UNIT 3.4

We are network engineers

Exploring computer networks, including the internet

1 About this unit

Software: Simple diagnostic tools accessed via the command prompt: ping, ipconfig, nslookup, tracert/equivalent web-based tools
Apps: Web-based equivalent tools via a web browser
Hardware: Desktop or laptop computer/Raspberry Pi
Outcome: Pupils use network diagnostic tools to test and explore network connections

UNIT SUMMARY

In this unit, the pupils investigate how computer networks work. They use a simulation and learn some simple command prompt (C:) tools for testing network connections.

CURRICULUM LINKS

Computing PoS

- Understand computer networks, including the internet; how they can provide multiple services.
- Use technology safely, respectfully and responsibly; recognise acceptable/unacceptable behaviour; identify a range of ways to report concerns about content and contact.

Suggested subject links

- **D&T:** Complex systems such as the internet and computer networks illustrate engineering ideas.
- **Geography:** The children can follow the geographical route taken by data packets.

TRANSLATING THE COMPUTING PoS

- Networking hardware makes it possible for computers to pass data to one another, to create a *computer network* (see unit poster reverse). These networks can be connected together to make the *internet*. A standard system (known as 'protocol') is used for passing data between computers. Data is first broken into small 'packets'. The packets are then passed from one router to another until they reach the recipient.
- Computers connected to the internet can provide many *different services*, such as serving web pages, dealing with email, responding to test packets of data ('pings'), or converting server names (like www.bbc.co.uk) into internet protocol (IP) addresses.
- Understanding the internet at this level empowers users to *use this technology safely and responsibly*, through recognising that the internet is not always secure and that traffic can be monitored and filtered.

LEARNING EXPECTATIONS

This unit will enable the children to:

- understand the physical hardware connections necessary for computer networks to work
- understand some features of internet protocols
- understand some diagnostic tools for investigating network connections
- develop a basic understanding of how domain names are converted to IP addresses.

The assessment guidance on page 50 will help you to decide whether the children have met these expectations.

Assessment should focus on whether pupils retain knowledge of how these technologies work, and whether they understand the technical details of some of the commands and their output. Use observation, targeted open questions and self-assessment.

VARIATIONS TO TRY

- There are many ways for the pupils to record what they learn in this unit, e.g. a poster or presentation, a class wiki, blog posts, or audio or video recordings.
- The pupils can use the tools from this unit on various platforms including a Raspberry Pi, an emulator or a website with online versions of the tools – see *Useful links* on page 43.

2 Getting ready

THINGS TO DO

- Read the *Core steps* sections of *Running the task*.
- Decide how you wish to run this unit. Ideally, the pupils will be able to use the diagnostic tools (ping, ipconfig, nslookup, tracert) accessed via the command prompt, C: on Windows computers. Your network manager may need to enable this feature for the pupils. If this isn't possible, versions of the commands can be used on a number of websites (see *Useful links*).
- Download your chosen software/tools (see *Useful links*) and spend some time familiarising yourself with them.
- Think about the individuals and groups you have in your class. Could you use any of the *Extensions* on pages 44–49 to extend your more able children? Could you use any of the suggestions in *Inclusion* (see below) to support children with specific needs, e.g. SEN or EAL? Have you considered how a Teaching Assistant will support you and the children, if one is available?
- Ensure you have sufficient computers/laptops/tablets and other equipment booked in advance.

THINGS YOU NEED

- Computers/laptops/tablets loaded with, or having access to, the software/tools you have chosen
- A plan of the classroom/computer lab

CD-ROM RESOURCES

- Commands with definitions
- Passing messages activity step-by-step guidance
- IP address cards for activity
- Message slips for activity
- Classroom set-up sheet for activity
- Unit poster – Networks
- Pupil self-assessment information

E-SAFETY

- There is a perceived risk associated with providing Windows users with access to the command prompt. On properly configured systems the command prompt can be used without risk to the network, system settings, programs or data, as this neither requires nor grants administration privileges. If the pupils use these tools, the computers must be properly configured so that they can only edit files in their own user directory. Making changes to computer settings should require administrator privileges, which are denied to pupils.
- An alternative approach would be to use a Raspberry Pi or collection of equivalent web-based tools (see *Useful links*).
- Emphasise that the pupils should not change settings or alter files on computers unless they have permission and can undo any harm done. It's tricky to set a balance between encouraging experimentation and ensuring safe, respectful and responsible use.

INCLUSION

- Consider adjusting font sizes for the command prompt, or even using text-to-speech tools, if pupils have difficulty reading output.

USEFUL LINKS

Software and tools

- Sites offering access to networking tools via the web: http://centralops.net/co, www.ultratools.com, http://network-tools.com. (The information returned is for the web server and not the computer you're accessing them from.)
- Raspberry Pi: www.raspberrypi.org.
- http://sourceforge.net/projects/openvisualtrace provides a map-based view of the route of a packet to its destination.

Online tutorials

- Raspberry Pi: http://downloads.raspberrypi.org/Raspberry_Pi_Education_Manual.pdf.
- Connecting a Raspberry Pi to a network: www.ocr.org.uk/Images/125299-classroom-challenge-connecting-to-a-network-learner-sheet.pdf.
- Google Maps: www.google.com/earth/outreach/tutorials/all.html#maps.

Information and ideas

- A guide to how the internet works: http://prezi.com/vapcu1okprv4/network-of-networks.
- A unit of work for primary pupils on how the internet works: http://code-it.co.uk/year5/index.htm with extension resources at http://code-it.co.uk/year5/more4.html.
- Infographic about how the internet works: http://cloudnewsdaily.com/2012/08/how-the-internet-works-infographic.
- A quick introduction to the internet from Google: https://educourses.withgoogle.com/101/course.

3 Running the task – We are network engineers

Software: Simple diagnostic tools accessed via the command prompt: ping, ipconfig, nslookup, tracert/equivalent web-based tools **Apps:** Web-based equivalent tools via a web browser
Hardware: Desktop or laptop computer/Raspberry Pi **Outcome:** Pupils use network diagnostic tools to test and explore network connections

Core steps

Step 1: Physical and wireless connections

RESOURCES

- Unit poster reverse – Networks

POSSIBLE OUTCOME FOR THIS STEP:

Discuss this step with your network manager and adapt it so that it works in the context of your school's network.

- Ask the children to list all the things they use the internet for. What would life be like without it?
- Explain that the school's network and the internet are possible because of connections between computers. Display the reverse side of the unit poster to help pupils visualise the connections between computers. Trace a simple route to show how data can be passed across the internet. If pupils are using a wired connection, ask them to look at the back of their computers and work out what each cable does. Show which cable connects to the school network.
- Ask the pupils to find what the cable connects to – typically a wall box or cable trunking. Where does this cable go? Follow the connection to the room's network switch and then follow the route of the cable connecting it to the school's network server(s). Talk about the school's server(s).
- If the pupils are using Wi-Fi connections, show them the classroom's Wi-Fi access point and walk along the route of the cable connecting it to the school's server(s).
- Show the pupils how the school network is connected to the internet, explaining about the router and any filter, cache or firewall hardware.

Extensions

SCHOOL

- Encourage pupils to learn more about the connection from the telecom cabinet to the rest of the internet. One possible starting point is: www.ted.com/talks/andrew_blum_what_is_the_internet_really.html.

HOME

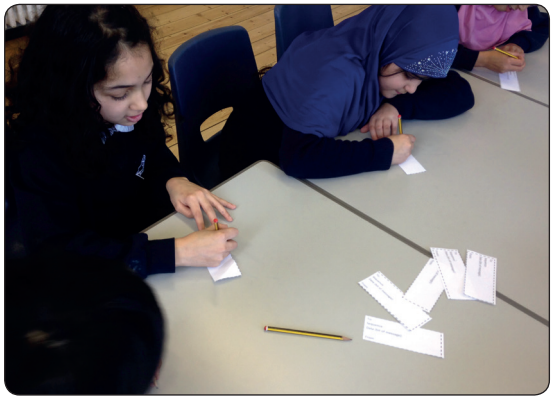
- The pupils should investigate their home network and internet connection, comparing this with the school network.

Step 2: Passing messages across networks

RESOURCES

- Passing messages activity step-by-step guidance
- IP address cards for activity
- Message slips for activity
- Unit poster reverse – Networks

POSSIBLE OUTCOME FOR THIS STEP:



This step is a simulation of how modern computer networks (including the internet) pass data between computers. The description here assumes five tables of six pupils, but you can easily adapt this for different numbers. Read the activity step-by-step guidance on the CD-ROM before starting this step.

- Explain that each computer on a network has a unique address – a short sequence of numbers that uniquely identifies it so that data can be sent to it. These are called IP addresses.
- Tell the pupils they are going to act out the roles of computers and networks to show how information can be passed across the internet. If appropriate, refresh the children's memories of how data is passed between computers by showing them the reverse side of the unit poster.
- Run the passing messages activity (see the CD-ROM) to show how data is passed across networks, including the internet. If time permits, the pupils could repeat the activity, responding to the messages they've received.
- While this activity represents most of the key ideas of the internet, explain that there are some significant differences.
    - IP addresses are much longer.
    - The switch for the sending network hardly ever communicates directly with the switch for the destination network – packets of data go through many different routers between the sender's switch and the recipient's switch.
    - All the data (i.e. the text of the messages they sent) is transmitted in binary code (lots of 0s and 1s) – simple on/off electrical or optical signals.

SCHOOL

- Phil Bagge has a more complex simulation of TCP/IP in Lesson 2 at http://code-it.co.uk/year5/index.htm, which focuses on peer-to-peer networks including a TTL (time-to-live) number for each packet, and random disruption of the network.

HOME

- Ask the pupils to explain how the internet works to their parents, using the analogy explored in the activity.

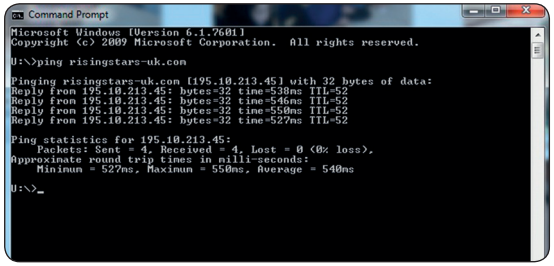
Core steps

Step 3: Testing network connections

RESOURCES

- Central Ops.net: http://centralops.net/co
- UltraTools: www.ultratools.com
- Network-Tools.com: http://network-tools.com

POSSIBLE OUTCOME FOR THIS STEP:



Ask your network manager to allow access to the Windows command prompt for this and the next two steps. Ask for the pupils to have access to the ipconfig, ping, tracert and nslookup commands. If this isn't possible, you can use the web-based tools listed in* Resources*. You'll also need a plan of the classroom to attach to the wall.

- Explain that network engineers often need to test whether two machines are connected. To do this, they talk directly to the computer, using the command prompt (C:). Show the pupils the command prompt (C:) on Windows (accessed via the Start menu). Ask pupils to type 'ipconfig' into the command prompt and press the Enter key. Show them how to identify the IP (internet protocol) address of their computer. Ask them to write this down on the plan of the classroom. Do the children notice anything about the IP addresses on the plan? (The first set of numbers is always the same.) Remind them of their work in Step 1.
- Explain that they can use another tool called 'ping' to check the connections between computers. Ping sends a very small message (packets of data) between two computers, collecting information about the time it takes for the packets to be transmitted.
- Ask the pupils to type in 'ping' followed by the IP address of another computer in the room, and then press the Enter key. Show the pupils how to read how long the packets took to transmit. If appropriate, explain that 'ms' means millisecond (one thousandth of a second – very fast indeed!).
- The pupils should now experiment with 'pinging' packets of data to other computers on the internet, e.g. typing 'ping risingstars-uk.com', and then trying some of their favourite web servers. Compare and contrast the time the ping packets take to get through.

Extensions

SCHOOL

- ipconfig and ping have a number of additional options that pupils might like to investigate. See 'ipconfig – help' and 'ping – help' respectively. The pupils could independently research the meaning of any terms they don't recognise.

HOME

- The pupils could compare their results in school with results obtained from **running the same commands** on their home computer.

Step 4: Getting from here to there

RESOURCES

- Unit poster reverse – Networks

- Google Maps: http://maps.google.com
- Geolocation tools:
  www.iplocation.net
  www.infosniper.net
  www.ipligence.com/geolocation
  www.yougetsignal.com/tools/visual-tracert

POSSIBLE OUTCOME FOR THIS STEP:

- Ask each pupil to use the web to plan a trip from school to Mountain View, California. If time allows, invite them to plot the stages of their journey on a shared Google Maps layer. Were there big differences between routes? Did many pupils take the same route?
- Explain that the way a message travels across the internet is not that different, although packets in a message usually take the same, most efficient route. Using your finger, trace a possible route of data on the reverse side of the unit poster to clarify this point.
- Explain that sometimes a network engineer needs to find out the route an individual packet of data takes, and they use another tool, tracert, to do this. Open a command prompt and type 'tracert www.risingstars-uk.com'. Explain that the packet of data has 'hopped' between all the IP addresses shown to reach its destination.
- Ask the pupils to use tracert for some favourite web servers, such as www.bbc.co.uk. Which web servers took the smallest number of hops? Which took the largest? Did any fail to respond to tracert requests? Explain that this information helps network engineers to spot problems with the network if it takes a long time to respond.
- Show the pupils how to use one or more of the web-based geolocation tools listed in *Resources* to estimate the location of the switches and routers the packet travels through. Ask the pupils to use a geolocation tool to work out the approximate location of all the hops to a web server of their choice, plotting these as a layer on Google Maps. What locations are common to all pupils' maps? Why might that be? (Common locations will include the school, your internet service provider and London's Linx, Telehouse or GlobalSwitch.)

SCHOOL

- Another extension could be for pupils to learn more about the under-sea cables used for the internet, using, e.g. http://submarine-cable-map-2013.telegeography.com.

HOME

- Ask the pupils to compare the results obtained in school with those they get running the same command at home. Are there big differences?

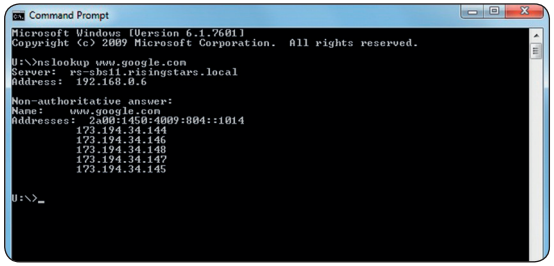
Core steps

Step 5: From names to numbers

RESOURCES

- Pupils can do name-server lookups online, e.g. www.centralops.net/co

POSSIBLE OUTCOME FOR THIS STEP:



- Talk to the pupils about how you (or your parents) used to keep a physical address book with the phone numbers of your friends and family, how BT still produce a printed phone book and how other telephone numbers can be obtained through directory enquiries.
- Draw an analogy with the way the internet works: the internet uses IP addresses (numbers) to transmit data, but we find it much more helpful to work with names, and so the Domain Name Service (DNS) has been invented to make it easy to convert from numbers to names.
- Explain to pupils that the DNS works in a similar way to phone books, with a local cache (quick access copy) of numbers, the ISP's (internet service provider's) own cache, and a master list.
- There are occasions when the DNS doesn't work quite as it should, and so network engineers need to use a tool, in this case the nslookup command, to identify these problems in order to solve them.
- Ask the pupils to build up their own small 'cache' of IP addresses for some of their favourite websites. Ask them to write down five websites that they regularly use. The pupils can then use the nslookup command (via the Windows command prompt) to look up the IP address for any website, e.g. 'nslookup www.google.com'.
- Ask pupils if they can think of any way they could have sped up this process. Would it have been quicker if they'd all shared their lists, so that they didn't need to look up addresses if someone else already had? Explain that this sharing of IP address lookups is done automatically by the DNS.

Extensions

SCHOOL

- Some pupils might like to explore domain registration details on the web via, e.g. http://whois.net.

HOME

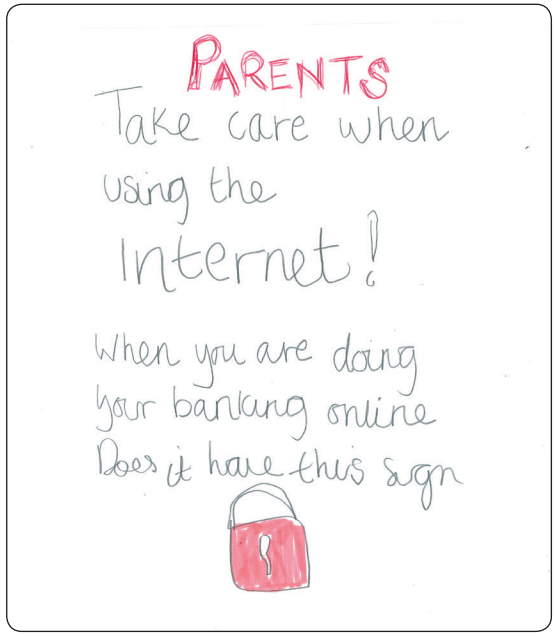
- Ask pupils to explain how the domain name system works to their parents, perhaps using the nslookup command to illustrate this.

Step 6: Implications for safety

RESOURCES

- Pupil self-assessment information

POSSIBLE OUTCOME FOR THIS STEP:



- Ask the pupils to imagine they want to send a private message to a friend through the post. In how many ways could someone either read their message or substitute a different message for it? Would they, or their friend, be able to tell that this had happened?
- Remind the pupils that packets of data on the internet make lots of hops on the journey from sender to recipient. Explain that any of the switches or routers along the way *could* read the data in the packet (like sending a postcard through the mail). How do the pupils feel about that? Are there occasions when this might be a problem or would worry them? Suggest examples of internet banking that their parents or carers use, or typing in passwords for other accounts.
- Explain that any time a computer sends or receives packets of data, the computer, and perhaps the routers and switches, can log that data has been sent or received. Remind the pupils that each computer on the internet has its own unique IP address, and that these can be located on a map. Do the pupils mind that there might be a record of all that they do using the internet?
- Ask the pupils to think about what could happen if the IP address for a web server was changed to point to another computer on the internet. Would it be a problem if, when they thought they were connecting to the school learning platform, they were actually using a different web server? What if it were their parents doing online banking?
- Ask the pupils to create a poster illustrating one or more of these issues, and drawing on their knowledge of how the internet works. The pupils should provide feedback on one another's posters.
- Finally, ask the pupils to reflect on what they have learned in this unit.

SCHOOL

- Some pupils could create a presentation discussing how knowing how the internet works can help keep you safe online.

HOME

- Ask the pupils to write up their work during the unit as a blog post, perhaps illustrating it with photos and screenshots.

4 Assessment guidance

Use this page to assess the children's computing knowledge and skills. You may wish to use these statements in conjunction with the badges provided on the CD-ROM or community site and/or with your own school policy for assessing work.

ALL CHILDREN SHOULD BE ABLE TO:	BADGE	COMPUTING PoS REFERENCE
Name some of the hardware that connects computers		Understand computer networks including the internet
Take part in a simulation of how data is transmitted via the internet		Understand computer networks including the internet
Use ping, ipconfig and tracert commands		Understand computer networks including the internet; use technology responsibly
Appreciate the implications of how networks work for their online safety		Use technology safely

MOST CHILDREN WILL BE ABLE TO:		
Describe the functions of the different hardware used to connect computers		Understand computer networks including the internet
Describe how data is transmitted via the internet		Understand computer networks including the internet
Describe the different uses of ping, ipconfig, tracert and nslookup commands		Understand computer networks including the internet
Consider some of the ways in which their safety or privacy may be compromised by using the internet		Recognise acceptable/unacceptable behaviour

SOME CHILDREN WILL BE ABLE TO:		
Discuss the hardware involved in connecting a classroom computer to a web server in another country		Understand computer networks including the internet
Discuss some of the protocols involved in transmitting data via the internet		Understand computer networks including the internet
Discuss the output produced by ping, ipconfig, tracert and nslookup commands		Understand computer networks including the internet

PROGRESSION

The following units will allow your children to develop their knowledge and skills further.

- *Unit 3.5 – We are communicators*
- *Unit 5.2 – We are cryptographers*
- *Unit 5.4 – We are web developers*

5 Classroom ideas

Practical suggestions to bring this unit alive!

DISPLAYS AND ACTIVITIES

- There is scope for lots of effective display work around digitisation.
- Mapping the tracert hops between school and some common websites would be an interesting display, drawing together the pupils' technical and geographic knowledge. Open Visual Traceroute (see *Useful links* on page 43) helps children to visualise the geographical movement of data.
- If pupils create posters during the unit, these would also be an effective and informative display.
- A couple of role-play activities are suggested during the unit. With rehearsal, these could be demonstrated in assembly.

WEBLINKS

- The Journey Inside the internet: www.intel.com/content/www/us/en/education/k12/the-journey-inside/explore-the-curriculum/internet.html.
- Course on internet history, technology and security: www.coursera.org/course/insidetheinternet.
- Course on computer networks: www.coursera.org/course/comnetworks.
- Activities on how different types of information can be represented as numbers: http://csunplugged.org/activities.
- A guide to DNS: http://coding.smashingmagazine.com/2011/05/25/introduction-to-dns-explaining-the-dreaded-dns-delay.
- The CAS infrastructure whitepaper: http://community.computingatschool.org.uk/resources/446.

VISITS

- The Science Museum's new Information Age gallery (due to open from September 2014) would be well worth a visit for this unit.
- The National Museum of Computing at Bletchley Park, and Bletchley Park itself, have many exhibits directly relevant to this work. Some of these resources are available via the NEN to subscribing schools at www.hoc.lgfl.net.
- Take a virtual tour of a Google data centre: http://www.google.co.uk/about/datacenters/inside/streetview, www.google.co.uk/about/datacenters/inside.

BOOKS

- Blum, A. *Tubes: Behind the Scenes at the Internet*. (Penguin, 2012)
- Freeman, J. *The Tyranny of E-mail*. (Scribner, 2009)
- Hafner, K. and Lyon, M. *Where Wizards Stay Up Late: The Origins of the Internet*. (Simon and Schuster, 1998)
- Lowe, D. *Networking All-in-One For Dummies*. (John Wiley and Sons, 2012)
- Naughton, J. *A Brief History of the Future: Origins of the Internet.* (Phoenix, 2000)
- Naughton, J. *From Gutenberg to Zuckerberg. What You Really Need to Know About the Internet*. (Quercus, 2012)
- Ryan, J. *A History of the Internet and the Digital Future*. (Reaktion, 2013)

6 Taking it further

When you've finished, you might want to extend the project in the following ways.

- Look for further opportunities for the pupils to use the command prompt.
- Look for other ways in which pupils could use a Raspberry Pi – there are plenty of ideas online, and much interest in using these simple, low-cost computers in education.
- Setting up a new computer suite or adding new devices onto an existing network, either at school or at home, would allow the pupils to see practical application of this technical knowledge.
- Encourage the pupils to explain the ideas in this unit to others, including their parents or carers and your colleagues.
- Take care to use 'internet' and 'web' correctly, and gently correct the pupils if they use one term for the other.