The University Of Sheffield.

COM1008: Web and Internet Technology

Lecture 7: Networks and protocols

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Thanks to Mike Stannett whose lectures slides this lecture is based on

1. Introduction

- Communication Networks
  - why do networks form?
  - what sorts are there?
- Sending Signals
  - what can we send?
  - how should we send it?
  - what's the best route?
- Protocols
  - how do we make sure our message is understood?
  - can we keep things simple?

http://en.wikipedia.org/wiki/Roman_roads

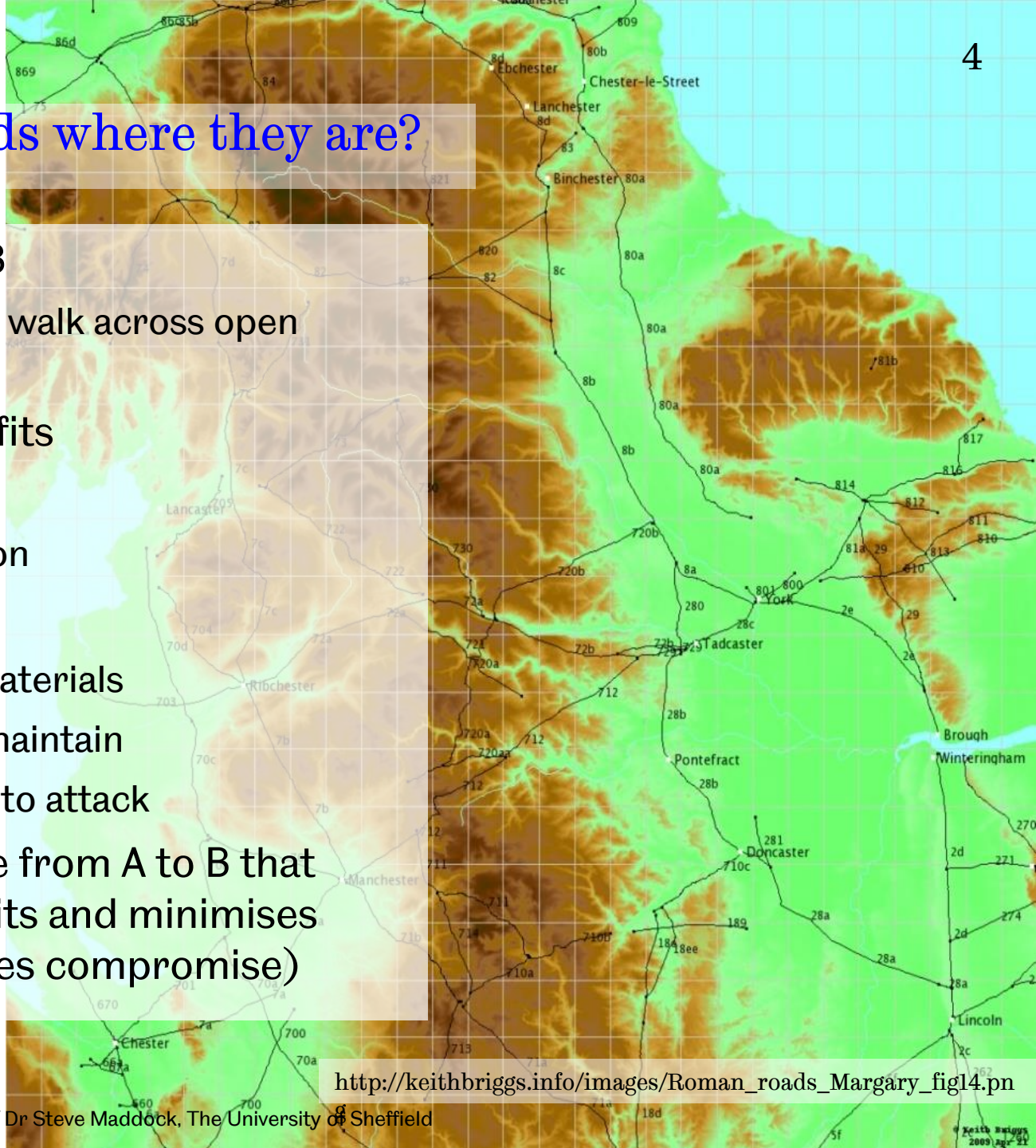
2.1 Getting from A to B

- How?
  - on foot, horse, cart, ship, slave-power, train, plane
- Why?
  - commerce, strategy, adventure, information
- Obstacles
  - Mountains, wars, deserts
  - Rivers, lakes, seas
- Routes
  - Footpaths, tracks, roads (major, minor), rivers, canals, sea

http://en.wikipedia.org/wiki/Roman_roads

2.2 Why are roads where they are?

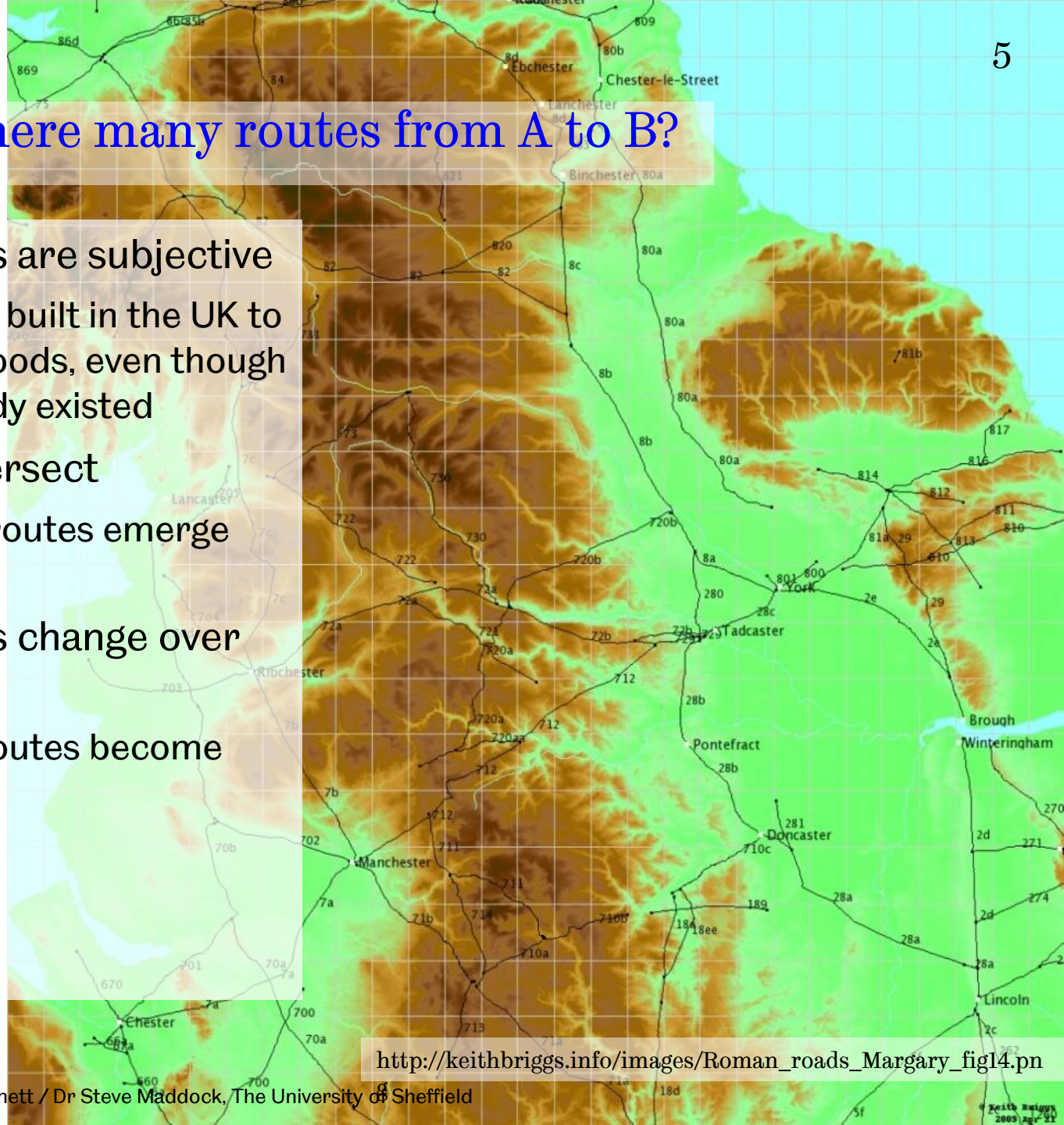
- To go from A to B
  - why not simply walk across open country?
- Roads have benefits
  - quicker travel
  - easier navigation
- Roads are costly
  - need special materials
  - time to build/maintain
  - make you easy to attack
- Choose the route from A to B that maximises benefits and minimises costs (this involves compromise)



http://keithbriggs.info/images/Roman_roads_Margary_fig14.pn

2.3 Why are there many routes from A to B?

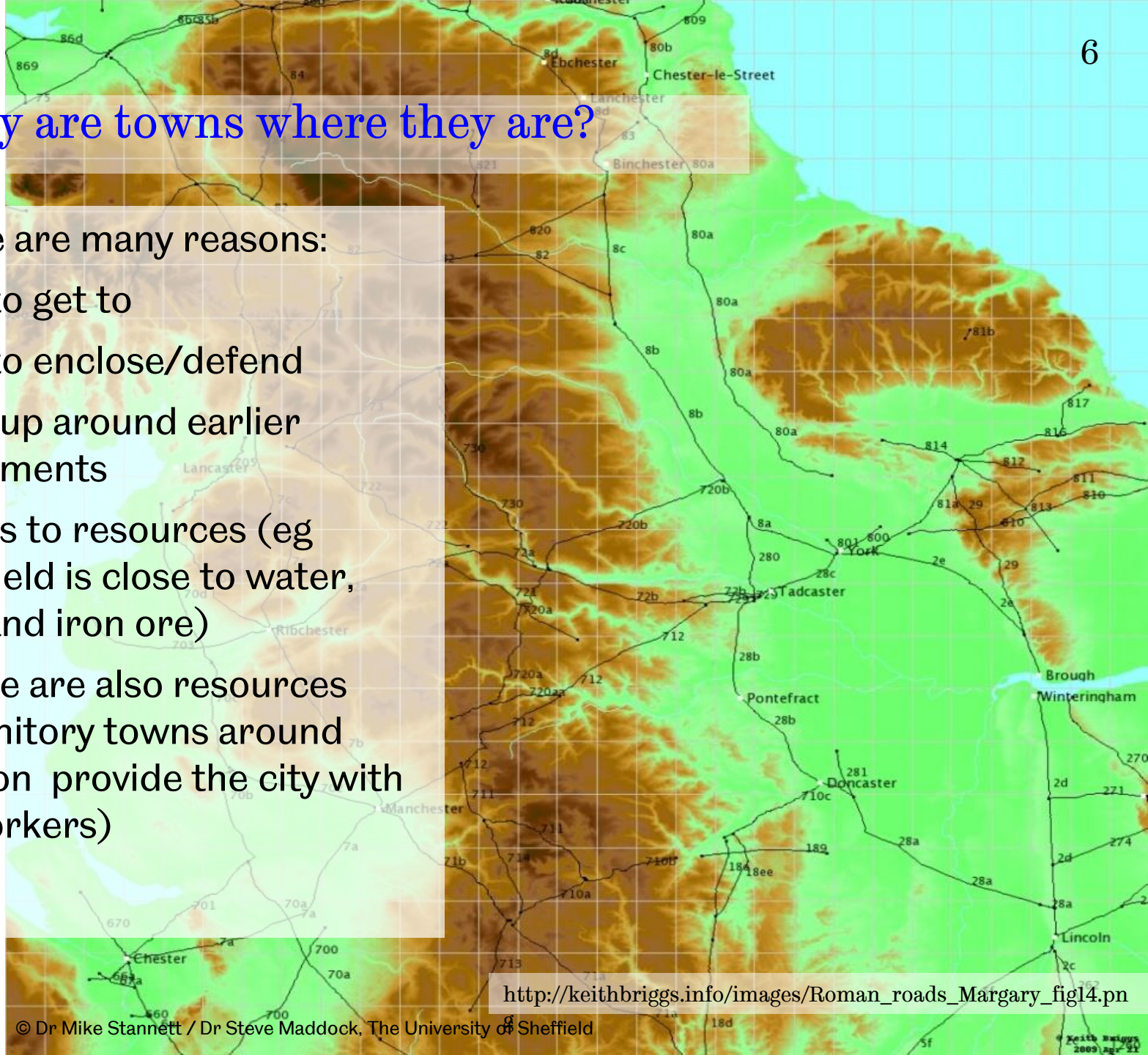
- Costs/benefits are subjective
  - canals were built in the UK to transport goods, even though roads already existed
- Roads can intersect
  - alternative routes emerge naturally
- Costs/benefits change over time
  - expensive routes become affordable



http://keithbriggs.info/images/Roman_roads_Margary_fig14.pn

2.4 Why are towns where they are?

- There are many reasons:
- easy to get to
- easy to enclose/defend
- grow up around earlier settlements
- access to resources (eg Sheffield is close to water, coal and iron ore)
- people are also resources (dormitory towns around London provide the city with its workers)



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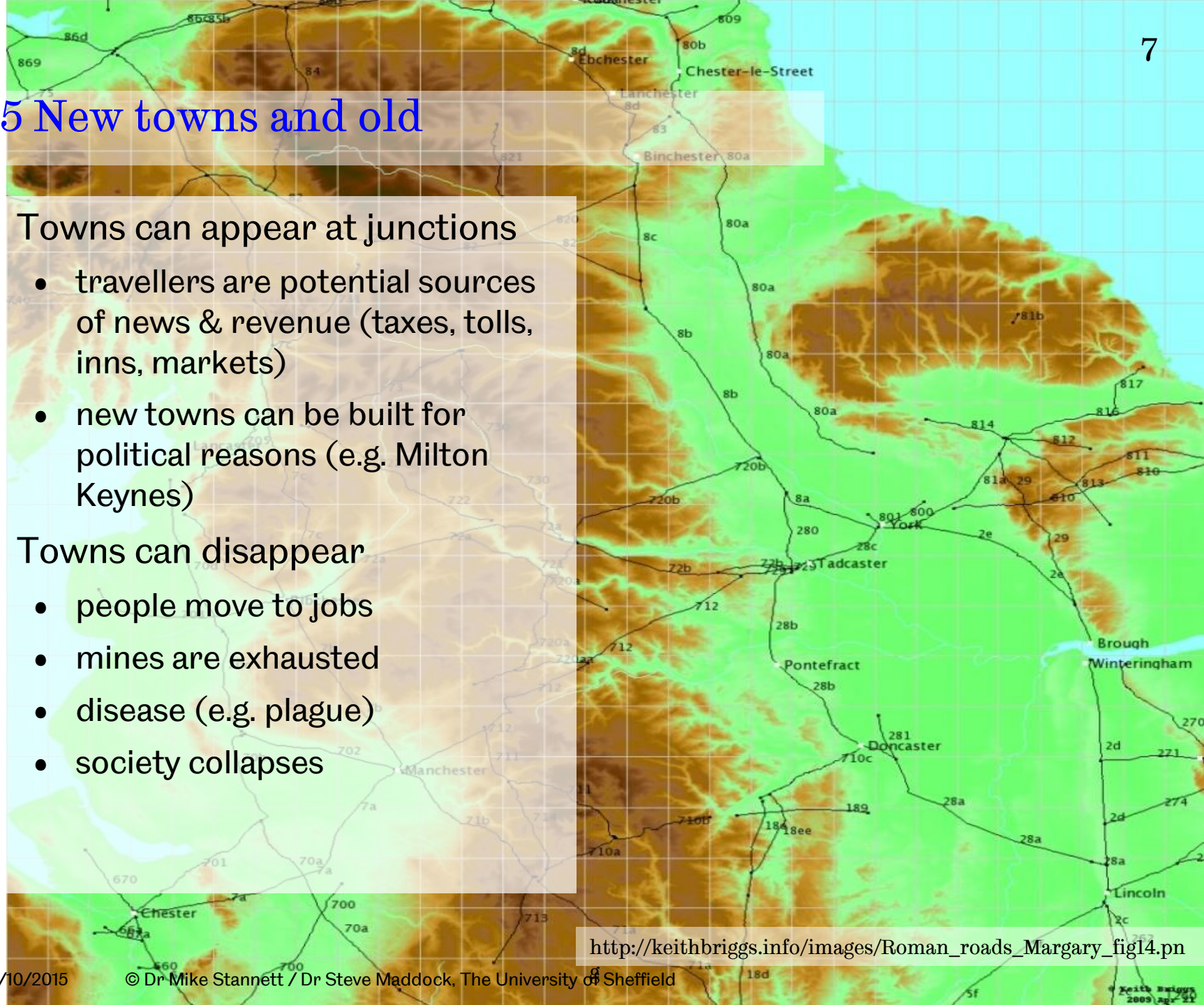
2.5 New towns and old

- Towns can appear at junctions
  - travellers are potential sources of news & revenue (taxes, tolls, inns, markets)
  - new towns can be built for political reasons (e.g. Milton Keynes)
- Towns can disappear
  - people move to jobs
  - mines are exhausted
  - disease (e.g. plague)
  - society collapses



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2.6 The Changing Network Topology

- The general layout of nodes and the routes between them is called the network topology
- The network topology can change over time: new nodes (towns) and routes can appear, and old ones can disappear.

Summary

- There can be many different routes from A to B
- Different users may prefer different routes
- Different routes may involve different technologies
- The nodes and routes may change with time

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  - **how should we send it?**
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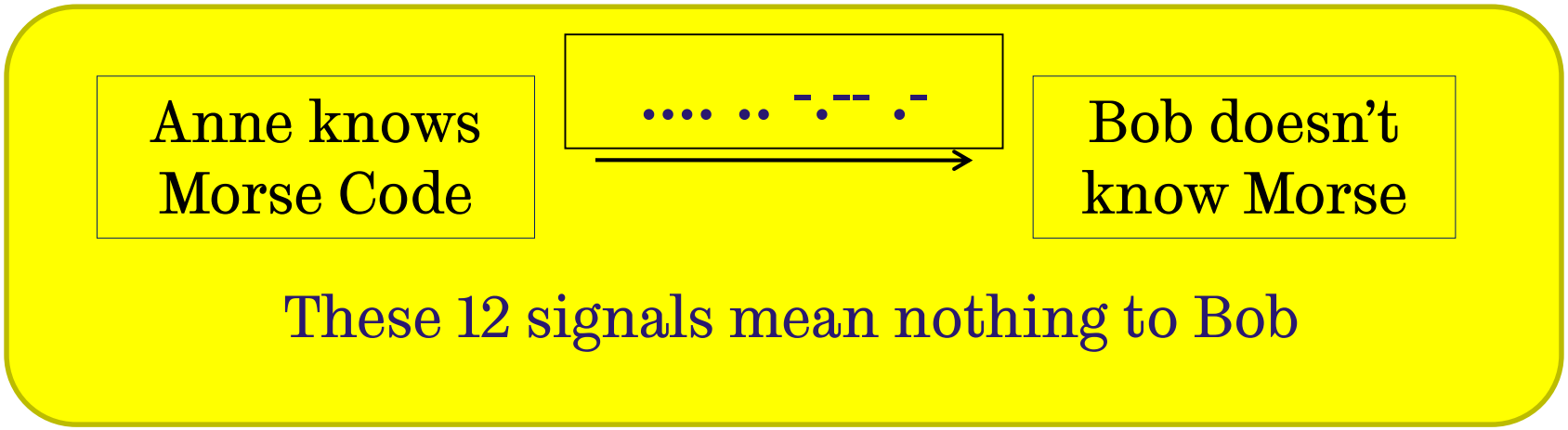
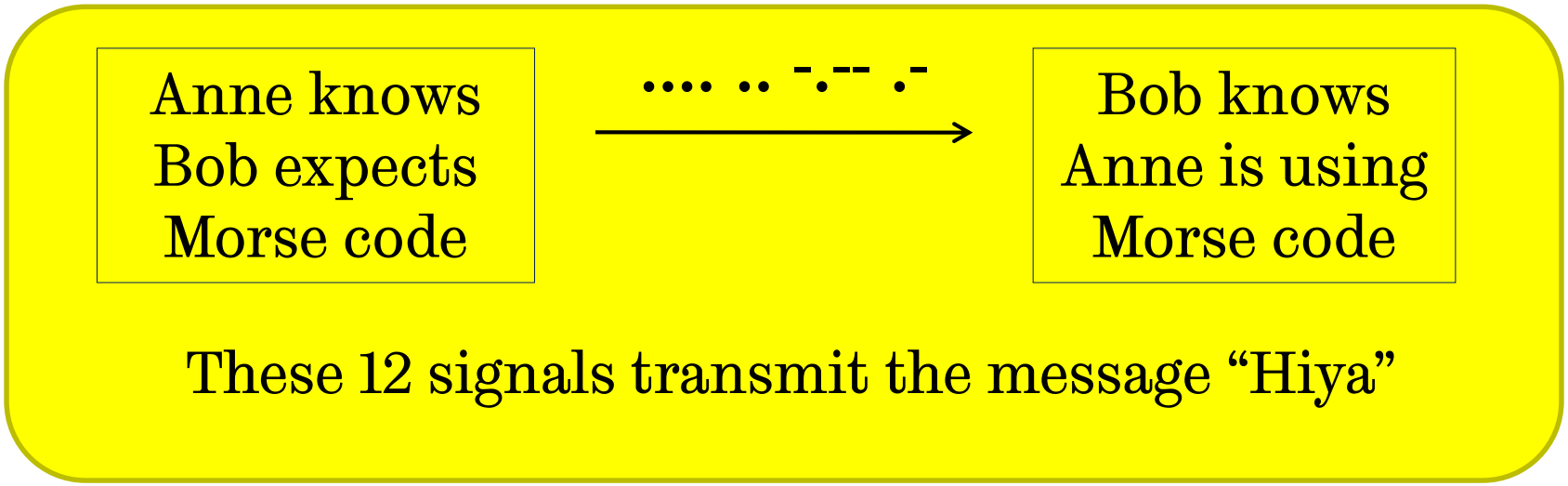
3.1 Sending a signal

- A signal is sent from one agent (the source or sender) to another (the target or receiver) across a physical medium
- If the two agents understand the same thing when they observe the signal, then it represents a message (the target understands what the signal means)



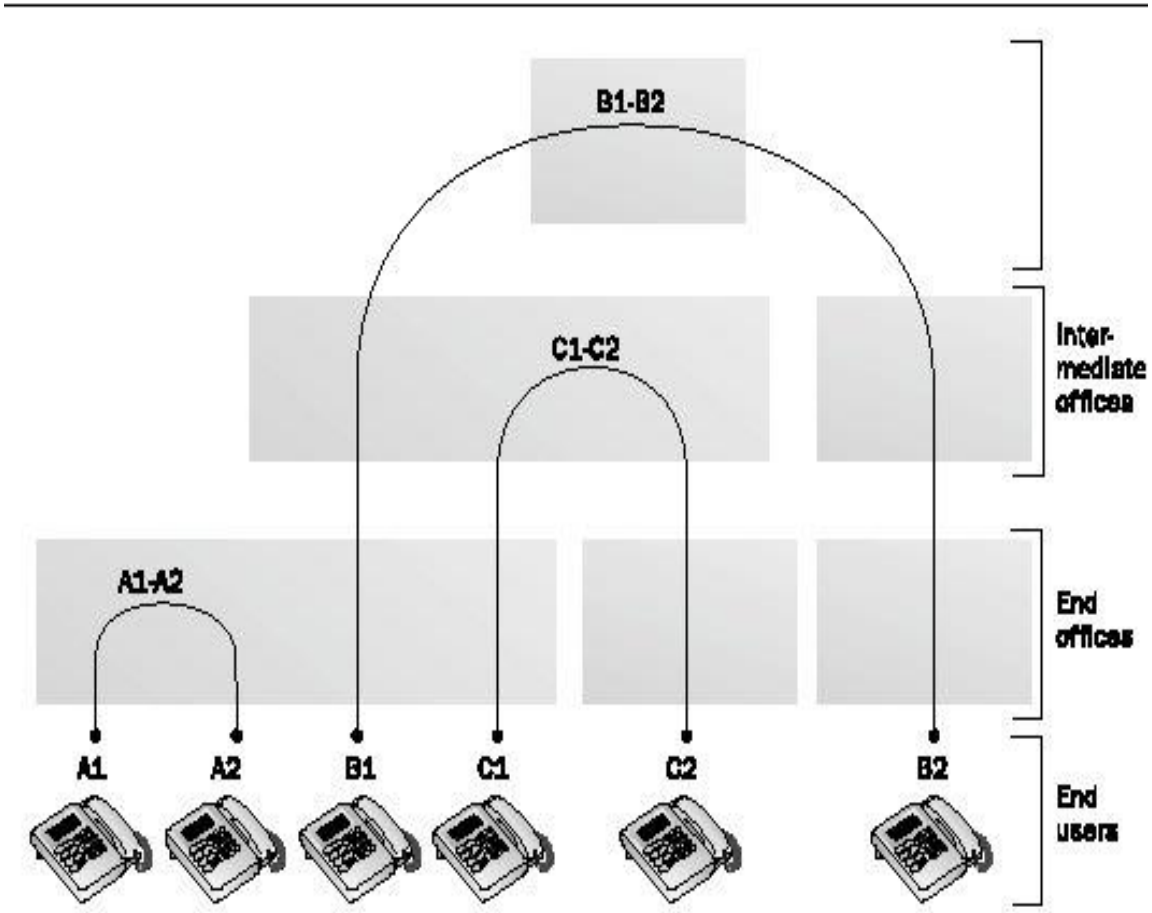
3.2 Sending a message or file

- Anne and Bob agree on a scheme for representing data using signals
- Anne represents the message/file as a sequence of signals
- Anne sends these signals across the network to Bob
- Bob interprets the signals and reconstructs the message



3.3 Circuit switching

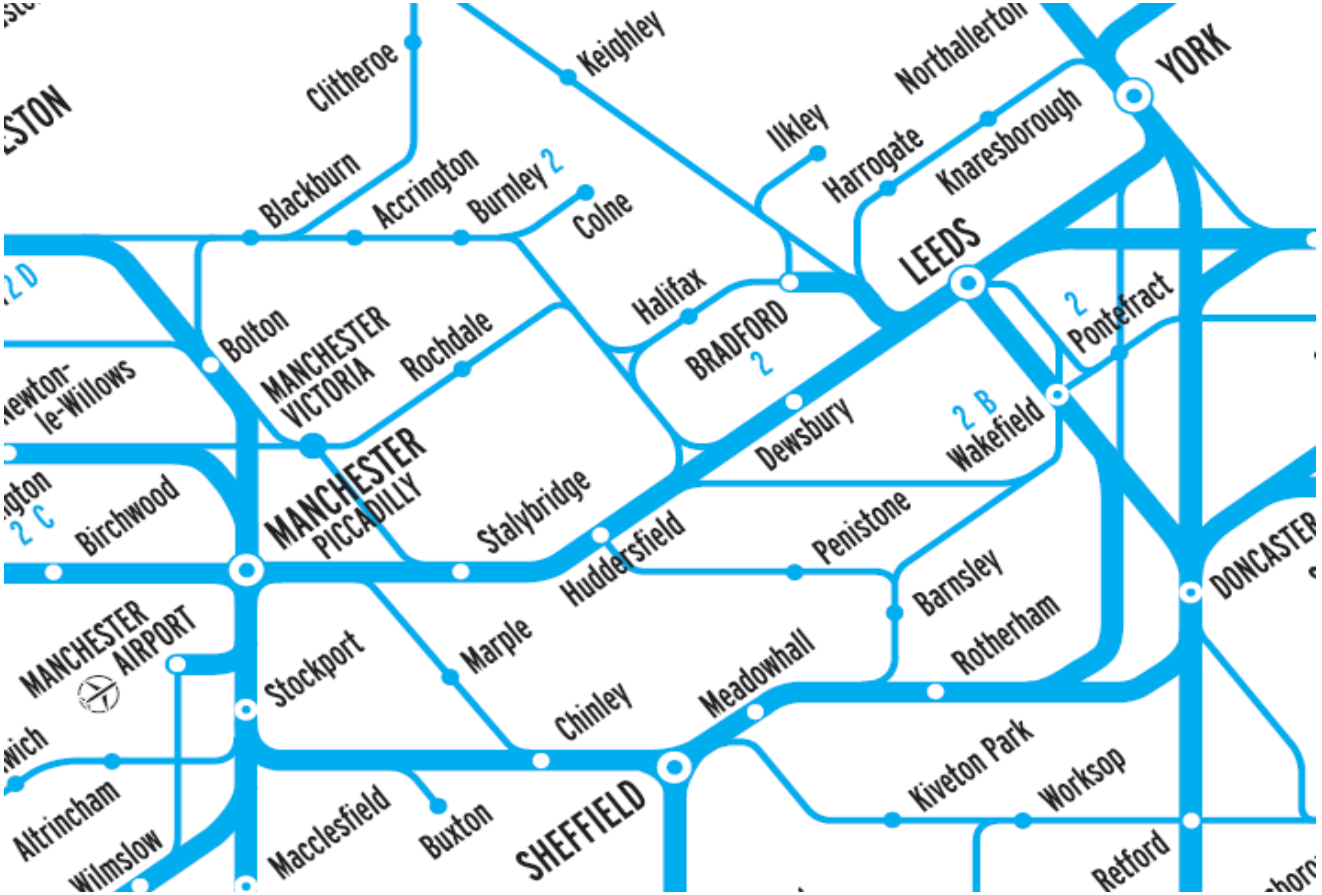
- Some phone networks set up a dedicated connection when you ring someone, called a circuit (with links made of twisted-pair copper wire). When the call ends, the links in the circuit can be re-used to create new circuits.
- This is called circuit switching



http://www.linktionary.com/c/circuit_switching.html

3.3 What about networks with fewer links?

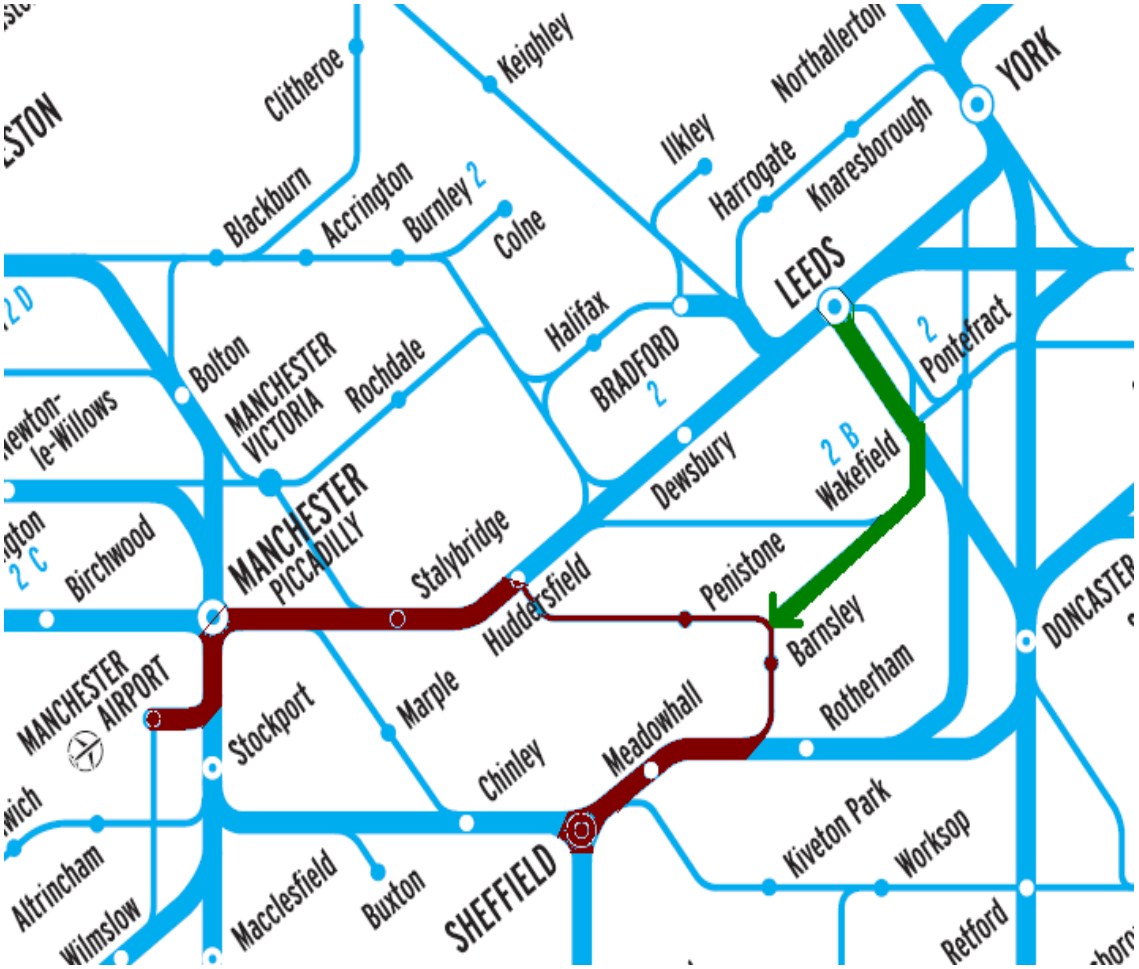
- Suppose everyone travels by train…



http://www.nationalrail.co.uk/tocs_maps/maps/OfficialNationalRailmaplarge.pdf

3.4 Circuit switching for trains?

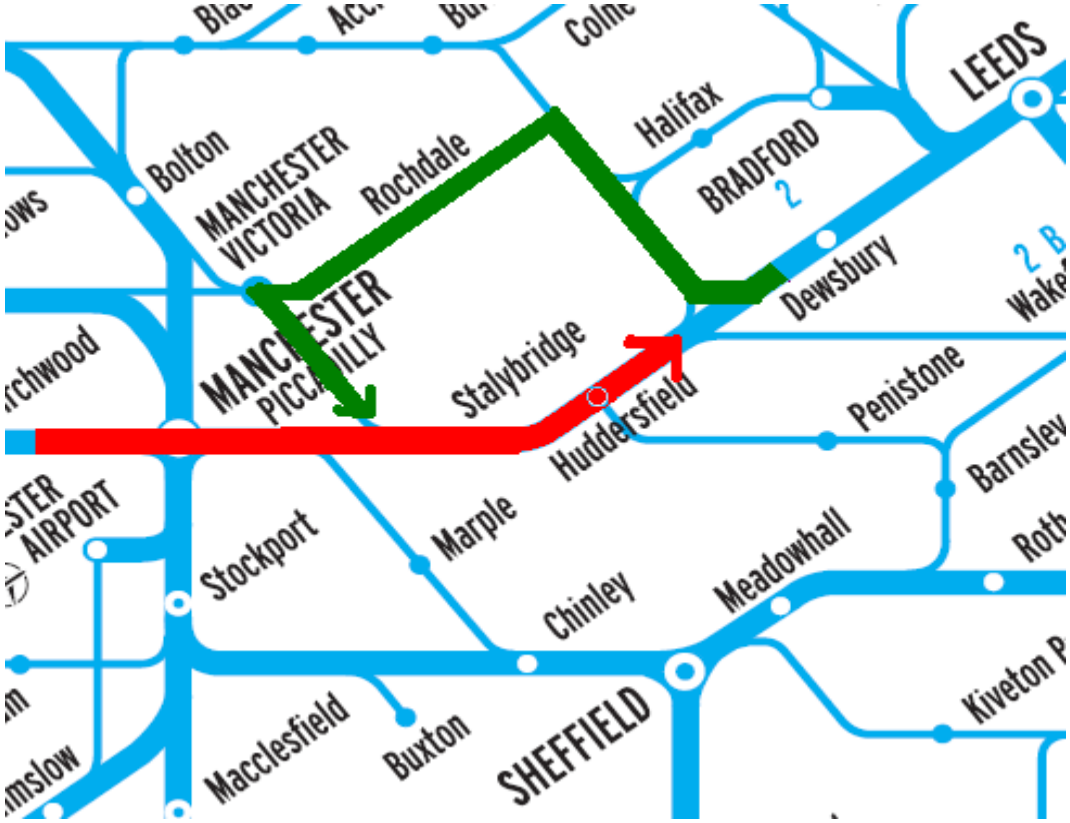
- To go from Manchester Airport to Sheffield, first work out an entire route.
- Don't let any other train use any part of the route until the journey is complete.
- The train from Leeds is stuck at Leeds station for 1½ hours… Oops



Adapted by MPS from http://www.nationalrail.co.uk/tocs_maps/maps/OfficialNationalRailmaplarge.pdf

3.5 What happens if trains get very long?

- If a train is longer than the distance between two towns along its route, there's a risk of deadlock
- DEADLOCK: Each train is waiting for the other one to move (this section of the network is no longer usable)



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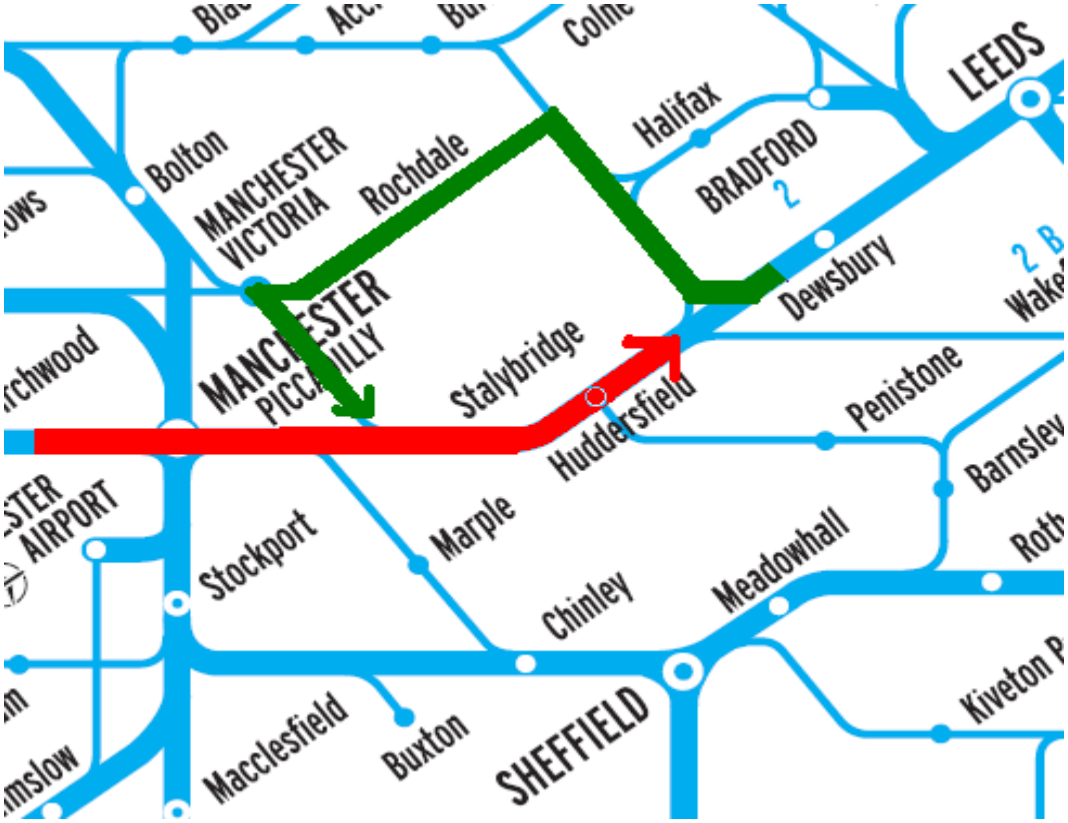
3.6 Relevance to computer networks

- Each track has a certain length. If trains are too long, there's a risk of deadlock
- Each link has a certain capacity. If signals are too big, there's a risk of deadlock
- Signals are usually broken into small chunks called **packets**



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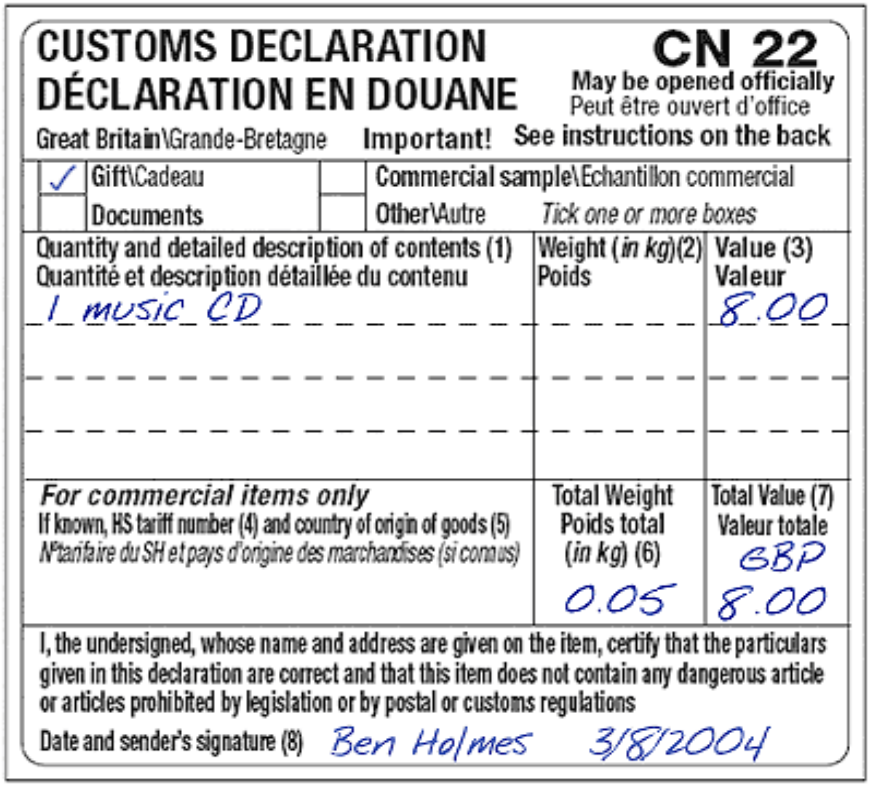
3.7 Sending a packet via Royal Mail

- Labelling (control info)
  - Who am I for?
  - Who am I from?
  - When was I sent?
  - What should I contain?
  - How can you tell if my labelling is accurate?
- Contents (userdata, payload)
  - The items being transmitted
- The sorting office uses the labelling info
  - (they don't look at the contents, though customs officers might)



CUSTOMS DECLARATION / DÉCLARATION EN DOUANE — **CN 22**

May be opened officially / Peut être ouvert d'office

Great Britain\Grande-Bretagne — **Important!** See instructions on the back

✓	Gift\Cadeau		Commercial sample\Echantillon commercial
	Documents		Other\Autre

Tick one or more boxes

Quantity and detailed description of contents (1) / Quantité et description détaillée du contenu	Weight (*in kg*)(2) / Poids	Value (3) / Valeur
1 music CD		8.00

For commercial items only / If known, HS tariff number (4) and country of origin of goods (5) / *N°tarifaire du SH et pays d'origine des marchandises (si connus)*	Total Weight / Poids total (*in kg*) (6)	Total Value (7) / Valeur totale
	0.05	GBP 8.00

I, the undersigned, whose name and address are given on the item, certify that the particulars given in this declaration are correct and that this item does not contain any dangerous article or articles prohibited by legislation or by postal or customs regulations

Date and sender's signature (8) Ben Holmes 3/8/2004

3.8 Packet switching

SENDER

- Break the file into packets
- Number the packets
- Label the packets
  - `TO  STEVE`
  - `FROM MIKE`
  - `notes.pdf`
  - `PART 3 OF 17`
- Send each packet to a router

RECEIVER

- Join packets together
- Put the packets in order
- Check the labels
  - `TO  STEVE`
  - `FROM MIKE`
  - `notes.pdf`
  - `PART 3 OF 17`
- Receive each packet from a router

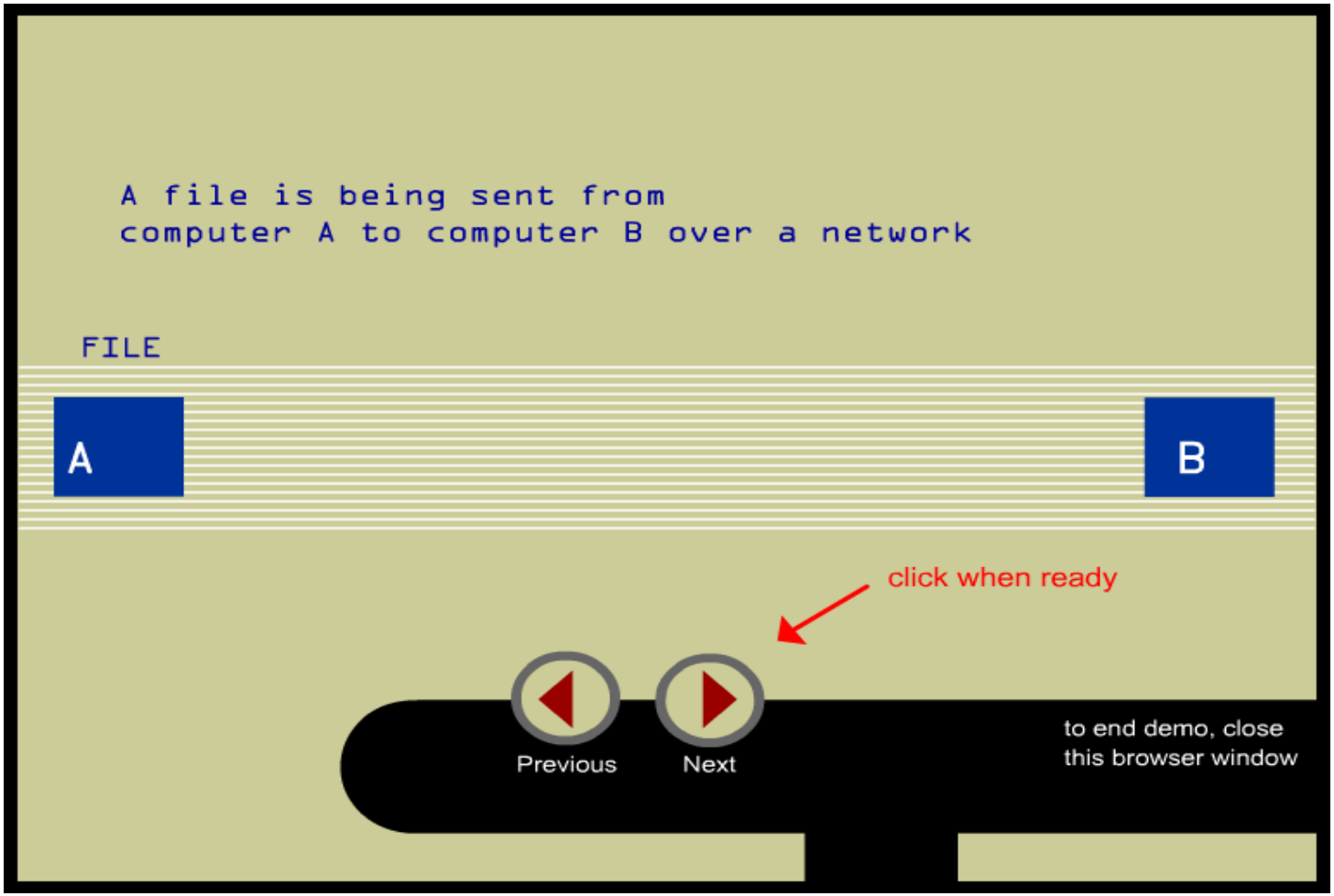
- Routers work out a route to the target
- The sender doesn't need to know the network topology

3.8.1 IPv4 Packet Header Structure

In practice, the labelling may contain a lot of information:

- 4 bits: which version of IP is this?
- 4 bits: the length of the header in multiples of 4 bytes
- 8 bits: what priority should the packet have?
- 16 bits: length of the packet in bytes,
- 16 bits: identification tag to help reconstruct the packet
- 3 bits: information about fragmentation
- 13 bits: which fragment is this packet attached to?
- 8 bits: how many hops is this packet allowed to make?
- 8 bits: what protocol are we using?
- 16 bits: a number used in error detection,
- 32 bits: the source IP address,
- 32 bits: the destination address.

3.8.2 Packet Switching (online demo)



https://www.youtube.com/watch?v=vSlcoQowe9I

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4.1 Files to packets, packets to files

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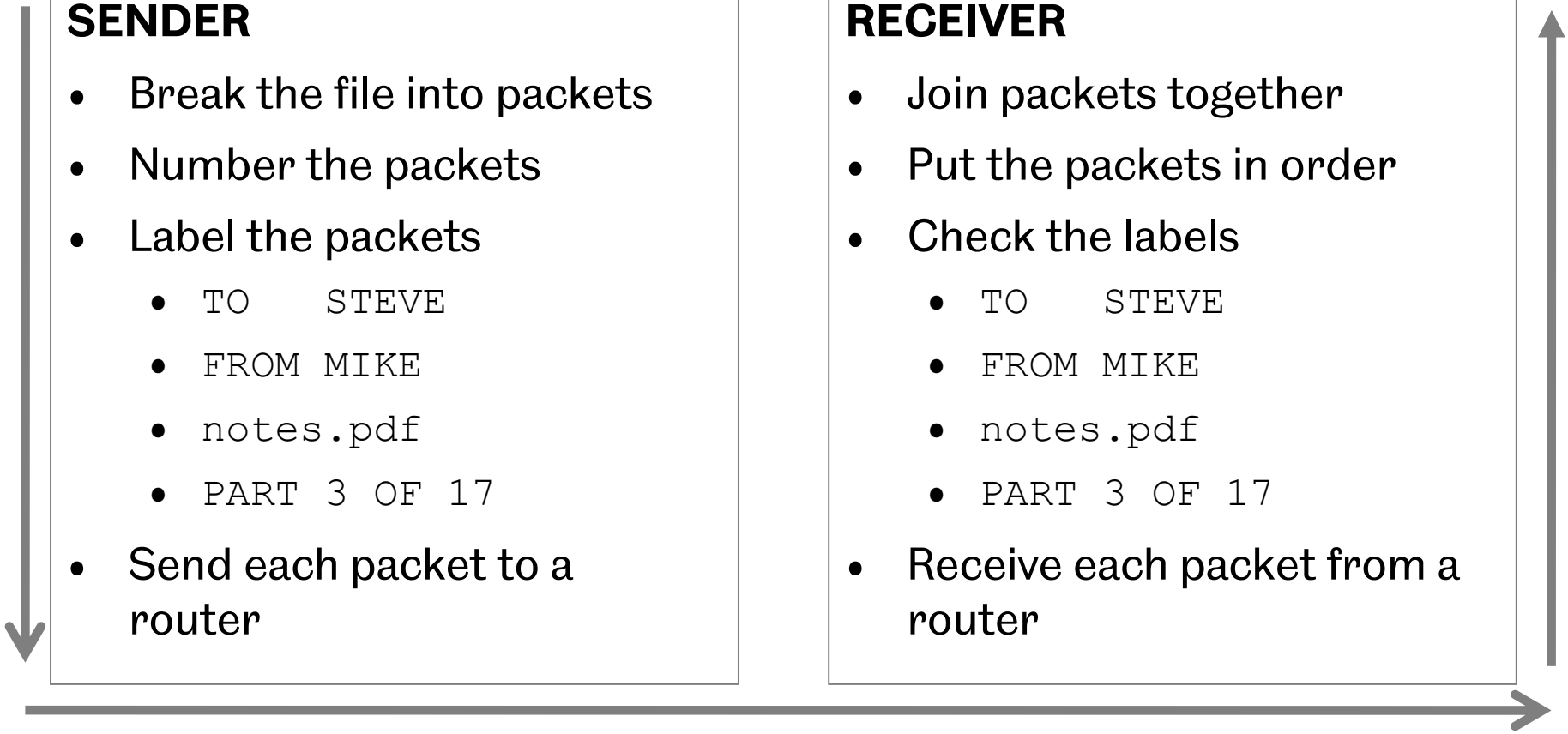

- The sender and receiver both understand how packets should be arranged to generate the original file.

4.2 A simple protocol

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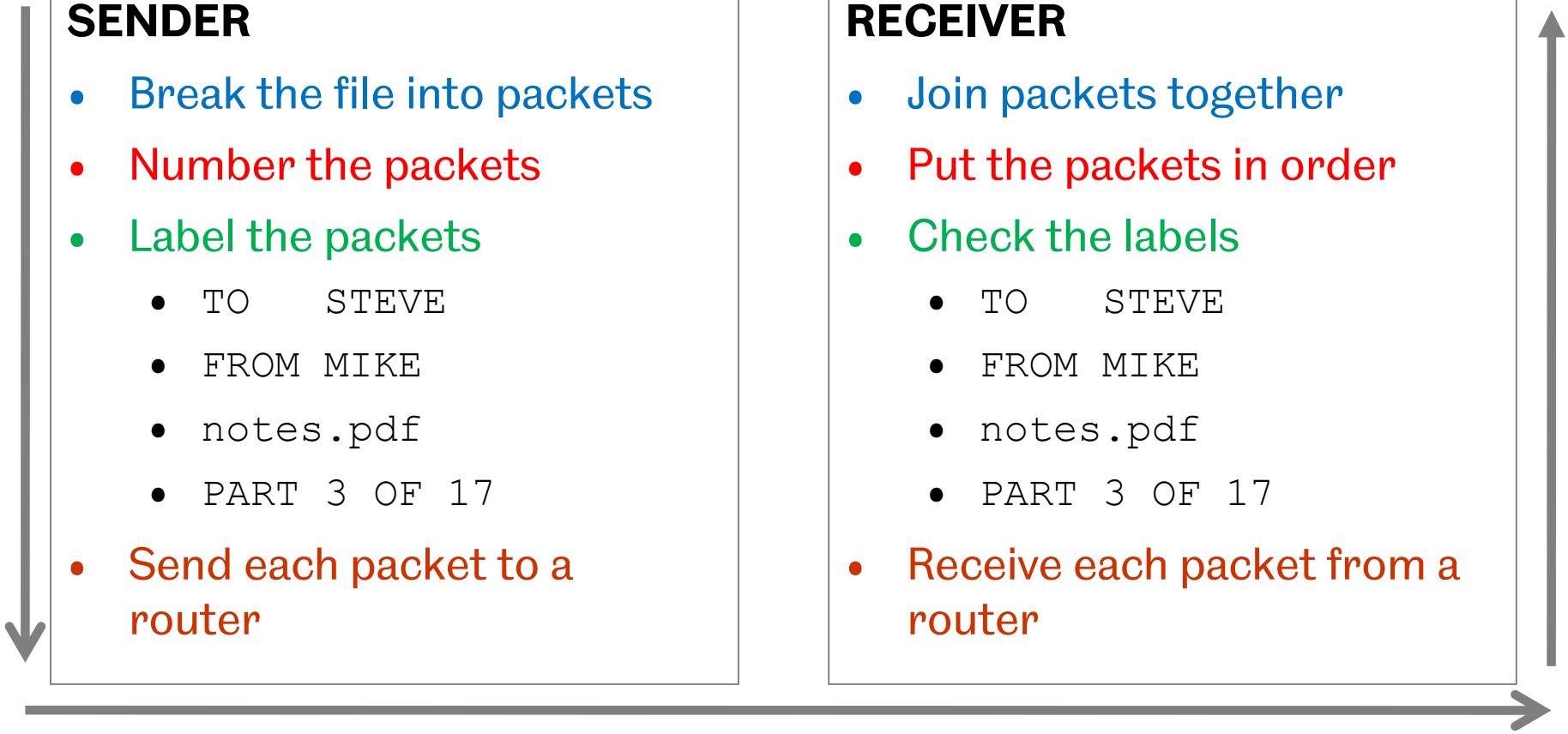

- The rules for the sender and receiver complement one another. They are obeying the same **protocol**.

4.3 Keeping things simple

SENDER

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- Number the packets
- Label the packets
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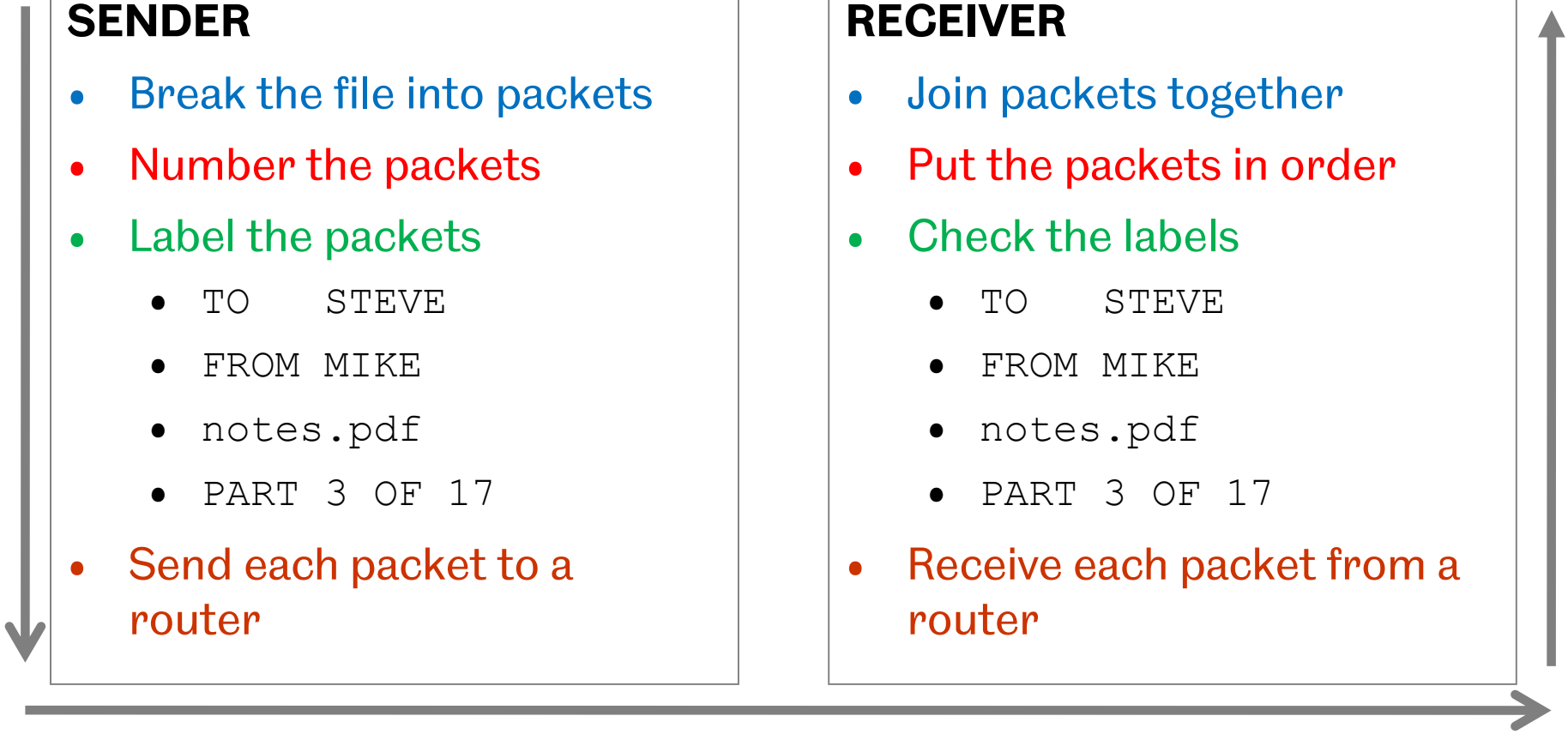
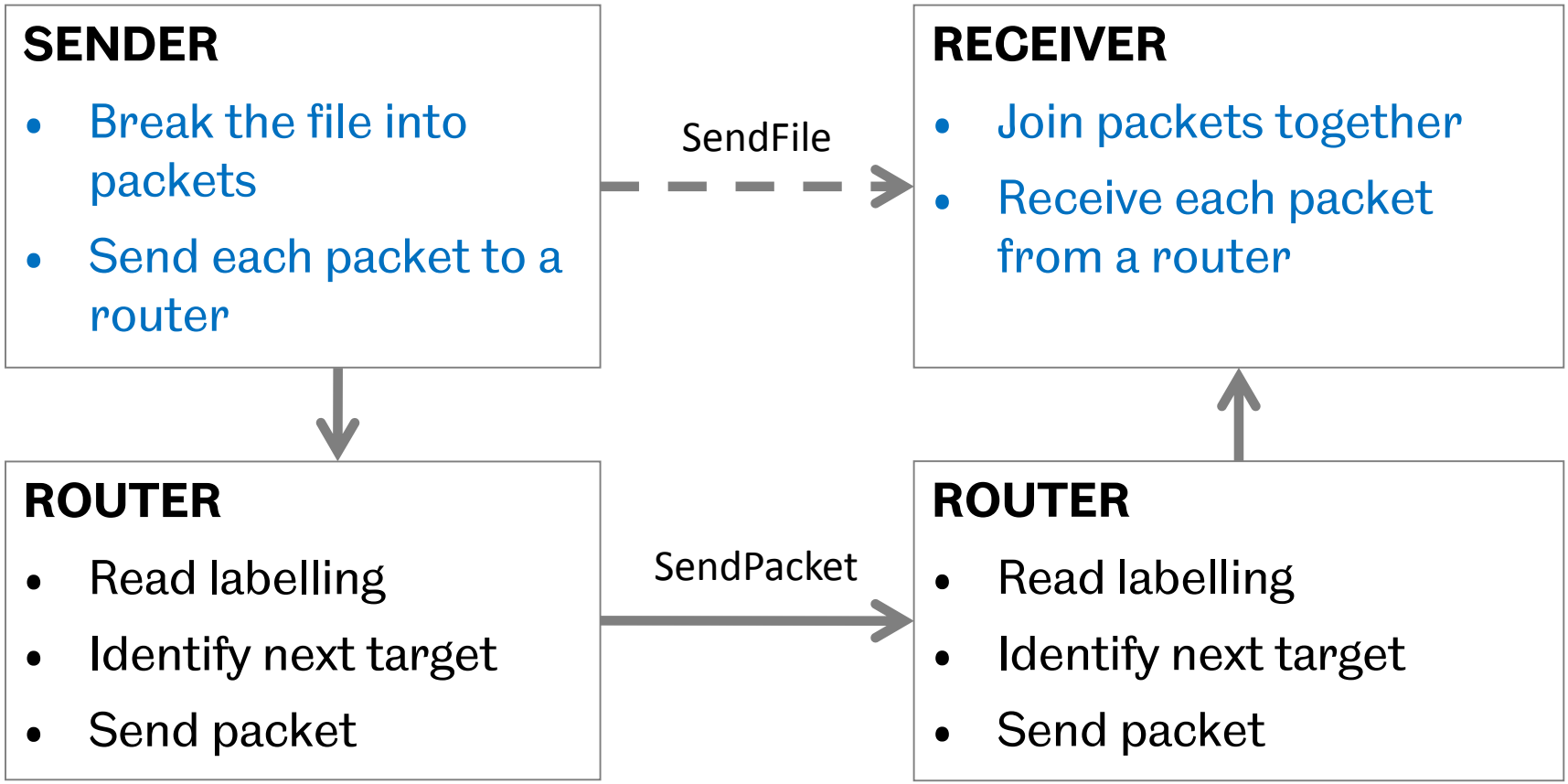


- This protocol only deals with "how files are made from packets". To send a packet, we use a **service** provided by the router.

4.4 Layered services



- The SendFile process uses a lower-level SendPacket service provided by the next layer down

4.5 OSI 7 layer Reference Model

- Each layer handles a different aspect of what's involved in sending data from one computer to another
- Each layer is governed by one or more protocols. Different protocols are used for different types of data.

OSI Model			
	Data unit	Layer	Function
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation and encryption
		5. Session	Interhost communication
	Segment	4. Transport	End-to-end connections and reliability
Media layers	Packet	3. Network	Path determination and logical addressing
	Frame	2. Data Link	Physical addressing
	Bit	1. Physical	Media, signal and binary transmission

http://en.wikipedia.org/wiki/OSI_model

4.5 OSI 7 layer Reference Model

- The OSI Reference Model concerns standards for systems that are open to one another
  - systems that can exchange information because they use the standards
- The OSI Reference Model is a framework for people to use when they want to specify services and protocols for connecting systems together.

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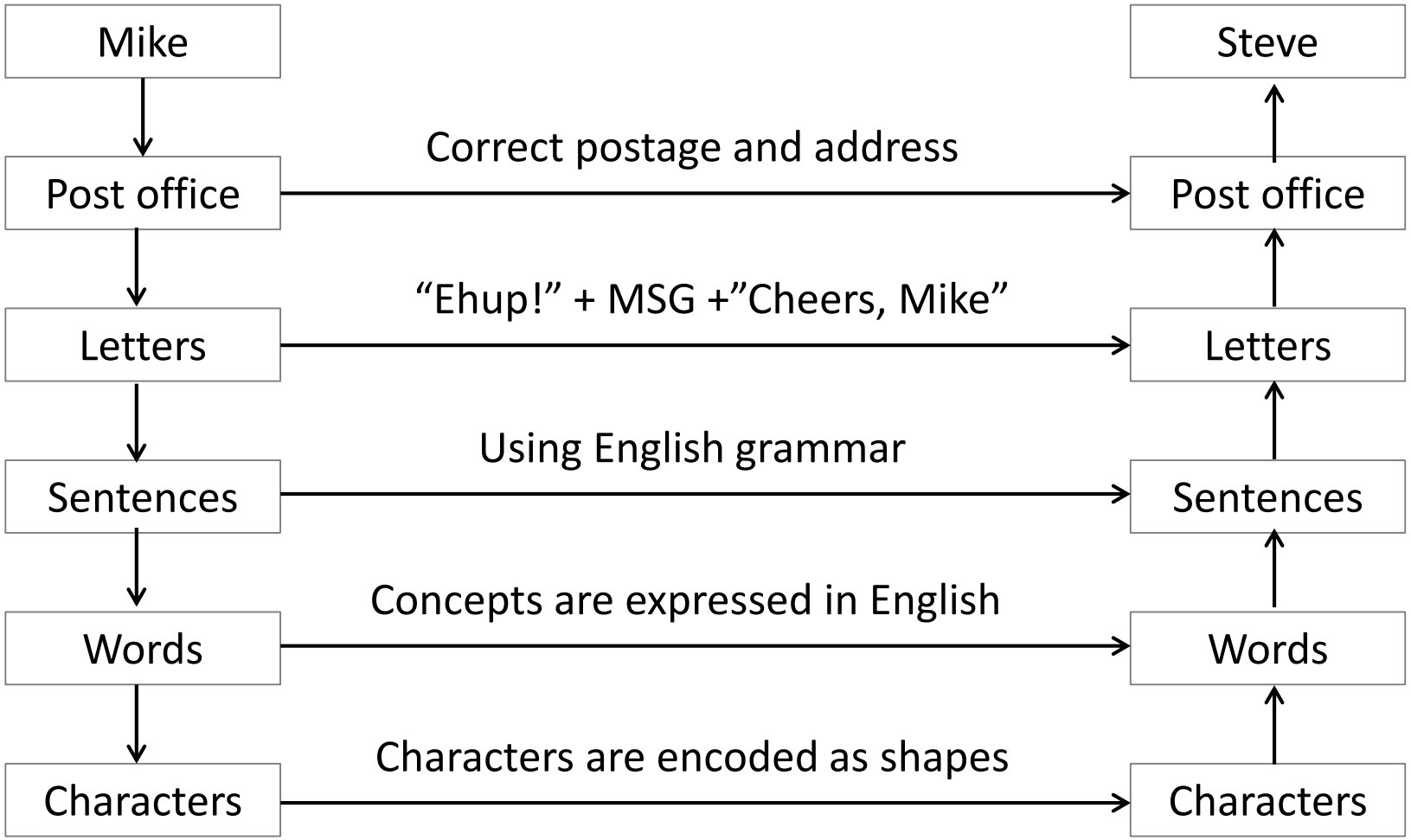
4.6 Example: Email vs streaming

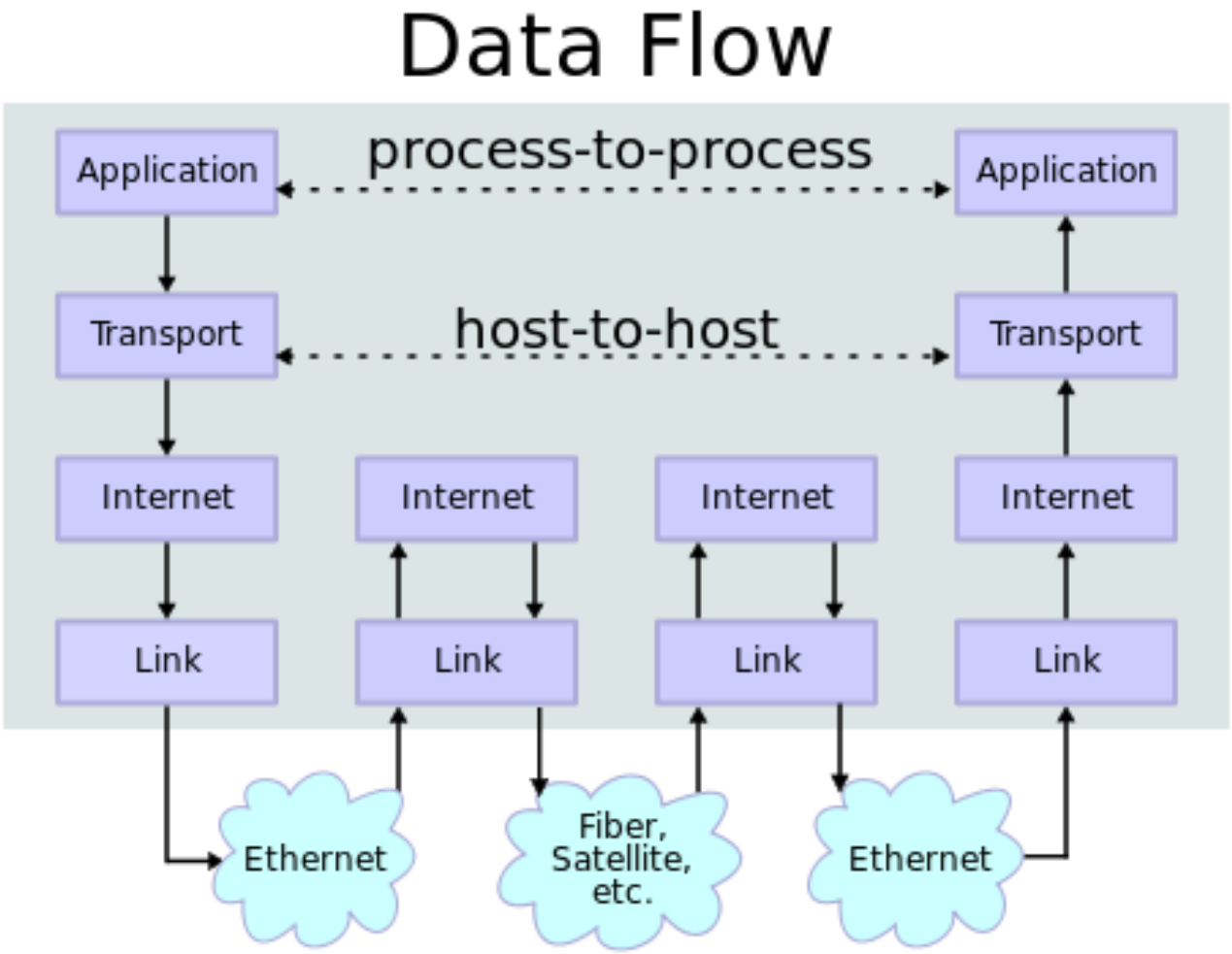
- Email
  - Transmission needs to be reliable
  - Message must arrive intact and unaltered
  - If packets are lost, they must be re-requested
- Streaming live TV
  - Can't wait for lost data to be resent, as it'll probably arrive too late
- Different requirements mean different protocols

4.7 An everyday example of layering



4.8 The Internet Protocol Suite (TCP/IP)

- 4 layers to model communications
  - (and the physical layer)
- Terminology:
  - TCP – Transmission Control Protocol
  - IP – Internet Protocol



http://en.wikipedia.org/wiki/TCP/IP_model

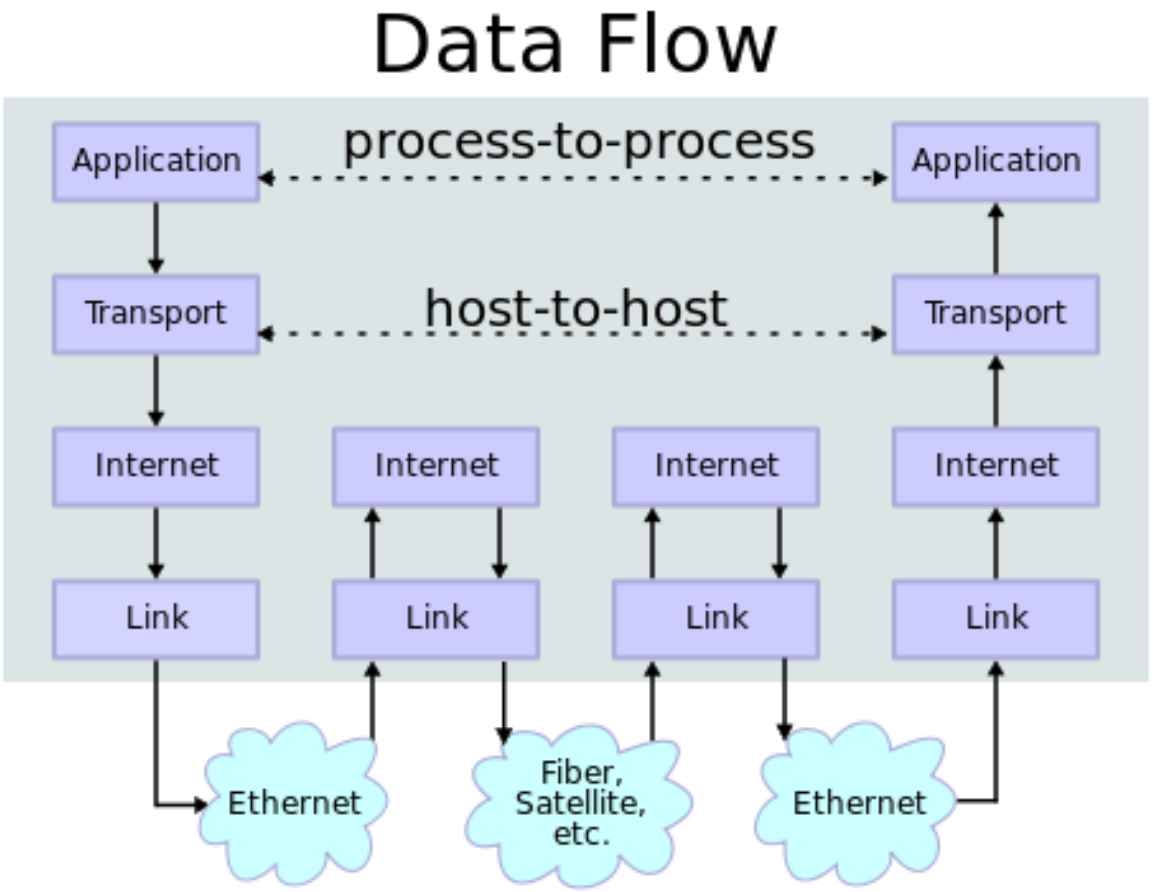
4.8 The Internet Protocol Suite (TCP/IP)

TCP

- Doesn't care about intermediate nodes
- Establish connection
- Transfer data
- Terminate connection

IP

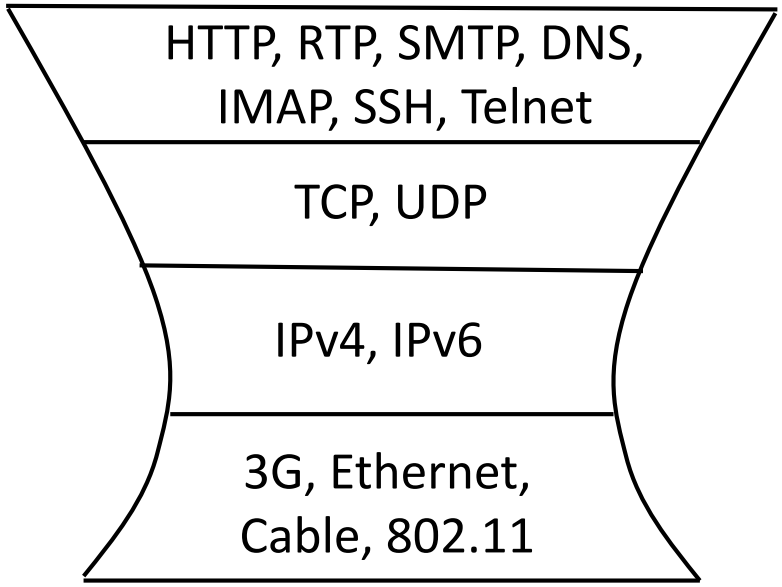
- Delivers packets from source to destination using addresses
- Unreliable, e.g. allows lost packets



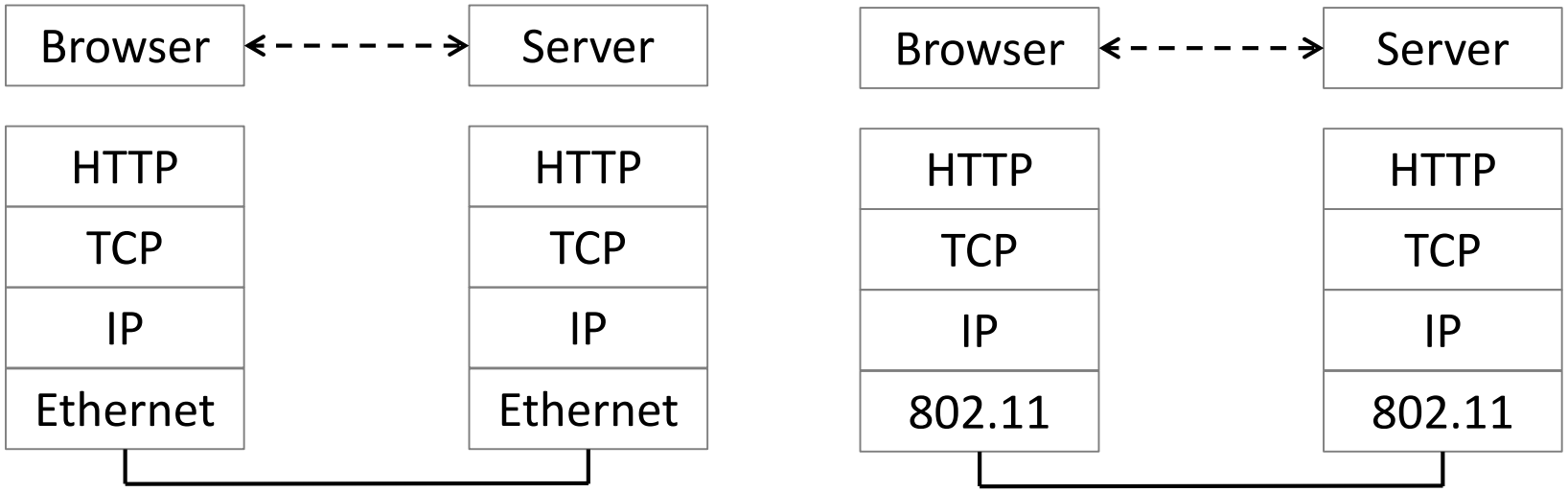
http://en.wikipedia.org/wiki/TCP/IP_model

4.8.1 Example protocols

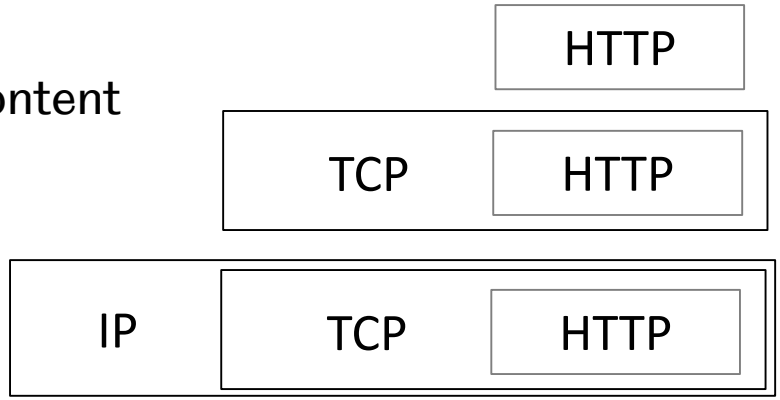
- TCP/IP are just two protocols used on the Internet, but because they were developed so early, the entire suite is named after them
- Internet layer (IP protocol) is sometimes called the "narrow waist" of the Internet



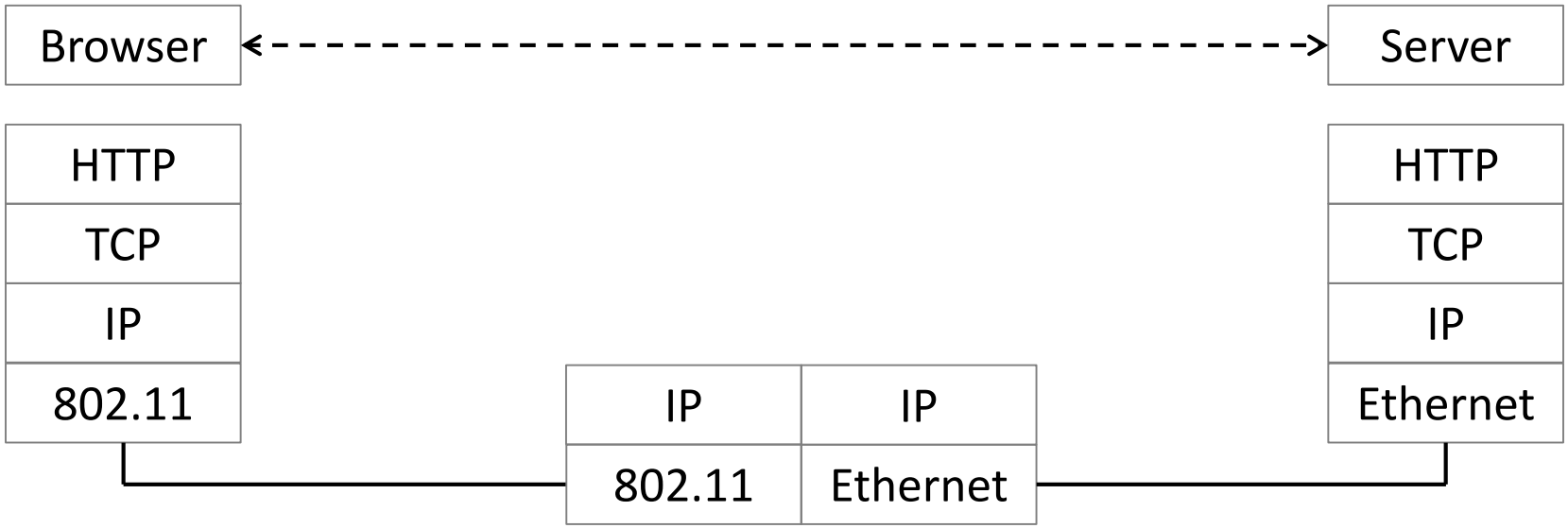
4.8.2 Different protocol stacks



- Encapsulation
  - Lower layer wraps higher layer content
  - Header; payload



4.8.3 Layering advantage – information hiding



5. Summary

- Network topology is always changing
- Packet switching breaks signals into small chunks called packets
- A *protocol* is a set of rules that govern data exchange between two communicating devices
- The OSI Reference Model is a framework for people to use when they want to specify services and protocols for connecting systems together
  - Influential standard
- Layering offers many advantages for communicating
  - Layers are guidelines; not strict
- The TCP/IP 4-layer model is a practical model based on experience

