solution #1 – no VLSM



You need two Class C Addresses!

Solution #2 – using VLSM



What is the network prefix used for the smaller subnets?

The 3 subnets for the router links have /30

Why not use /31 ?

Requirements for VLSM

- Routing table → need to specify the extended network prefix information (subnet mask) for every entry.

- Routing protocol → must carry extended network prefix information with each route advertisement
  - 131.175.192.0 = 10000011.10101111.11000000.00000000
  - Prefix /27 →
  - 255.255.250.224 = 11111111.11111111.11111111.11100000

- VLSM needs to be supported by the routing protocol (RIPv2, OSPF, EIGRP, BGP)

Classless addresses (CIDR)

- 10.23.64.0/25 = <u>00001010.00010111.01000000.0</u>0000000
- 130.5.10.0/25 = <u>10000010.00000101.00000110.0</u>0000000
- 200.7.128.0/25 = <u>11001000.00000111.10000000.0</u>0000000
- What is the difference between these <u>network addresses</u>?
  - None! They are similar as they all have 126 <u>usable</u> hosts available.

VLSM subnetting – example

- You are designing a new network with network address 192.168.13.0/24 and the following requirements:
  - First subnet with 100 computers (usable addresses)
  - Second subnet with 30 computers (usable addresses)
  - Third subnet with 5 computers (usable addresses)
  - Fourth subnet with 3 computers (usable addresses)
- Classful approach:
  - /24 means → 24 NetID bits & 8 HostID bits
  - /24 means → default mask is 255.255.255.0
  - We need **4 subnets**, so we reserve 2 bits from the Host ID.
    - We are left with 6 bits for (new) HostID

VLSM subnetting – example

- After performing the subnetting using the classful approach we end up with:
  - 4 subnets of equal size: 2^6 = 64 total addresses
  - Out of which, only 62 are usable per subnet
- What is the problem?
- We can only reduce the number of subnets or reduce number of hosts per subnet or request a Class B network address! ☒

VLSM subnetting – example

- Classless approach – VLSM
- Network address: 192.168.13.0/24

- **Always start subnetting with the largest subnet in mind first**:
  - It needs 100 usable host addresses (102 total)
  - If we reserve 1 bit and create two subnets
    - Subnet A: 192.168.13.0 – 192.168.13.127 mask /25
    - Subnet B: 192.168.13.128 – 192.168.13.255 mask /25
  - Subnet A satisfies the first requirement > 100 addresses ✓

VLSM subnetting – example

- Subnet B can used to accommodate the remaining <u>required</u> subnets.
  - Subnet B: 192.168.13.128 /25
  - Create smaller subnets within Subnet B
  - Sub-subnet should hold 30 usable host addresses
  - We reserve 2 HostID bits to create 2^2 (4) subnets.
  - The new subnet mask will be 25bits + 2bits = /27
    - SubnetB1: **192.168.13.128 – 192.168.13.159 mask /27**
    - SubnetB2: 192.168.13.160 – 192.168.13.191 mask /27
    - SubnetB3: 192.168.13.192 – 192.168.13.223 mask /27
    - SubnetB4: 192.168.13.224 – 192.168.13.255 mask /27
  - SubnetB1 can accommodate the 30 computers ✓

VLSM subnetting – example

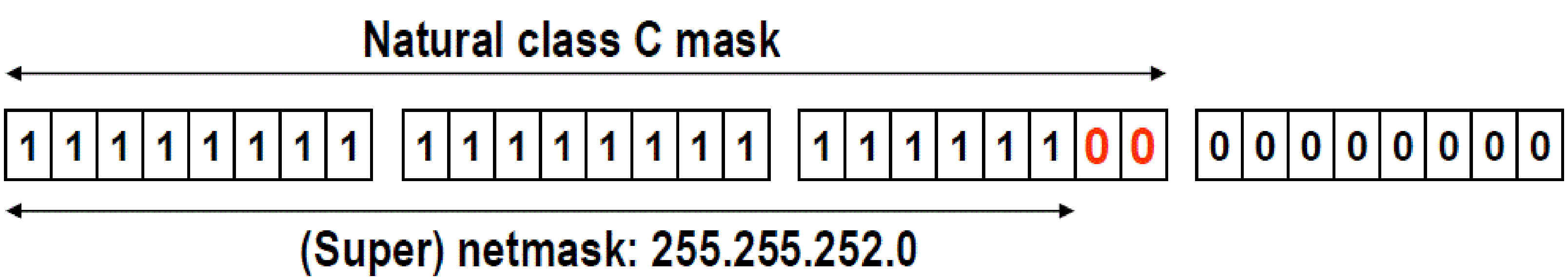
- SubnetB2 can be used to accommodate the remaining two required subnets
  - Third subnet needs 5 usable addresses → total 7
  - Fourth subnet needs 3 usable addresses → total 5
  - The newly created subnets need 8 total addresses each
  - 2^x >= 8 hosts → x = 3 HostID bits needed
  - (new)HostID should be 3 bits long. (currently is 5 bits)
    - The remaining 2 bits become part of NetID
    - Mask: 27bits + 2bits = 29 bits → new mask is /29
  - SubnetB2: **192.168.13.160 – 192.168.13.191 /27**
    - **SubnetB2a: 192.168.13.160 – 192.168.13.167 mask /29 ✓**
    - **SubnetB2b: 192.168.13.168 – 192.168.13.175 mask /29 ✓**
    - SubnetB2c: 192.168.13.176 – 192.168.13.183 mask /29
    - SubnetB2d: 192.168.13.184 – 192.168.13.191 mask /29

VLSM subnetting – example

- To sum it up….
- The addressing scheme will be:
  - 1st subnet: 192.168.13.0 – 192.168.13.127 mask /25
  - 2nd subnet: 192.168.13.128 – 192.168.13.159 mask /27
  - 3rd subnet: 192.168.13.160 – 192.168.13.167 mask /29
  - 4th subnet: 192.168.13.168 – 192.168.13.175 mask /29
- What did we achieve?
  - We met all requirements without any restrictions!
  - We have another 80 addresses to spare for future expansion
    - 192.168.13.176 – 192.168.13.255

CIDR – Supernetting

- Supernetting is combining several small (class C) networks into a big one to create a large range of addresses.
- Example: An organisation is assigned a range of 2^n class C addresses
  - The ranges MUST BE contiguous (in sequence)
  - Addressing: Reserve network bits for use by host_id
    - The opposite of subnetting!



Supernetting – Common bits approach

- You have been assigned 4 contiguous network addresses:
  - 213.2.96.0 → 11010101.00000010.01100000.00000000
  - 213.2.97.0 → 11010101.00000010.01100001.00000000
  - 213.2.98.0 → 11010101.00000010.01100010.00000000
  - 213.2.99.0 → 11010101.00000010.01100011.00000000
  - Two bits reserved → 2^2 class C networks included into the new supernet
- Supernet mask:
  - 255.255.252.0
- Supernet address:
  - 213.2.96.0/**22**
  - **11010101.00000010.011000 00.00000000**

Supernetting – Restrictions

- The common bits approach is not always accurate.

- You need to be careful:
  - Notice the produced supernet address
  - It should not be using addressing space outside of the contiguous networks you are trying to marge
  - The supernet address will always be the network address of the first of the contiguous networks

- Next Week
  - Classless Inter Domain Routing – CIDR
  - A recap of all three addressing schemes
    - Classful
    - Classless – VLSM
    - Supernetting