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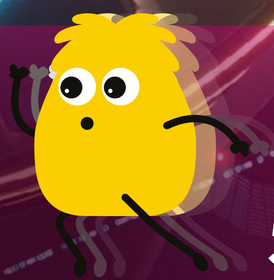
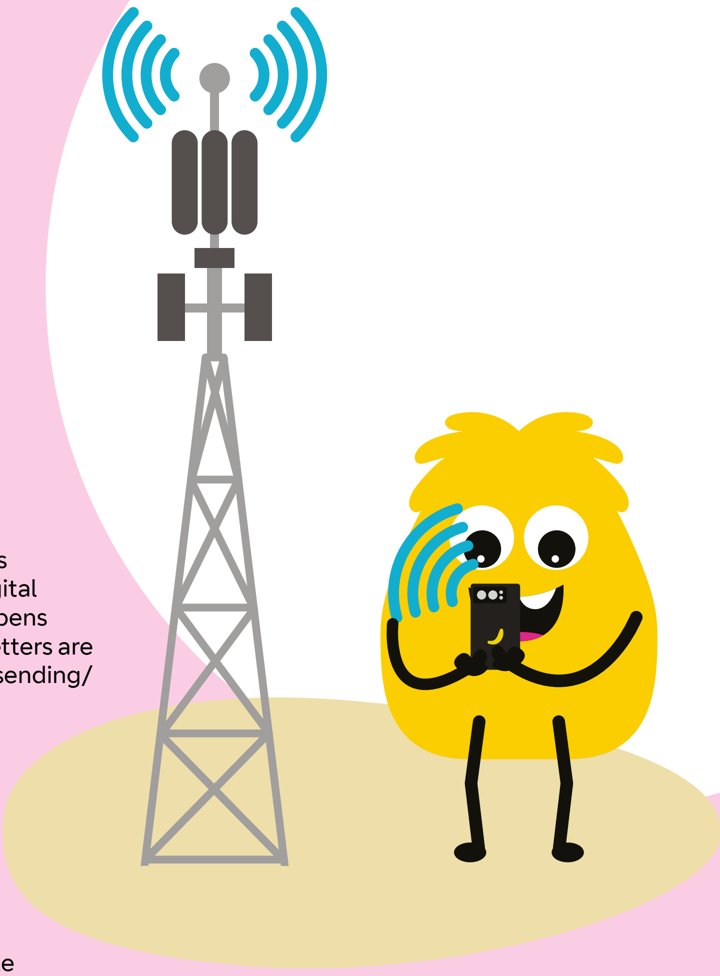


5G
activity pack

5G



Imagine a world where every digital connection is super-fast, and you can chat with your friends, share videos, and play online games in the blink of an eye. That's the magic of 5G!

It's the fifth generation of mobile networks, and there are some big improvements over the previous versions, 3G and 4G. Do you know how your phone connects to the internet when you're not on Wi-Fi? 5G makes that connection faster, more reliable and with less delay than ever before. It's like upgrading from an ordinary car to a Formula 1 car!

With 5G, you can download your favourite games, stream 4K videos, and video chat with friends seamlessly, all at the same time, without those annoying delays where the buffer wheel spins endlessly. 5G therefore opens up new possibilities for innovation and technology.

But to do all of those cool things that use 5G, there is a network behind the scenes that allows it to happen.

A network is like a giant web that connects all of our devices (phones, computers, tablets, you name it!).

Have you ever physically posted a letter? Well, the 5G network (or any telecommunications network) is like a digital version of what happens with the post. The letters are like the data you're sending/receiving. The post boxes are like the routers that you have in your home or school and the people who deliver the post are instead replaced by clever algorithms that route the packets of data over cables (ever heard of fibre-optic cables?). So as much as these networks may appear invisible, there is lots of physical kit needed to enable it all.

With faster speeds and lower latency (the time it takes for information to travel from point A to point B), 5G networks create a more responsive and connected world. It's not just about making our videos load faster; it's about building a foundation for futuristic technologies like smart cities, self-driving cars, and the Internet of Things (IoT).

Get ready for the 5G revolution!

We'd love to see pictures of you all getting involved with the activities. Email these to us at **computerscience@bt.com** telling us which school you're from.

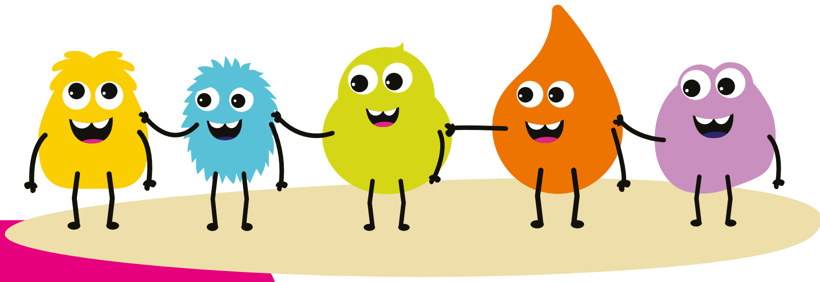
Teacher Links

- Network Hunt - Understand computer networks https://tinyurl.com/48e2ucpz
- Modelling the Internet - Understanding how the internet provides services such as the world wide web https://tinyurl.com/yzvwn9x5

Find Out More

- Hello World – Download your free issue all about Systems & Networks https://www.raspberrypi.org/hello-world/issues/20

Activity 1



Human Network

The first activity is going to focus on what a network is and what it's made up of.

In order for devices to communicate, they have to be connected to one another, either physically or wirelessly. In its simplest form, a network is made up of the end devices and the bit in the middle connecting them. Those devices could be smartphones, tablets, computers or Internet of Things (IoT) devices. The biggest example of a network is the Internet, which is made up of tonnes of smaller networks that allow all our devices to talk to one another.

Question: How many devices (also known as nodes) do you think make up the smallest form of network?

If you said 2 devices/nodes, then you would be correct!

This type of network is called 'point-to-point', where the device at one end of the network can only talk to the device at the other end of the network, and vice-versa.

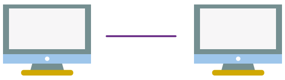
Question: What potential problems or limitations can you think of with a point-to-point network?

Well… here is one potential problem: what if that bit of cable in between your device and the other device you're communicating with gets damaged or becomes faulty? There's no back-up. That might be ok if your message can wait until it is fixed, but what if you needed to phone the emergency services or communicate a message urgently to somebody?

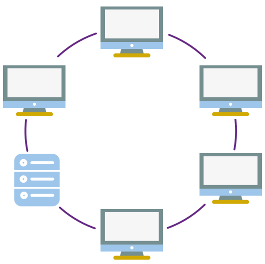
In terms of the limitations… what if you wanted to be able to message your Mum as well as your friend? That wouldn't be possible; you would need a different type of network. Thankfully, there are lots of different types of networks which we'll explore in this activity. They are also known as Network Topologies or the Network Architecture.

Here are six different types:

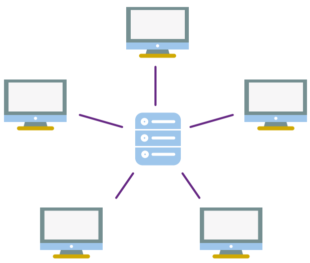
- Point-to-point



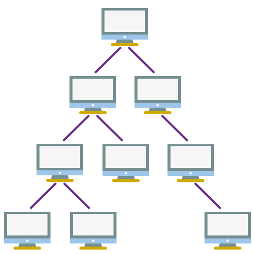
- Ring



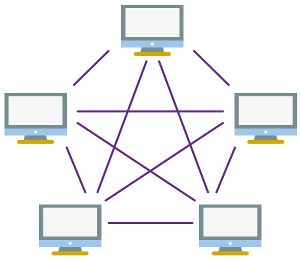
- Star



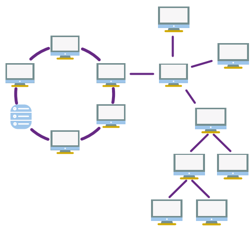
- Tree



- Mesh



- Hybrid



You're going to test out these network topologies using pieces of string, before selecting which network topology best fits some different requirements we'll challenge you with.

Rules:

- The string will connect you with somebody else meaning you can talk to them.
- If you aren't connected to one of your classmates by a piece of string, then you're not allowed to talk to them.
- Only two people can be connected by a single piece of string.
- One person can be connected to lots of people at once by having multiple pieces of string.

Kit List

- **Scissors**
- **String (Cut roughly into 1.5m lengths)**
- **Paper**
- **Pens or Pencils**

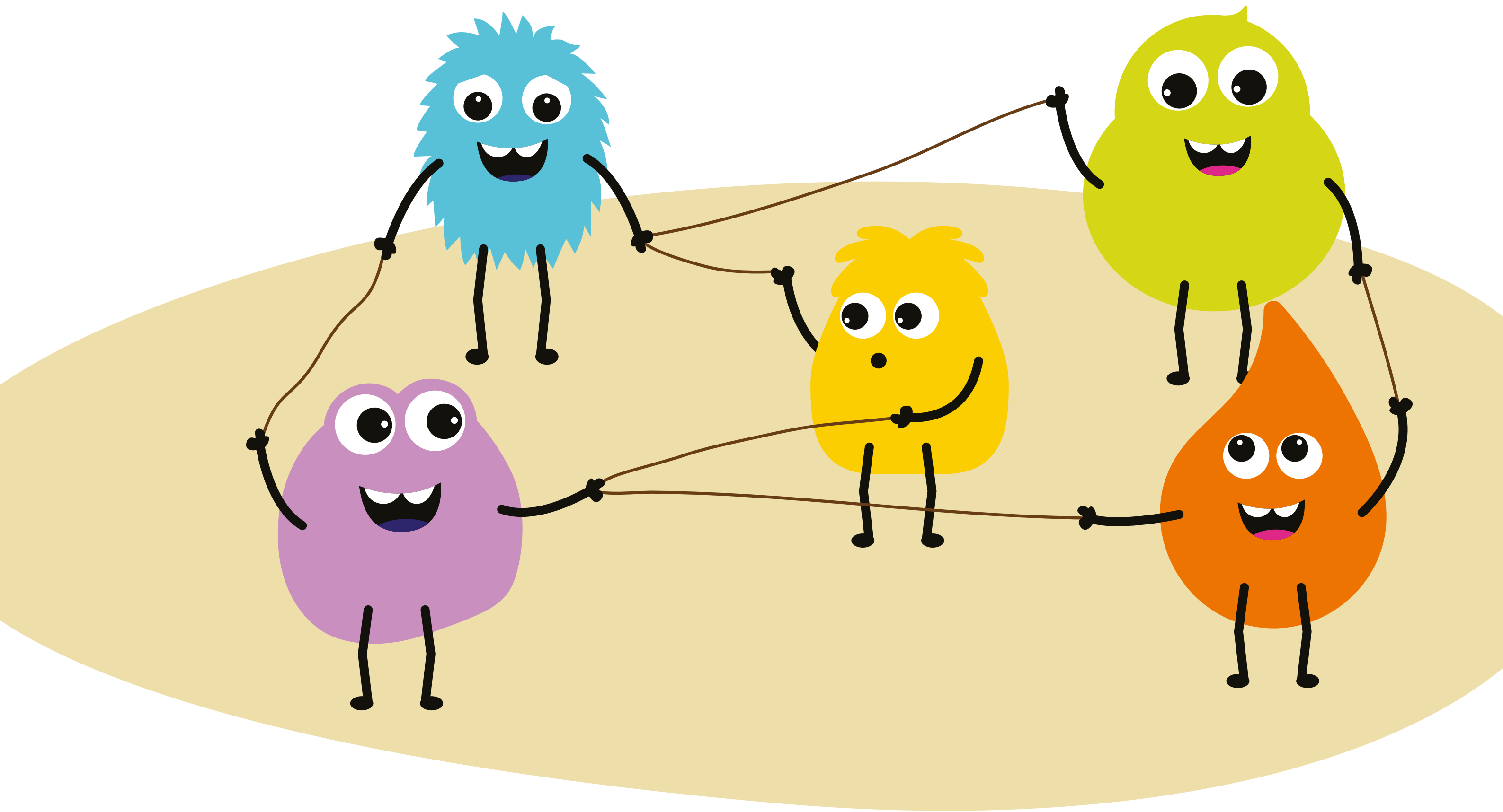
Instructions

1. Firstly, you'll need to get into groups of 6.
2. One person from your group should collect 15 pieces of string from your teacher.
3. With the string, make each of the following 5 network topologies using the people in your group. You should then start a conversation between you all, making sure that you follow the rules from page 3 in order to communicate with the other members of your group.
   - a) Point-to-point
   - b) Ring
   - c) Star
   - d) Tree
   - e) Mesh
4. You're now going to be given three different business requirements.

   Your task is to select which network topology that you've learned about best solves the problem in your group's opinion.

   Be prepared to explain the strengths and weaknesses of the network architecture that you've chosen (feel free to draw your network out on some paper if it helps).

- **Challenge 1:** No expense spared; we need a network where everybody can speak to everyone else.
- **Challenge 2:** String is very expensive! Create a network that connects everybody but uses the smallest number of strings.
- **Challenge 3:** String can be cut. This means people get disconnected from the network. Make a network that keeps everyone connected even if one of the connections is broken.



Activity 2

Packet Switching

We're now going to look more closely at how messages get sent from one device to another within a network (regardless of the network topology). It uses something called Packet Switching.

To help us understand Packet Switching, we're going to compare it to sending a physical letter in the post.

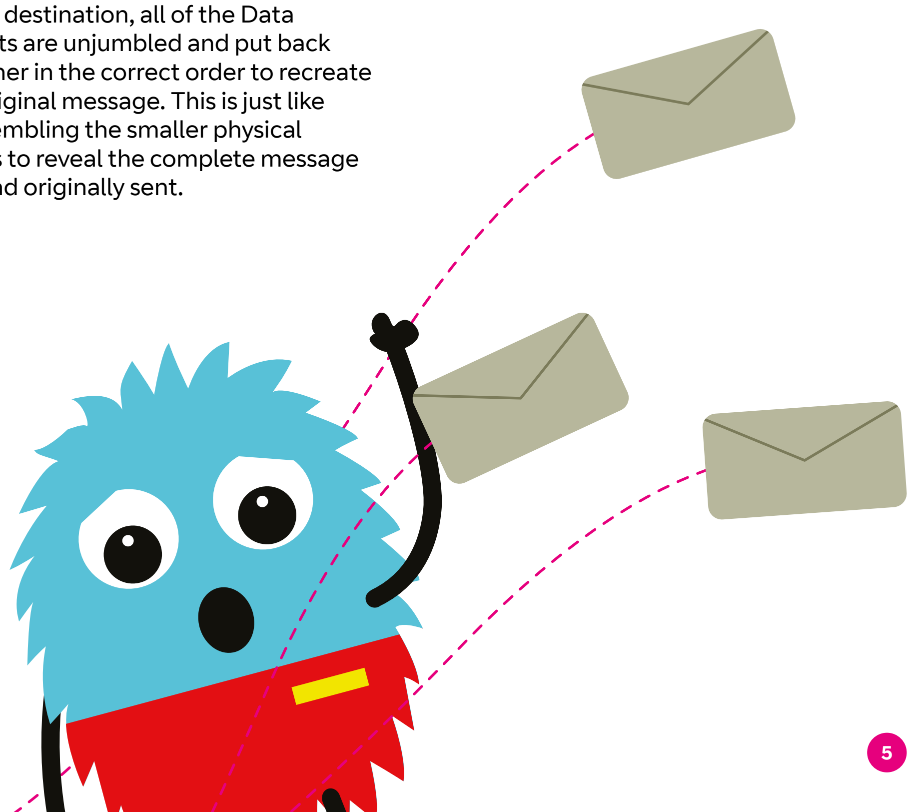
In the past, the only way to send a message to your friend who lives far away was to send them a letter. When you wrote your letter, you would put it in an envelope. On the front of the envelope you would write the address you want to send it to, and on the back of the envelope you would write your own address so that the letter could be returned if it got lost. You would then put a stamp on the front of the envelope and post it in a post-box. The information on this envelope helps the postal workers know where the letter is coming from, where it needs to go and how quickly it needs to get there.

Now imagine you wanted to send that same message today, digitally, over the internet. You would type it out on a computer or a smartphone and hit 'Send'. This is where Packet Switching gets to work.

Instead of sending that entire digital message in one go, Packet Switching breaks that message down into smaller chunks called Data Packets. Each Data Packet is sent separately, but they are given a number so they can be put back together in order at the other end. Each data pack also includes the address it is being sent to, the address it is being sent from and something called Quality of Service (QoS). The Quality of Service is like the stamp on the envelope; a first-class stamp is higher priority than a second-class stamp and should therefore be delivered more quickly.

These Data Packets don't all take the same route to reach your friend. Instead, they take different routes through the internet to reach their destination and may even arrive in the wrong order! Going back to your physical letter, imagine if that was split into lots of smaller letters, and each smaller letter could find its own way to your friend's house via different post offices and roads. That's what happens with Packet Switching.

At the destination, all of the Data Packets are unjumbled and put back together in the correct order to recreate the original message. This is just like reassembling the smaller physical letters to reveal the complete message you had originally sent.



Kit List

Classroom with tables and chairs

Pens or Pencils

Print out templates on Pages 9 - 12

- **Router Card (1 per classroom)**
- **Switch Cards (based on a bank of tables that seats 4 students: give this to 1 of every 4 students)**
- **Computer Cards (based on a bank of tables that seats 4 students: give this to every 3 out of 4 students)**
- **Message Cards (3 per student)**

Questions to think about:

- Did you receive your messages in order every time?
- Did any messages get lost?
- What do you think the benefits of Packet Switching are?

Instructions

There are 5 key roles in this activity as shown below:

- The **classroom** will act as the Internet – one large network full of many smaller networks.
- Each bank of **tables** will be its own Local Area Network (LAN) - think of this like a home or school network.
- The person with the **Router Card** will act as the Network Router.
- Those with a **Switch Card** will act as the Network Switch for that block of tables.
- Everyone with the **Computer Cards** will be acting as a computer with their own unique IP Address.

1 Based on a bank of tables that seats 4:
- Print out the '**Computer Card Template**' from page 11, and hand them to every 3 out of 4 students.
- Print out the '**Message Card Template**' from page 12 three times for each student who has a Computer Card.
- Print out the '**Switch Card Template**' from page 10, and hand them to 1 of every 4 students.

↘ Nominate a student in class to have the **Router Card** – they will need to sit separately from the other banks of tables (or the teacher can have the **Router Card**).

2 Number each bank of tables, starting from 1.

↘ Ask the students with a **Switch Card** to sit down at separate banks of tables so that each bank only has one person with a **Switch Card**.

↘ Ask the rest of the students, who have a **Computer Card** to fill the rest of the seats.

3 Each **Computer** needs to write their unique IP Address on their **Computer Card** and in the '**From IP address**' field of all three of their **Message Cards**.
- The first number is the table number they are sitting at.
- The second number should be different for each **Computer** sitting at that bank of tables.

4 Each **Computer** now needs to think of a message or a question they want to send to someone else in the class. You will need to split your message up into three parts.
- Write the first part of your message in the '**Data**' field of your first **Message Card** and make sure you add that this is '**Packet Number**' 1 of 3.
- Repeat this step for the 2nd and 3rd parts of your message on the other **Message Cards**, making sure to change the '**Packet Number**' each time.
- You won't know who you're sending your message to as you won't know which IP address everyone has got. Therefore include your name in your 3-part message so the recipient knows who they've received their message from.

5 Each **Computer** needs to write the IP address of the person they want to send their message to in the '**To IP address**' field of each of their three **Message Cards**.

6 Once each **Computer** has finished filling in their three **Message Cards**, they should hand these to the **Network Switch** (person with the Switch Card) on their table.

It doesn't matter which order each **Computer** passes their **Message Cards** to the **Switch**, or whether the **Switch** jumbles them all up before delivering them to the **Router**.

7 The **Network Switch** should now look at the '**To IP address**' field of every **Message Card** they have been handed from the **Computers** on their bank of tables.

Is the first number of the '**To IP address**' the same as the table number they are already sitting on?
- If so, they should look at the second number of the '**To IP address**' and hand that **Message Card** to the relevant Computer on their table.
- If not, they should pass that **Message Card** to the **Router**.

8 The **Router** should now look at the '**To IP address**' field of every **Message Card** they have been handed from the **Switches**.

They should deliver each **Message Card** to the **Switch** on the relevant table number e.g. if the **Message Card** has '**To IP address**: 4.3', this should be delivered to the **Switch** on Table 4.

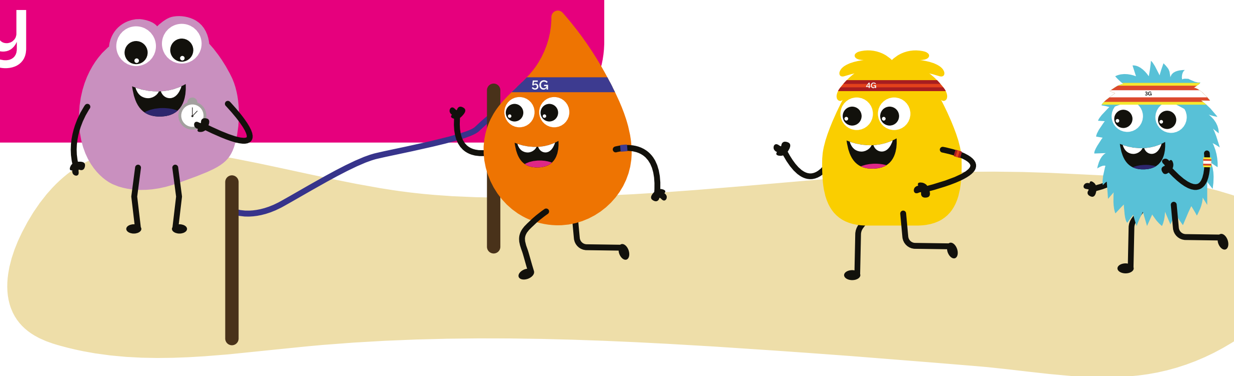
9 The **Network Switch** should now look at the '**To IP address**' field of every **Message Card** they have been handed from the **Router**. They should deliver each **Message Card** to the correct **Computer** on their bank of tables.

10 Once **Computers** have received three **Message Cards** from the same '**From IP address**', they should rearrange them into the correct order so they can read the message (**Data**).

11 **Computers** can choose whether to respond to their message / question and the activity can keep going on and on…

Activity 3

Network Latency Relay



Kit List

- **Stopwatch or timer**
- **Cones or markers to create a path**
- **Tape or marker to make a start and finish line as well as a middle marker**
- **Something to use as a blindfold**
- **Any object to act as the data being sent**
- **Pens or Pencils**
- **Paper**

From Activity 1, we learned about what a network is and how they can be set up in different topologies.

From Activity 2, we then looked at how a message is sent across these networks using packet switching.

For Activity 3, we are going to look at latency. This is the delay, or time, it takes for information to get from the sender to the receiver, the lower the better.

Latency is relevant to 'Networks: 5G', because one of the main benefits of wireless 5G connectivity is that it has very low latency. That's a really great thing because it means your messages send superfast!

But it's not only great for messaging your friends. If you are playing online games, latency (also known as ping time) can affect your ability to play. In gaming terms, latency refers to the delay between you pressing a button on a controller and the on-screen response in the game e.g., a character performing an action.

Low latency means faster response times and an overall improved gaming experience where you don't get the annoying buffer wheel! If you're gaming on a low latency network compared with the people you're playing with, you can potentially gain a competitive advantage!

This exercise is therefore going to demonstrate the impact of latency in networks, and compare the difference in latency between the 3G, 4G & 5G wireless mobile networks.

Instructions

1. Clear three patches of space (if possible, one next to the other) - like shown in the diagram on page 8.

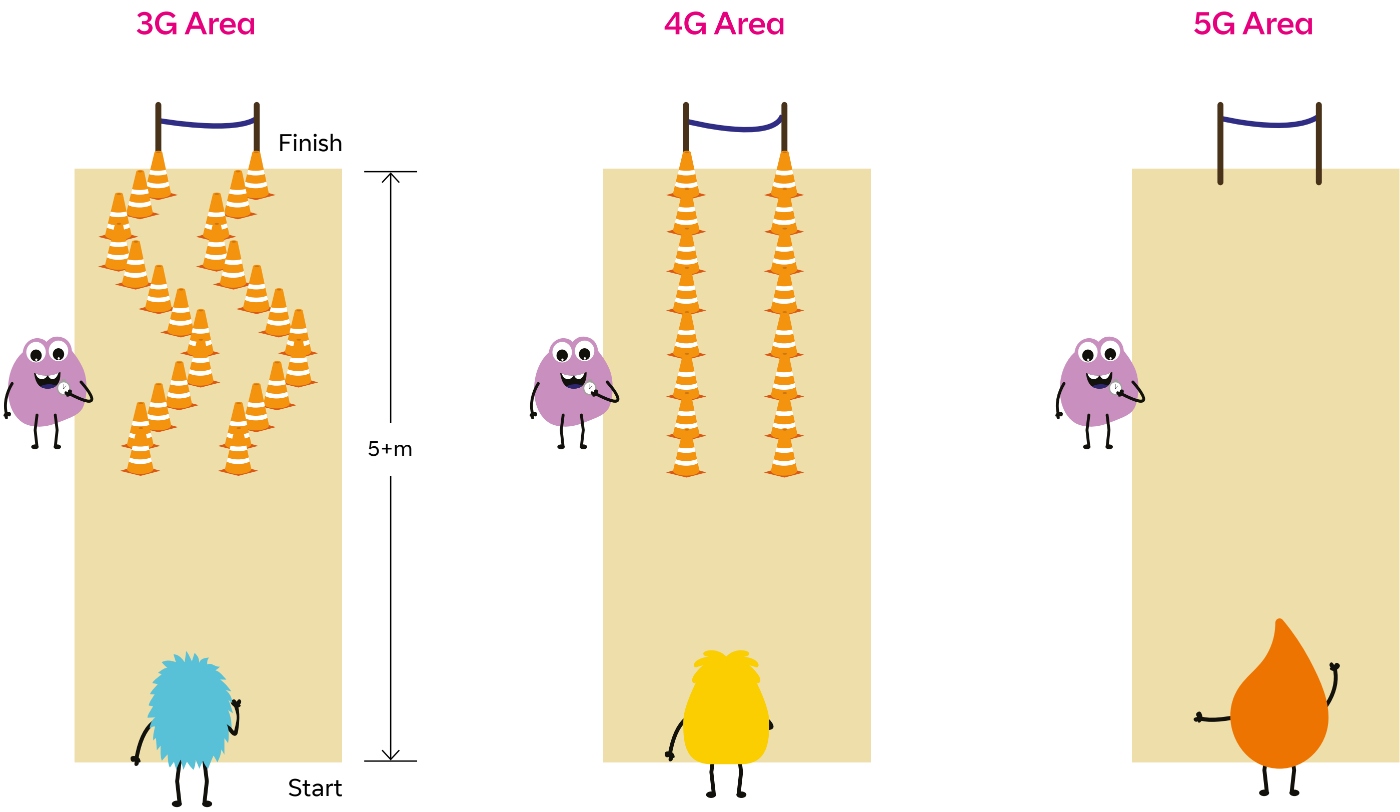
   One area will represent 3G, one will represent 4G and the final area will be for 5G.

   Mark a 'Start' and 'Finish' line at opposite ends of each of the three spaces you've cleared. Also mark the middle point of each course.

   Ideally you will need around 5-10m of space between the start and finish lines for each area.

2. - **3G area:** from the halfway marker to the finish line, create a windy path using cones or markers (wide enough for someone to walk between).
   - **4G area:** from the halfway marker to the finish line, create a straight path using cones or markers (wide enough for someone to walk between).
   - **5G area:** nothing needs doing to this space.

   If you want to further emphasise the impact of latency, you could add some obstacles to navigate along the path; ensuring that the obstacles for the 3G area are more difficult to work around than the 4G area, and that nothing is blocking the path for the 5G course.



3 Each area (3G, 4G & 5G) will require 5 people:
- **Sender**
- **Receiver**
- **Network Node**
- **Instructor**
- **Timer**

All three areas should kick off at the same time and run simultaneously. Therefore this activity may need to be run multiple times to allow for everyone to have a go.

4
- The **Sender** needs to stand on the Start Line, holding the object. The object represents data that needs to be sent over the network.
- The **Receiver** should stand on the Finish Line.
- The **Network Node** should be positioned on the marker indicating the middle of the track (the **Network Nodes** for the 3G & 4G areas should also be blindfolded).
- The **Timer** should position themselves on the sidelines, somewhere they can see the **Network Node**.
- The **Instructor** should position themselves on the sidelines, in between the middle marker and the Finish Line.

5 When the teacher says Go, the three **Senders** (one for each network), should walk their object in unison to the **Network Node**.

The **Timers** should start their stopwatches as soon as the **Senders** hand their objects (data) over to the **Network Nodes**.

6 Once the **Network Nodes** have hold of their objects, it is the job of the **Instructors** to provide instructions to the **Network Nodes** to guide them to the Finish Line (for the 5G area, this should be nice and easy as the **Network Node** can see where they need to go).

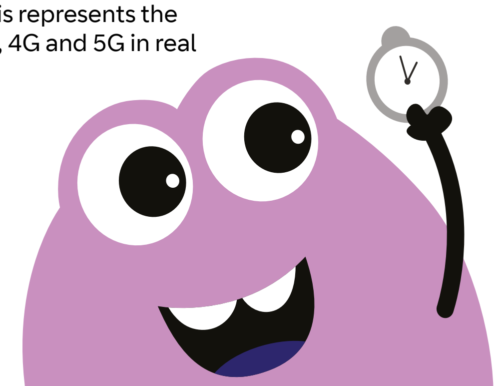
These must be spoken instructions. The **Instructor** must not physically guide the **Network Node** to the finish line.

7 The **Timers** should stop their stopwatch as soon as the **Network Node** hands their object (data) to the **Receiver**.

Each **Timer** should write their times down on a piece of paper.

Once all three areas are finished, the three groups should now compare their times. Which group took the longest to get their data from **Sender** to **Receiver**?

The time it takes for the object to travel from the **Sender** to the **Receiver** represents the latency in a network. What you should have found is that the 3G group took the longest, followed by the 4G group and that the 5G group was the fastest. This represents the different latencies for 3G, 4G and 5G in real life.



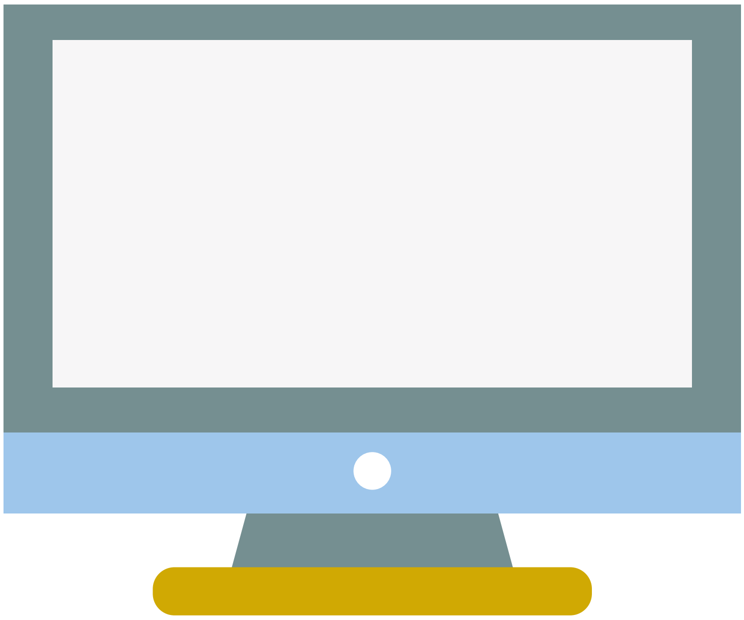
ROUTER

Switch Card Template

SWITCH

Packet Switching
Computer Card Template

Computer



IP Address ____ . ____

Packet Switching
Message Card Template

To IP address: ______________

Packet Number ____ of 3

Data:

From IP address: _____________