

CO1507 Introduction to Networking

IP Addressing

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What is an IP Address?

- Each network interface has a unique **physical** hardware address, a.k.a. **MAC** address that is unique to the device
- However, in order to build and organise networks we need to apply **logical** addressing for hosts on a network
- This is where **IP** (Internet Protocol) **Addressing** is needed
- **IP addressing** is part of the **TCP/IP** standard originally declared by the US department of Defence in 1982
- **IP addressing** (IP Version) is still commonly used to this day and uses **32 bit** IP addresses for hosts on a network

An IP Address

- IP addresses are **32 bits** in length
- For human comprehension we split this into **4** sets of **8** called '**octets**'
- Each octet corresponds to a decimal number between **0** and **255**
- We split these 4 numbers with a dot (.)
- A number greater than **255** in any of the positions is **IMPOSSIBLE** because it is limited to 8 bits

Example IP address **192.168.10.128** is represented in binary as:

11000000 10101000 00001010 10000000

(The spaces are not really there, but represent the separation of octets)

- Theoretically this allows for an address space of **0.0.0.0** to **255.255.255.255**
- However, for many reasons, many are not actually valid as host IP addresses

Subnet Mask

- A host IP address represents two pieces of information
 1. Which **network** a host belongs to
 2. The identity of the **host**
- Therefore every IP address is split into **NETWORK** and **HOST** portions
- These portions vary in length
- To specify the network and host portion a **SUBNET MASK** is required
- Example subnet mask: 255.255.255.0 11111111 11111111 11111111 00000000
- The **1**s align with bits of the **Network Address**
- The **0**s align with bits of the **Host ID**

Subnet Mask

- Lets look back to the previous IP address example **192.168.10.128**
- We will apply the subnet mask **255.255.255.0**

192.168.10.128

11000000 10101000 00001010 10000000

255.255.255.0

11111111 11111111 11111111 00000000

- '**192.168.10**' is the **network address portion** – so we write this as **192.168.10.0**
- The **Host ID** is **128**
- You may think we don't need binary and simply look out for a **255** or a **0**...
- Unfortunately that would be wrong, as in some cases other numbers come into play

Another Example

- Lets look at another IP address example **172.16.0.32**
- We will apply the subnet mask of **255.255.255.0**

172.16.0.32	10101100 00010000 00000000 00100000
255.255.0.0	11111111 11111111 00000000 00000000

- '**172.16**' is the **Network Address portion** - we would write this as **172.16.0.0**
- The **host ID** is **0.32**

Network address and Host ID

- A good analogy is to think of the **Network Address** as your **street address** and the **Host ID** as the **house number**
- Without **BOTH** parts an IP address is useless because a computer cannot decipher what network a host belongs to or which host it is
- For this reason we **MUST** always have a **Subnet Mask** along with an **IP address**
- There are the **MINIMUM** addressing requirements for a **Local Area Network**
- **MAC addresses** are **not** considered to be 'addressing requirements' as the physical addresses and unchangeable and depend on the hardware

Common Subnet Masks

- There are three commonly used subnets masks we will cover this week (these are the simple ones)

255.255.255.0

- Gives an **24 bit** network address and an **8 bit** host ID
- Theoretically 2^{24} network addresses, and 2^8 host IDs on each

255.255.0.0

- Gives an **16 bit** network address and an **16 bit** host ID
- Theoretically 2^{16} network addresses, and 2^{16} host IDs on each

255.0.0.0

- Gives an **8 bit** network address and an **24 bit** host ID
- Theoretically 2^8 network addresses, and 2^{24} host IDs on each

Common Subnet Masks

255.255.255.0

- **16,777,216** theoretical network addresses
- **256** theoretical host IDs

255.255.0.0

- **65,536** theoretical network addresses
- **65,536** theoretical host IDs

255.0.0.0

- **256** theoretical network addresses
- **16,777,216** theoretical host IDs

History

- These three **Subnets Masks** were once considered enough
- We used specific subnet masks with specific IP address ranges - this was called '**classful addressing**'
- However, this wasn't sufficiently flexible long-term and would lead to running out of available IP addresses prematurely
- Over the past 30 years classful addressing has been largely relegated to history
- However, you will still find that most software applies a **DEFAULT** subnet mask based on the IP address class
- These classful scenarios are still valid and correct, but we don't need to be constrained by them

Classful Addressing Context

- **Classful Addressing**
scenarios remain common in **Local Area** Networks
- E.g. you probably have a 'Class C' network as your home Wi-Fi

Address Class	RANGE	Default Subnet Mask
A	1.0.0.0 to 126.255.255.255	255.0.0.0
B	128.0.0.0 to 191.255.255.255	255.255.0.0
C	192.0.0.0 to 223.255.255.255	255.255.255.0
D	224.0.0.0 to 239.255.255.255	Reserved for Multicasting
E	240.0.0.0 to 254.255.255.255	Experimental

Note: Class A addresses 127.0.0.0 to 127.255.255.255 cannot be used and is reserved for loopback testing.

Network Address and Broadcast Address

- Within every network there is a **Network Address** and a **Broadcast Address**
- The **Network Address** is always the **first address** on the network and is **NOT VALID** as a host IP address e.g. 192.168.10.**0**
- The **Broadcast Address** is always the **last address** on the network and is **NOT VALID** as host IP address e.g. 192.168.10.**255**
- **Broadcasts Addresses** are used to **broadcast** packets to every host on a network simultaneously

Network Address and Broadcast Address

- Here is an example...
- You need the subnet mask to have any idea what the broadcast address and network address is
- Example address **192.168.10.128** with subnet mask **255.255.255.0**

The **network address** is **192.168.10.0**

in binary 11000000 10101000 00001010 **00000000** (host ID bits all 0)

The **broadcast address** is **192.168.10.255**

in binary 11000000 10101000 00001010 **11111111** (host ID bits all 1)

The valid **host IP** addresses are those address in-between

i.e. 192.168.10.**1** – 192.168.10.**254**

Another Example

- Here is another example...
- You need the subnet mask to have any idea what the broadcast address and network address is
- For the address **172.16.0.32** with subnet mask **255.255.0.0**

The **network address** is **172.16.0.0**

in binary 10101100 00010000 00000000 00000000 (host ID bits all 0)

The **broadcast address** is **172.16.255.255**

in binary 10101100 00010000 11111111 11111111 (host ID bits all 1)

The valid **host IP** addresses are all the address in-between these

i.e. 172.16.0.1 – 172.16.255.254

Calculating Networks : Example 1

Take the network address **192.168.10.0** with the subnet mask **255.255.255.0** as an example

IP 11000000 10101000 00001010 00000000

Mask 11111111 11111111 11111111 00000000

(Green is host id bits)

First valid host IP address: 11000000 10101000 00001010 00000001 (.1)

Last valid host IP address: 11000000 10101000 00001010 11111110 (.254)

Broadcast IP address: 11000000 10101000 00001010 11111111 (.255)

Subnet size of **254** possible hosts with an **8 bit** long host - ID address

Network address of **24** bits in length

Calculating Networks : Example 2

Take the network address **172.16.0.0** with the subnet mask **255.255.0.0** as an example

IP 10101100 00010000 00000000 00000000

Mask 11111111 11111111 00000000 00000000

(Green is host id bits)

First valid host IP address: 10101100 00010000 00000000 00000001 (.0.1)

Last valid host IP address: 10101100 00010000 11111111 11111110 (.255.254)

Broadcast IP address: 10101100 00010000 11111111 11111111 (.255.255)

Subnet size of **65,534** possible hosts with an **16 bit** long host - ID address

Network address of **16** bits in length

Calculating Networks : Example 3

Take the network address **10.0.0.0** with the subnet mask **255.0.0.0** as an example

IP 00001010 00000000 00000000 00000000

Mask 11111111 00000000 00000000 00000000

(Green is host id bits)

First valid host IP address: 00001010 00000000 00000000 00000001 (.0.0.1)

Last valid host IP address: 00001010 11111111 11111111 11111110 (.255.255.254)

Broadcast IP address: 00001010 11111111 11111111 11111111 (.255.255.255)

Subnet size of **16,777,214** possible hosts with an **24 bit** long host - ID address

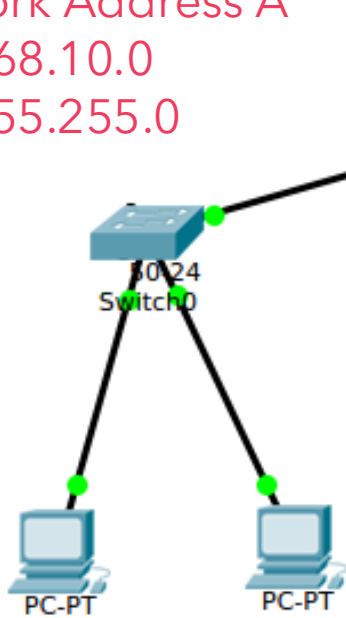
Network address of **8** bits in length

Default Gateway

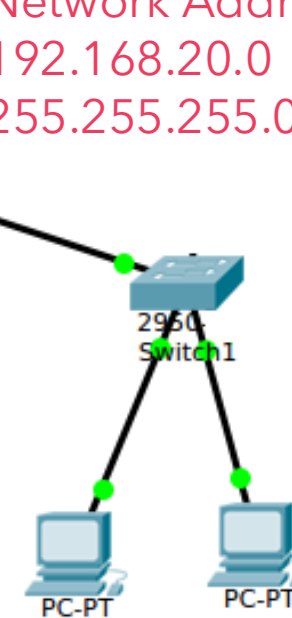
- You may have seen the label 'default gateway' in the network interface controls
- The default gateway is necessary in a **WIDE** area network but **not** in a **LOCAL** area network
- The default gateway is simply put; the IP address of the local router
- It is the gateway 'out of' your local area network
- E.g. if you ping across a wide area network and do not have the default gateway configured you will get the error '*destination host unreachable*'
- This is because the host PC knows that this IP address is **OUTSIDE** of the local area network due to having a different **network address**
- The PC also has no way of reaching a **router** to pass on the packets elsewhere

Wide Area Network Addressing

Network Address A
192.168.10.0
255.255.255.0



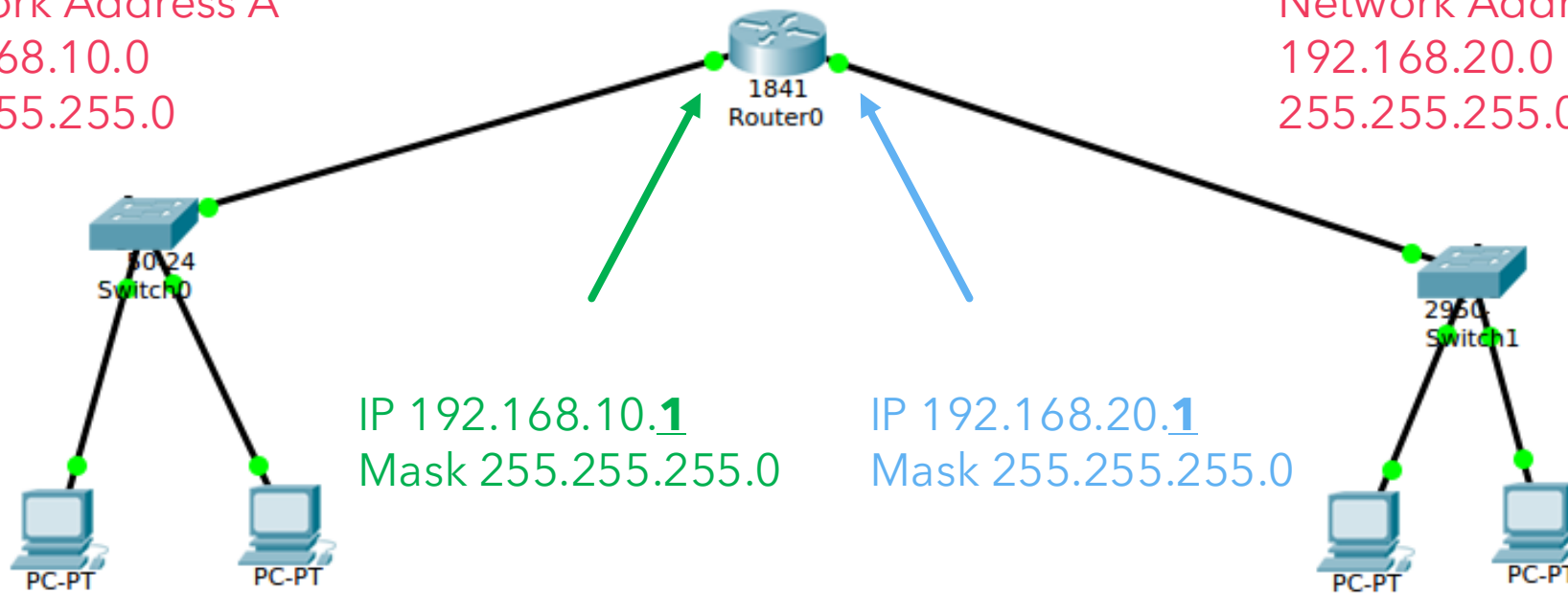
Network Address B
192.168.20.0
255.255.255.0



Wide Area Network Addressing

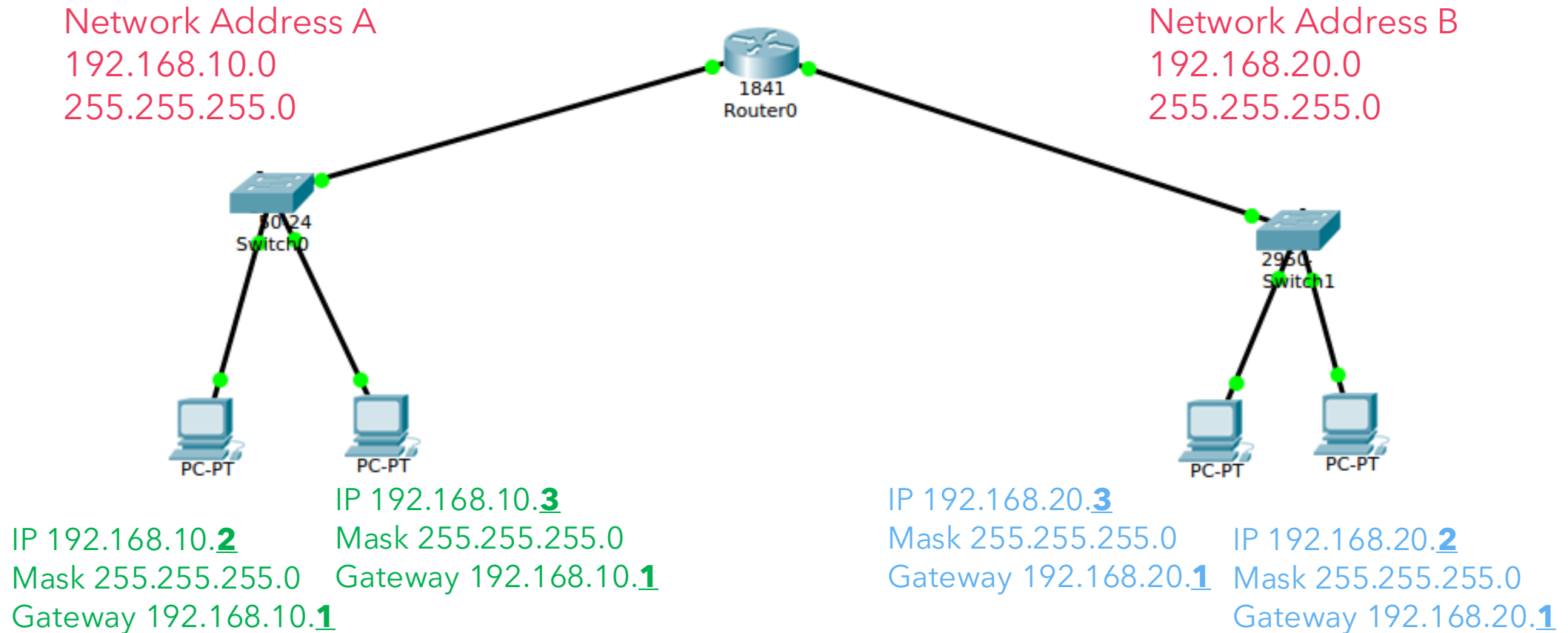
Network Address A
192.168.10.0
255.255.255.0

Network Address B
192.168.20.0
255.255.255.0



(routers IP doesn't need to always be the **first** host address in order to work
but to do so is common convention)

Wide Area Network Addressing



**Any
Questions?**

