Internet Systems

6CCS3INS, Dr Samhar Mahmoud

Contact details

Steve Phelps

- **steve.phelps@kcl.ac.uk**
- **http://www.kcl.ac.uk/nms/depts/informatics/people/atoz/phelpss.aspx**

Office hours this semester

- **10.00 to 12.00 Thursdays**
- **Room S6.18 (6th floor of Strand building)**

Samhar Mahmoud

- **samhar.mahmoud@kcl.ac.uk**

Office hours this semester

- **To be Confirmed**

Course structure

- Lectures
  - Every Tuesday from 11.00 to 13.00
- Tutorials
  - Same day as lecture, from 13.00 to 14.00
  - Exercises to work through in small groups
  - Start from next week (week 2)
- Reading Week
  - 31st Oct - 7th November
- Practice in labs in your own time

Resources

- Materials on KEATS
  - Slides
  - Notes
  - Quizzes
  - Tutorial questions
  - Tutorial answers available after each tutorial

- Many useful resources on the web
  - Introduced through course

Assessment

- 80% Exam
  - Early in January
- Some past exam papers with sample solutions available on KEATS, to be discussed in the final (revision) lecture
- 20% Coursework
  - Coursework will be assigned in week 5
  - Deadline in week 7 (after reading week)

Reading list

- Some recommendations in your handbook:
  - Web Application Architecture
  - Distributed Systems: Concepts and Design
  - HTTP: The Definitive Guide
  - Learning XML
  - Mastering HTML 4
  - Web Security, Privacy and Commerce
- The lectures are the primary source

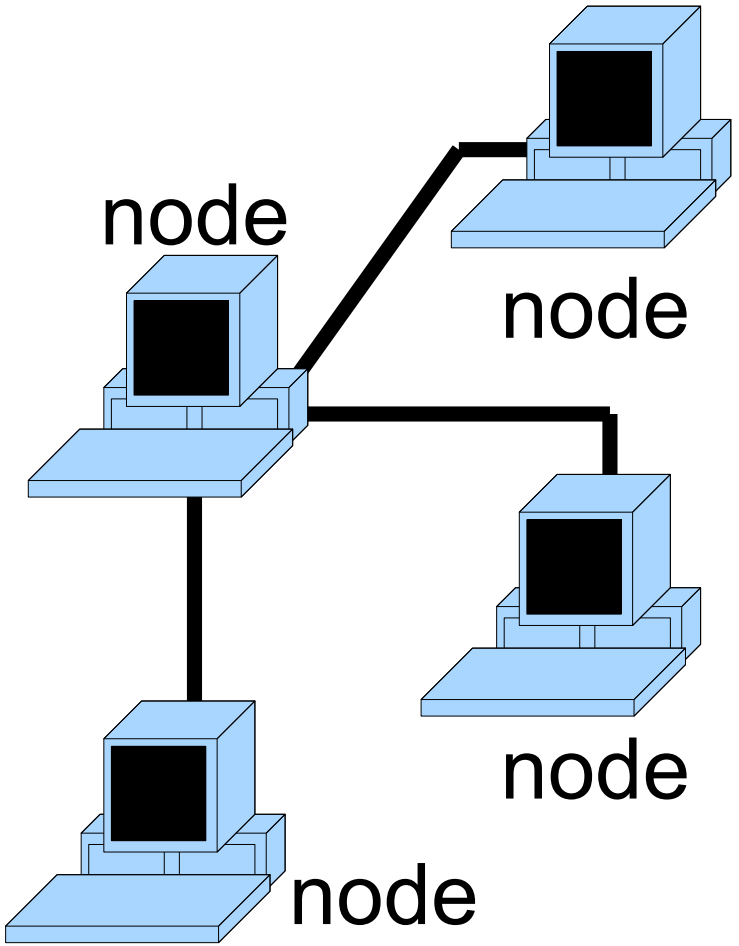
Course topics

1. Architecture and Addressing
2. The Internet Protocol (IP)
3. The Transmission Control Protocol (TCP)
4. The Hyper-Text Transfer Protocol (HTTP)
5. XML and HTML
6. Web Service and Semantic Web
7. Security
8. Virtualisation and Cloud Computing

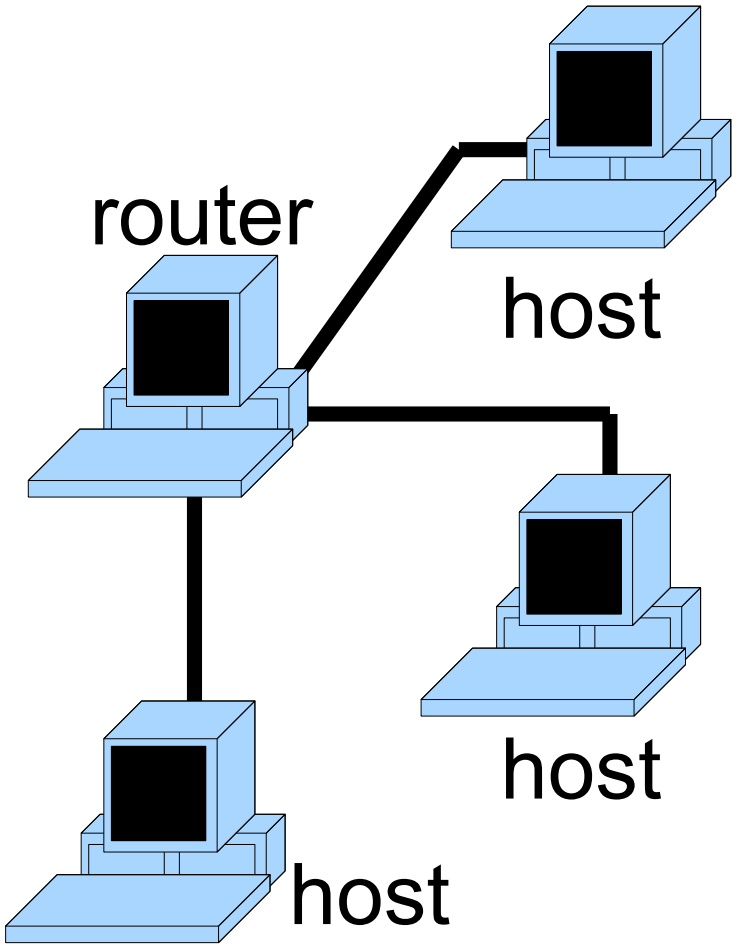
A quick introduction to everything

Basics, Historical Perspective, Concepts

Networks

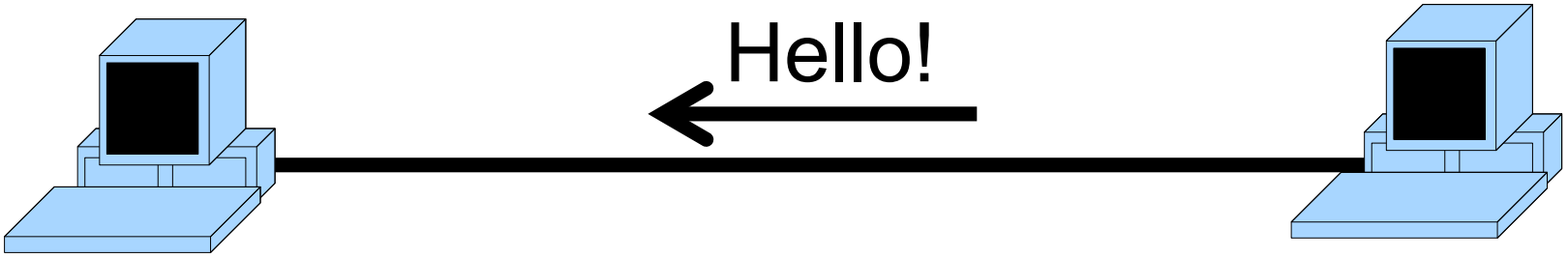


Networks

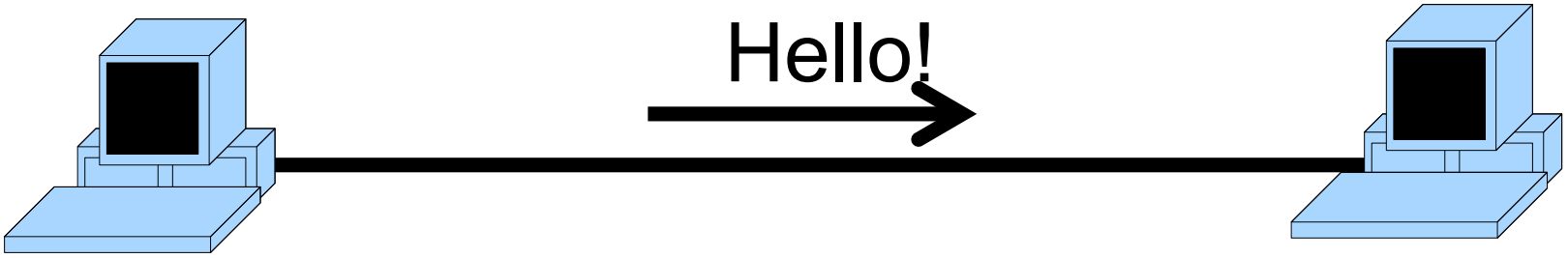


Protocols

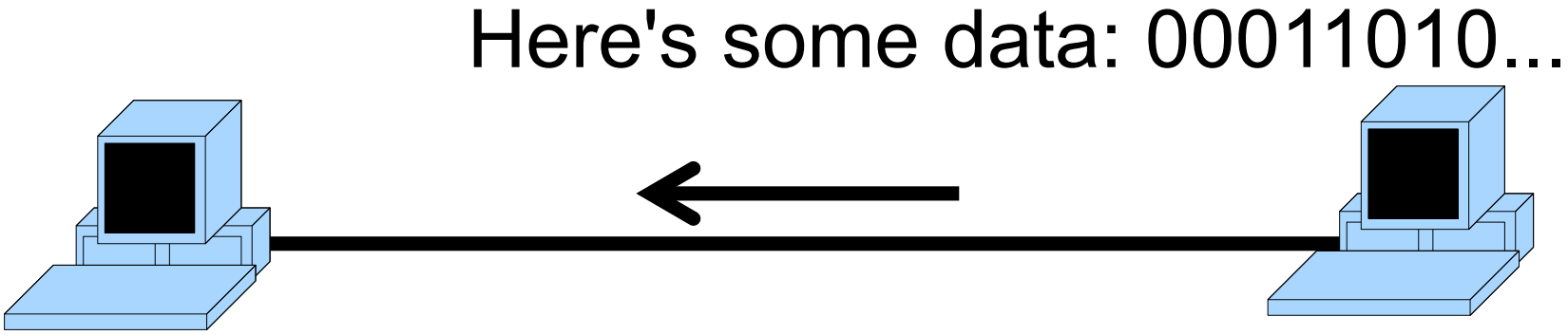
Protocols



Protocols

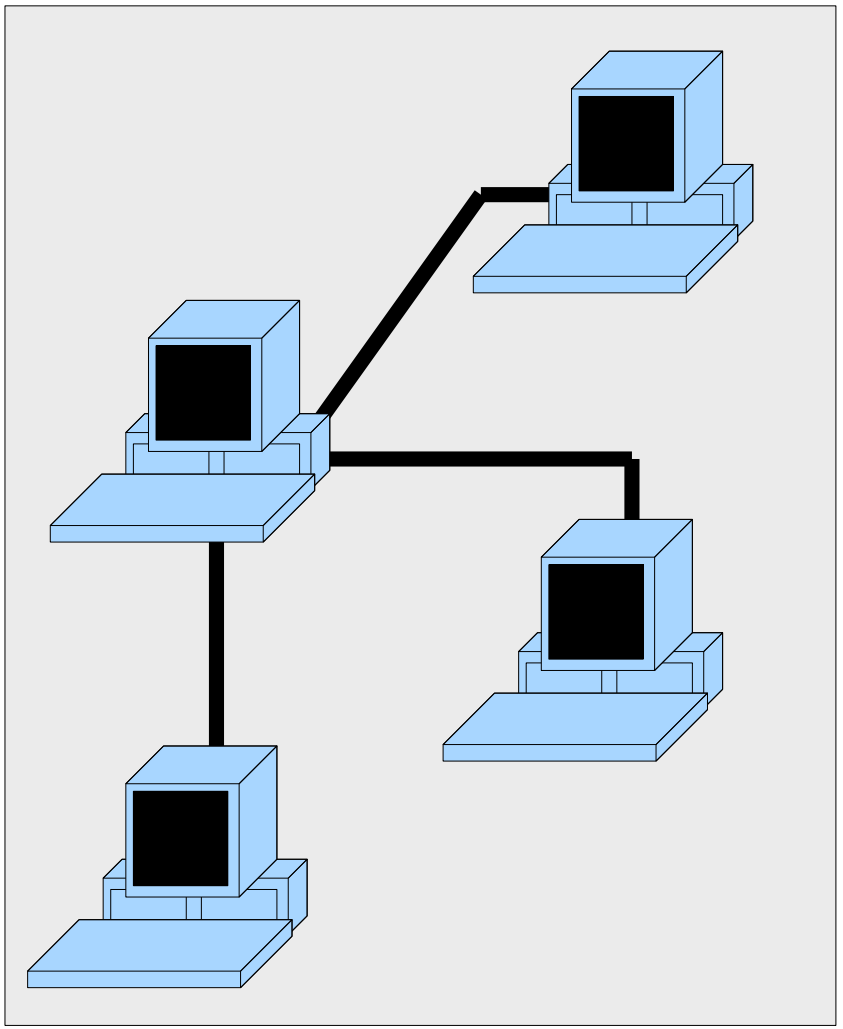


Protocols

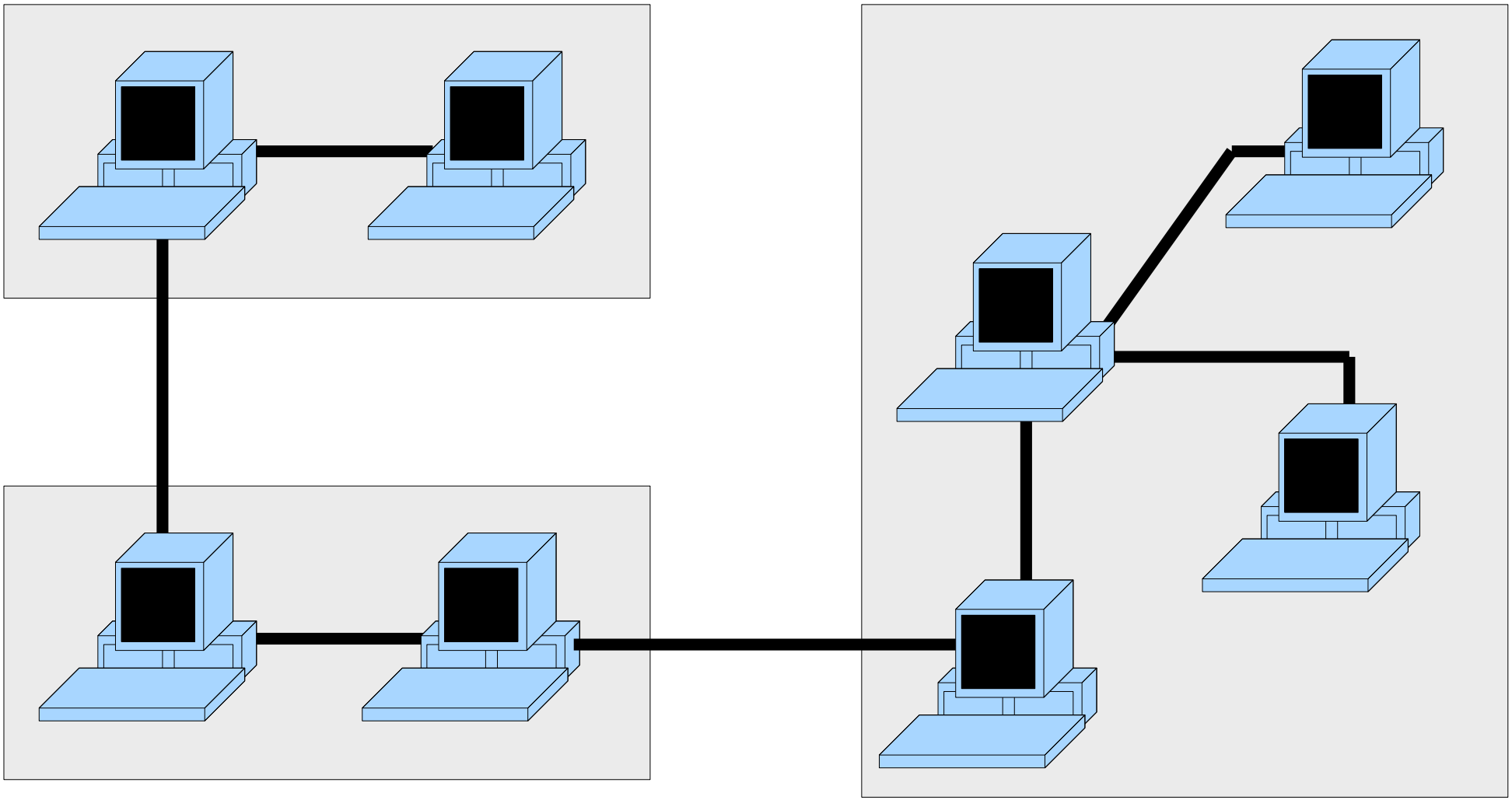


Protocols

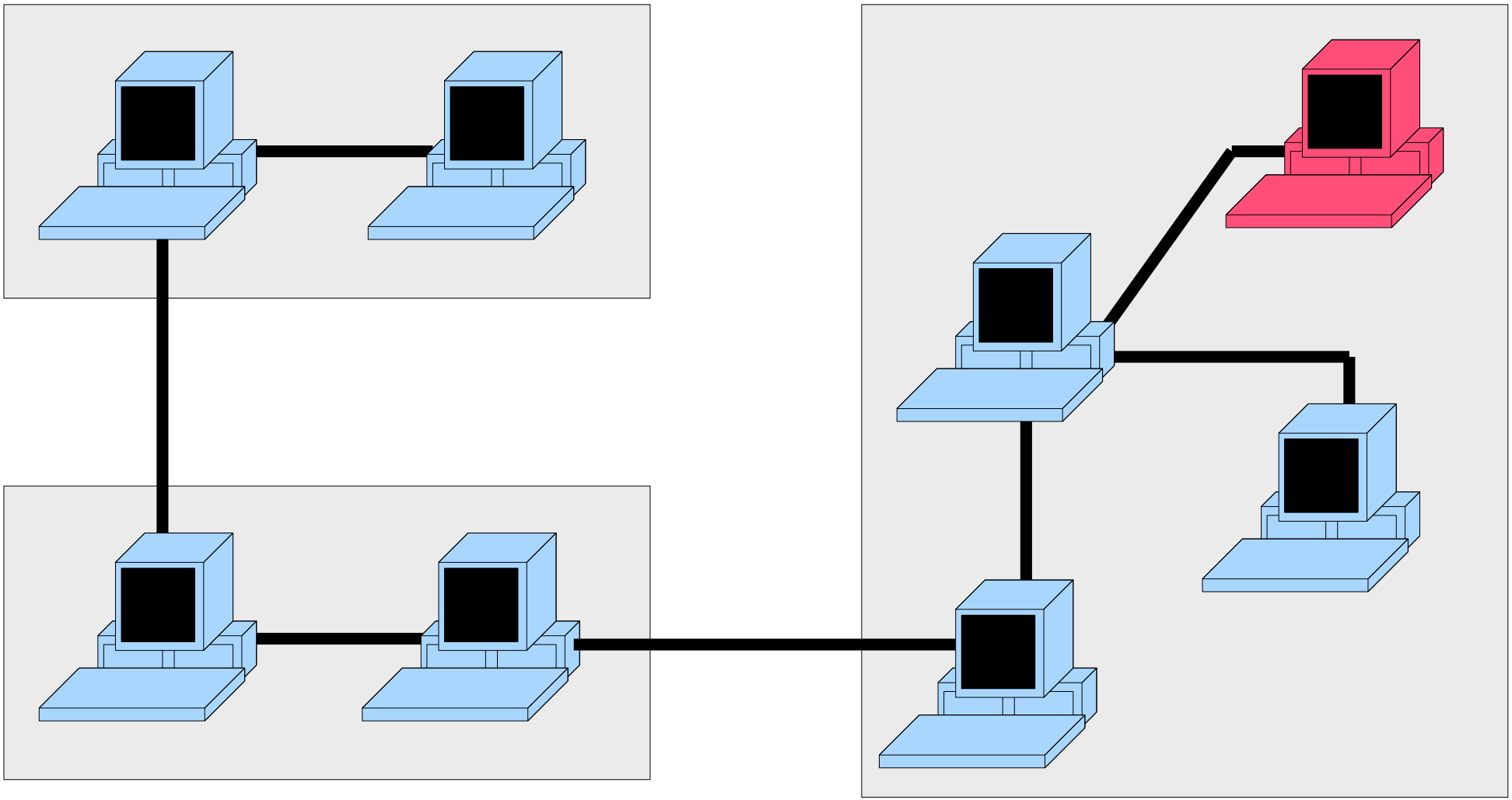
Local Area Networks



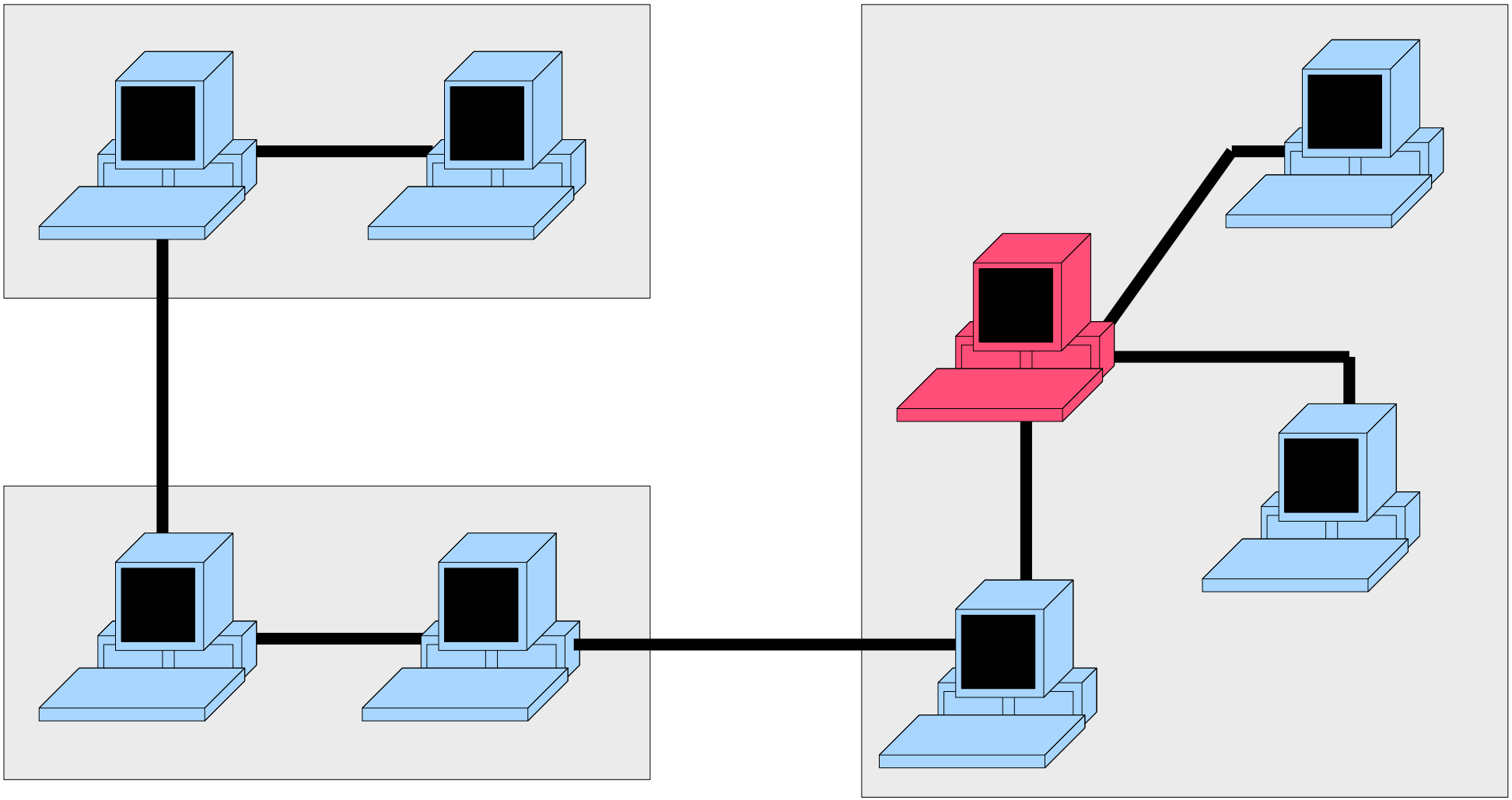
Wide Area Networks



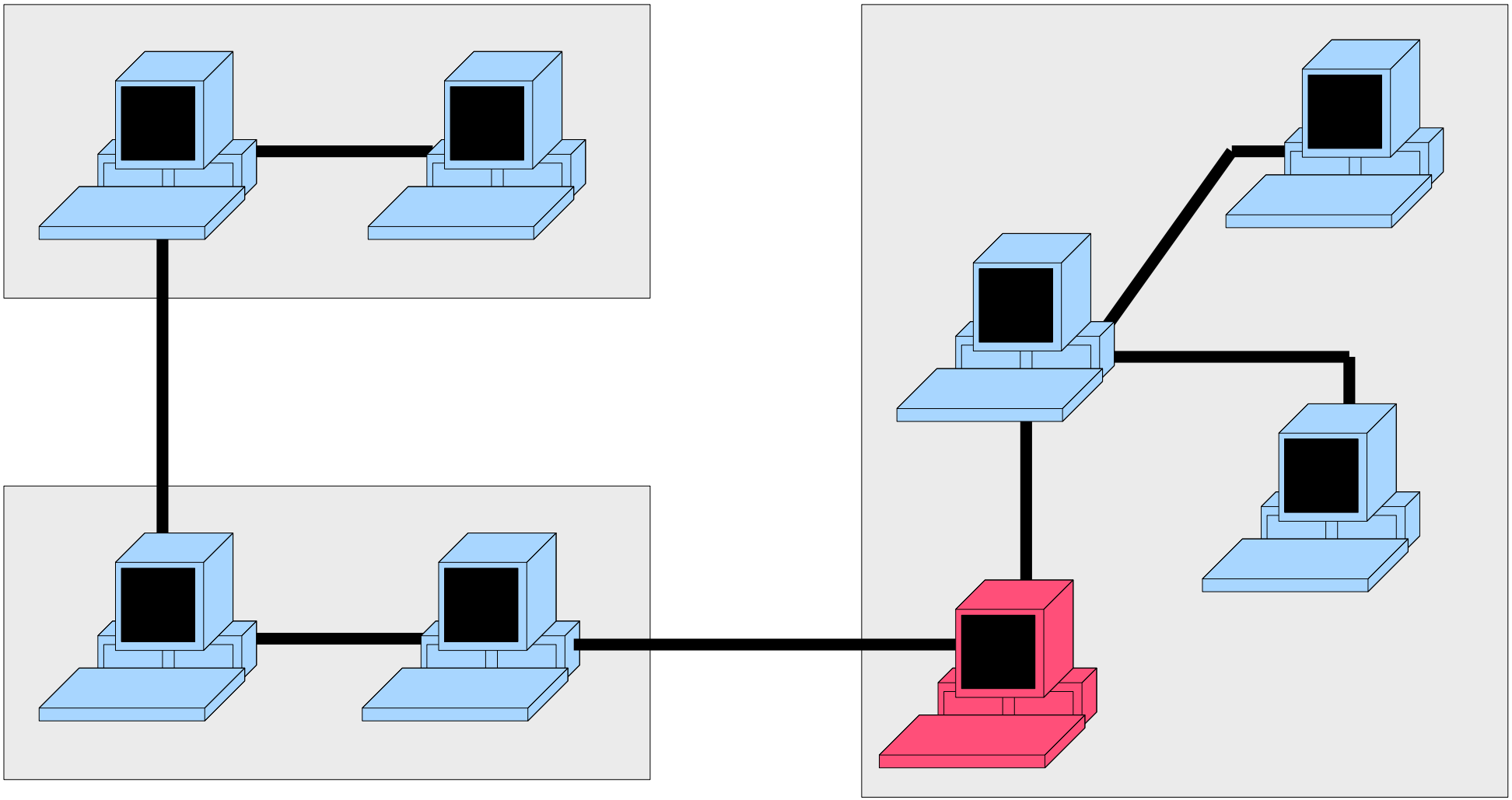
Routing



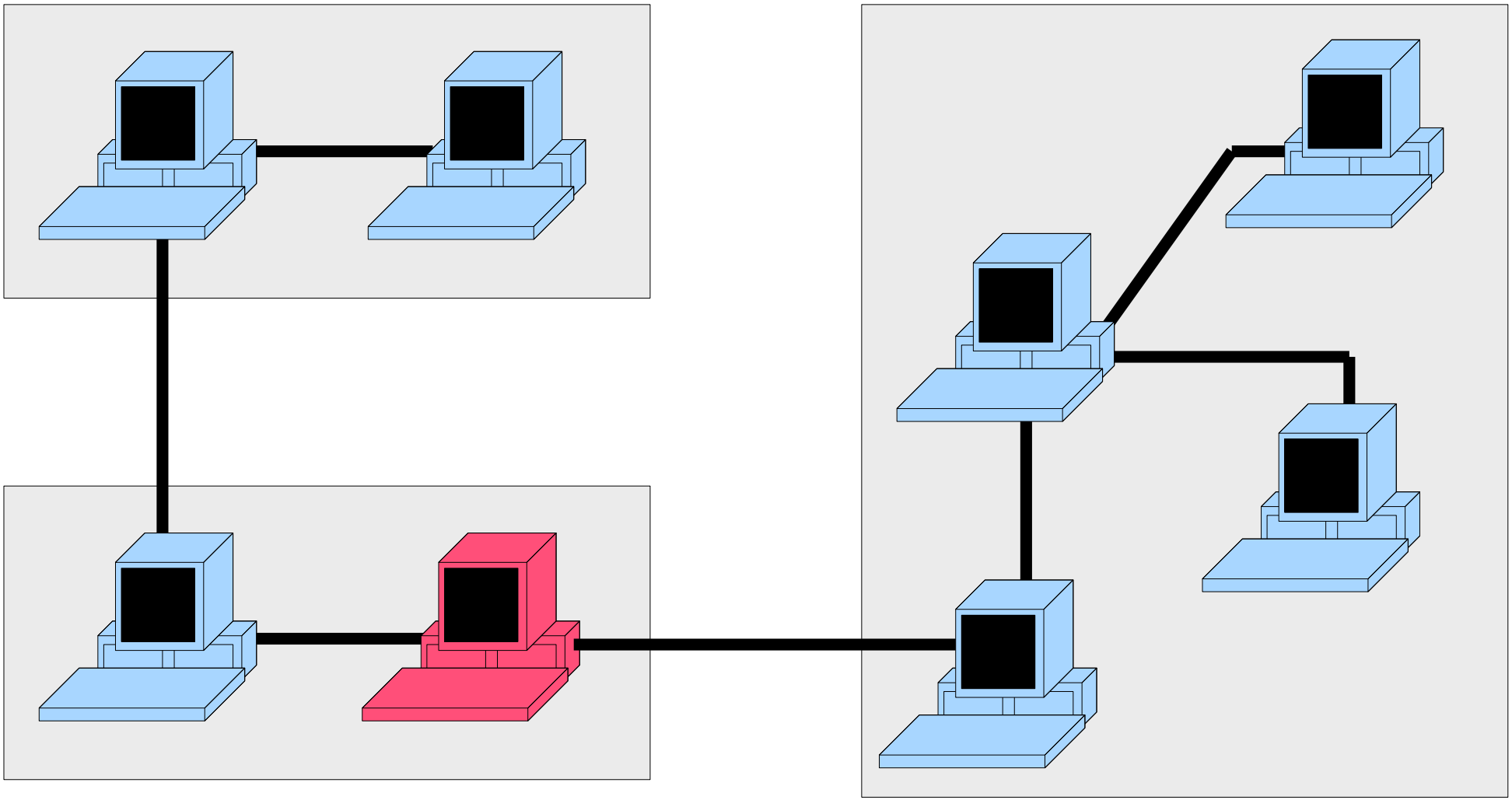
Routing



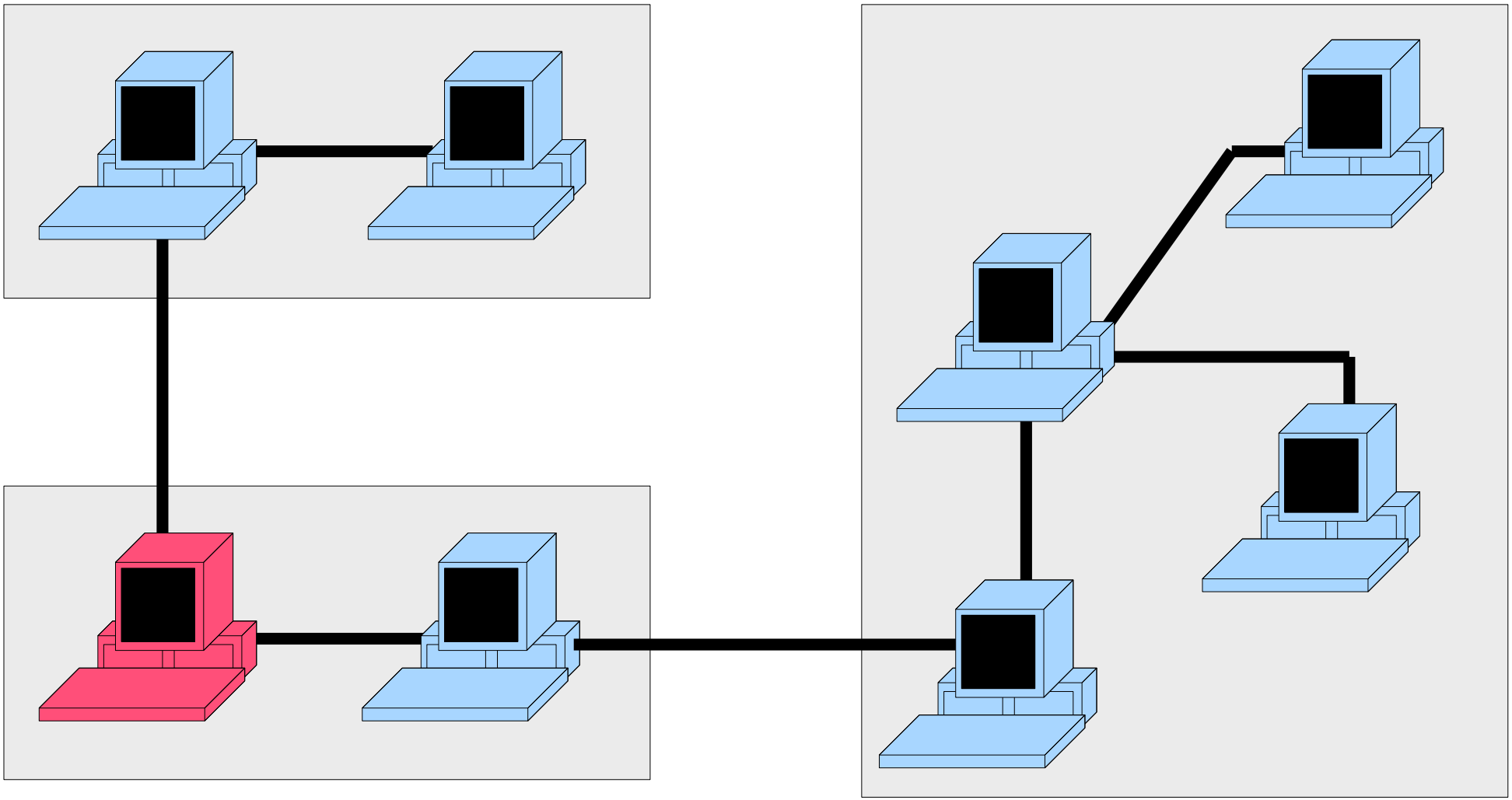
Routing



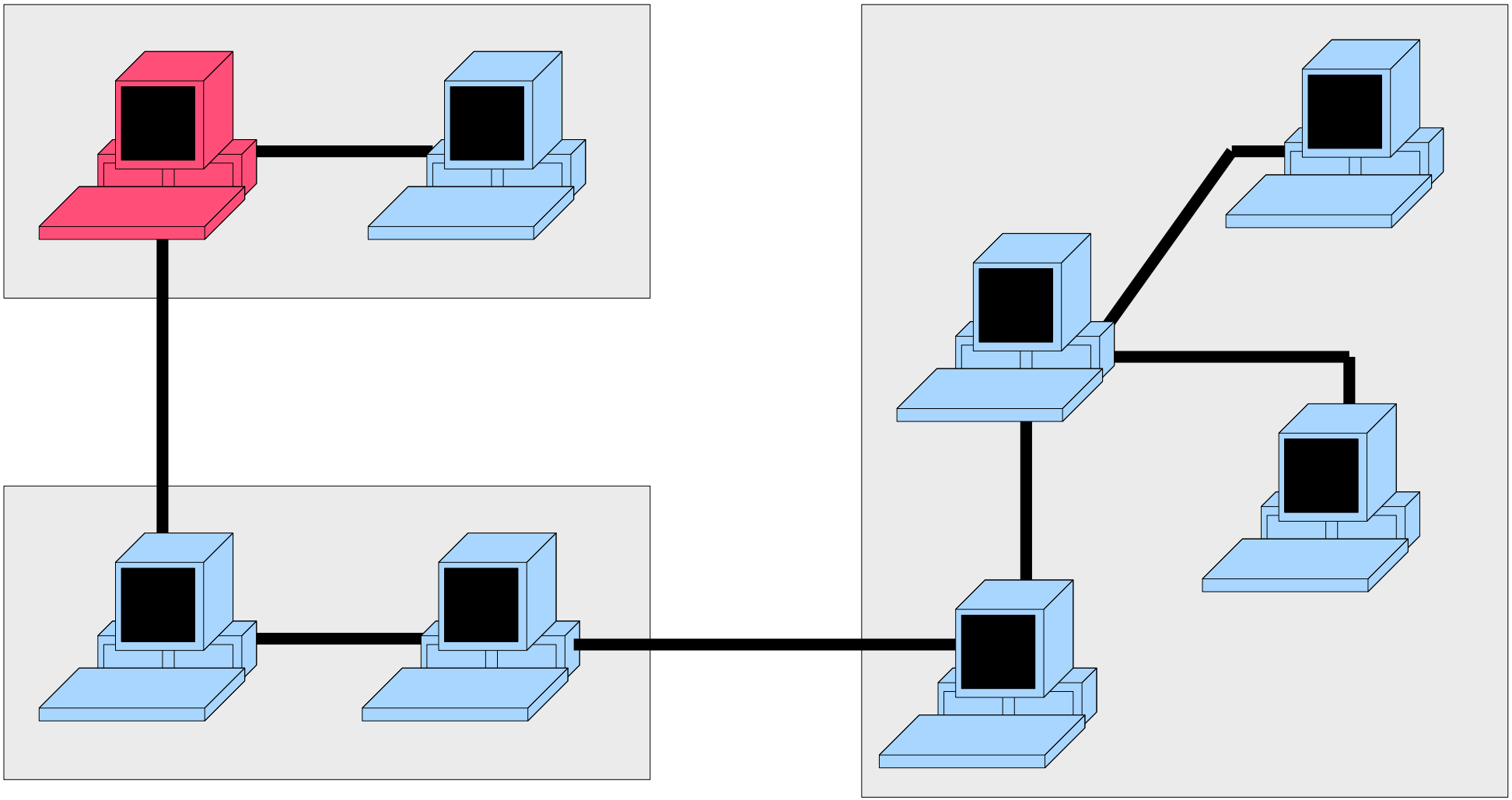
Routing



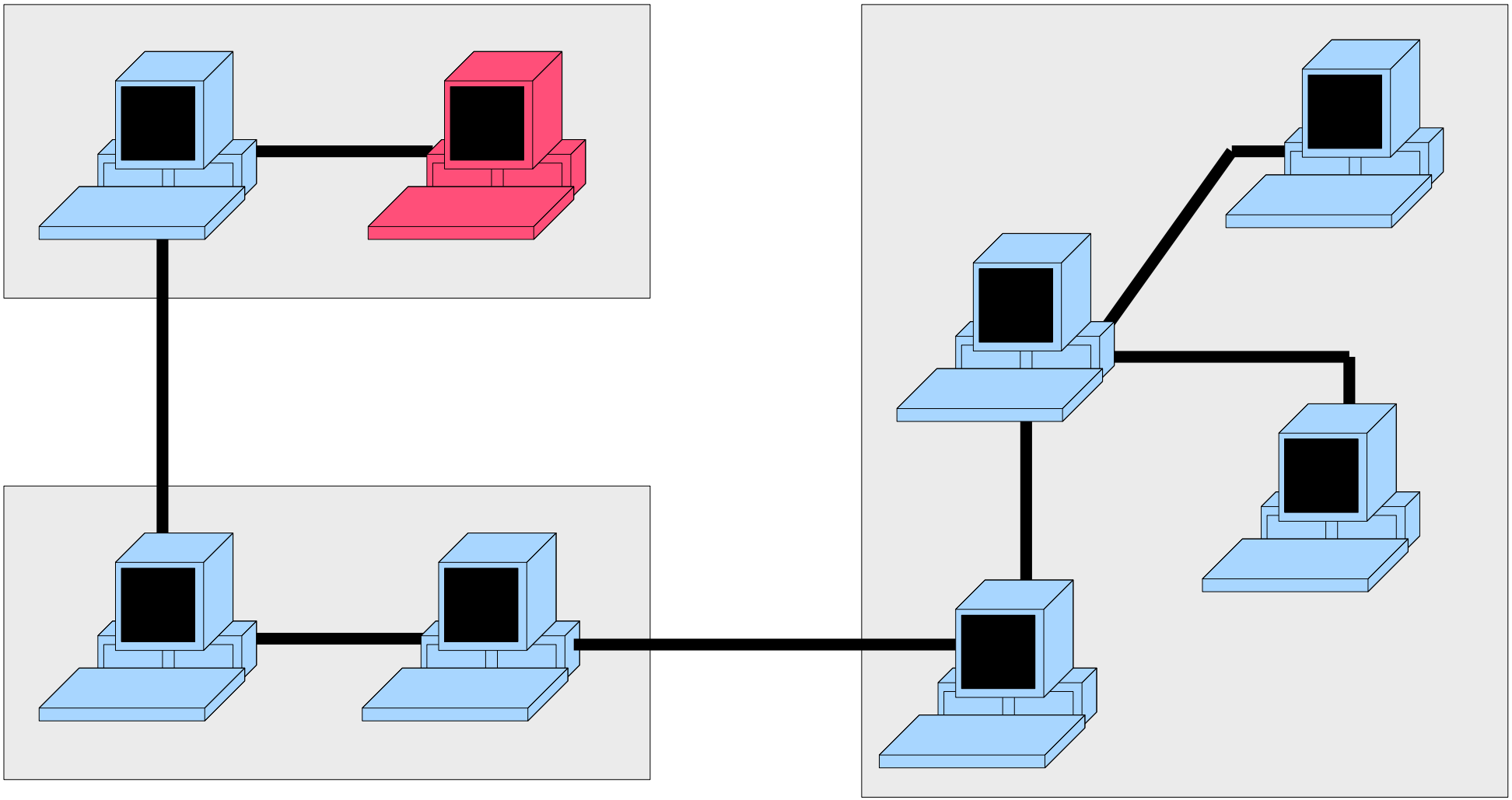
Routing



Routing



Routing



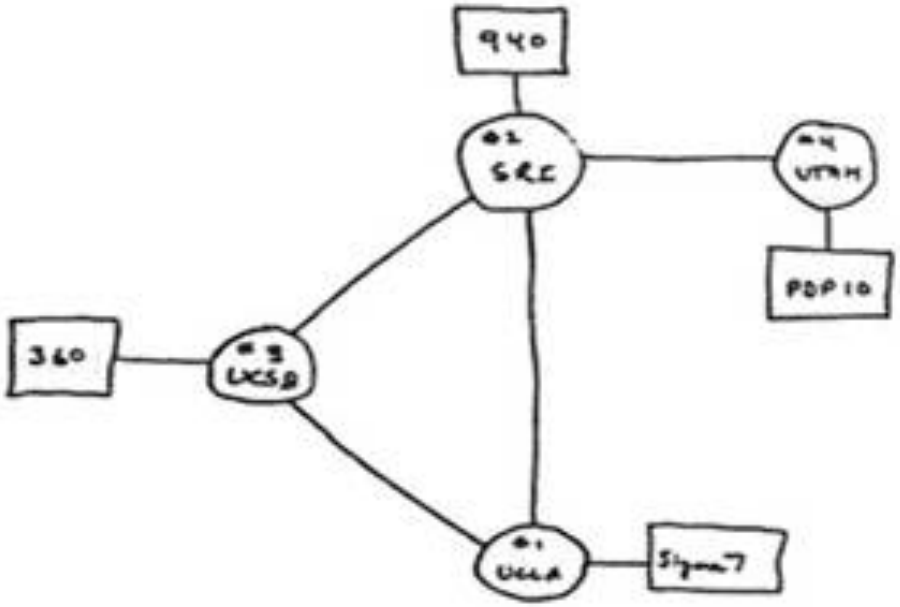
Origins of the Internet

- Computers were first interconnected with point-to-point links in the mid-1960s.

- Advanced Research Projects Agency (ARPA)
  - Part of US Department of Defense
  - Analysed networks in the 1970s

- Discovered problems with existing WANs
  - Created ARPANET that was:
    - Decentralised
    - Used public, open protocols to communicate data

First 4 nodes of the Internet



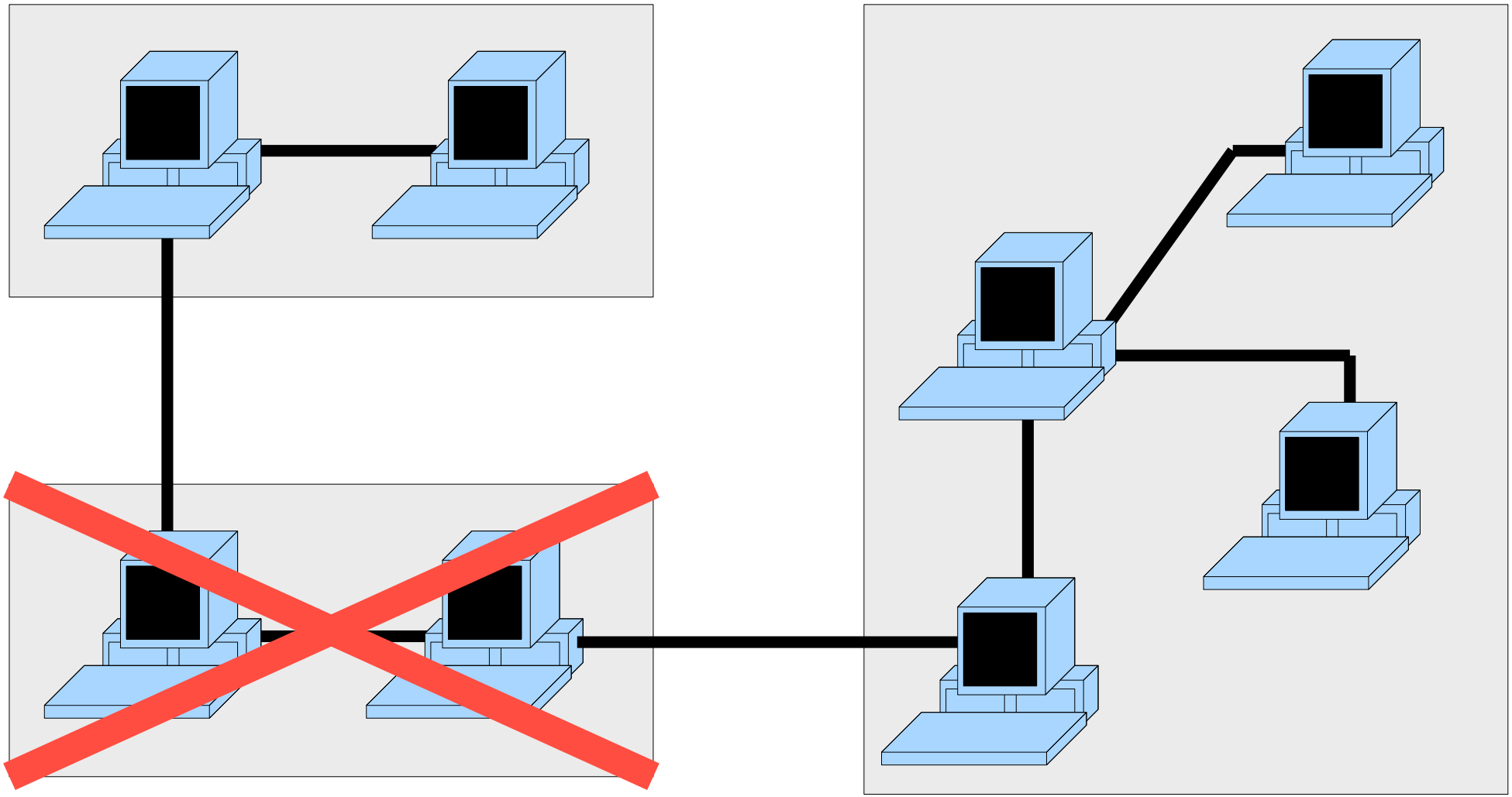
THE ARPA NETWORK

DEC 1969

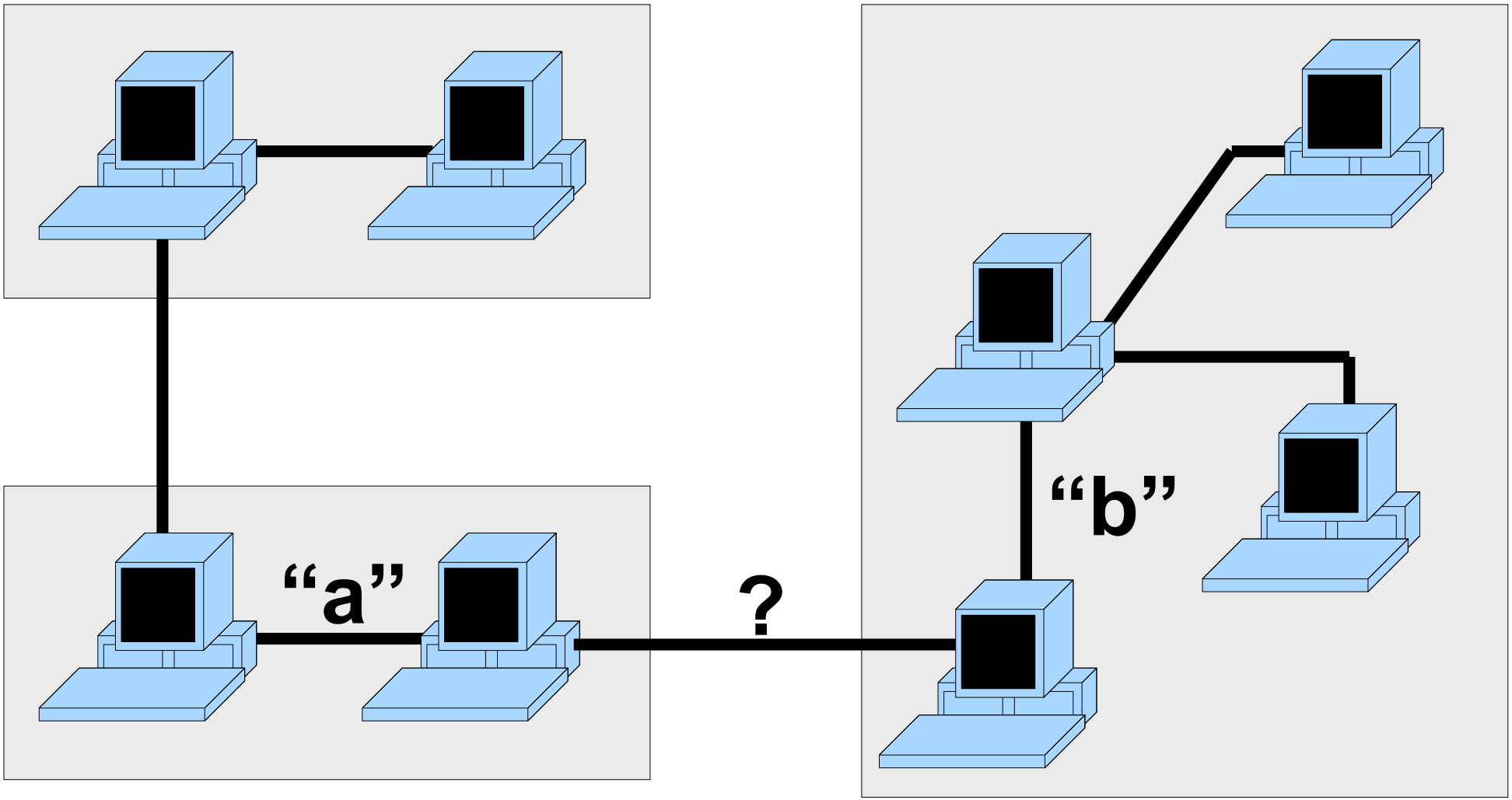
4 NODES

FIGURE 6.2 Drawing of 4 Node Network
(Courtesy of Alex McKenzie)

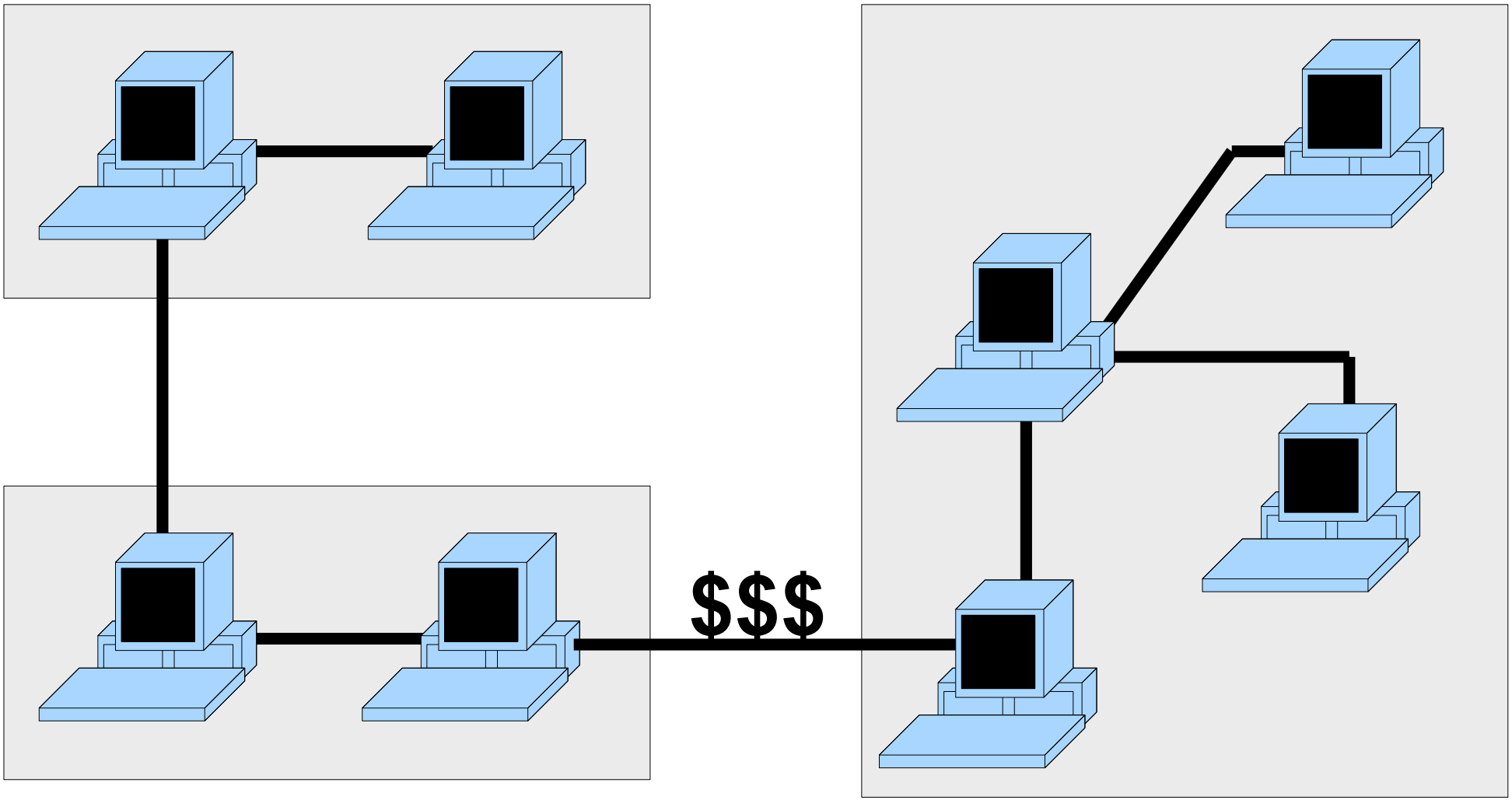
Problems: Centralisation



Problems: Different Protocols



Problems: Proprietary protocols

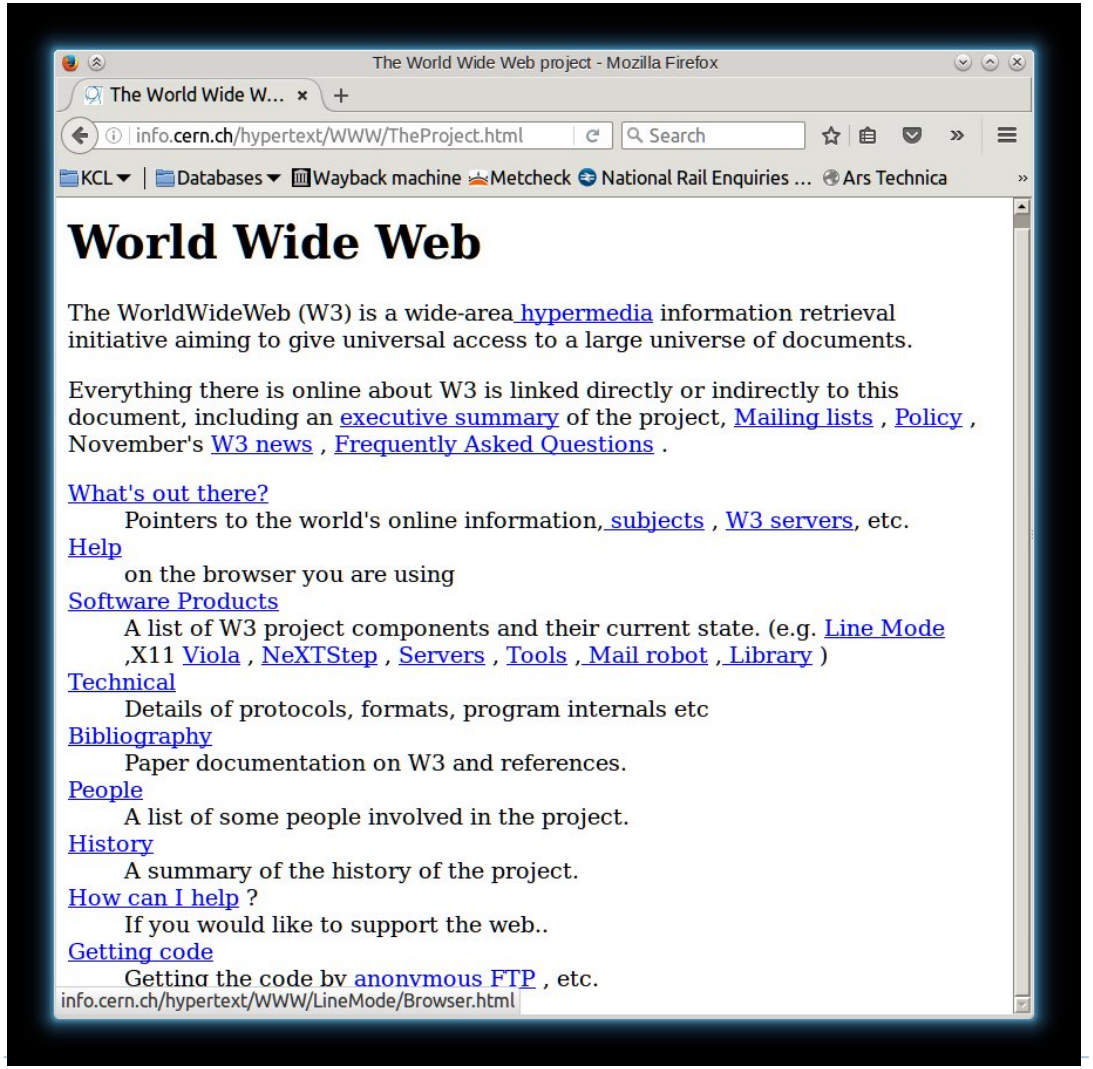


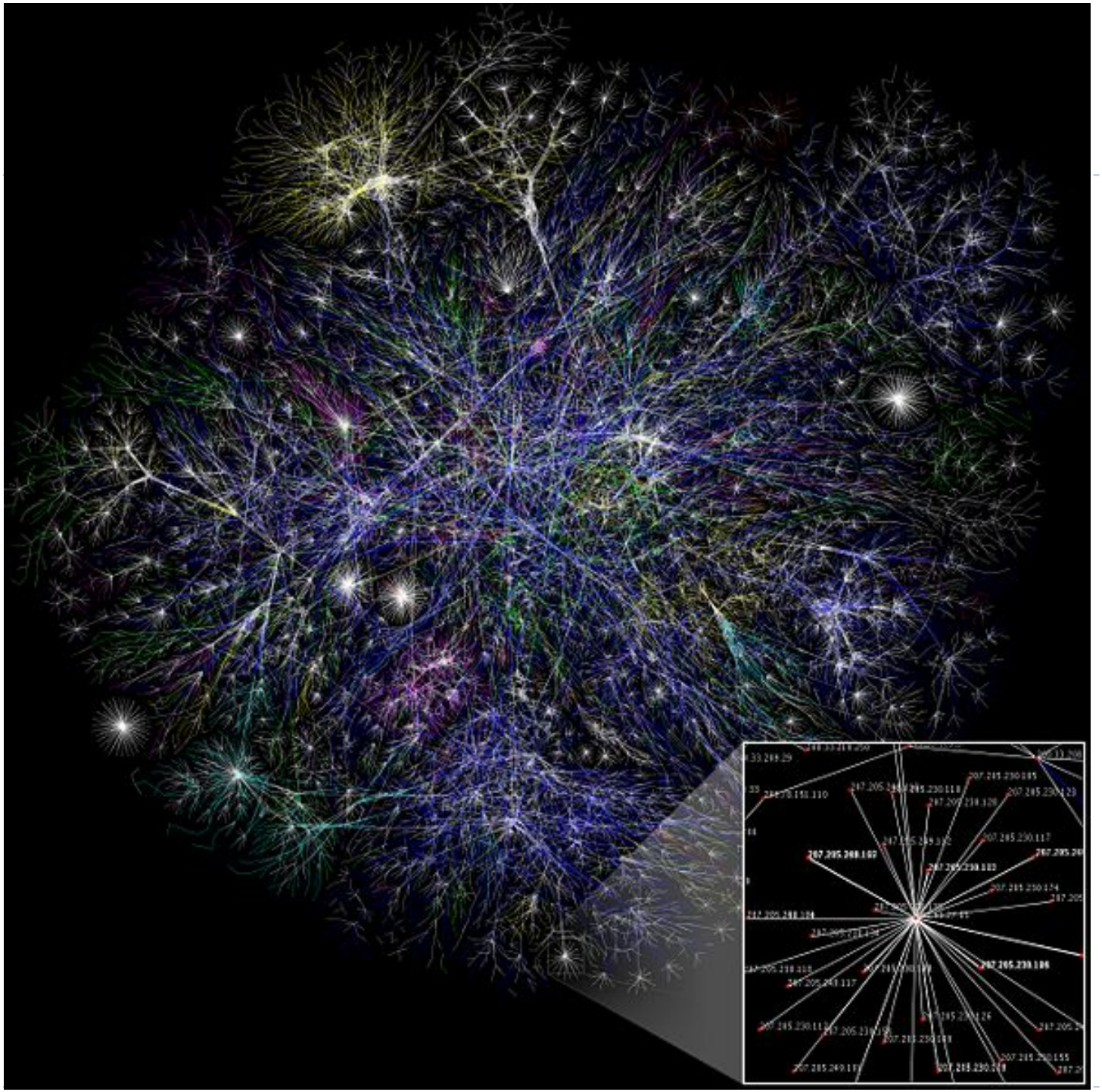
Internet History

- 1971 Ray Tomlinson invented email and adapted the "@" sign
- 1974 Telenet was opened which was the first commercial packet-switched network based on the ARPA-Net research.
- 1983 TCP/IP was introduced by ARPA and today's Internet became a reality.
- 1984 there were 1,000 host computers on the Net
- 1989 the number of servers was approximately 100,000.
- 1993, Tim Berners-Lee first started thinking about how people might exchange documents and information using a hyperlink system and the Internet.

The first html web page

- http://info.cern.ch/hypertext/WWW/TheProject.html





Today's Internet

- Others followed the decentralised approach and used the public protocols.
  - TCP/IP protocol is the foundation of an inter-networking design and the most widely used network protocol in the world.
  - Because of the public protocols, anyone can connect a host to the internet

- ARPANET was fundamentally unreliable in nature, as the Internet is still today.
  - The principle of unreliable delivery means that the Internet only makes a best-effort attempt to deliver packets.
  - The network can drop a packet without any notification to sender or receiver.
  - Remember, the Internet was designed for military survivability.
  - The software running on either end must be prepared to recognize data loss, retransmitting data as often as necessary to achieve its ultimate delivery.

The ARPANET was originally created by the *IPTO* under the sponsorship of *DARPA*, and conceived and planned by *Lick Licklider*, *Lawrence Roberts*, and others as described earlier in this section.

The ARPANET went into labor on August 30, 1969, when BBN delivered the first *Interface Message Processor* (IMP) to *Leonard Kleinrock*'s Network Measurements Center at UCLA. The IMP was built from a Honeywell DDP 516 computer with 12K of memory, designed to handle the ARPANET network interface. In a famous piece of Internet lore, on the side of the crate, a hardware designer at BBN named Ben Barker had written "Do it to it, Truett", in tribute to the BBN engineer Truett Thach who traveled with the computer to UCLA on the plane.

The UCLA team responsible for installing the IMP and creating the first ARPANET node included graduate students *Vinton Cerf*, *Steve Crocker*, Bill Naylor, *Jon Postel*, and Mike Wingfield. Wingfield had built the hardware interface between the UCLA computer and the IMP, the machines were connected, and within a couple of days of delivery the IMP was communicating with the local NMC host, an SDS Sigma 7 computer running the SEX operating system. Messages were successfully exchanged, and the one computer ARPANET was born. A picture of Leonard Kleinrock with the first ARPANET IMP is shown below (click on the picture to link to a larger image on Kleinrock's home site).

- Leonard Kleinrock with first IMP

The first full ARPANET network connection was next, planned to be with *Douglas Engelbart*'s NLS system at the Stanford Research Institute (SRI), running an SDS-940 computer with the Genie operating system and connected to another IMP. At about 10:30 PM on October 29'th, 1969, the connection was established over a 50 kbps line provided by the AT&T telephone company, and a two node ARPANET was born. As is often the case, the first test didn't work flawlessly, as Kleinrock describes below:

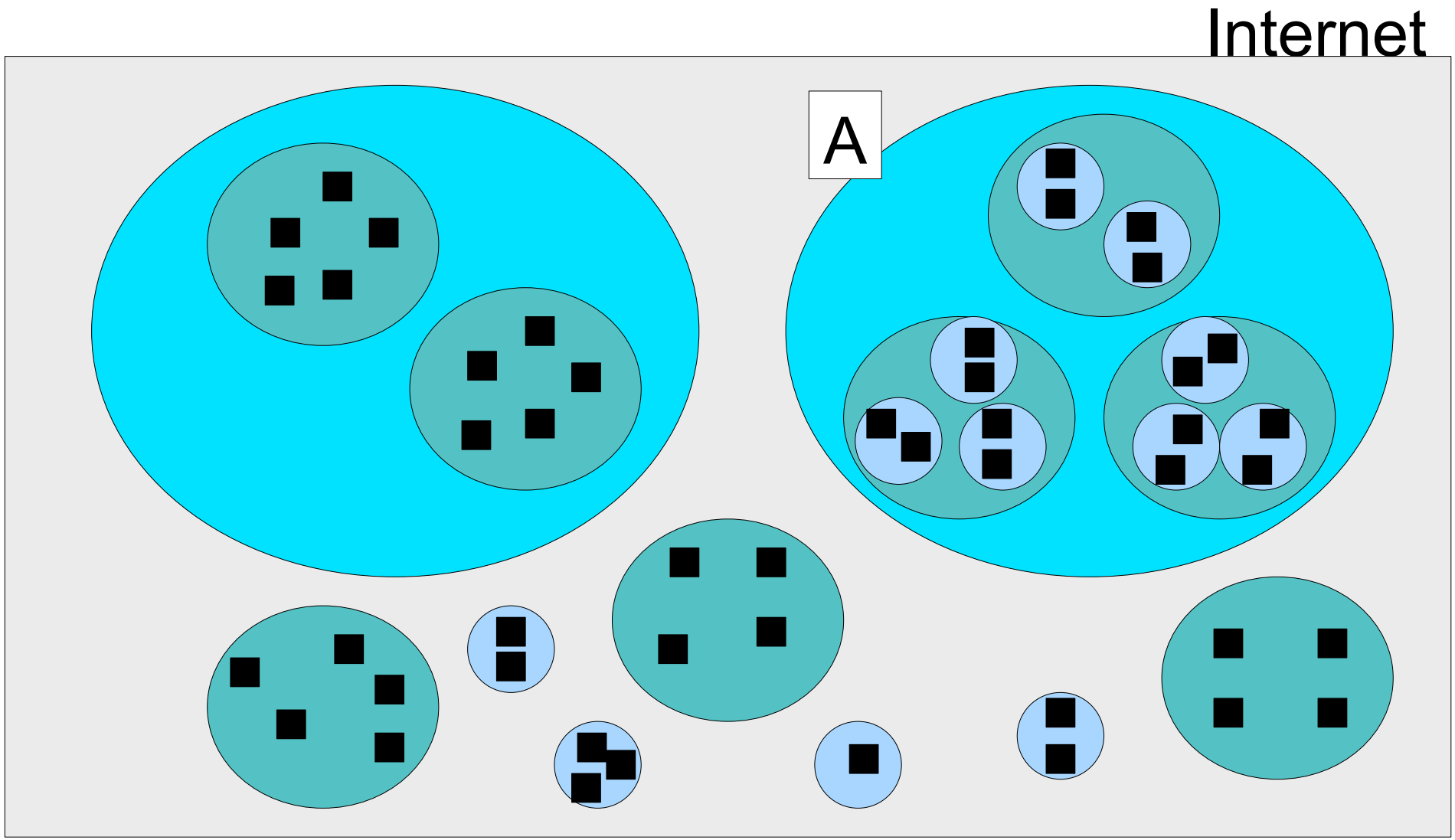
- John M. Mcquillan, Ira Richer, and Eric C. Rosen, "*The New Routing Algorithm for the ARPANET*," *IEEE Transactions on Communications,* Vol. COM-28, No. 5, May 1980.

- Vern Paxson, "*End-to-end routing behavior in the internet*," *SIGCOMM Computer Communications Review,* Vol. 36, No. 5, October 2006, pp 41-56.

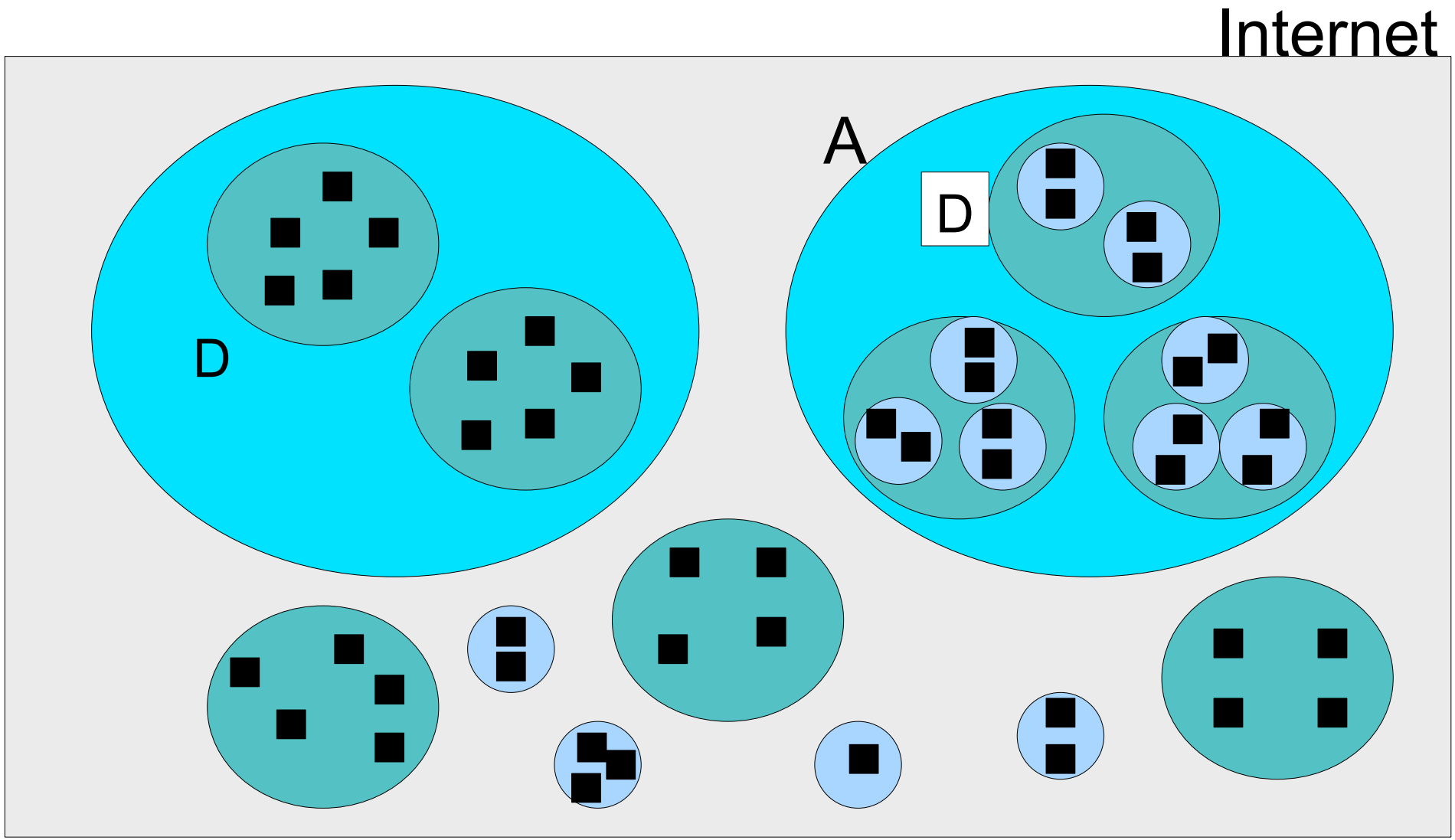
Course topics

1. **The architecture of the internet**
2. **Addressing resources on the internet**

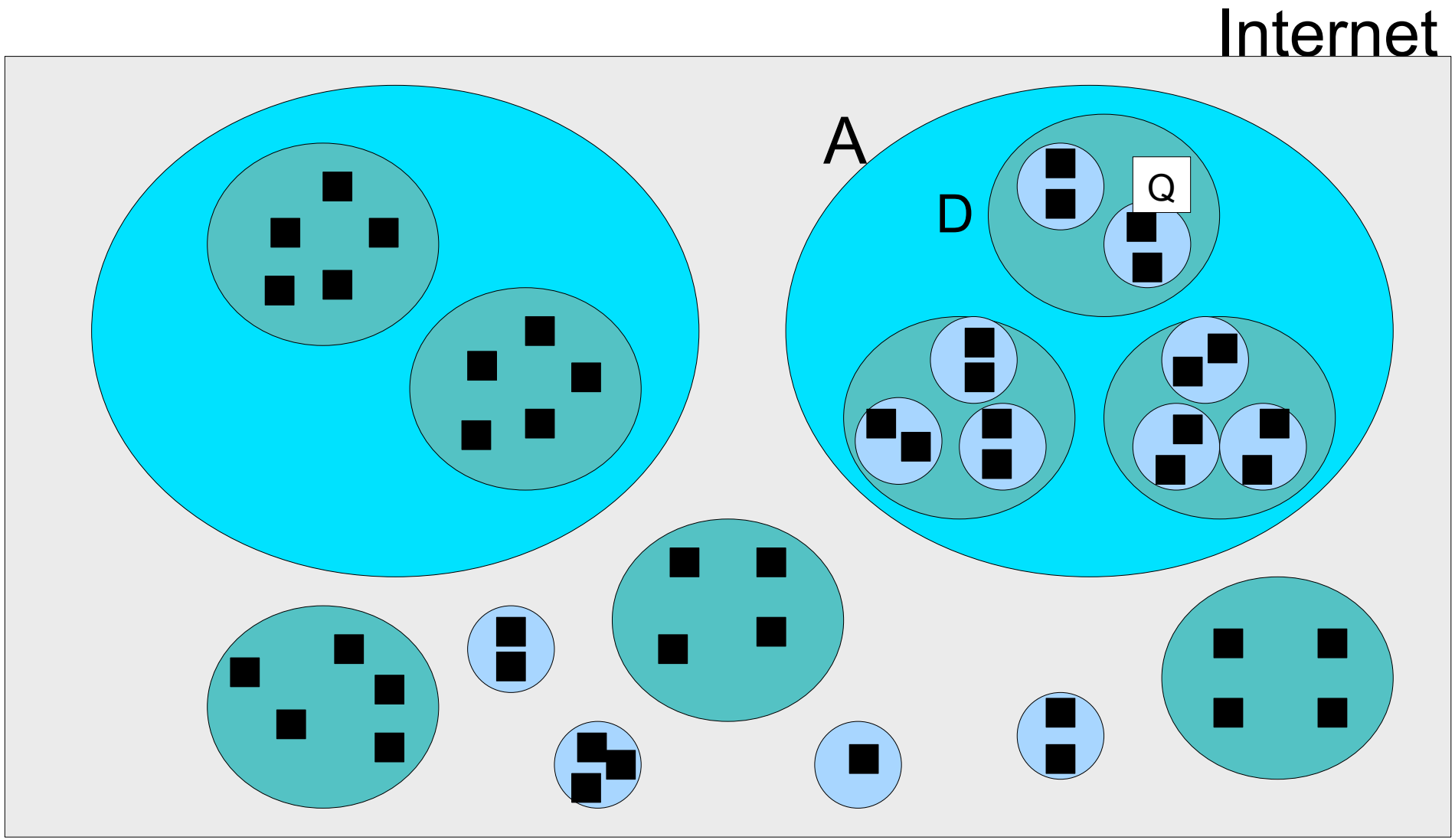
Hierarchical addressing



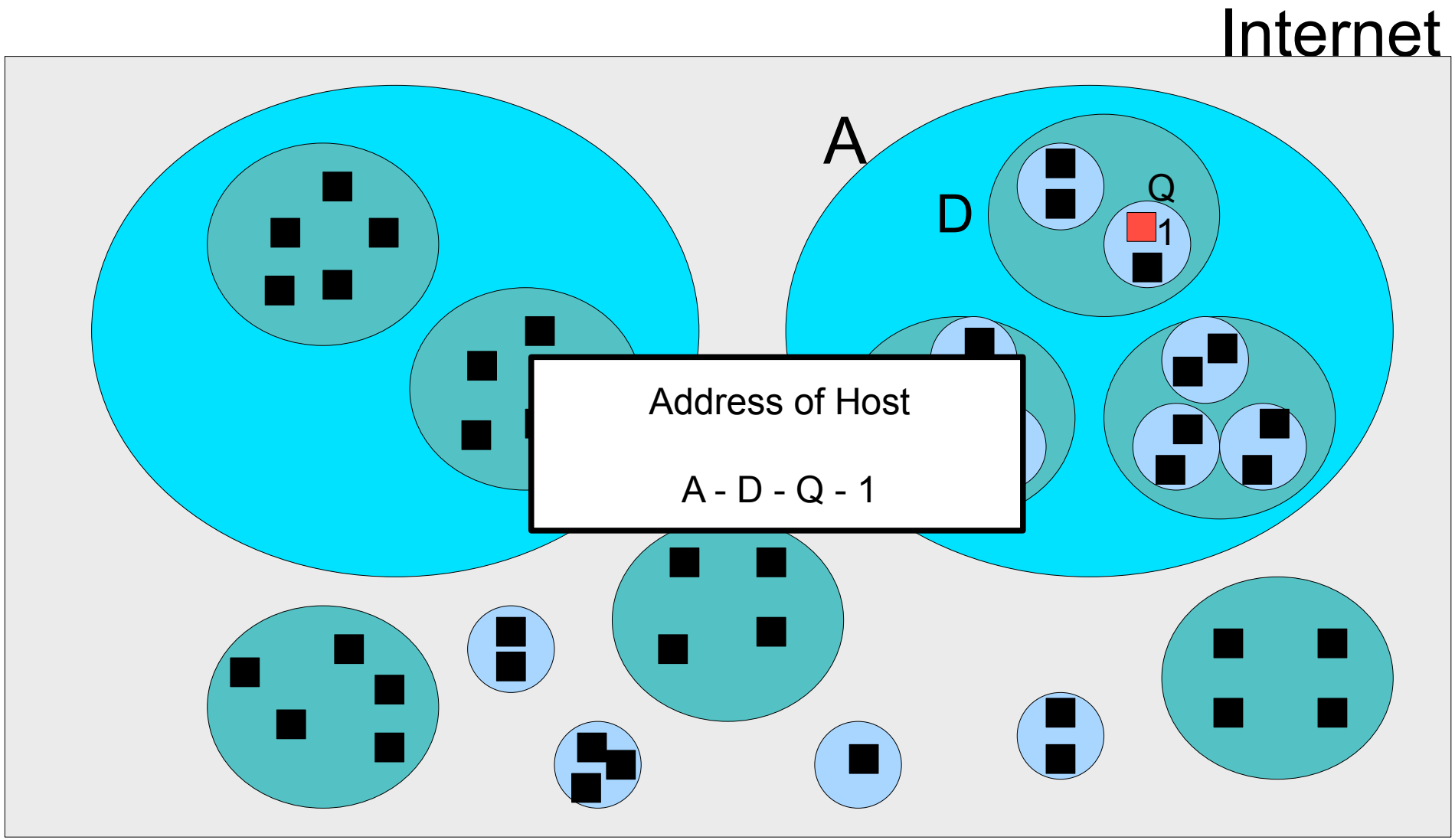
Hierarchical addressing



Hierarchical addressing



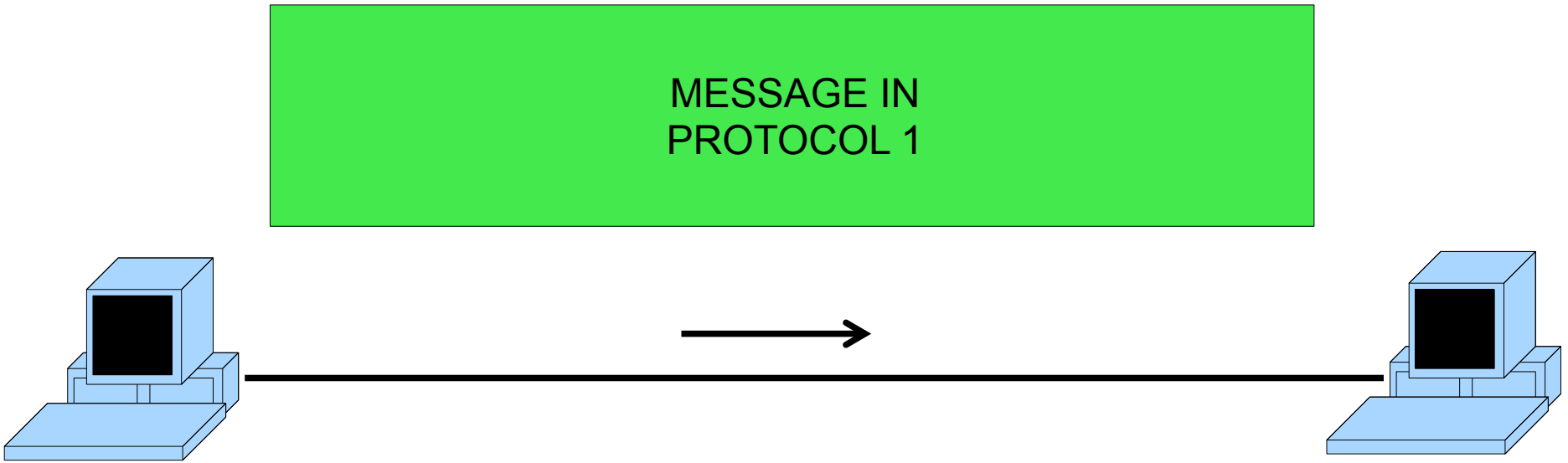
Hierarchical addressing



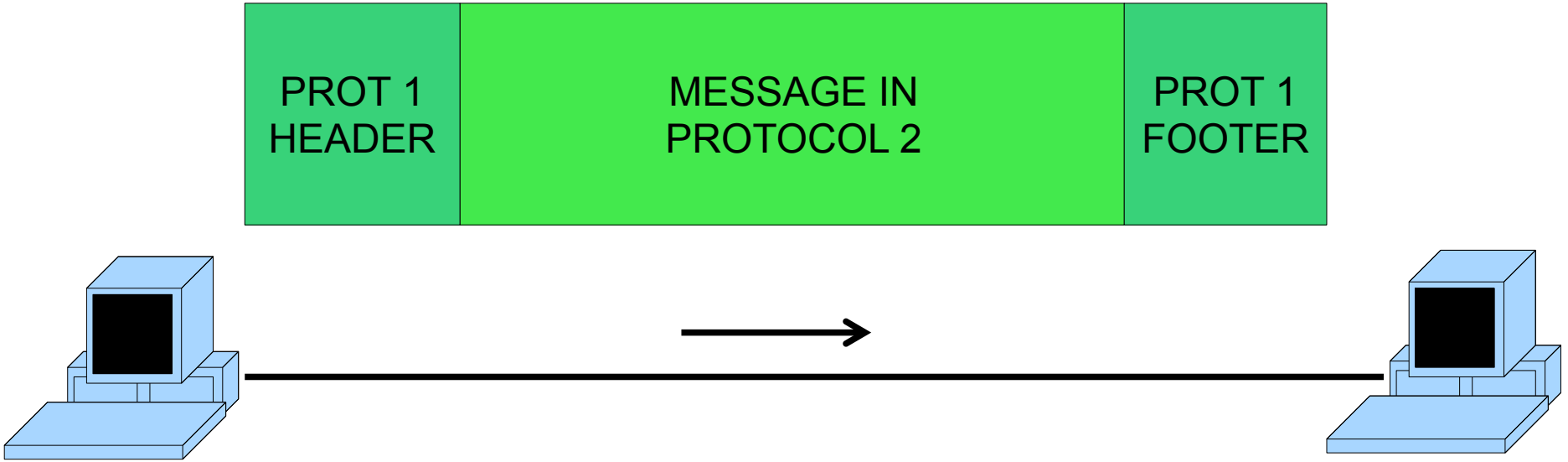
Course topics

1. The architecture of the internet
2. Addressing resources on the internet
3. **Internetwork communication (IP)**
4. **Handling communication problems (TCP)**

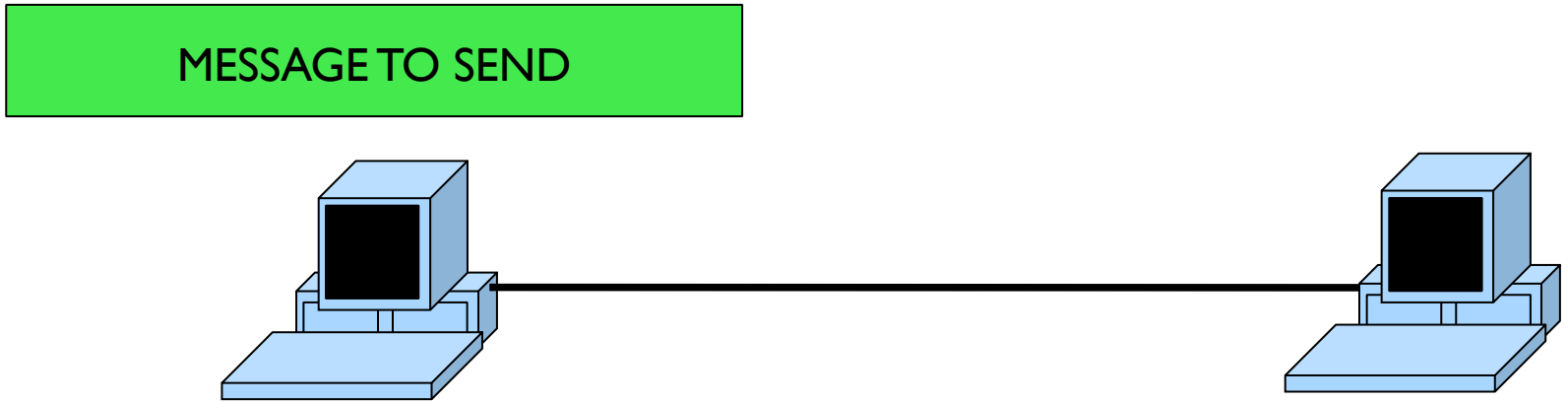
Embedded messages



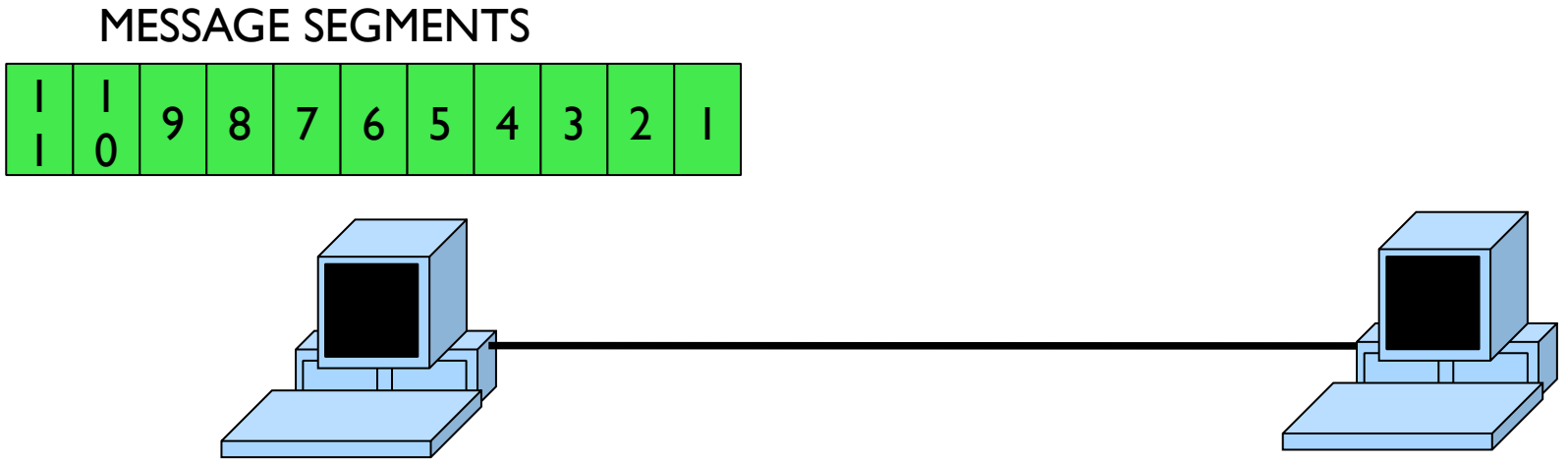
Embedded messages



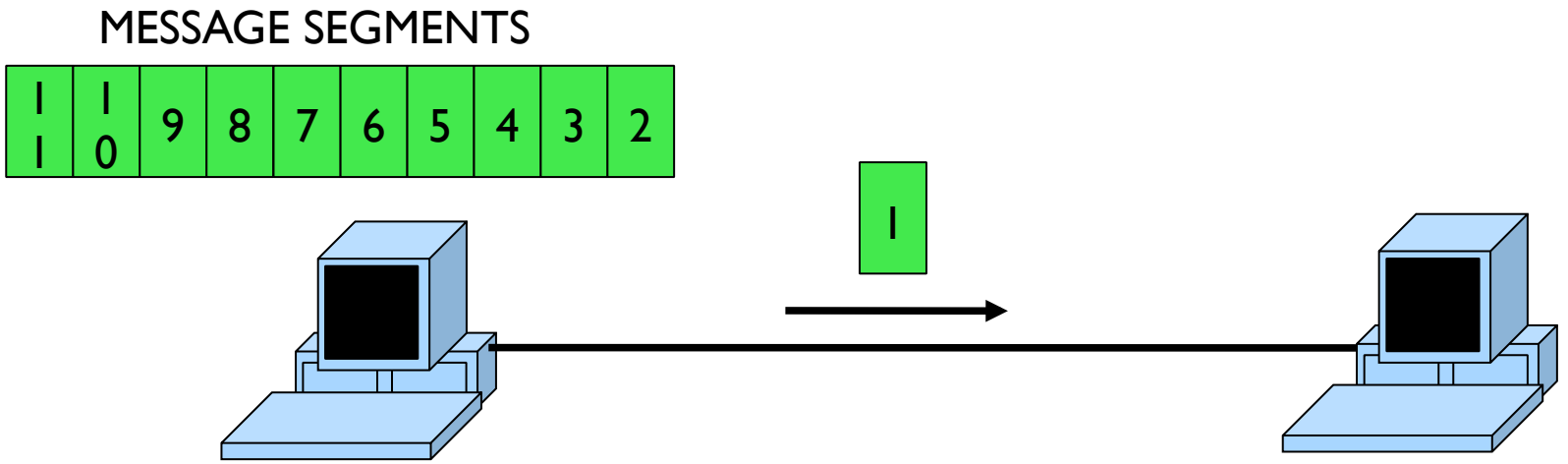
Flow Control



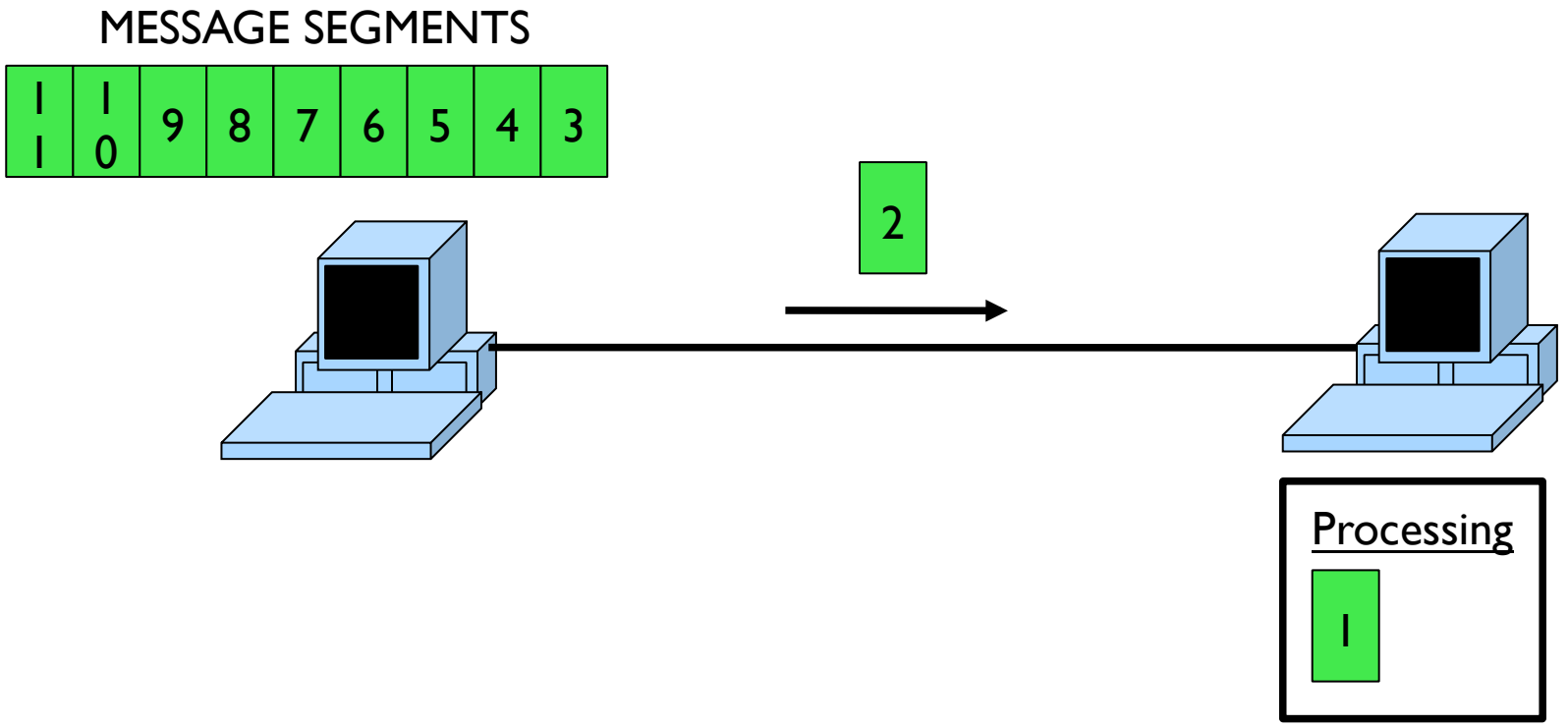
Flow Control



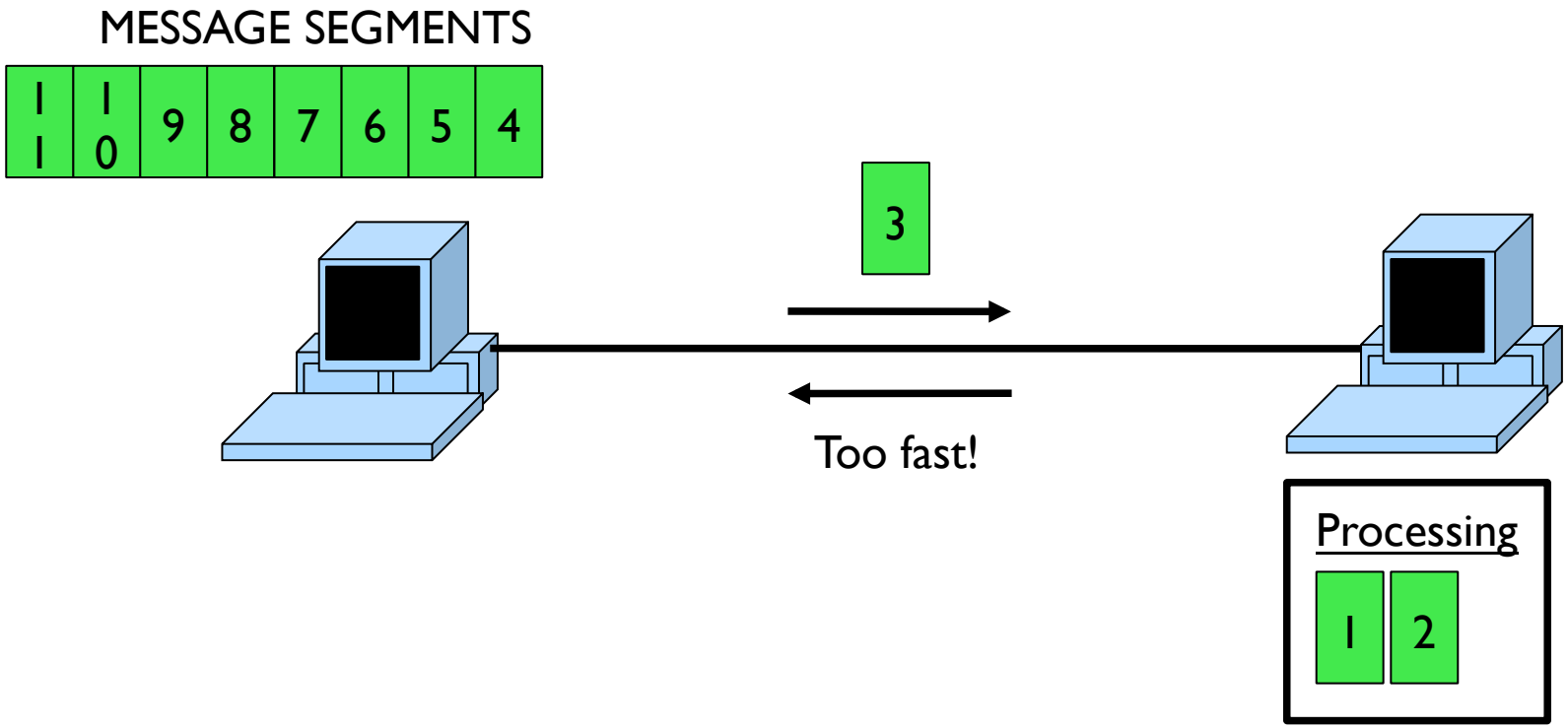
Flow Control



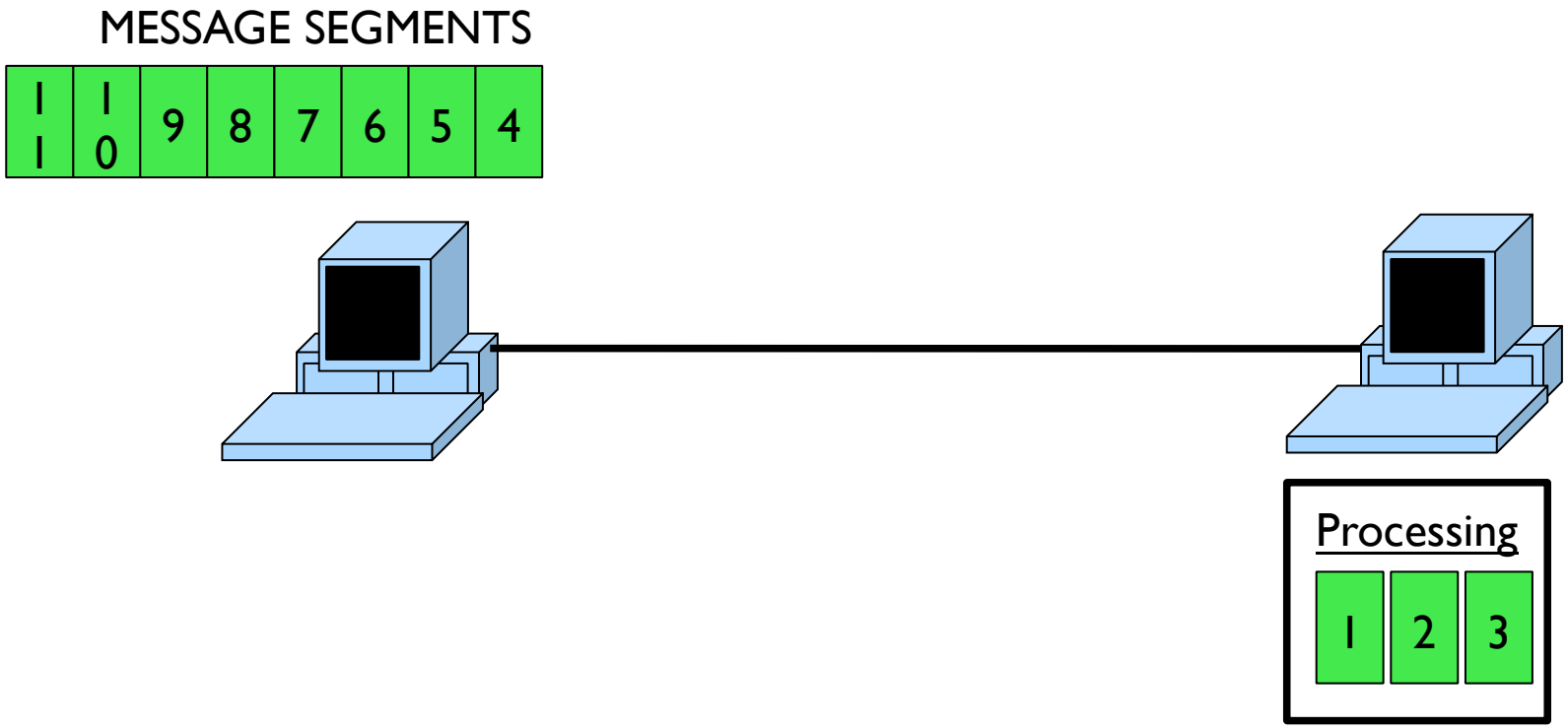
Flow Control



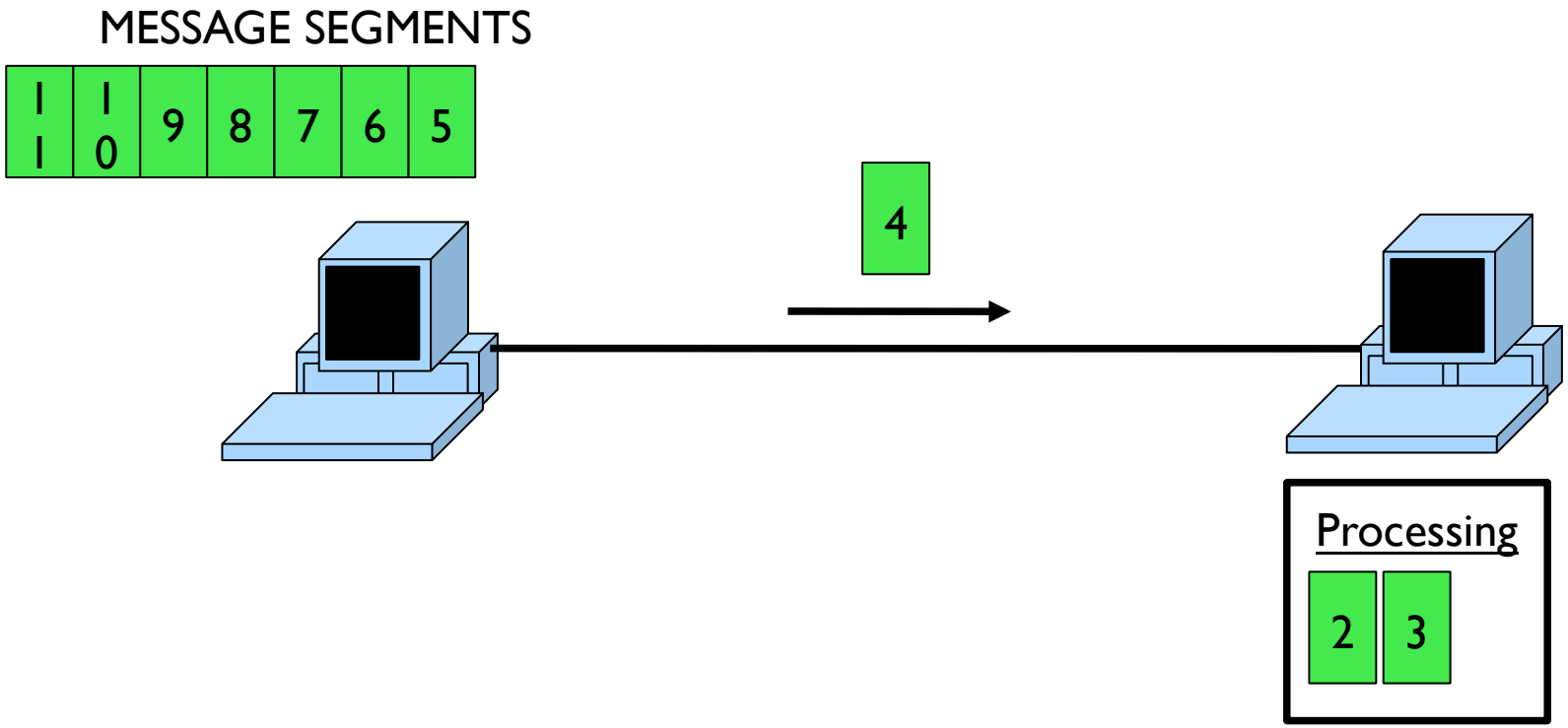
Flow Control



Flow Control



Flow Control



Course topics

1. The architecture of the internet
2. Addressing resources on the internet
3. Internetwork communication (IP)
4. Handling communication problems (TCP)
5. **Exchanging and interpreting text and other data (HTTP, MIME)**

Exchange of documents

- The internet allowed disparate people to exchange electronic versions of paper documents
- The inter-connectivity also allows for new forms of documents

Text Documents

Chapter 1

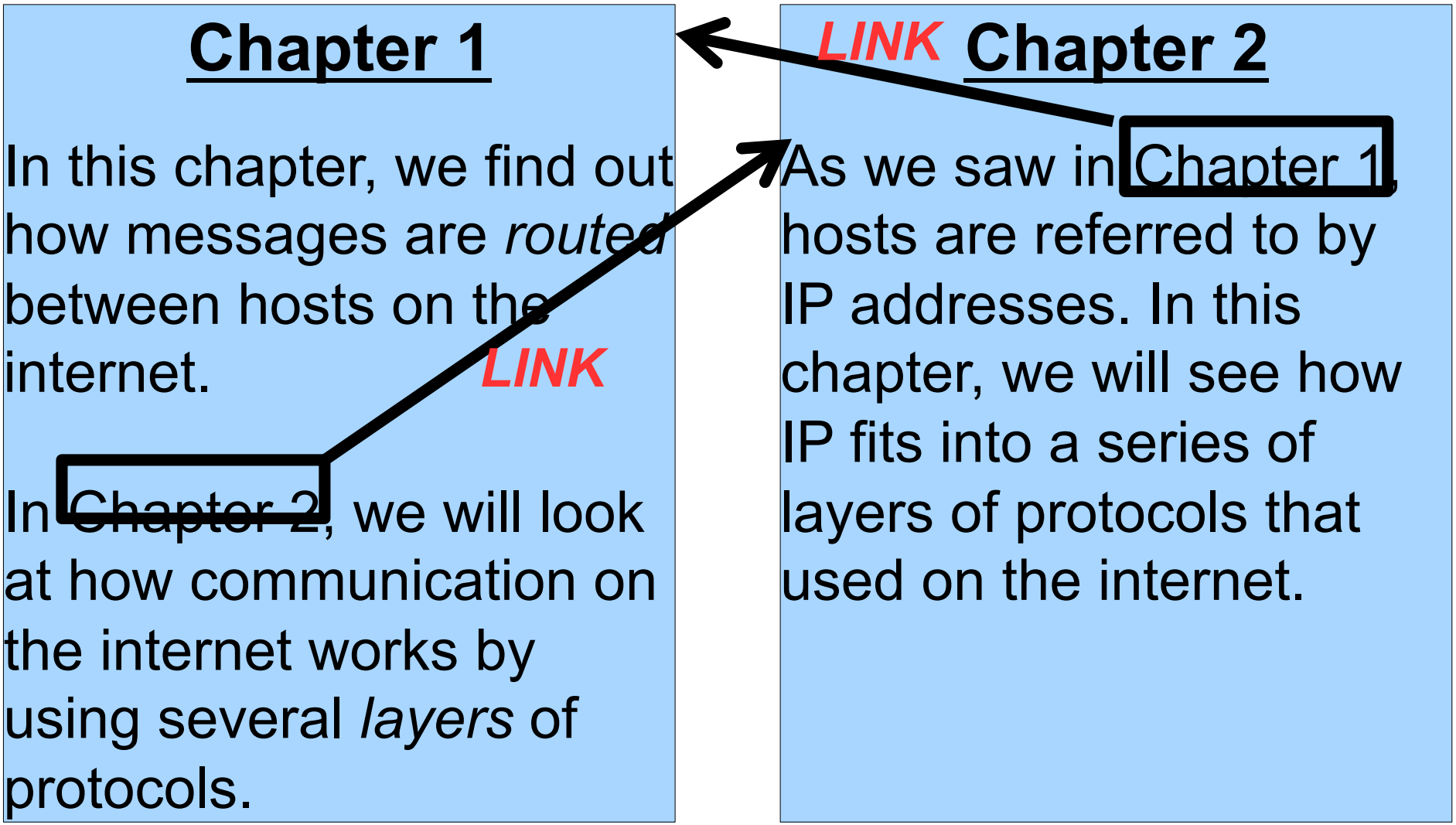
In this chapter, we find out how messages are *routed* between hosts on the internet.

In Chapter 2, we will look at how communication on the internet works by using several *layers* of protocols.

Chapter 2

As we saw in Chapter 1, hosts are referred to by IP addresses. In this chapter, we will see how IP fits into a series of layers of protocols that used on the internet.

Hypertext Documents



Hypertext and hypermedia

- **Hypertext** was a term coined by Ted Nelson in the 1960s

- Extended to **hypermedia**, to include sound, video and other ways of presenting information

The World Wide Web

- Proposed by Tim Berners Lee, then working at CERN
- Combined hypertext and the internet:
  - A World Wide Web of documents
  - The links of hypertext documents refer to other documents on remote computers
  - The internet provides the connection for the linked documents to be downloaded
- The internet provides the infrastructure on which the web operates

Personal publishing

- Languages were needed to write hypertext documents
  - HyperText Markup Language (HTML)
- ... and protocols to send them over the internet when a link was followed
  - HyperText Transfer Protocol (HTTP)
- As with the internet, these are public
  - Anyone can connect a host to the internet
  - Anyone can publish their own web pages

Mark-up

Introduction to Mark-up

Marking up text means adding annotations around pieces of it to explicitly indicate properties of those pieces. The mark-up was originally to aid people, mark-up men, to know how to present the text on a page. In HTML, it is still used for this purpose. XML generalises from this, so that mark-up is specific for the purposes of each application. Notice that, as long as mark-up does not overlap, it describes a hierarchy of annotations.

Mark-up

CHAPTER

Introduction to Mark-up

Marking up text means adding annotations around pieces of it to explicitly indicate properties of those pieces. The mark-up was originally to aid people, mark-up men, to know how to present the text on a page. In HTML, it is still used for this purpose. XML generalises from this, so that mark-up is specific for the purposes of each application. Notice that, as long as mark-up does not overlap, it describes a hierarchy of annotations.

Mark-up

CHAPTER

TITLE

Introduction to Mark-up

Marking up text means adding annotations around pieces of it to explicitly indicate properties of those pieces. The mark-up was originally to aid people, mark-up men, to know how to present the text on a page. In HTML, it is still used for this purpose. XML generalises from this, so that mark-up is specific for the purposes of each application. Notice that, as long as mark-up does not overlap, it describes a hierarchy of annotations.

Mark-up

CHAPTER

TITLE

Introduction to Mark-up

NEW TERM

Marking up text means adding annotations around pieces of it to explicitly indicate properties of those pieces. The mark-up was originally to aid people, mark-up men, to know how to present the text on a page. In HTML, it is still used for this purpose. XML generalises from this, so that mark-up is specific for the purposes of each application. Notice that, as long as mark-up does not overlap, it describes a hierarchy of annotations.

Mark-up

CHAPTER

TITLE

Introduction to Mark-up

NEW TERM

Marking up text means adding annotations around pieces of it to explicitly indicate properties of those pieces. The mark-up was originally to aid people, mark-up men, to know how to present the text on a page. In HTML, it is still used for this purpose. XML generalises from this, so that mark-up is specific for the purposes of each application. Notice that, as long as mark-up does not overlap, it describes a hierarchy of annotations.

TECHNICAL TERM

TECHNICAL TERM

Mark-up in XML

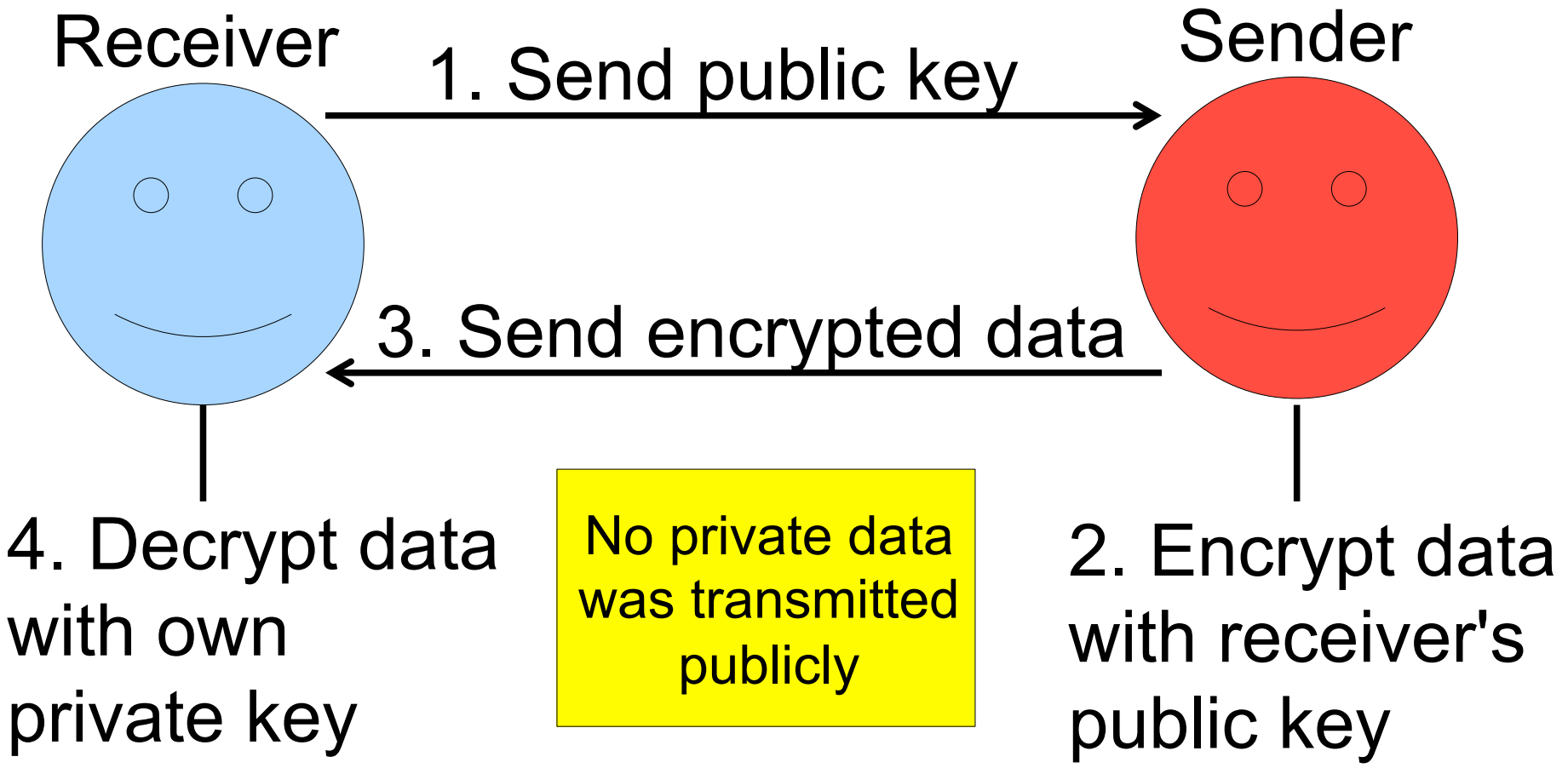
<chapter><title>Introduction to Mark-up**</title>**

Marking up text means adding annotations around pieces of it to explicitly indicate properties of those pieces. The mark-up was originally to aid people, **<newterm>**mark-up men**</newterm>**, to know how to present the text on a page. In **<technical>**HTML**</technical>**, it is still used for this purpose. **<technical>**XML**</technical>** generalises from this, so that mark-up is specific for the purposes of each application. Notice that, as long as mark-up does not overlap, it describes a hierarchy of annotations.**</chapter>**

Course Topics

1. The architecture of the internet
2. Addressing resources on the internet
3. Internetwork communication (IP)
4. Handling communication problems (TCP)
5. HTTP
6. XML and HTML
7. **Integrity and security on the internet**

Security on the Internet



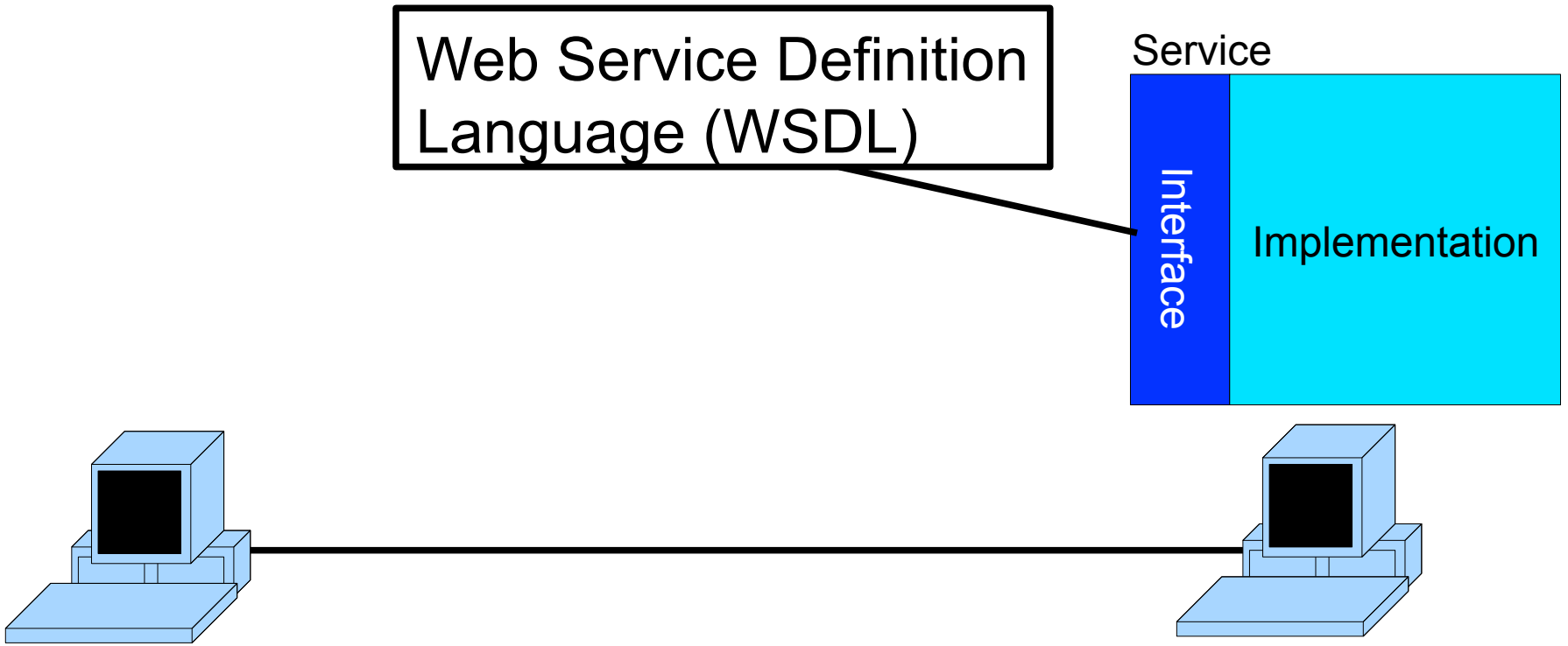
Digital certificates

- X.509 is a popular form of certificate
- An X.509 certificate consists of three parts:
  - The certificate details
  - The signature of the certificate
  - The algorithm used to sign the certificate
- The certificate details then include:
  - A unique serial number for the certificate
  - The period (from X to Y) that the certificate is valid
  - The name of the certificate's issuer
  - A unique identifier for the issuer
  - The name of the certificate's owner
  - The public key of the owner

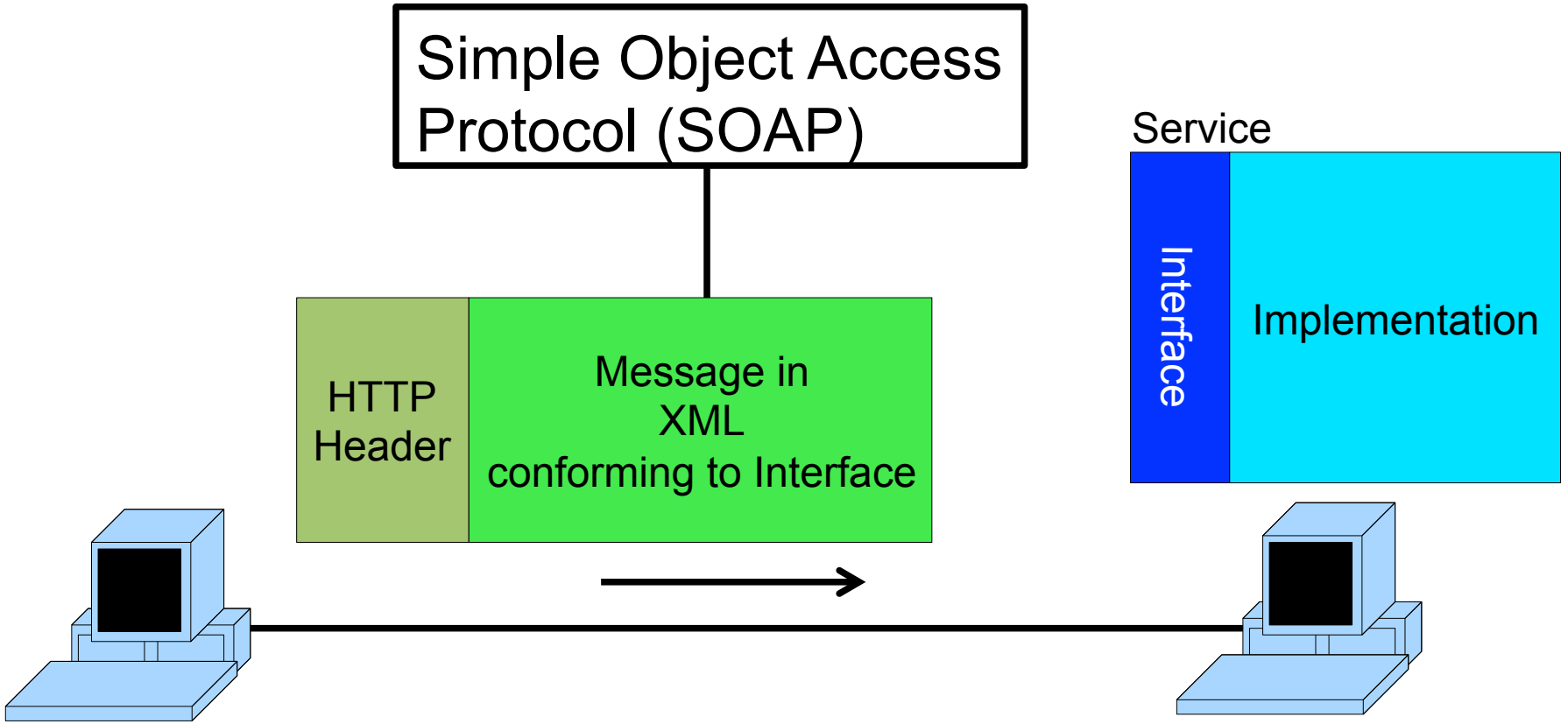
Course Topics

1. The architecture of the internet
2. Addressing resources on the internet
3. Internetwork communication (IP)
4. Handling communication problems (TCP)
5. HTTP
6. Integrity and security on the internet
7. **Web Service and Semantic Web**
8. **Internet paradigm shift: SDN, Virtualisation, cloud-base services**

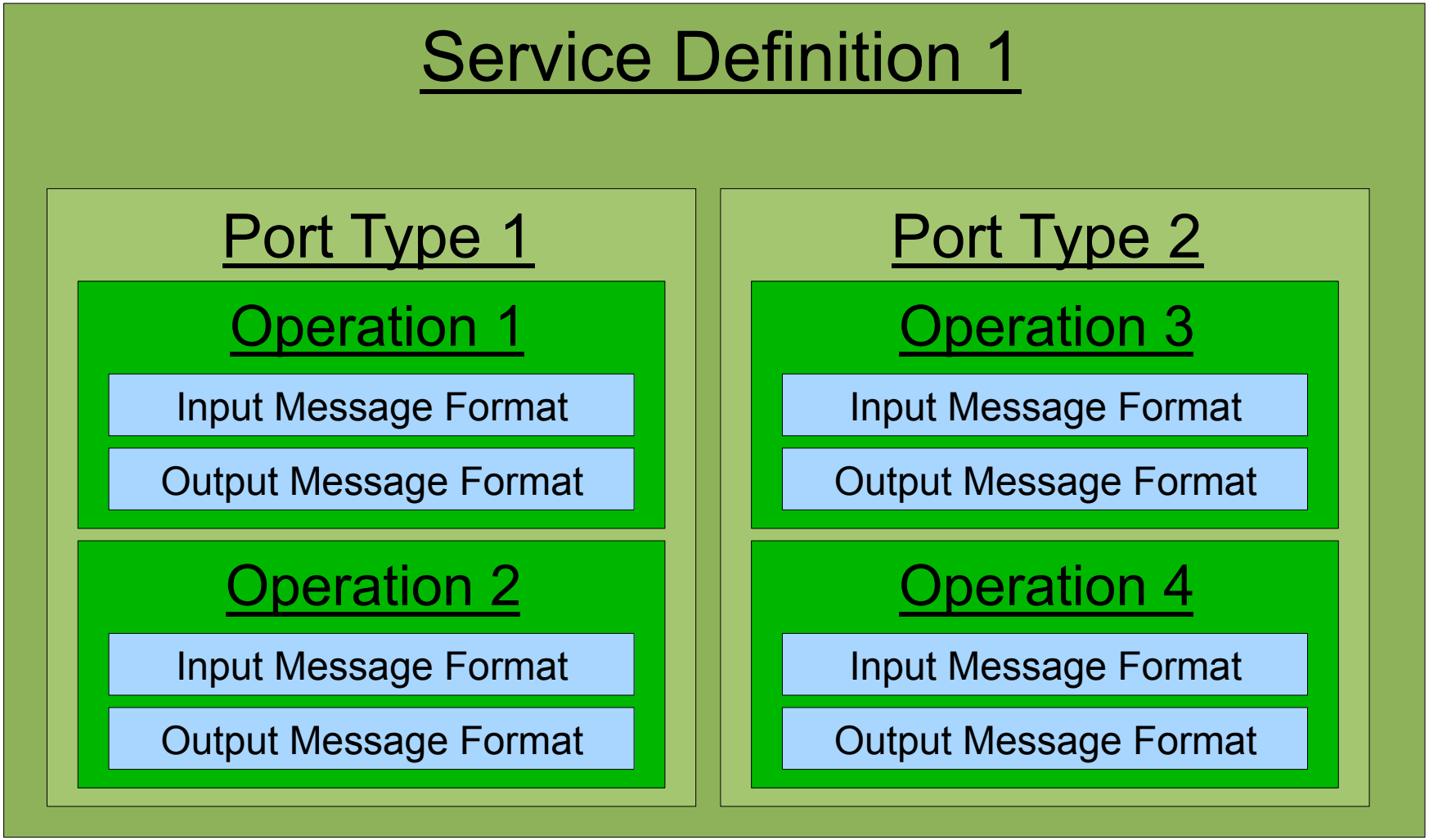
Web Services



Web Services



WSDL interface



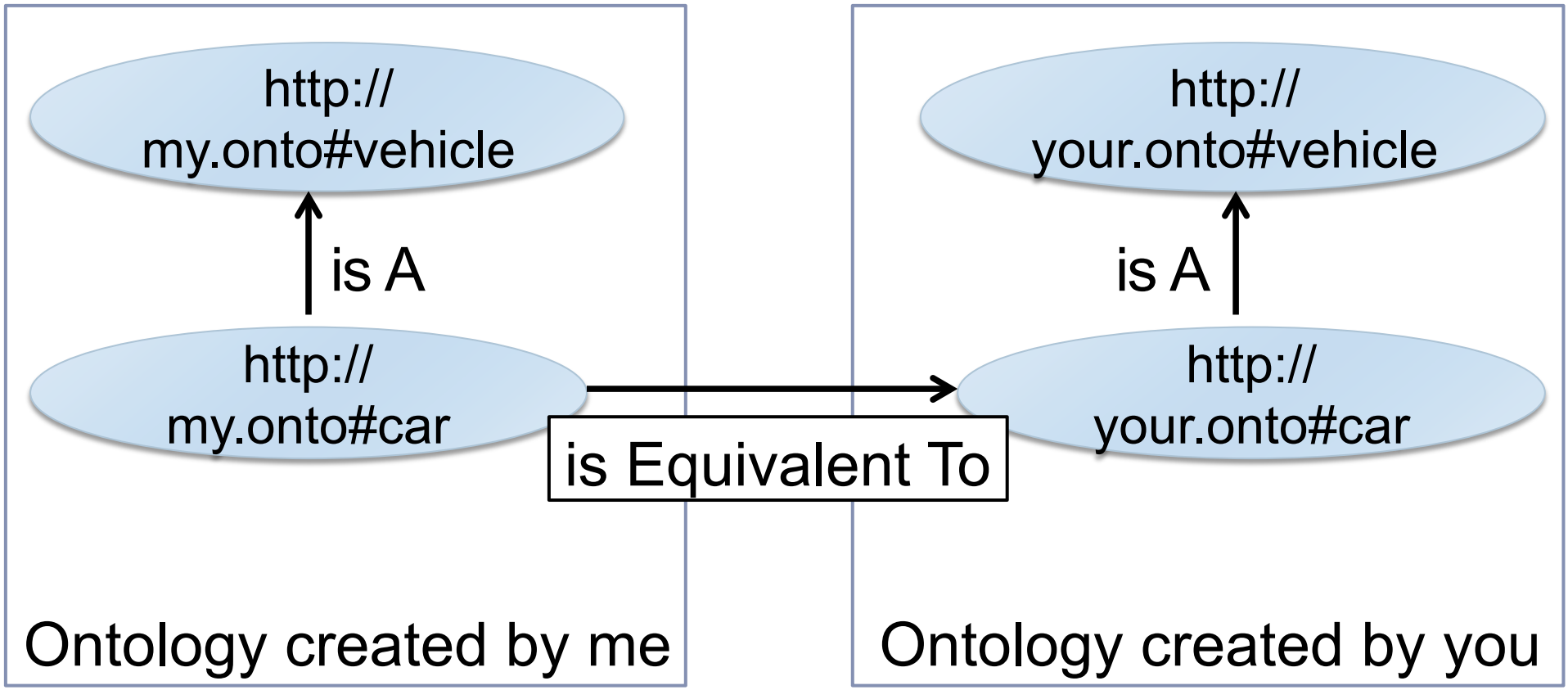
Semantic Web

- HTML: Mark-up for presentation
- XML: Arbitrary application-specific mark-up

- Semantic Web
  - Using application-specific mark-up in web pages
  - Distributed users agreeing on mark-up concepts
  - Agreed concept meanings in computer-parsable form: ontologies

- Software can "understand" information on web

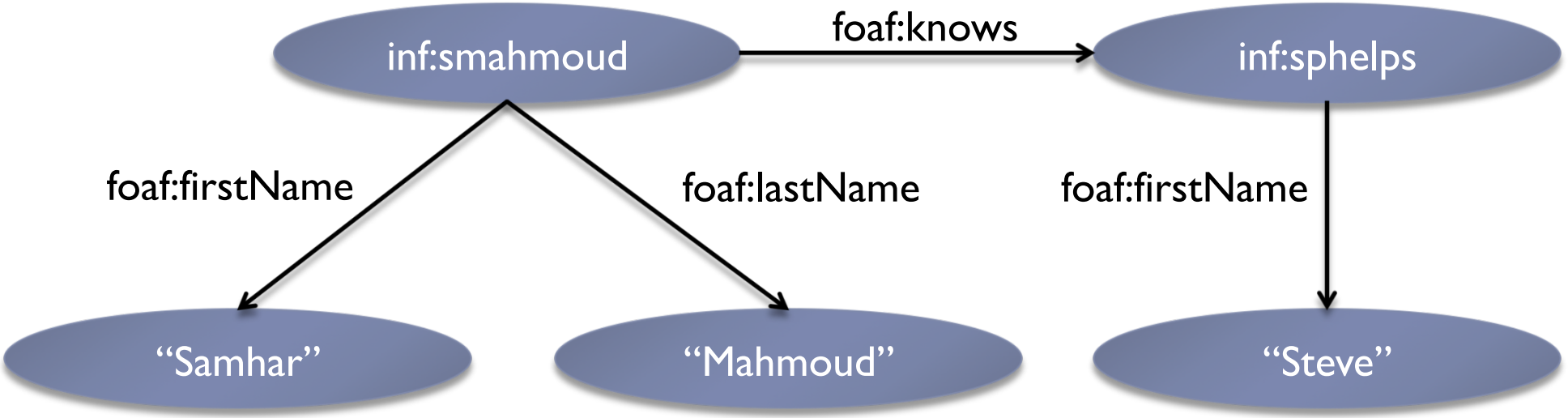
Ontologies



Can reason that a car in my ontology is a type of vehicle in your ontology

RDF graphs

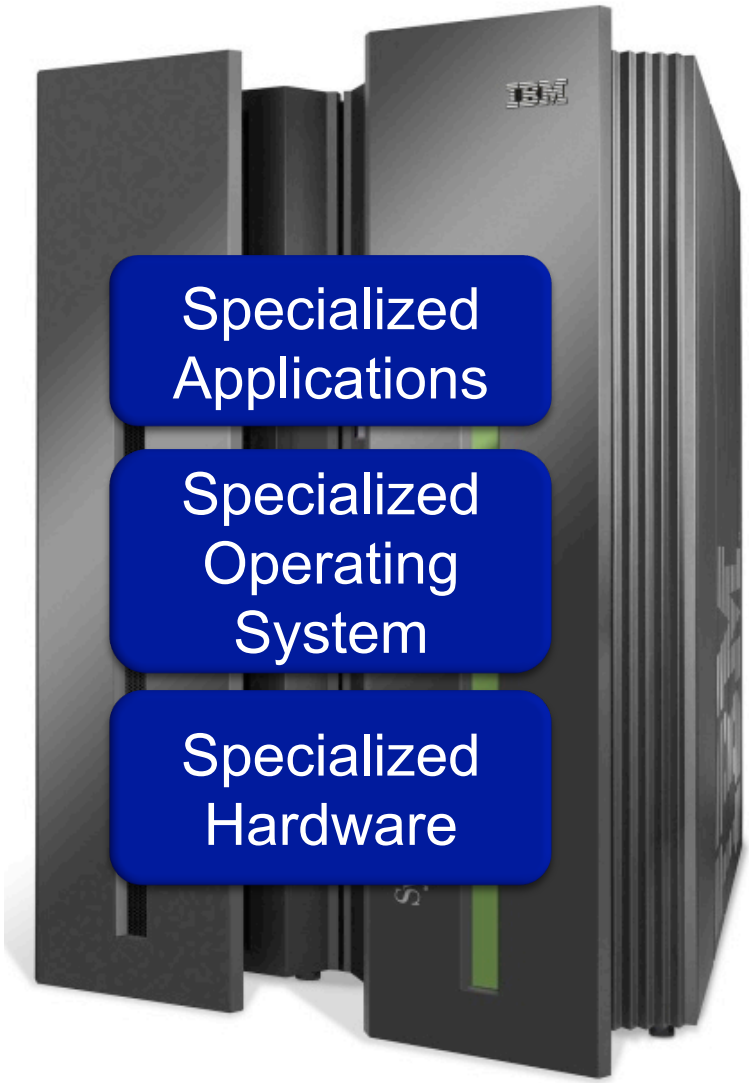
- A set of RDF statements is often called an **RDF graph**, because the information forms a graph with the resources and values as nodes and the predicates as edges



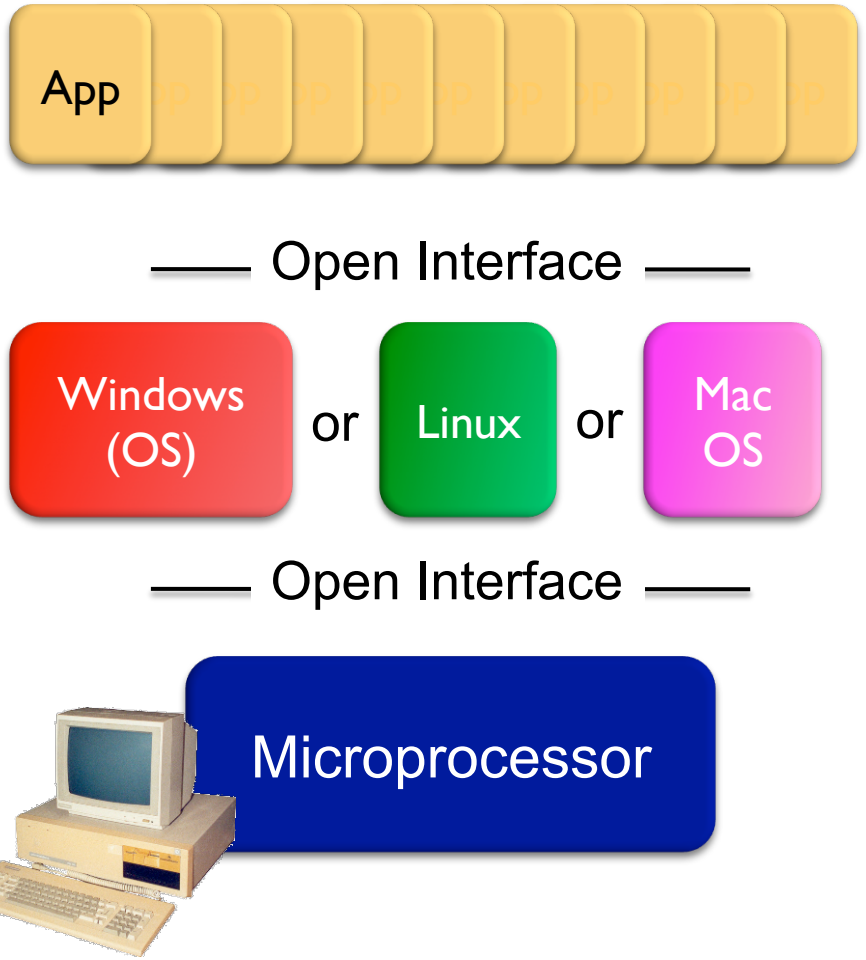
Internet Paradigm Shift

- Software-based systems
  - Possibility of quick modifications
- Variety of applications
  - specially for the mobile Internet
- Cloud-based Services
- Virtualisation

- ✓ Vertically integrated
- ✓ Closed, proprietary
- ✓ Slow innovation
- ✓ Small industry



- ✓ Horizontal
- ✓ Open interfaces
- ✓ Rapid innovation
- ✓ Huge industry



Cloud Service Models

Software as a Service (SaaS)	Platform as a Service (PaaS)	Infrastructure as a Service (IaaS)

SalesForce CRM

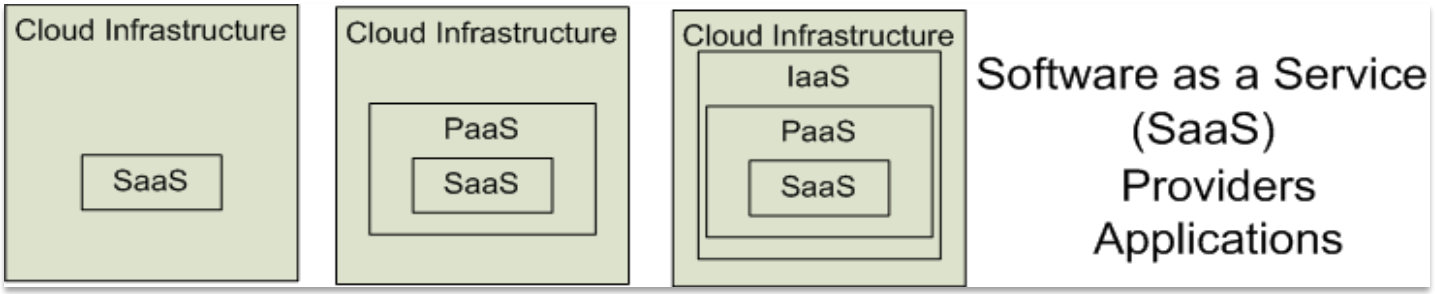
LotusLive

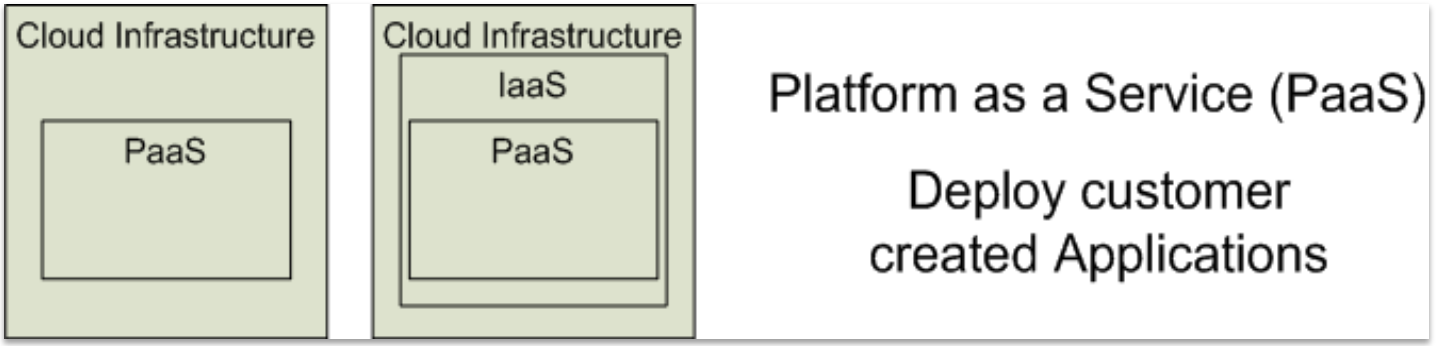
Google App

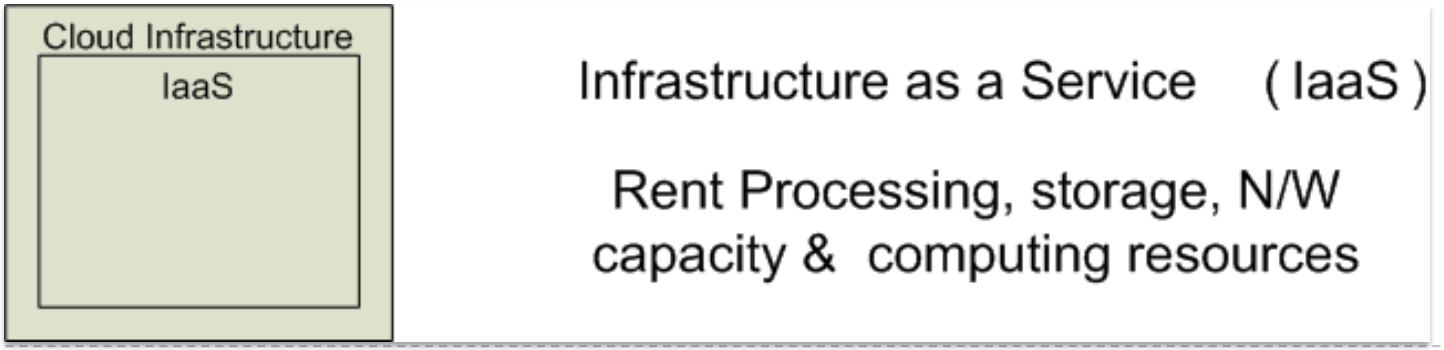
Windows Azure
The Future Made Familiar

amazon web services™

rackspace HOSTING







See you next week