Networking IoT

Lê Thế Dũng, Ph.D.

Dep. of Computing Fundamentals, FPT University, Viet Nam

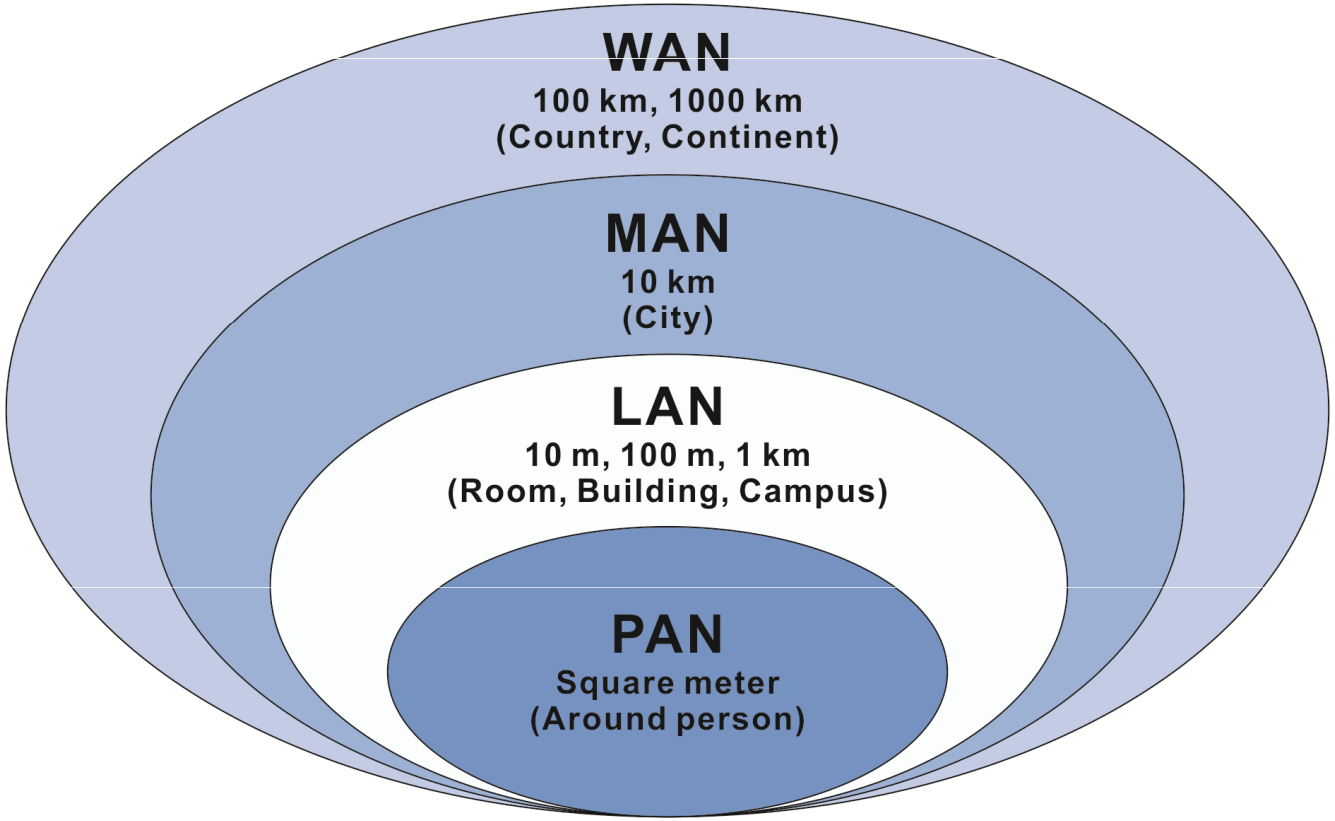
January 2023

Outlines

- Network Types
- Network Components
- Communication Medium
- Routing
  - Example 1: Uploading a photo to the Internet
  - Example 2: Viewing the photo uploaded to the Internet
- Trace the Route
- Internet Protocol (IP) Addresses
- IP Addresses Lookup
- Domain Name Servers
- Protocols and Standards
- IoT Connecting

Network Types

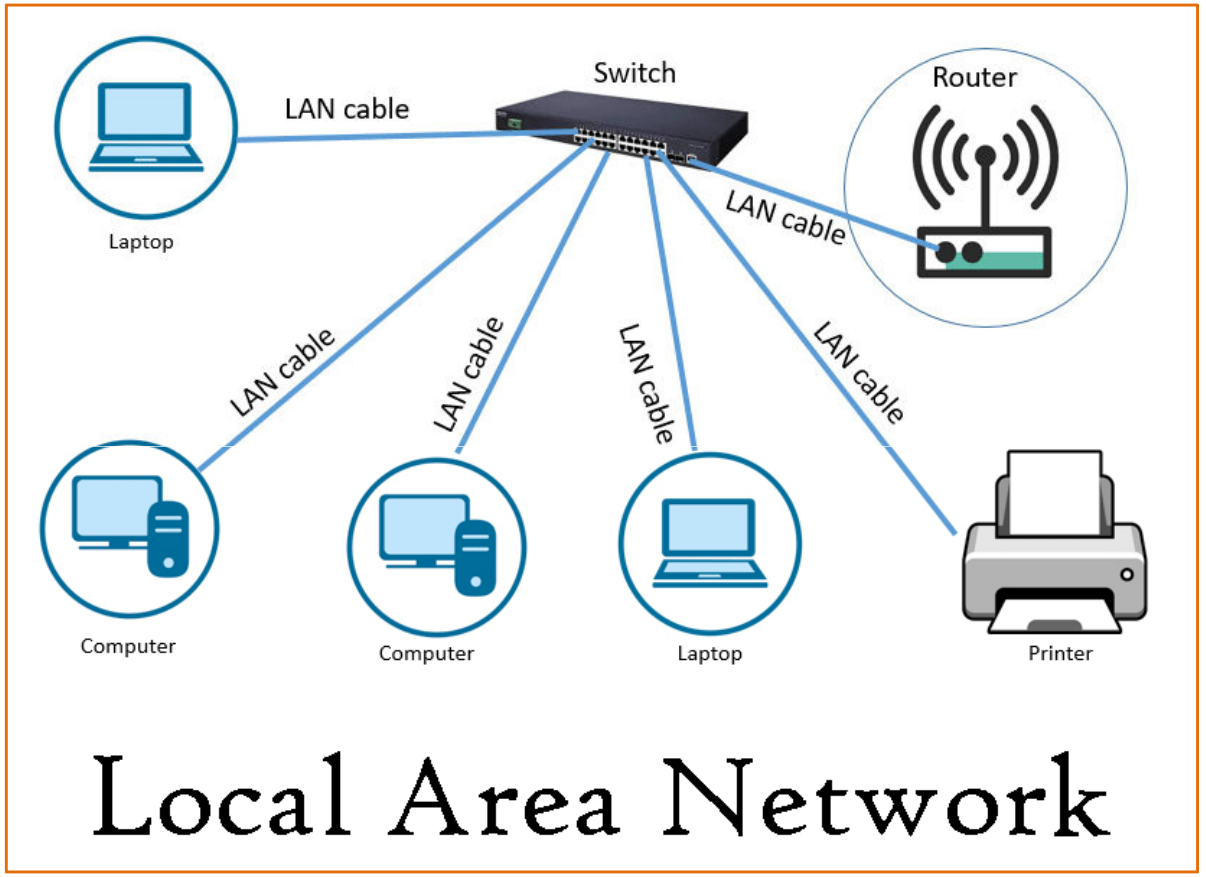
- Network types can be defined on the basis of network size, their capabilities and the geographical regions they cover.



WAN (wide area network); **MAN** (metropolitan area network); **LAN** (local area network); **PAN** (personal area network)

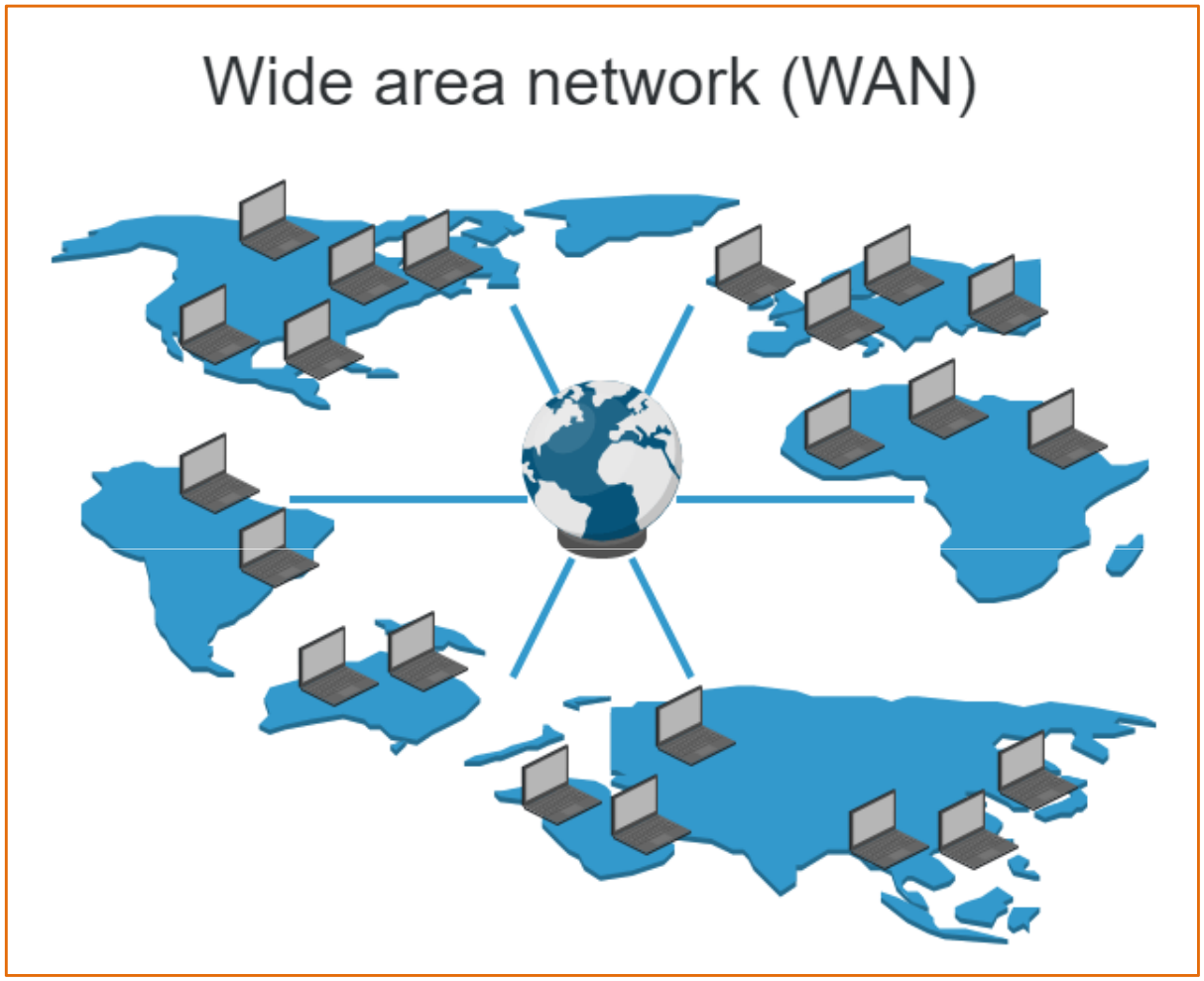
Network Types (cont.)

- In your home office you might have a computer and a printer. When you print something, the computer sends a message to the printer, and this message travels by either copper cable or wireless communication. This is your **home network**.

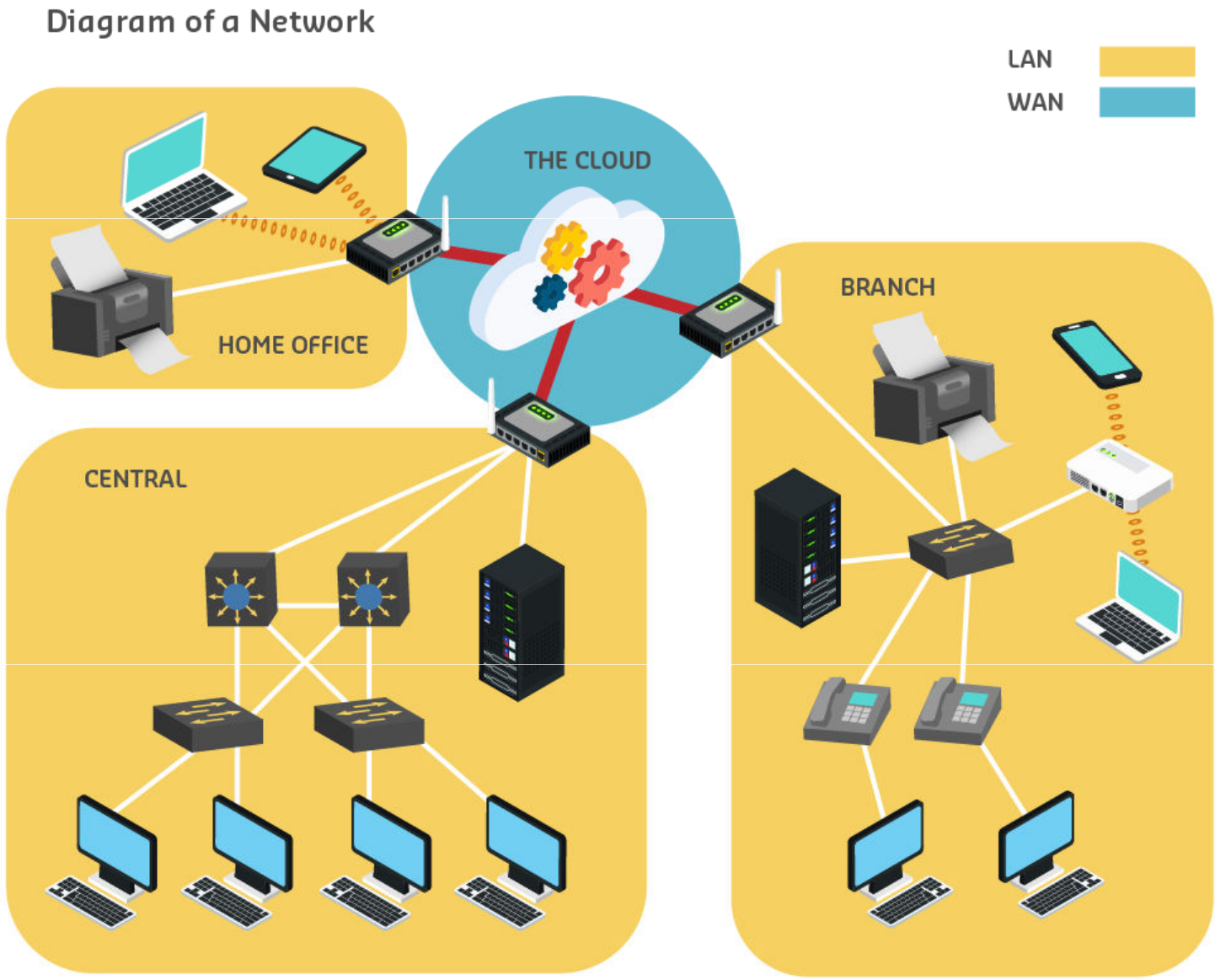


Network Types (cont.)

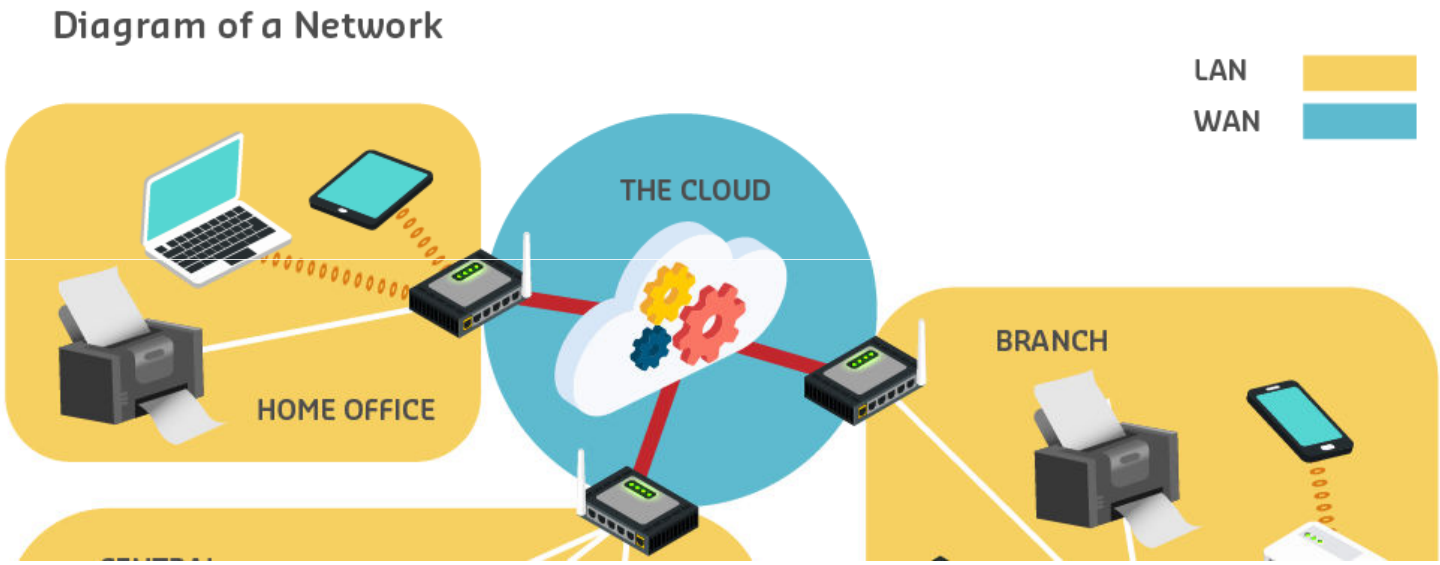
- When you want to look at a web page or send an email, you need to connect your computer, smartphone, or other device, to the internet. The internet is a network of networks, or internetwork.



Network Components



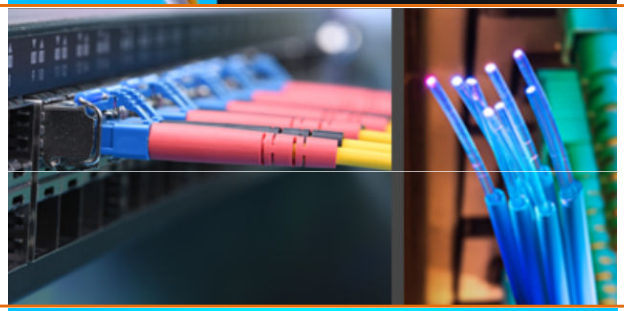
Network Components (cont.)



- This simple network has several key components:
  - Devices - includes the computers, printers, routers and servers.
  - Media - includes the cabling or wireless connections.
  - Services - includes the software that support operations, such as email hosting.
- You should know that the Internet of Things adds many more devices as well as more services to networks

Communication Medium

- Communication in the network is carried through a **medium** – currently this means via either a **cable** (for example, metallic wires in copper cables, or glass or plastic fibres in fibre optic cables) or the **air** (wireless transmission).

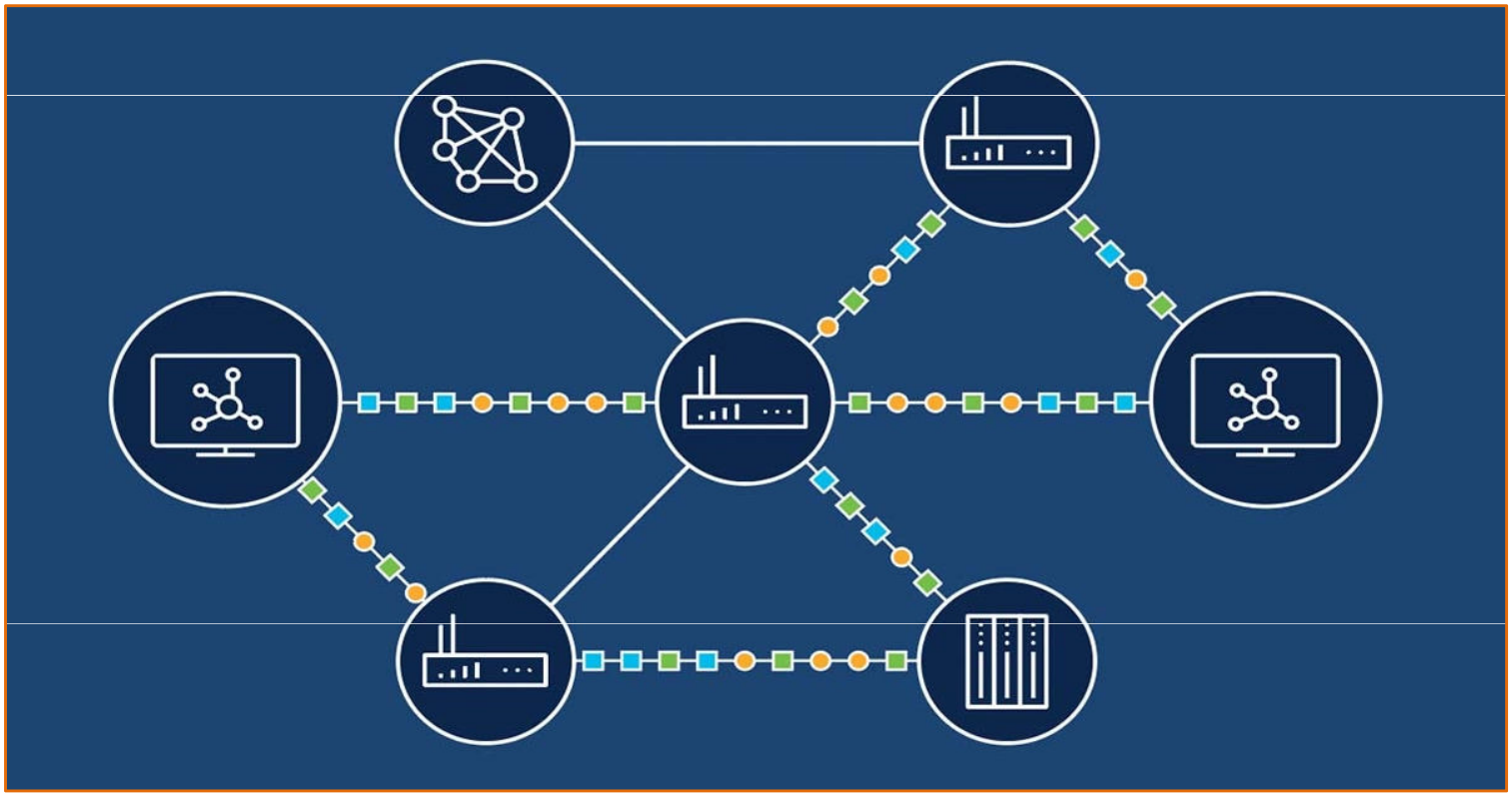
Metallic wires in cables – Cooper		Transfers data in electrical signals that match specific patterns
Glass or plastic fibers in cables – Fiber optic		Transfers data in pulses of light in either infrared or visible light range
Wireless transmission		Transfers data in patterns of electromagnetic waves

Communication Medium (cont.)

- The different media have different characteristics, which makes each better suited to different circumstances, taking into consideration factors such as:
  - the **distance** a signal needs to travel
  - the **environment** it is travelling in
  - the **amount** and **speed** of the data
  - the **cost** of the media and its installation.
- The IoT adds even more circumstances and considerations for connectivity, making the 'world wide web' look more like a web than ever before.

Routing

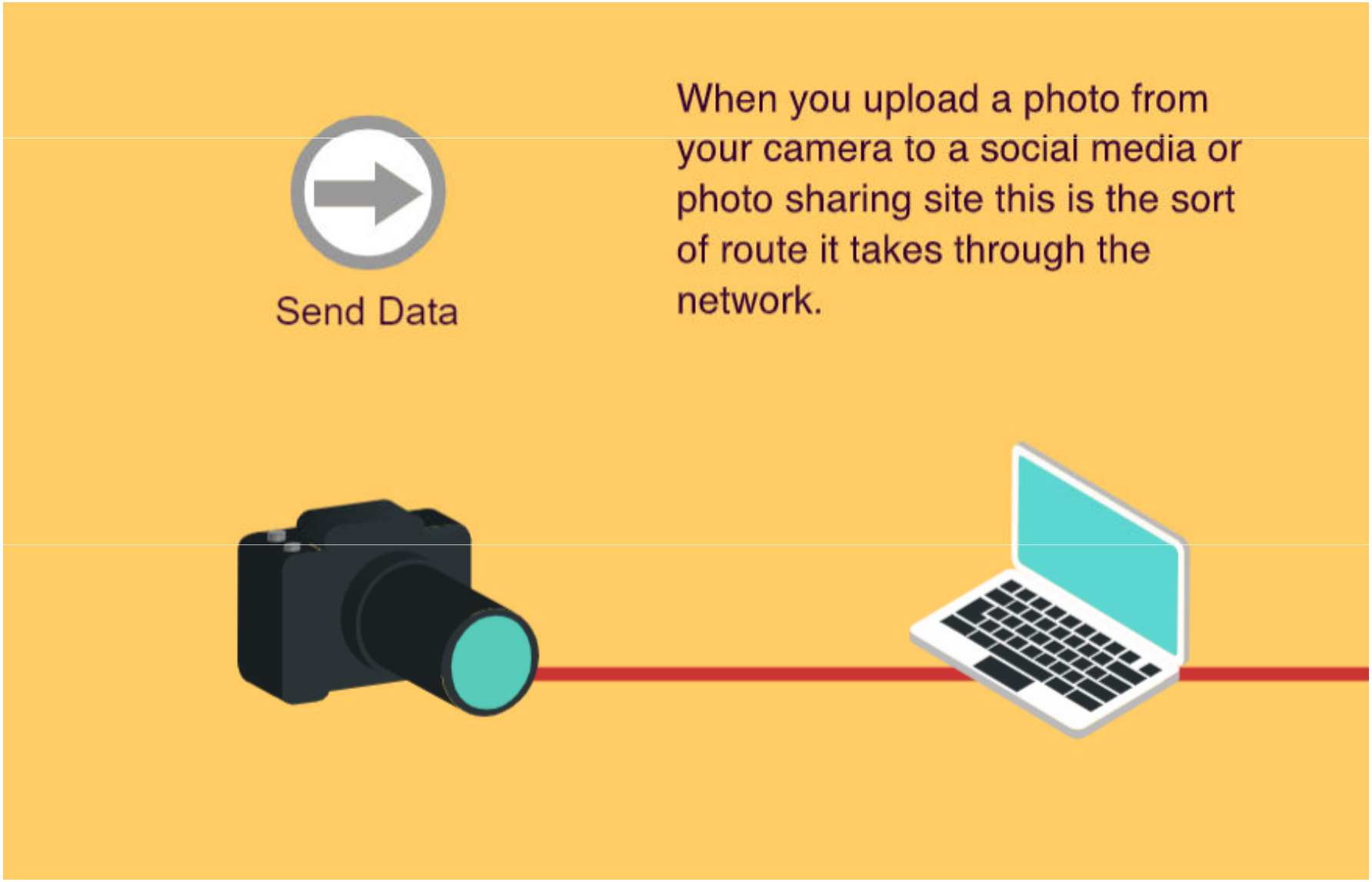
- Routing is the process of selecting a path for traffic in a network, or between or across multiple networks.



- Broadly, routing is performed in many types of networks, including circuit-switched networks, such as the public switched telephone network (PSTN), and computer networks, such as the Internet.

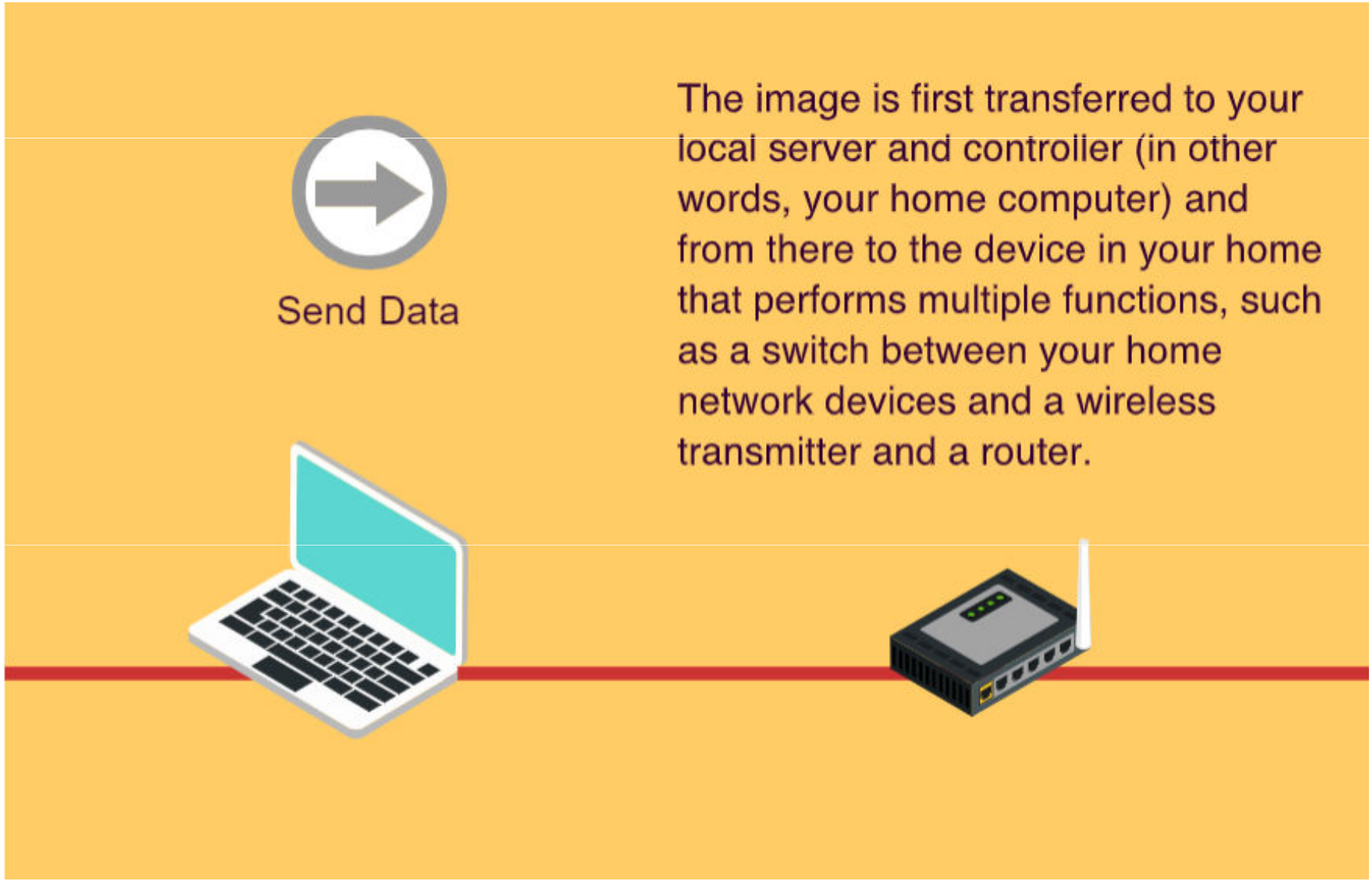
Routing – Example 1

- Example 1: uploading a photo from your camera to the Internet.



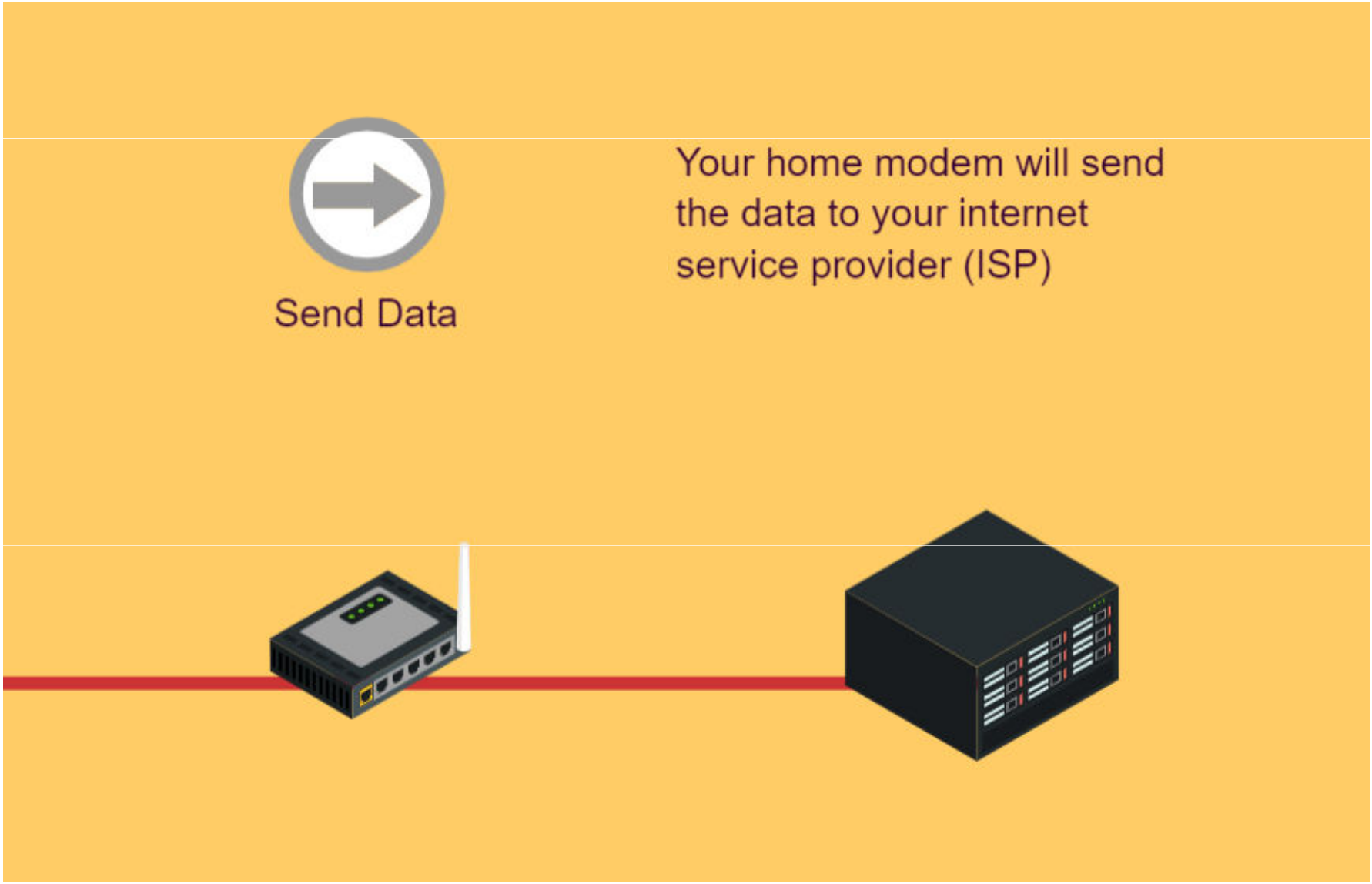
Routing – Example 1 (cont.)

- Example 1: uploading a photo from your camera to the Internet.



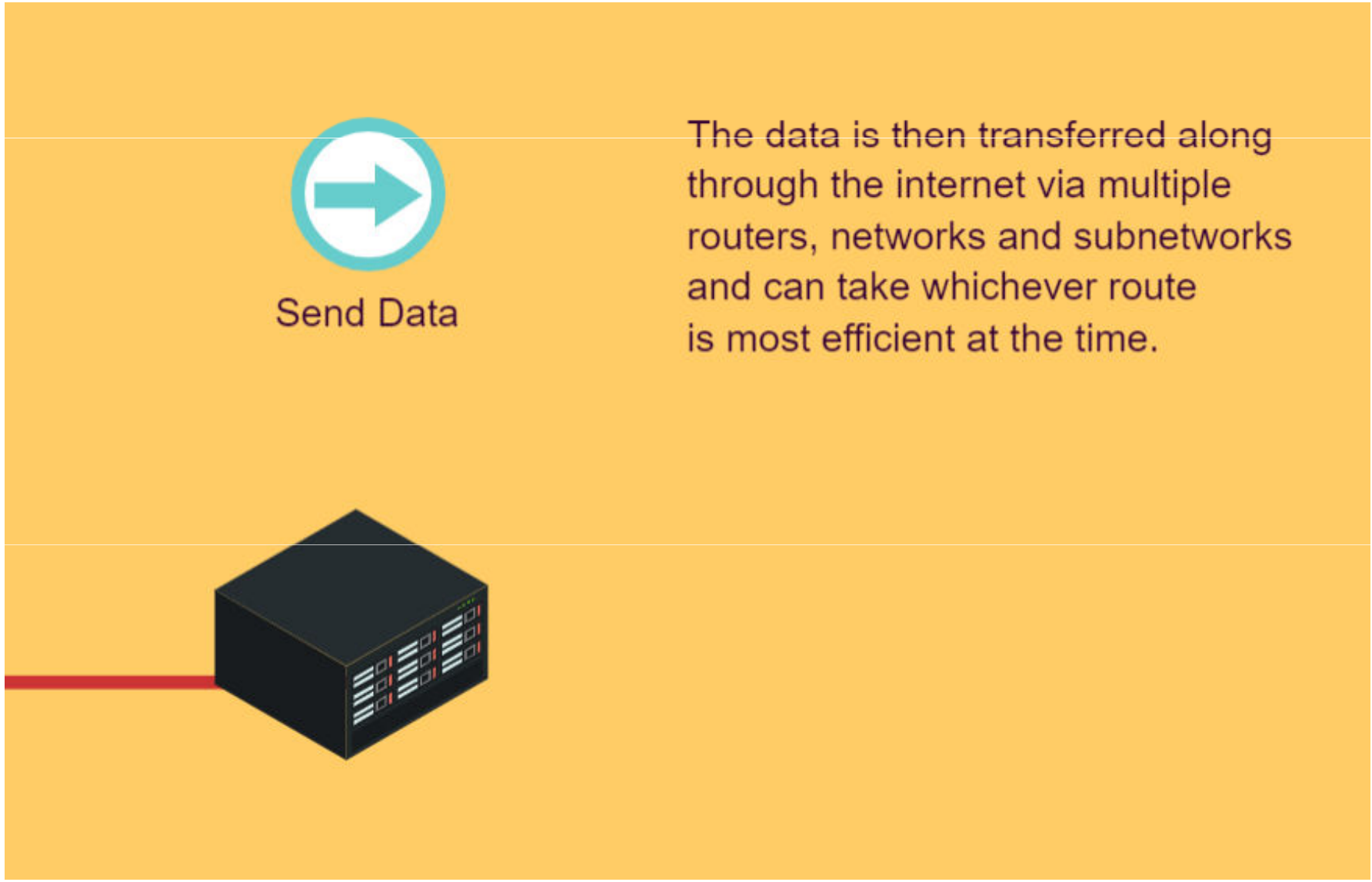
Routing – Example 1 (cont.)

- Example 1: uploading a photo from your camera to the Internet.



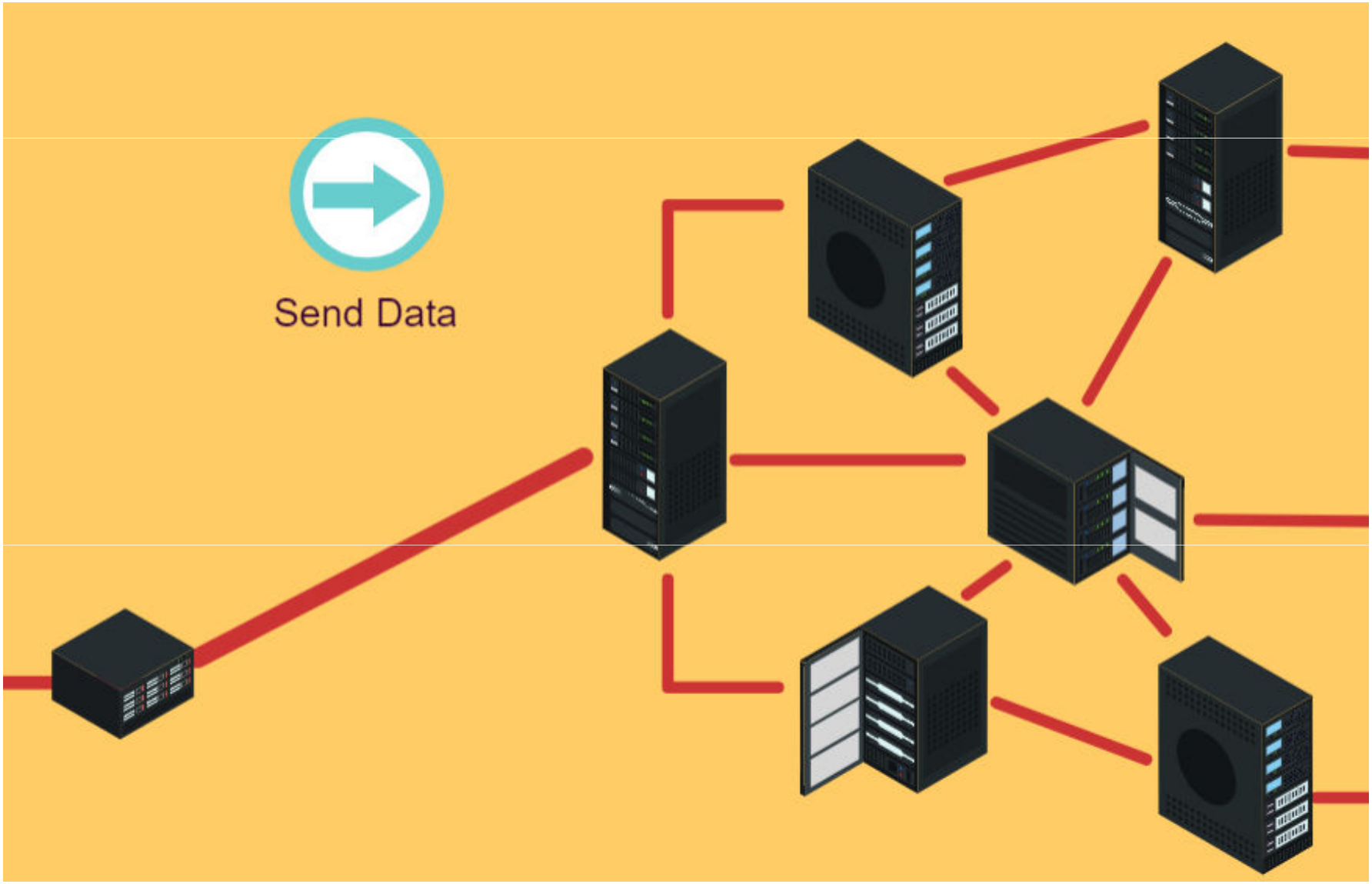
Routing – Example 1 (cont.)

- Example 1: uploading a photo from your camera to the Internet.



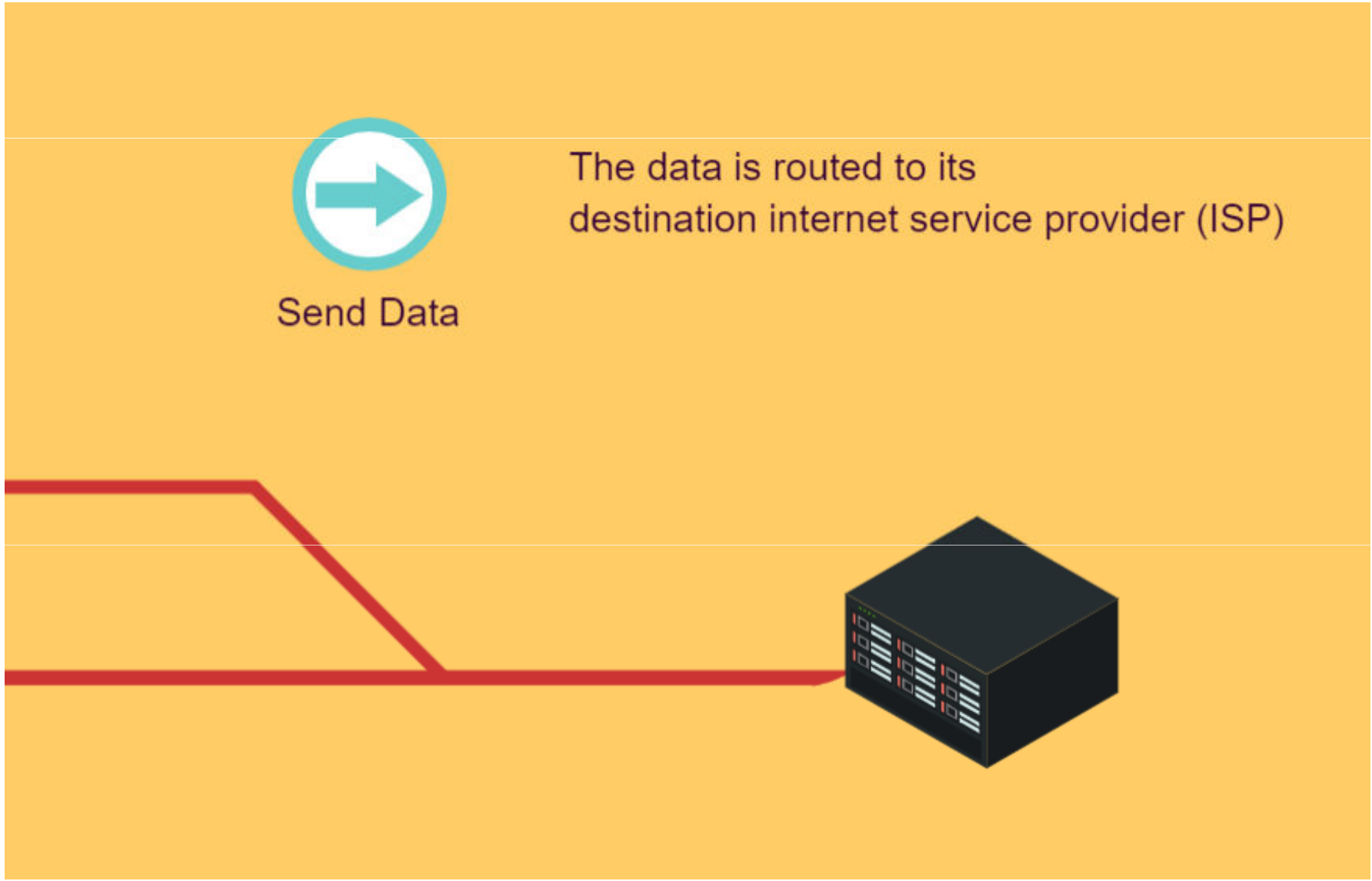
Routing – Example 1 (cont.)

- Example 1: uploading a photo from your camera to the Internet.



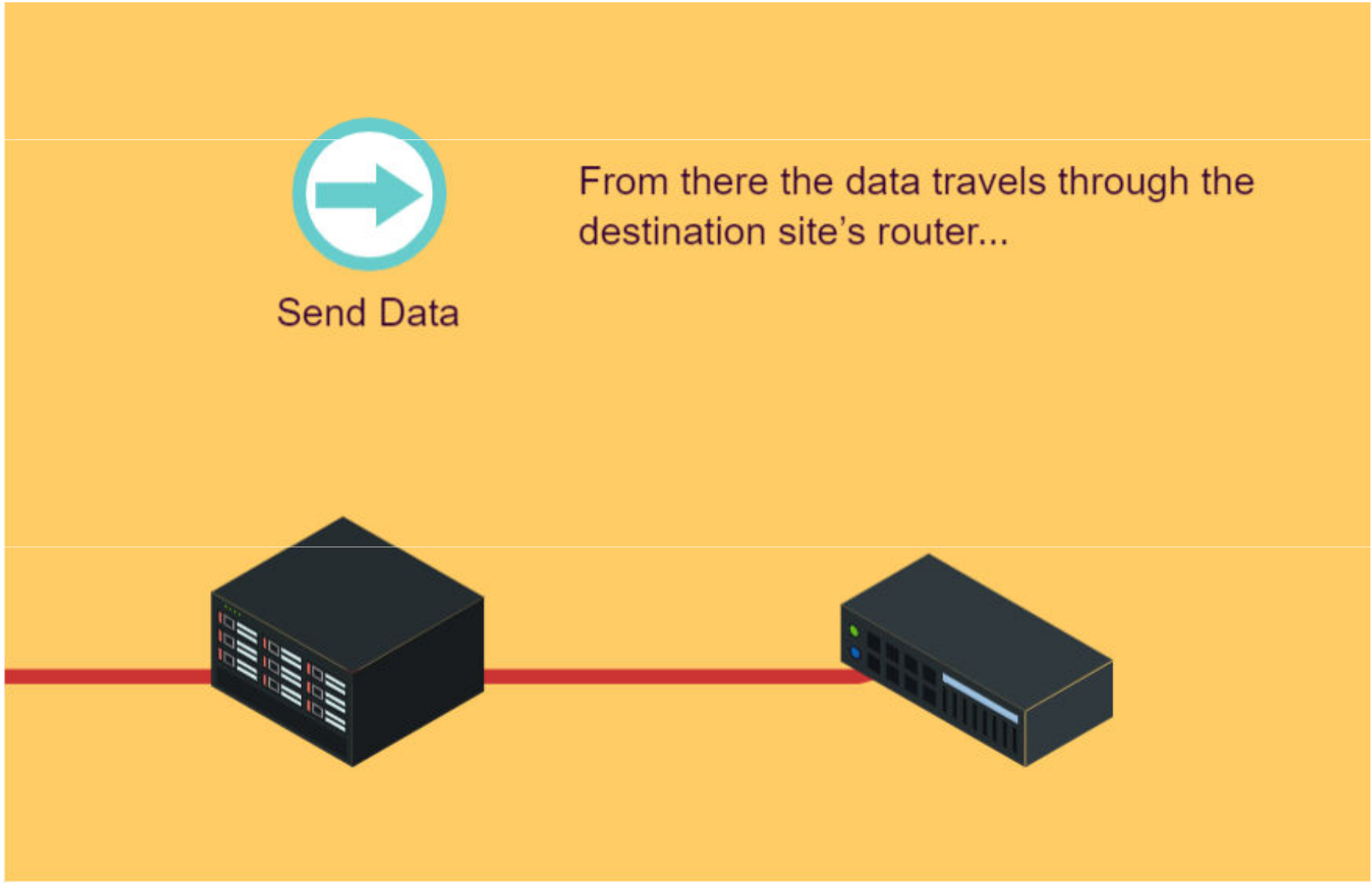
Routing – Example 1 (cont.)

- Example 1: uploading a photo from your camera to the Internet.



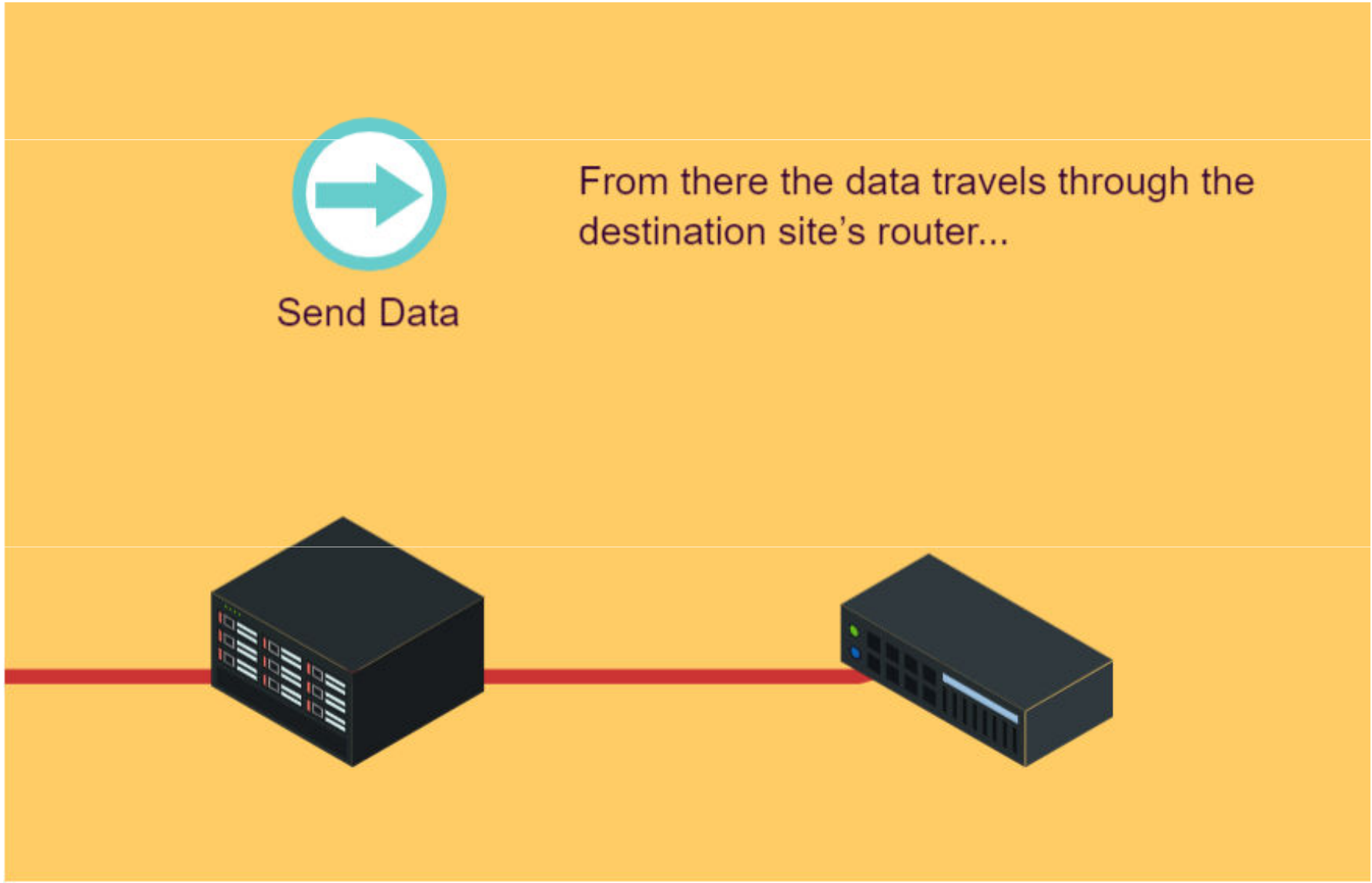
Routing – Example 1 (cont.)

- Example 1: uploading a photo from your camera to the Internet.



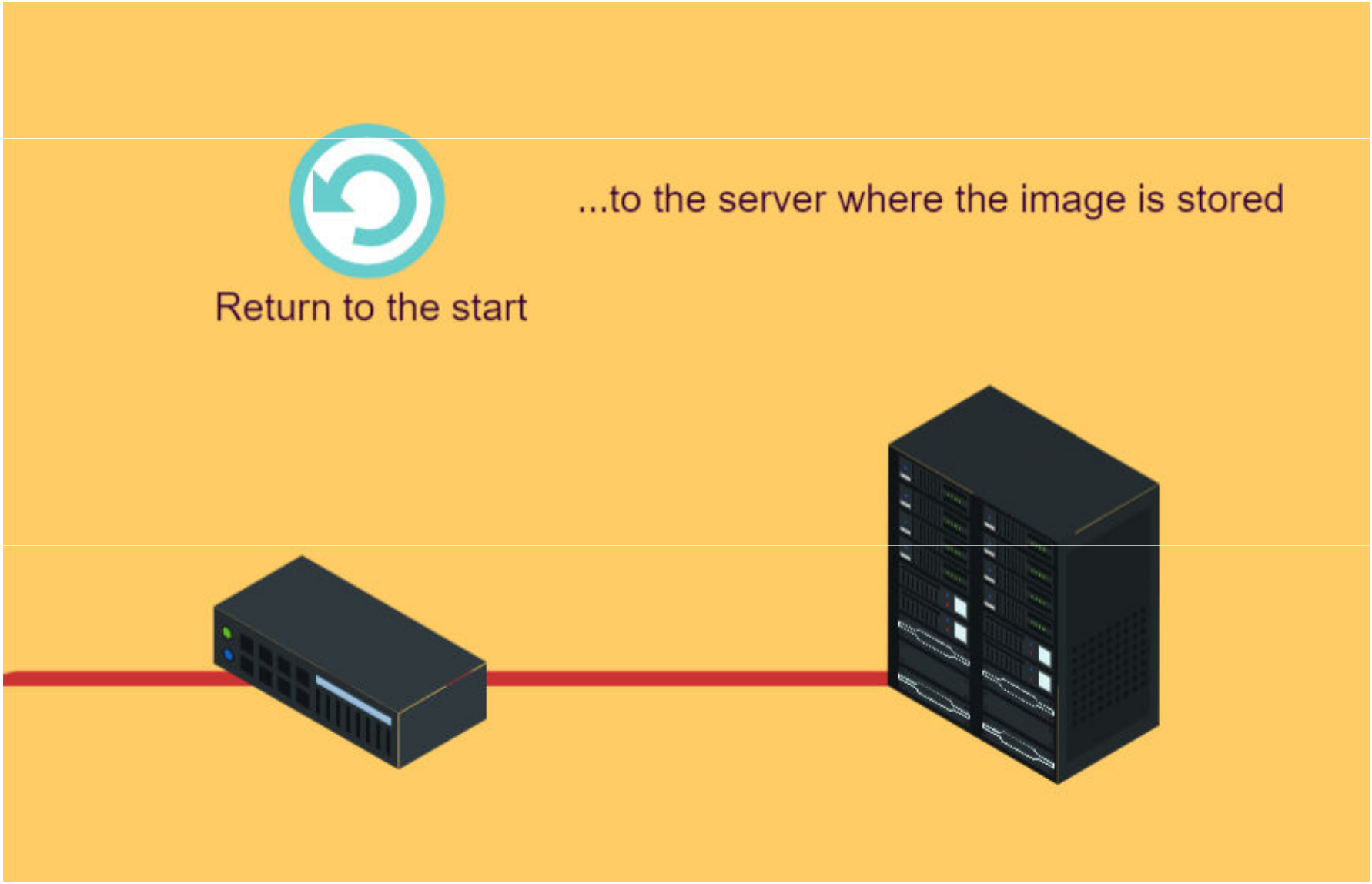
Routing – Example 1 (cont.)

- Example 1: uploading a photo from your camera to the Internet.



Routing – Example 1 (cont.)

- Example 1: uploading a photo from your camera to the Internet.

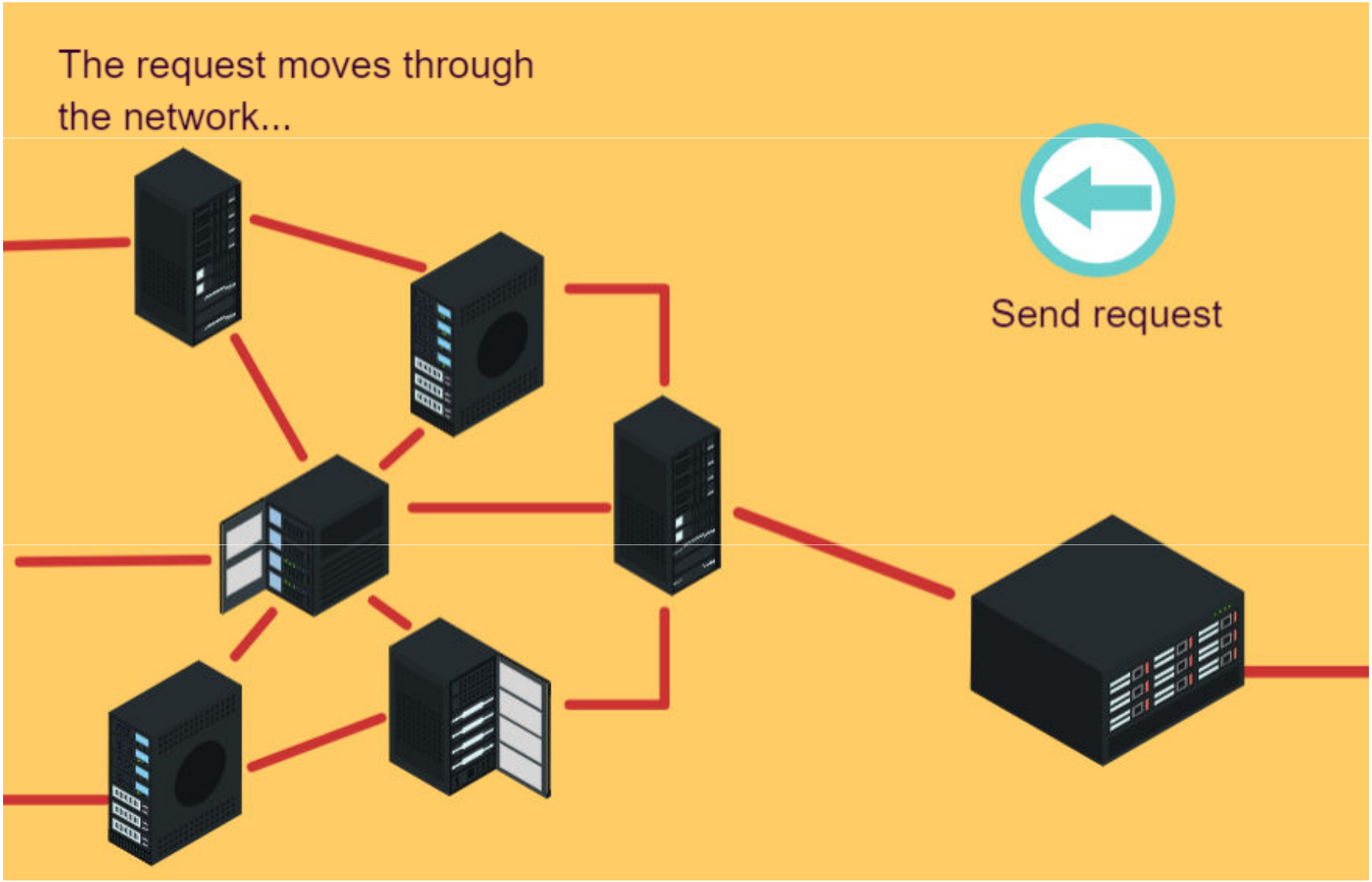


Routing – Example 2

- Example 2: view the photo uploaded to the Internet using smart phone.

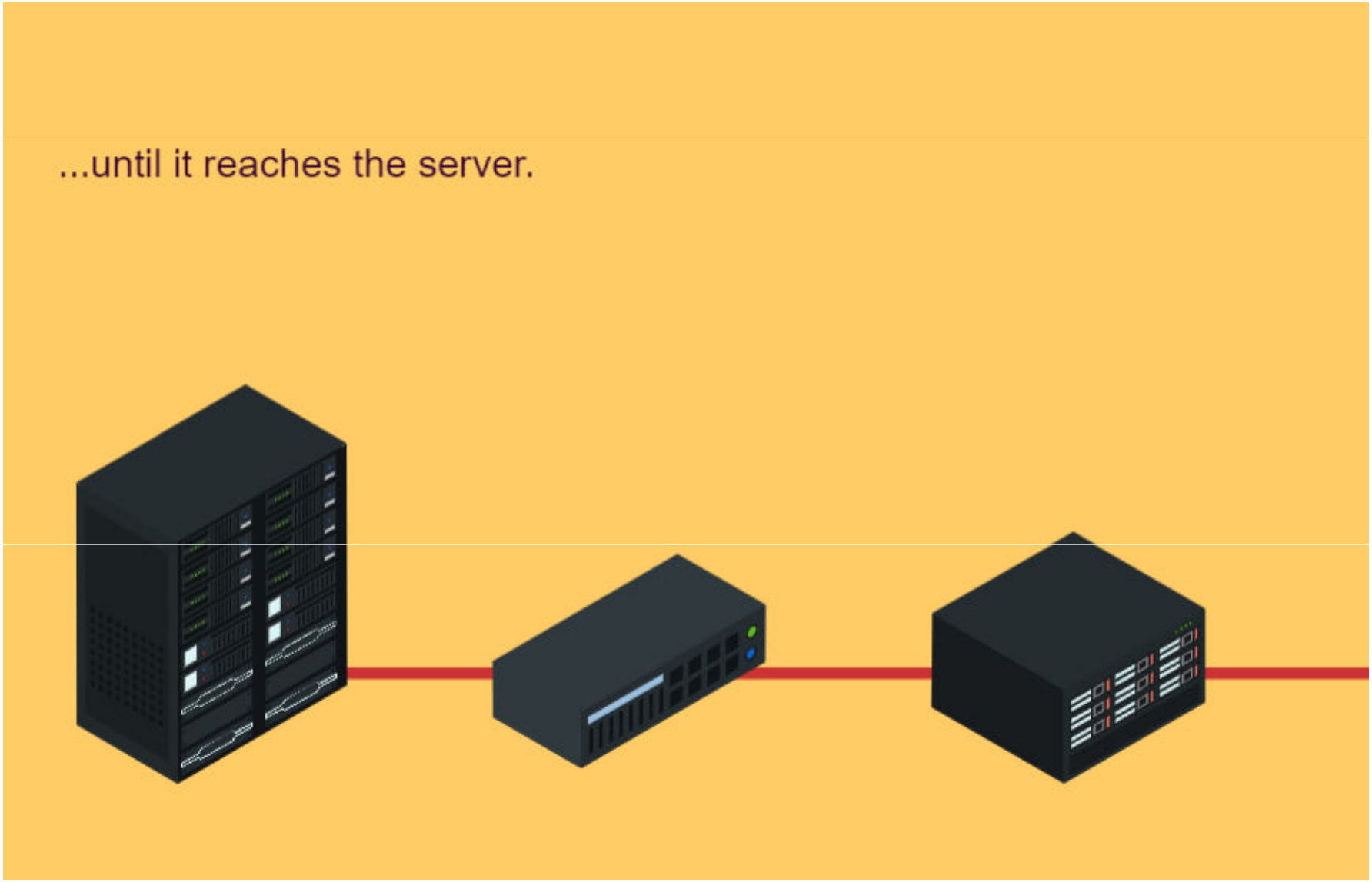
Routing – Example 2 (cont.)

- Example 2: view the photo uploaded to the Internet using smart phone.



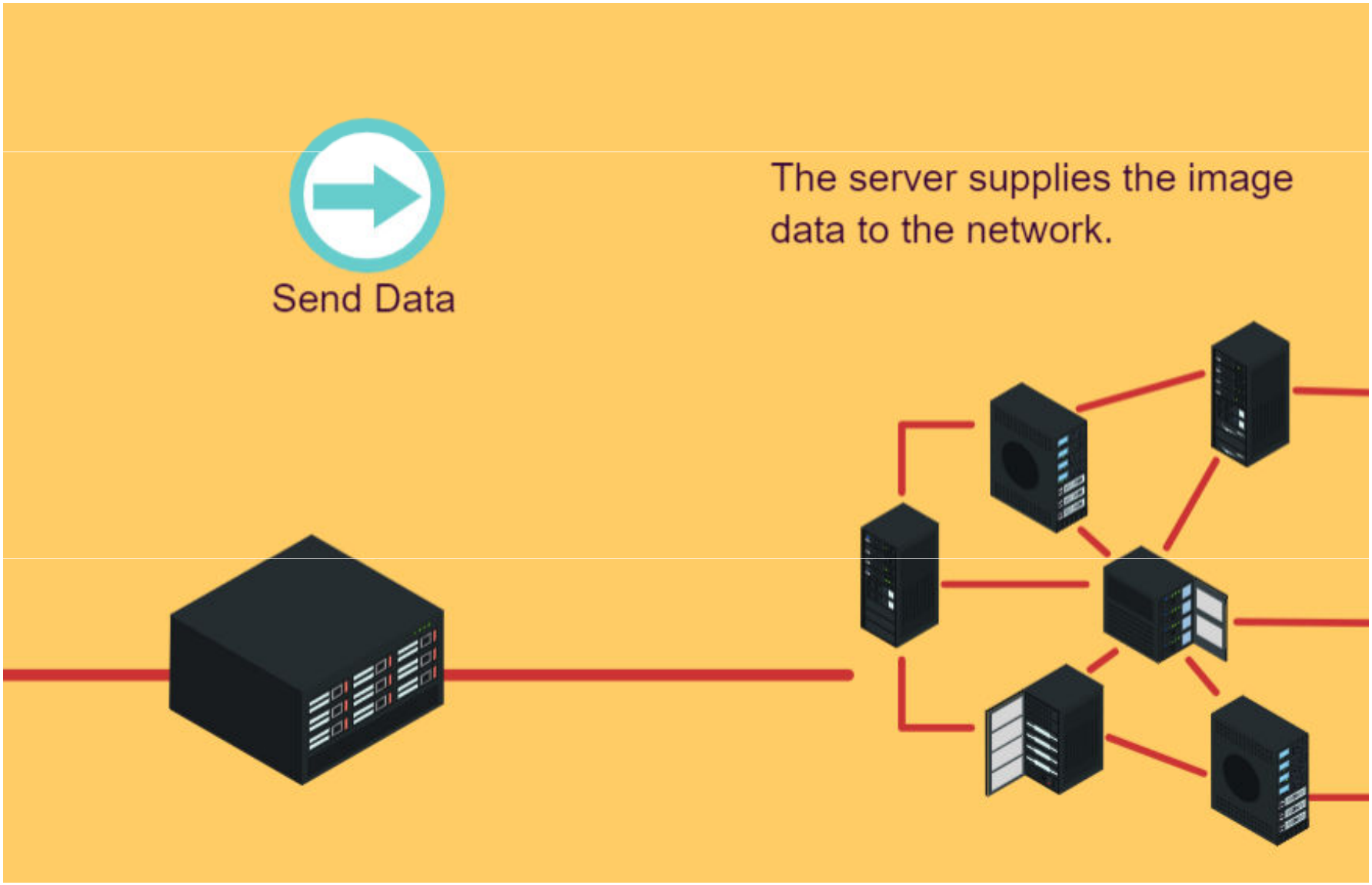
Routing – Example 2 (cont.)

- Example 2: view the photo uploaded to the Internet using smart phone.



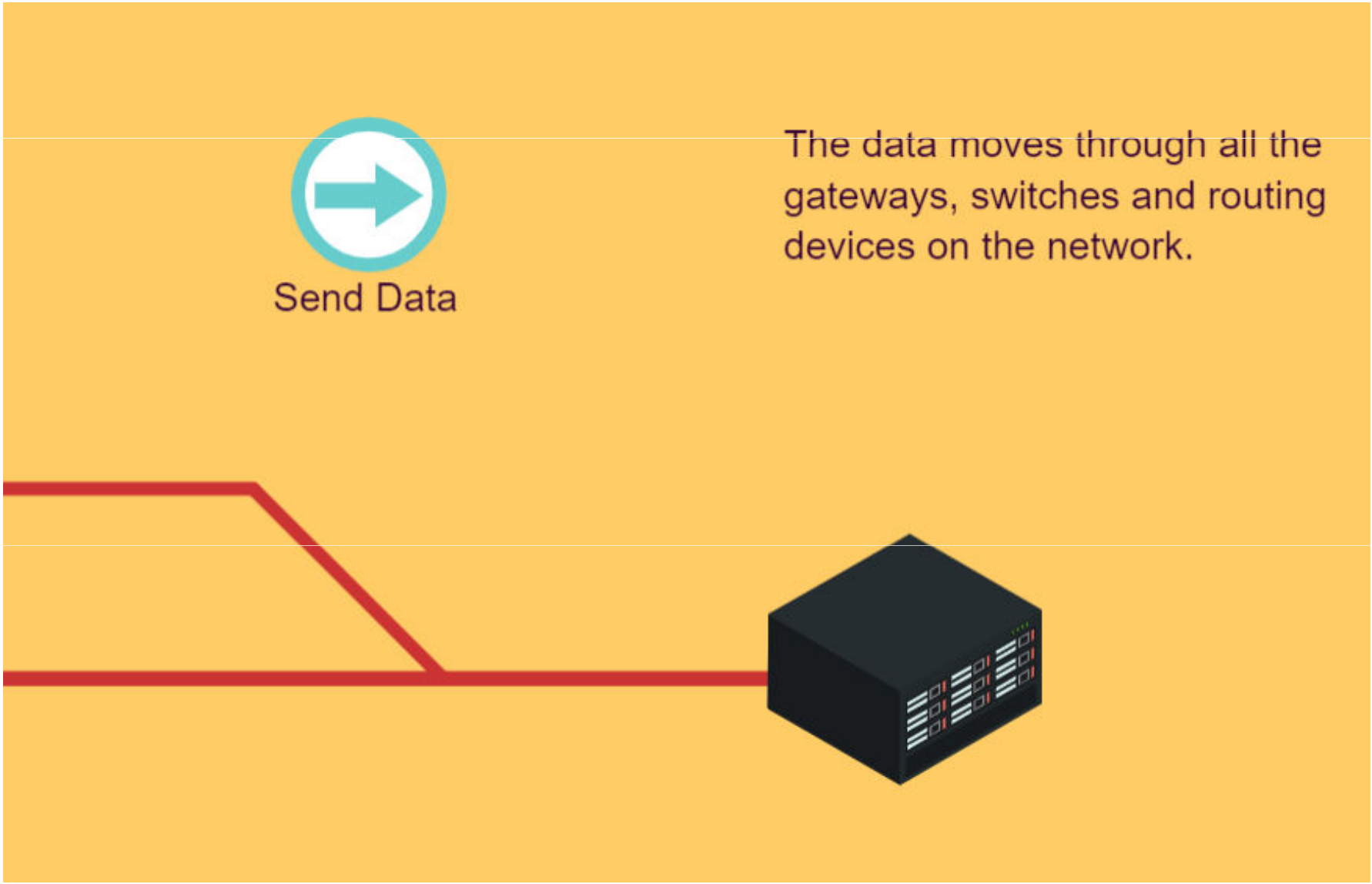
Routing – Example 2 (cont.)

- Example 2: view the photo uploaded to the Internet using smart phone.



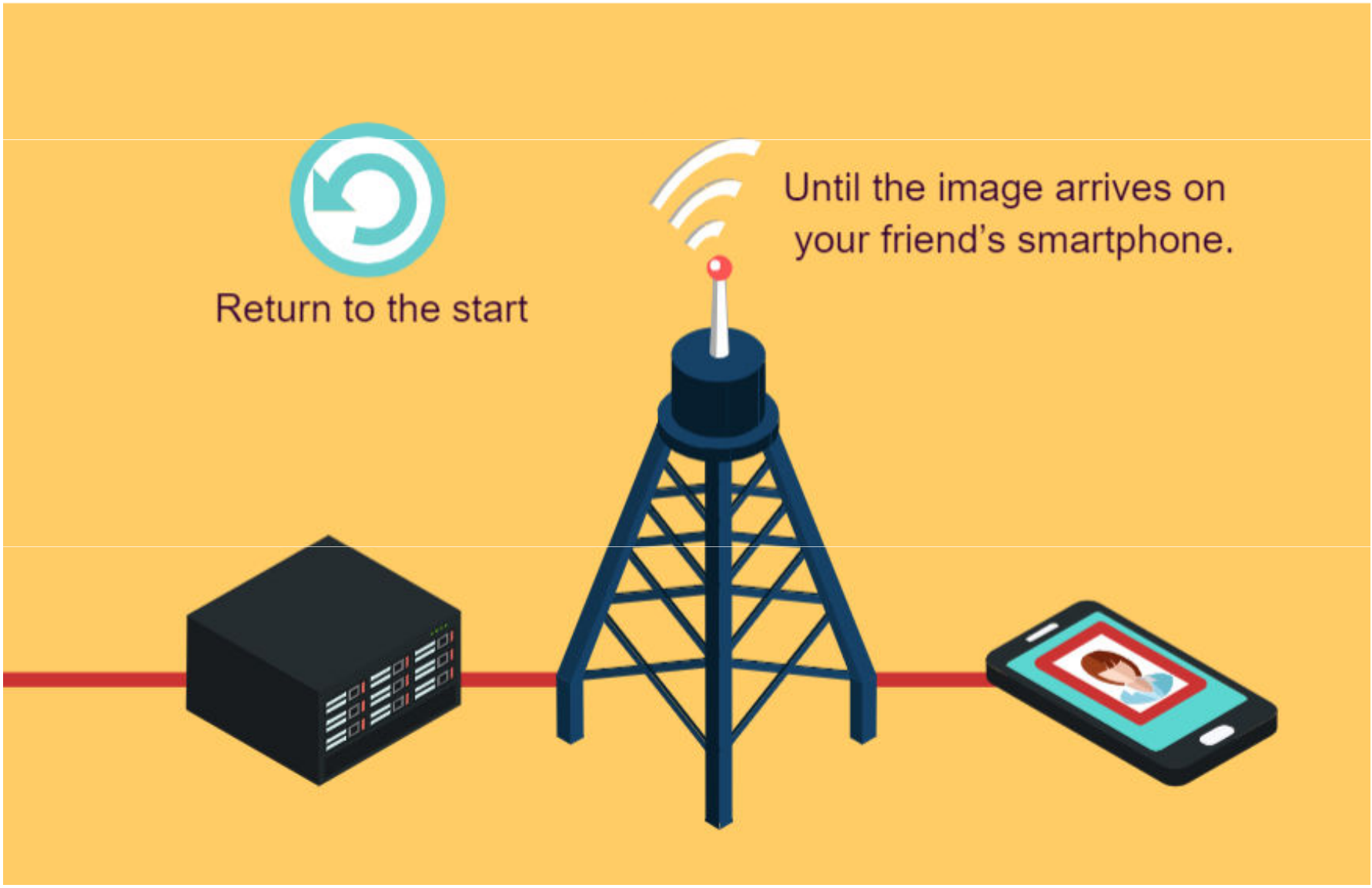
Routing – Example 2 (cont.)

- Example 2: view the photo uploaded to the Internet using smart phone.



Routing – Example 2 (cont.)

- Example 2: view the photo uploaded to the Internet using smart phone.

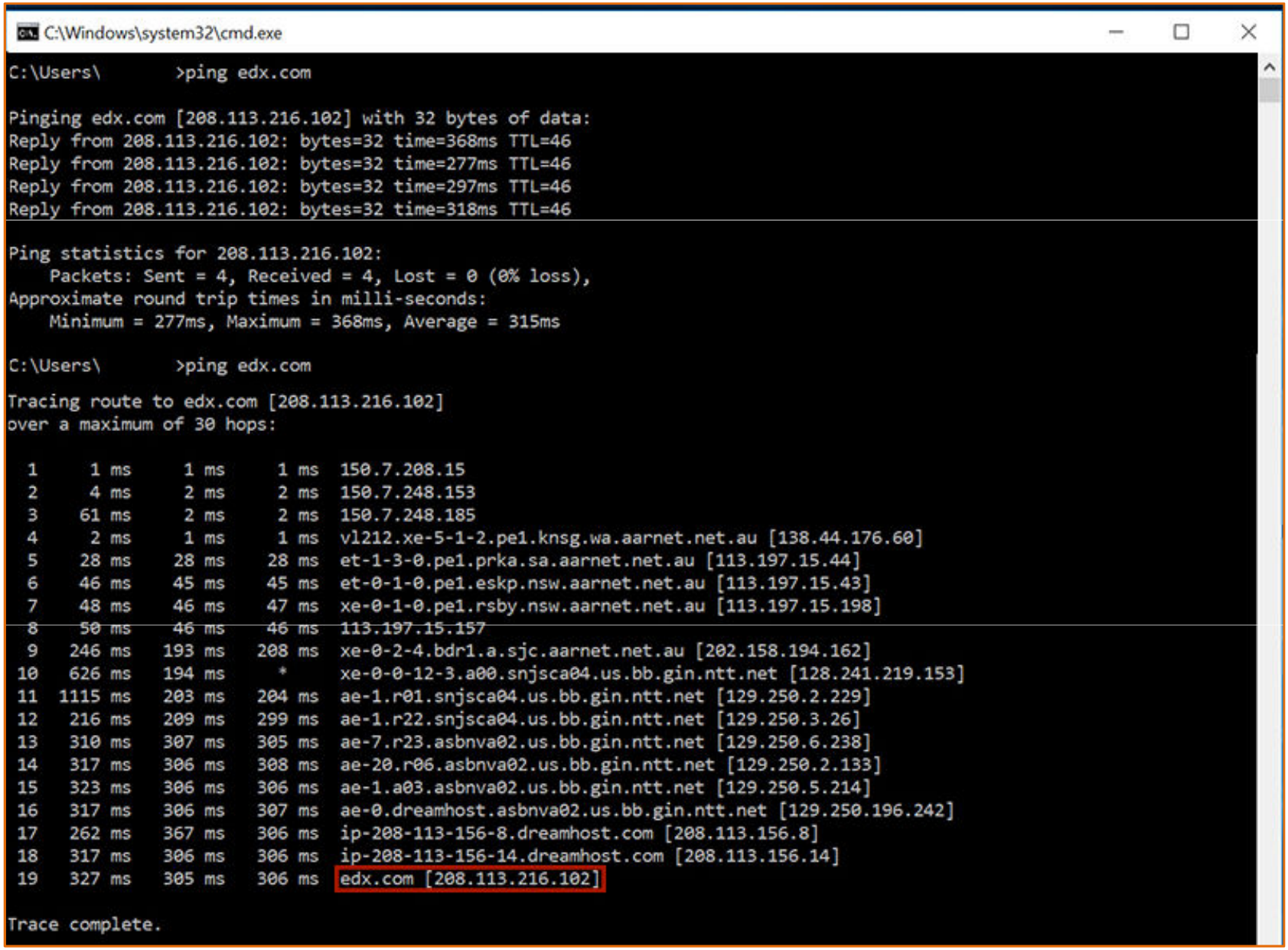


Trace the Route

- Step 1: Open your **Command Prompt** by navigating to the **search field**, and typing **cmd** into the search field.
  - (Another fast way to open the **Command Prompt** is to press the **Win +R** keys on your keyboard then type in **cmd**)
- Step 2: Try a '**ping**' to see if a computer on the network is there. You will see the approximate time it takes for the round trip of the '**ping.** '
  - For example, type: **ping edx.com** and press Enter.
- Step 3: Now type: **tracert edx.com** or substitute **edx.com** with whatever website you would like to ping.

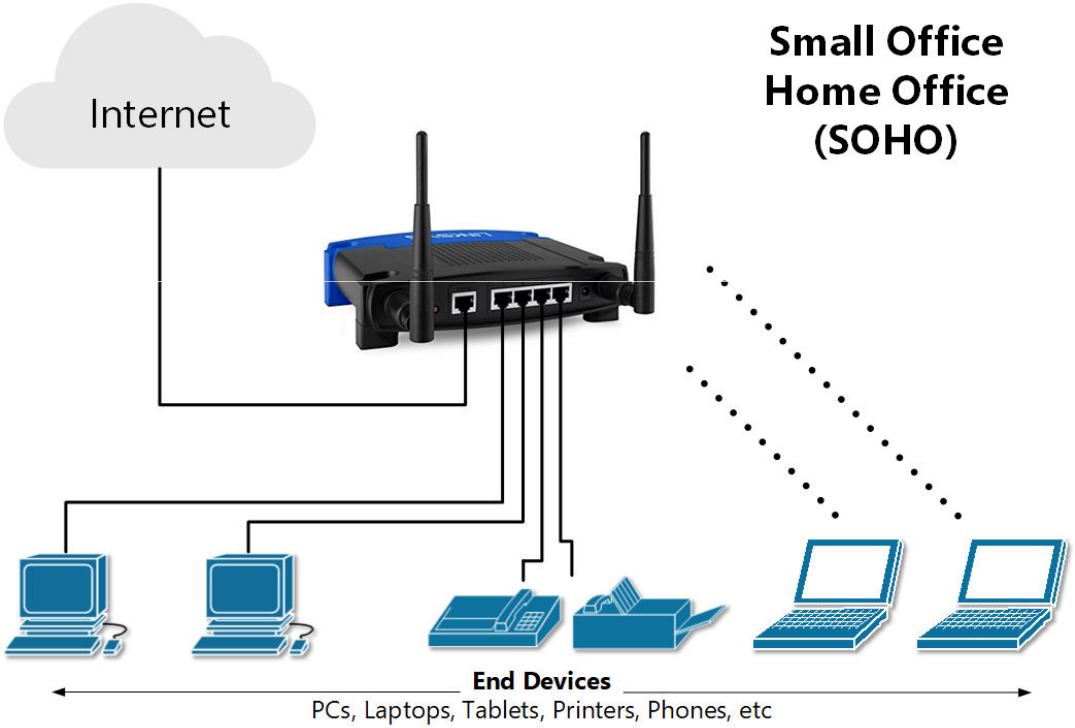
- Sending a command to trace the route of a website request (Step 3) will show you the route in detail - you will see all the different **routers and networks** that the request travels through, and finally the destination site with its IP address.

Trace the Route (cont.)



Internet Protocol (IP) Addresses

- End devices are those that provide a way for users to interact with the network. Examples include computers, smartphones and sensors.
- End devices are either the source or destination of data going over the network.
- Every device has a unique Internet Protocol (IP) address, so it is distinguishable from all other devices. When sending a message, the IP address of the destination is used to specify where the message is being sent, similar to the address printed on the envelope of a letter.

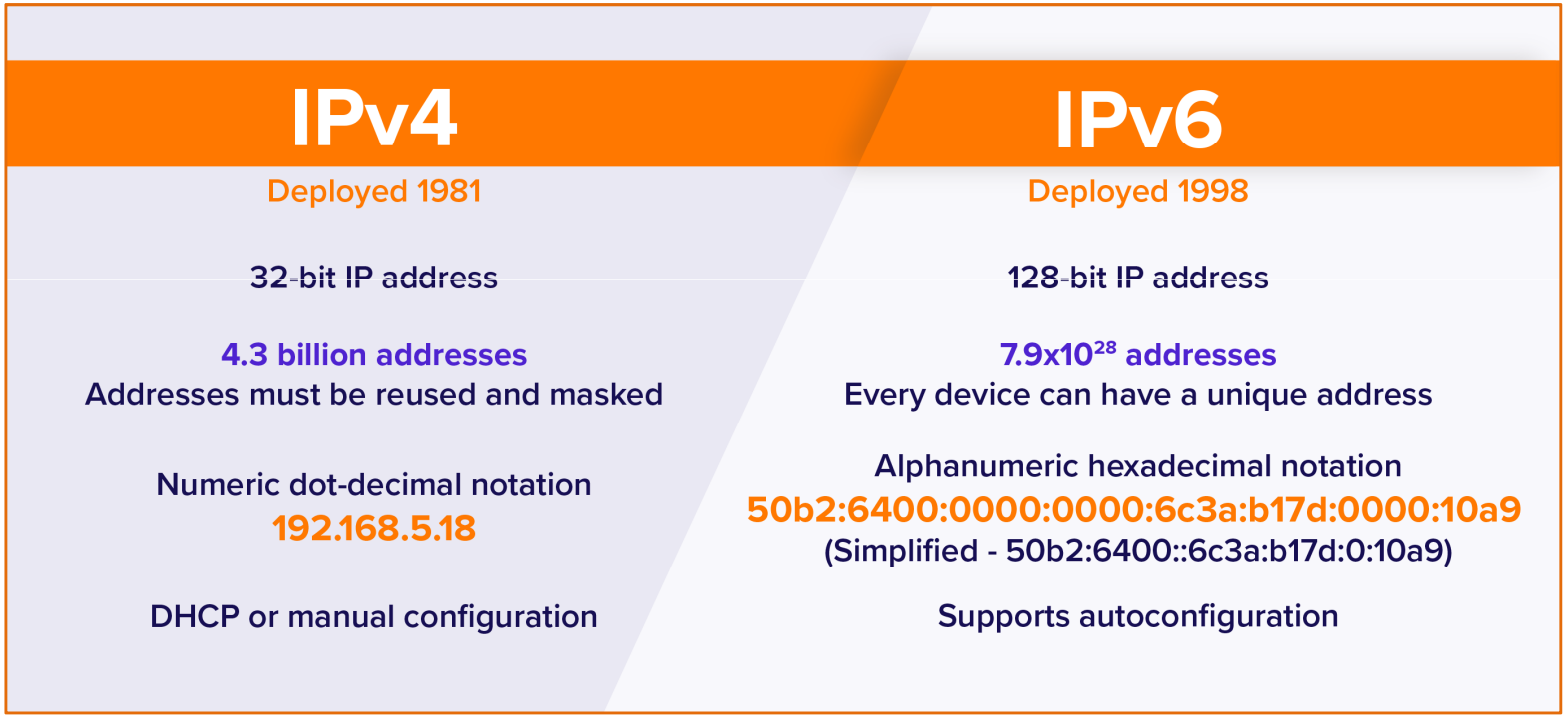


Internet Protocol (IP) Addresses (cont.)

- Intermediary devices interconnect end devices; host to the network, and networks to other networks. Intermediary devices also manage the data through the network - they act like the 'post master' in mail delivery scenarios.

Internet Protocol (IP) Addresses (cont.)

- The addresses used to send data in networks are called **Internet Protocol (IP) addresses**. Ipv4 (version 4) is what is typically in use currently.
- Ipv4 addresses consist of four sets of numbers separated by periods, and each number is between 0 - 255.
- Ipv6 is being developed using six sets of numbers, colons and hexadecimal numbering to allow many more destination addresses. These will help to facilitate IoT, as well as adding features for improved routing, security and data flow.



IP Addresses Lookup

- **Step 1:** Open **Command Prompt** (PC) or **Terminal** (Mac) as described previously in the Trace the Route activity.
- **Step 2:** Type **nslookup** and press Enter/Return.
- **Step 3:** Type in the address of a web site you want to look up. Try looking up a website you use often.

DISCUSSION: Facebook IP addresses

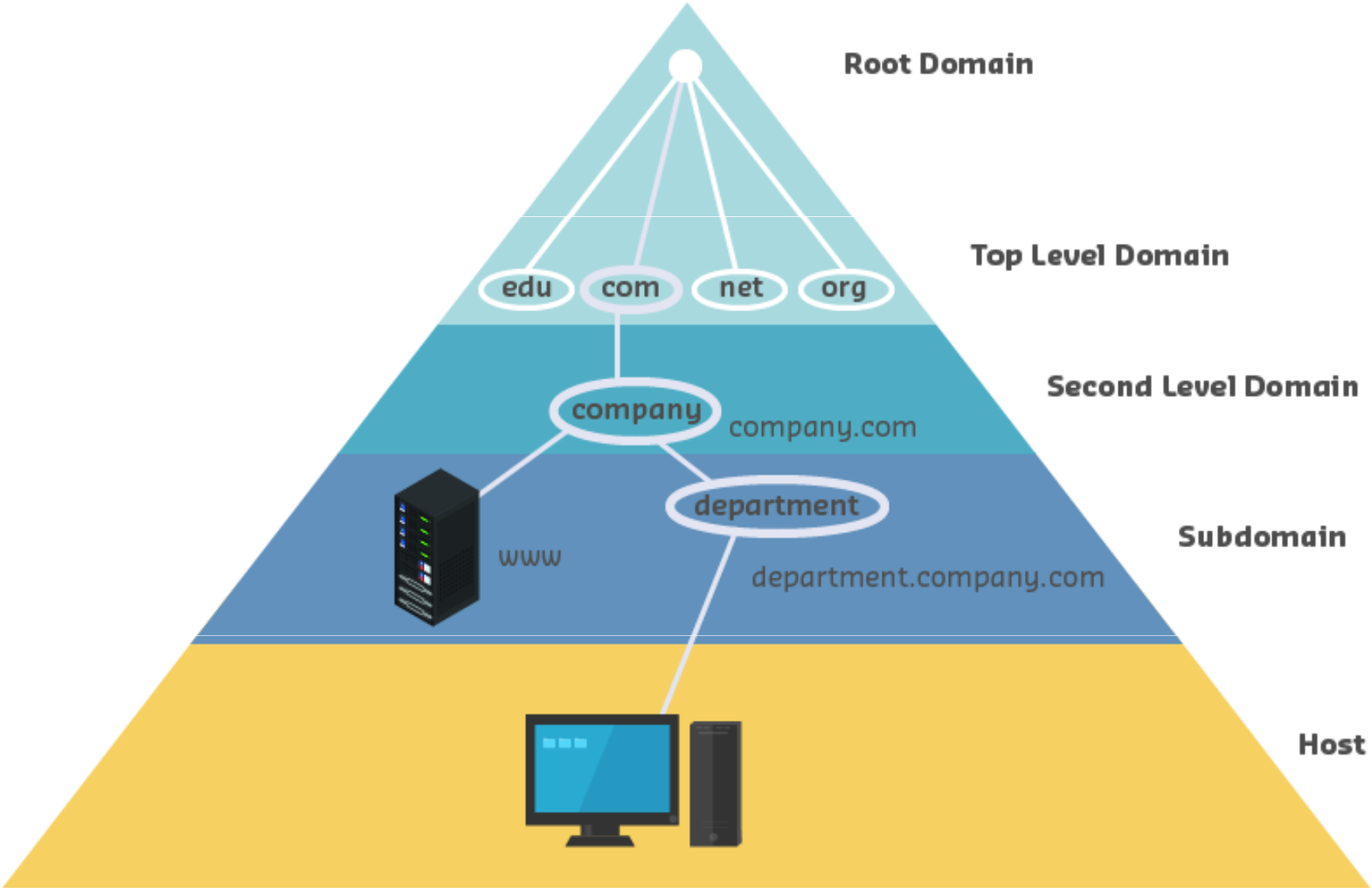
Q: Large and popular websites often use multiple internet servers, and therefore have multiple IP addresses. How many IP addresses do you think Facebook and Google might have?

Hint: Use **nslookup**.

Domain Name Servers (DNS)

- When you 'look up' a website the way you just did, you are looking up its **IP address** in the **Domain Name Service** or **DNS**, which is the Internet equivalent of a telephone book. It matches a name (like *facebook.com*) to a number (like 157.240.8.35) - because humans prefer to deal with names and computers prefer numbers.
- The DNS is a large database of computer names and their internet addresses, but it is spread out so that no server has **all** the information.
- If a computer requests a domain name and that server doesn't have it, it forwards the request to another DNS server. The Domain Name Service has a hierarchical structure, so **requests get sent from the bottom up**.
- As you can see in the diagram below, at the top of the hierarchy are the most familiar domain roots: .com, .org, .gov, etc.
- When setting up an internet connection on a computer, it is usual to allocate a **primary DNS server** and one or more **secondary servers**. This information is generally provided by your ISP.

Domain Name Servers (DNS)



Source: https://technet.microsoft.com/en-us/library/2005.01.howitworksdns.aspx

Protocols and Standards

- Internet Protocol (IP) addresses are one of many protocols that operate within the Internet. Combining IoT 'things' and applications increases the number of protocols required.
- Having agreed protocols that operate at a set **standard** allows for computers on different sides of the world to communicate with each other.
- **A protocol is an agreed (or accepted) set of rules for a procedure**. For example, there are many protocols in place across the world that help to determine how people interact with each other.



Protocols and Standards (cont.)

- In the same way, the internet has many protocols to make sure computers can interact with each other in an agreed, standard way.
- The internet operates on a layered structure. When data is sent from one place to another, the data passes through different layers. Each layer has a protocol determining what and how information passes through.
- It is similar to when you go to the shops to buy groceries. We can break that trip down into layers of operation - and at each layer there is a procedure you need to follow for a successful shopping trip!
  1. You leave the house – you need to remember to take your keys, wallet and shopping bag.
  2. You get transport to (and from) the shop – you either need to find the right public transport, or follow traffic laws while driving/riding and find a parking spot.
  3. In the shop, you locate and select your groceries – you follow a system of aisles and a way to choose your items.
  4. You check out of the shop – you need to use a payment method and have a way to carry your groceries home.

Protocols and Standards (cont.)

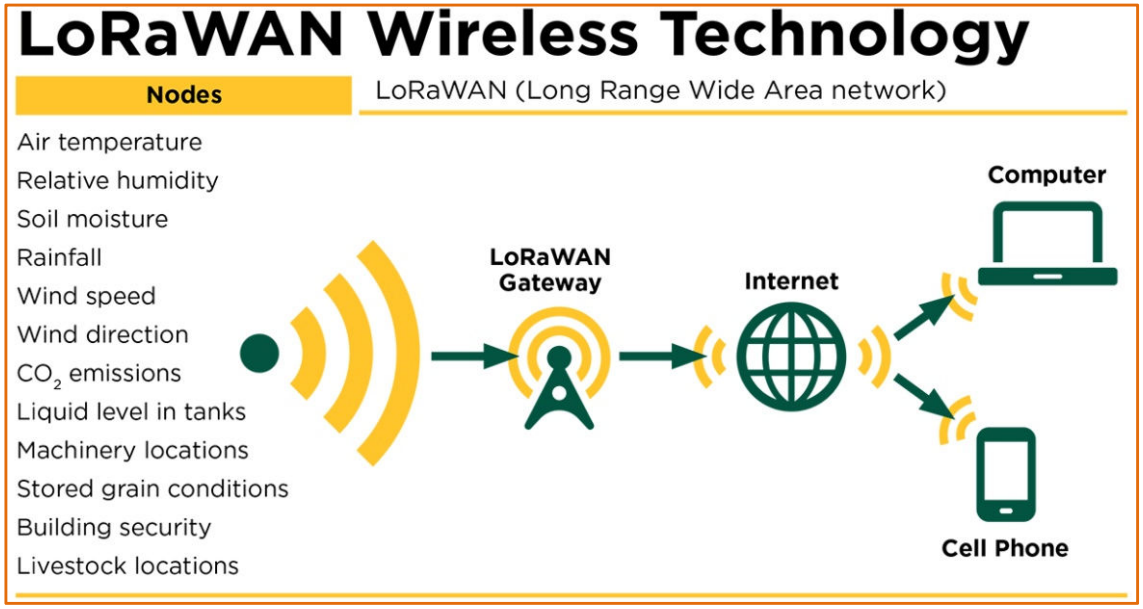
- The Internet Engineering Task Force (IETF) is the premier Internet standards body. They define the TCP/IP model (Transmission Control Protocol/Internet Protocol) which is the most common networking protocol suite.

Layer	Function	Example Protocol
Application	Services to user applications such as web browsers.	Hypertext Transfer Protocol (HTTP)
Transport	Manages conversations between servers and browsers and divides data into segments to be sent down a layer.	Transmission Control Protocol (TCP)
Internet	Packages segments with source and destination addressing.	Internet Protocol (IP)
Network Access	Transmits data over a physical link.	Ethernet

- Standards and protocols exist so that messages can get through and miscommunication is minimised.
- It helps to remember that **communication between machines** and **communication between people** fit the same model.

IoT Connecting – LoRa WAN

- LoRa stands for Long Range Radio. It is a wireless technology targeting M2M (Machine to Machine) and IoT networks.



- LoRa is a type of Narrowband RF technology. Narrowband RF technologies operate over longer distances and at lower power levels, but their trade-off is that they only offer smaller bandwidth connectivity, limiting their use to restricted data and bandwidth applications.
- The main advantage of Narrowband RF technologies is that they are low cost to set up and operate, and the devices that they support use minimal power.

Case Study Protocols

Case study	Consideration	Communication media or protocol choice
Dairy farm	• Transmit from sensor to server up to 1km • Low power in sensor – stays on cow for life of battery (about 5 years) • RFID on cow entering/leaving dairy	UHF
Foot drop	• Lightweight devices (low power but rechargeable) • Range in home or clinic situation.	RF could use PAN or Bluetooth
Autonomous bus	• Mobile device • Safety and security critical	Wired and 3G, 4G (LTE) GPS, RF, WiFi
Sydney Harbour Bridge	• Large structure • 3200 sensors	Fibre optics / Ethernet
Rotating machines monitoring	• Various situations, some of them remote or difficult to access • Low range and long range	Bluetooth, WiFi, Bluetooth (Low Energy) LoRa, Zigbee

THANK YOU ALL FOR LISTENING

QUESTIONS AND ANSWERS