

# INTERNET SYSTEMS

5CCS2INS

Samhar Mahmoud

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# Contact details

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Office hours this semester

- **17:00 to 19:00 Tuesdays**
- **Contact me to book an appointment**
- **At least one day in advance**

# Course structure

- Lectures
  - Every Tuesday from 14.00 to 16.00
- Tutorials
  - Same day as lecture, from 16.00 to 17.00
  - Exercises to work through in small groups
  - Start from next week (week 2)
- Reading Week
  - 30<sup>st</sup> Oct - 5th November
- Practice in labs in your own time

# Resources

- Materials on KEATS
  - Slides
  - Notes
  - Quizzes
  - Tutorial questions
  - Tutorial answers available a week 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
7. Security
8. Virtualisation and Cloud Computing

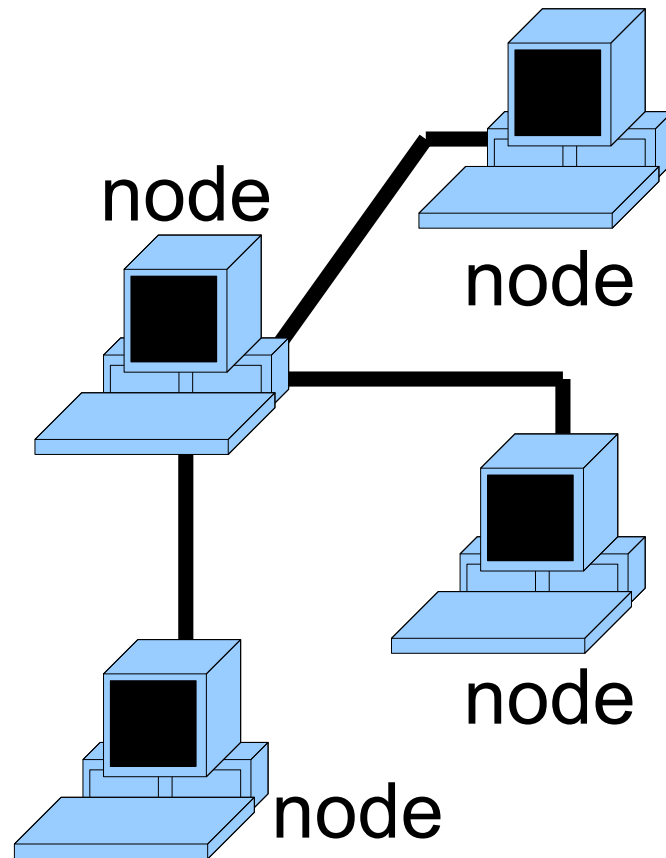
# A quick introduction to everything

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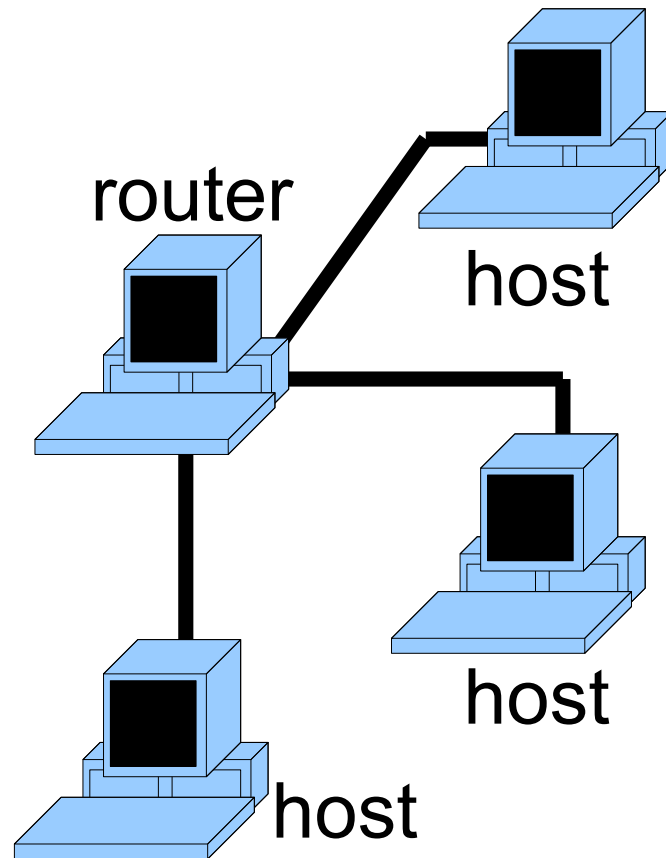
**Basics, Historical Perspective, Concepts**



# Networks



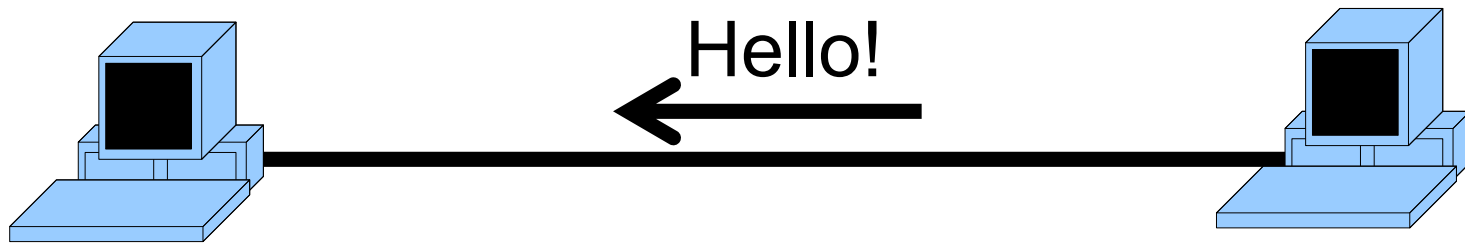
# Networks



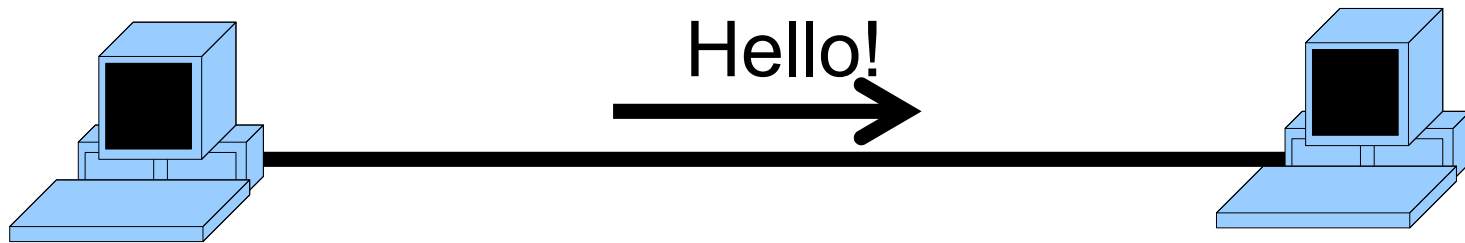
# Protocols



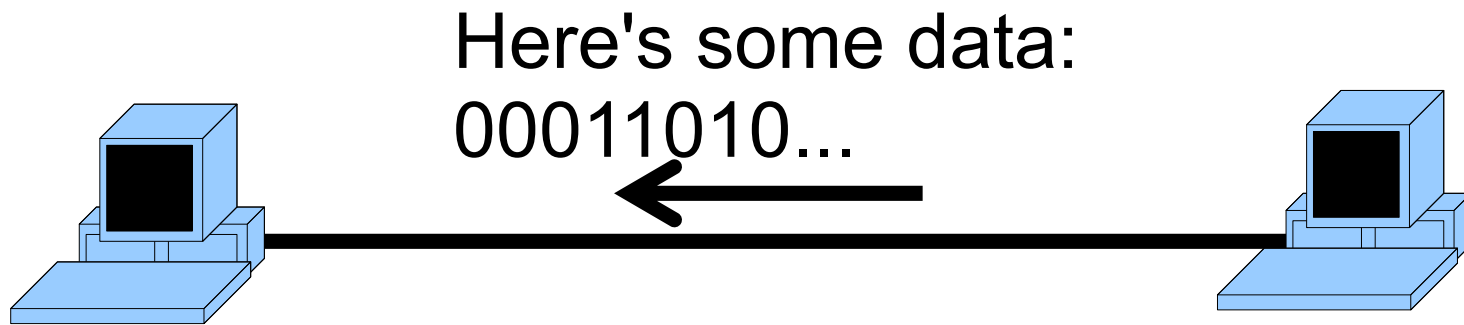
# Protocols



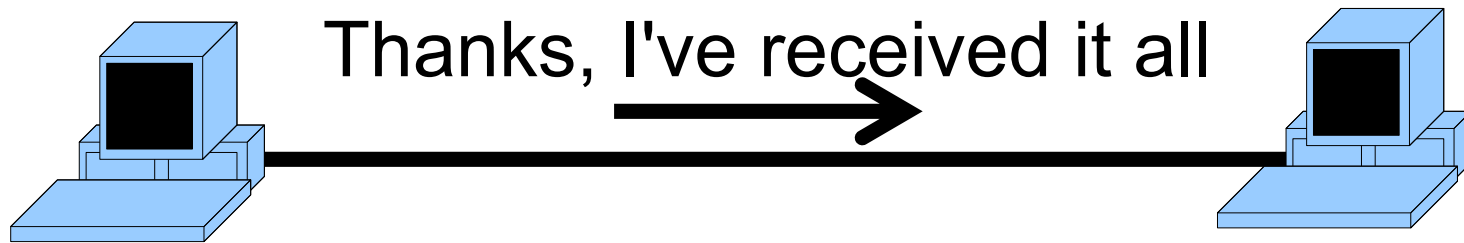
# Protocols



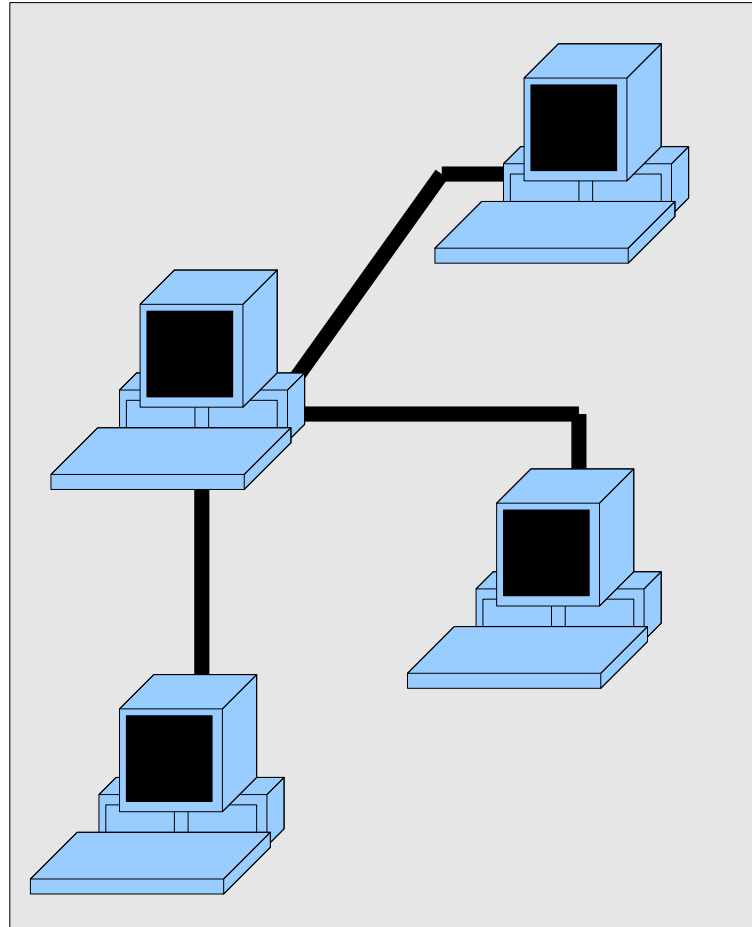
# Protocols



# Protocols

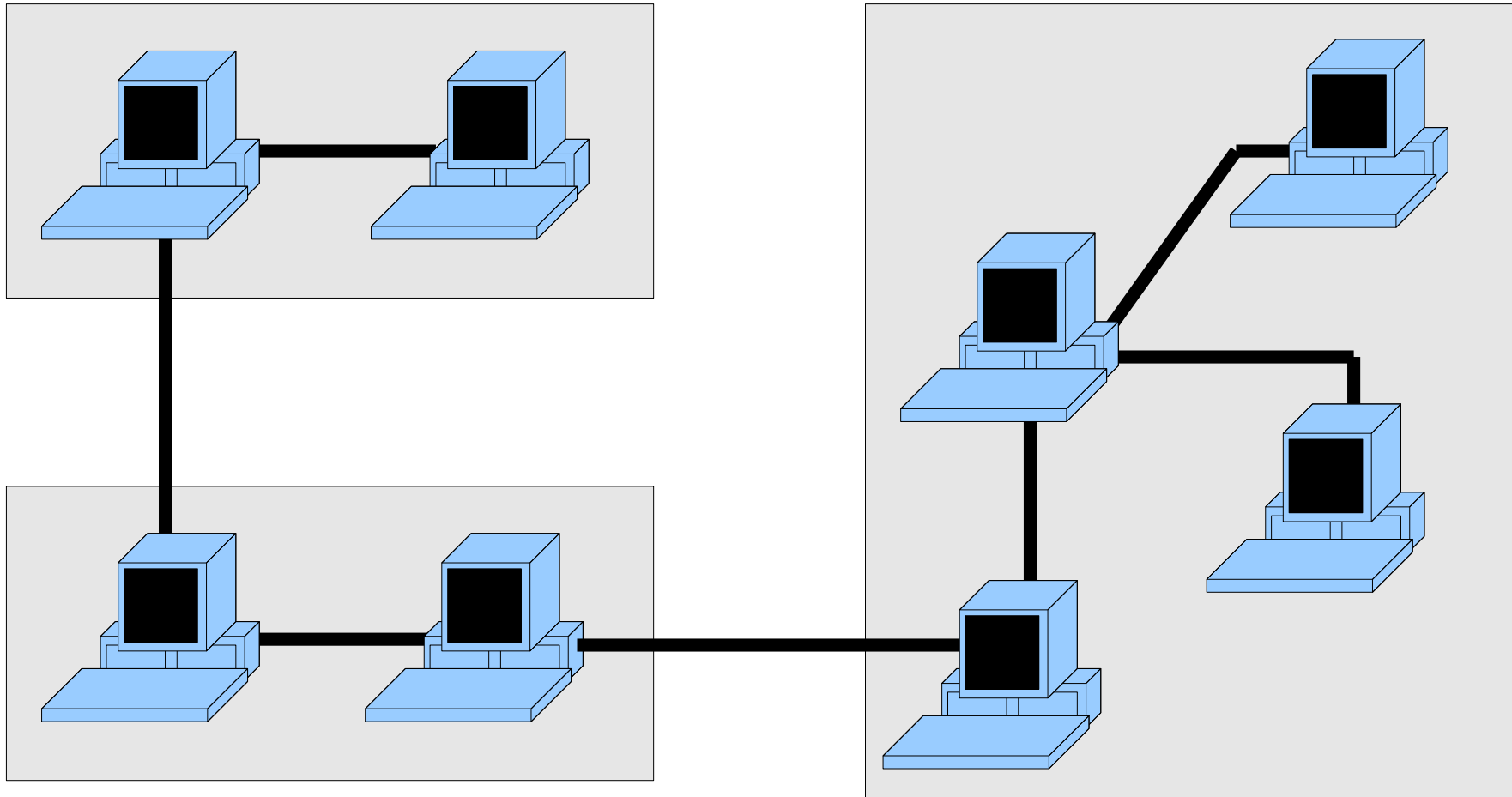


# Local Area Networks

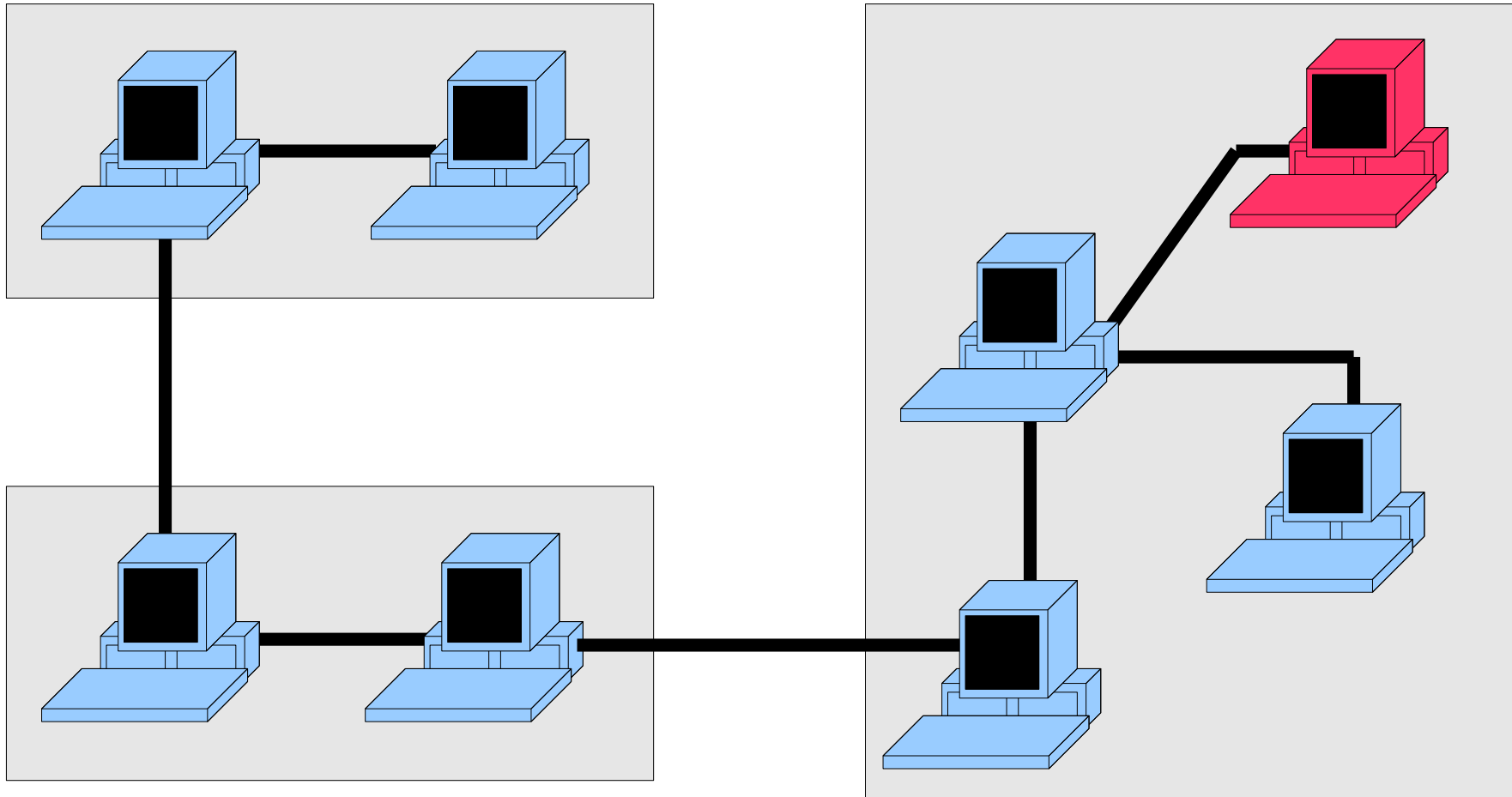




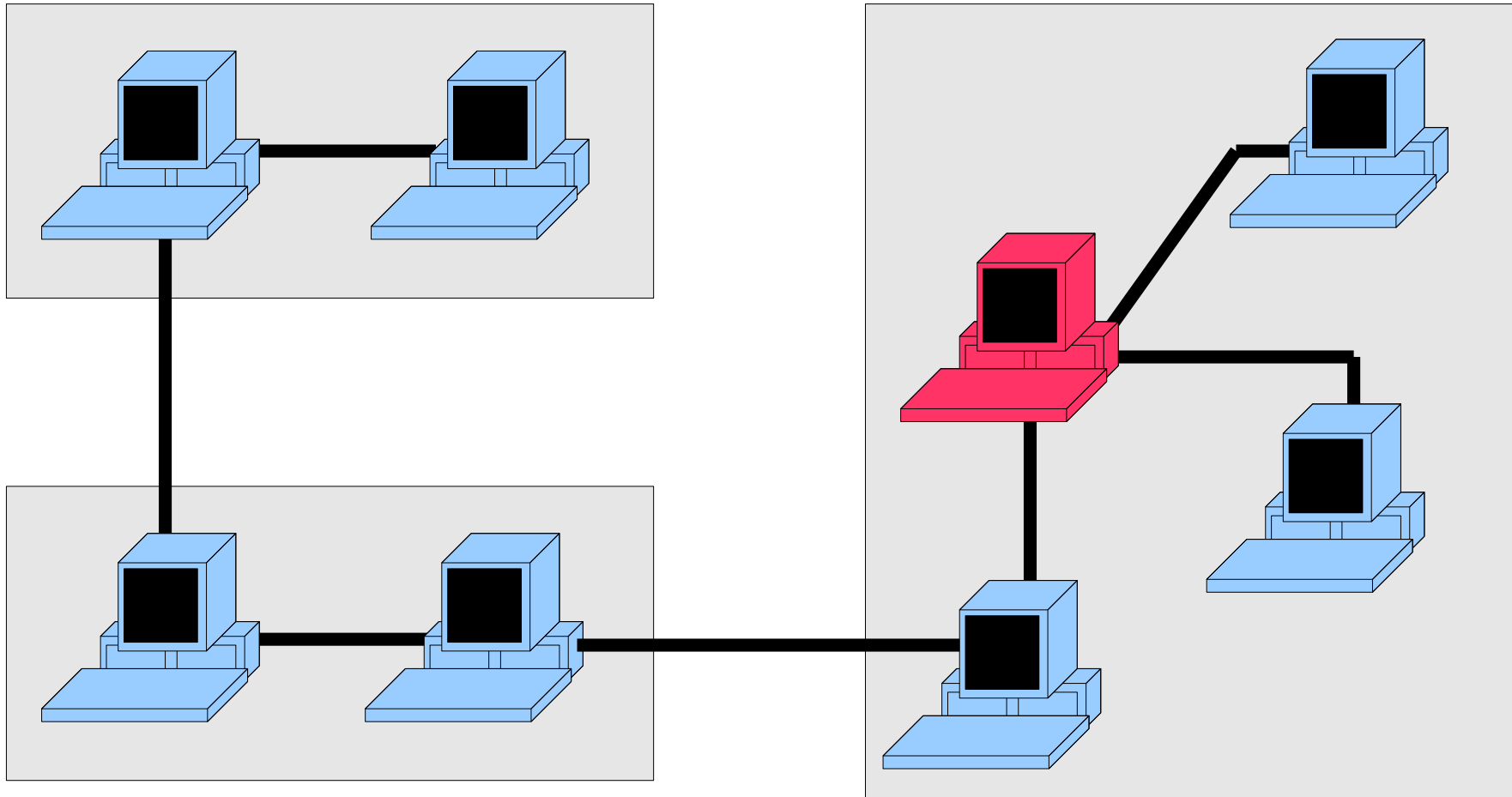
# Wide Area Networks



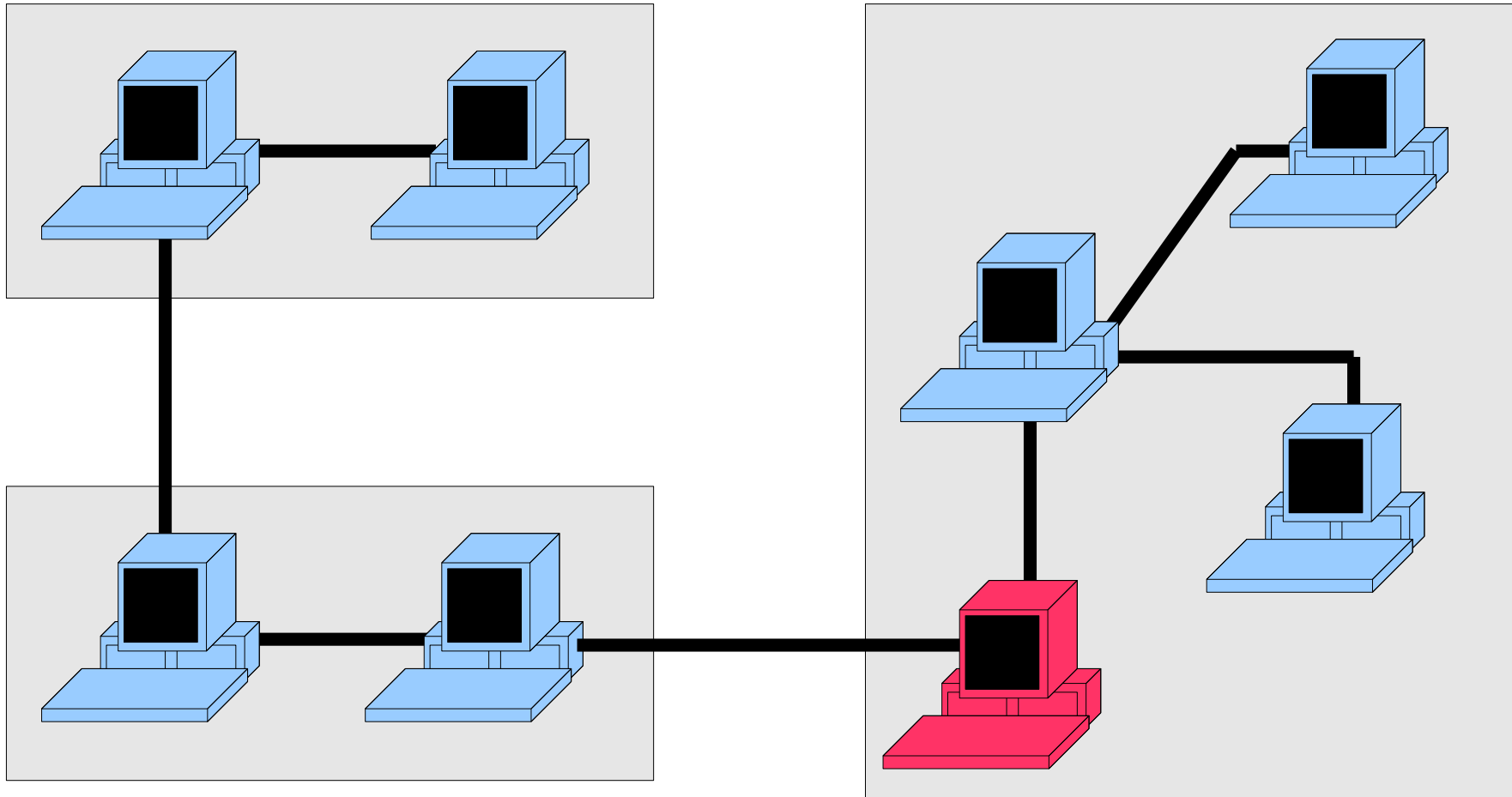
# Routing



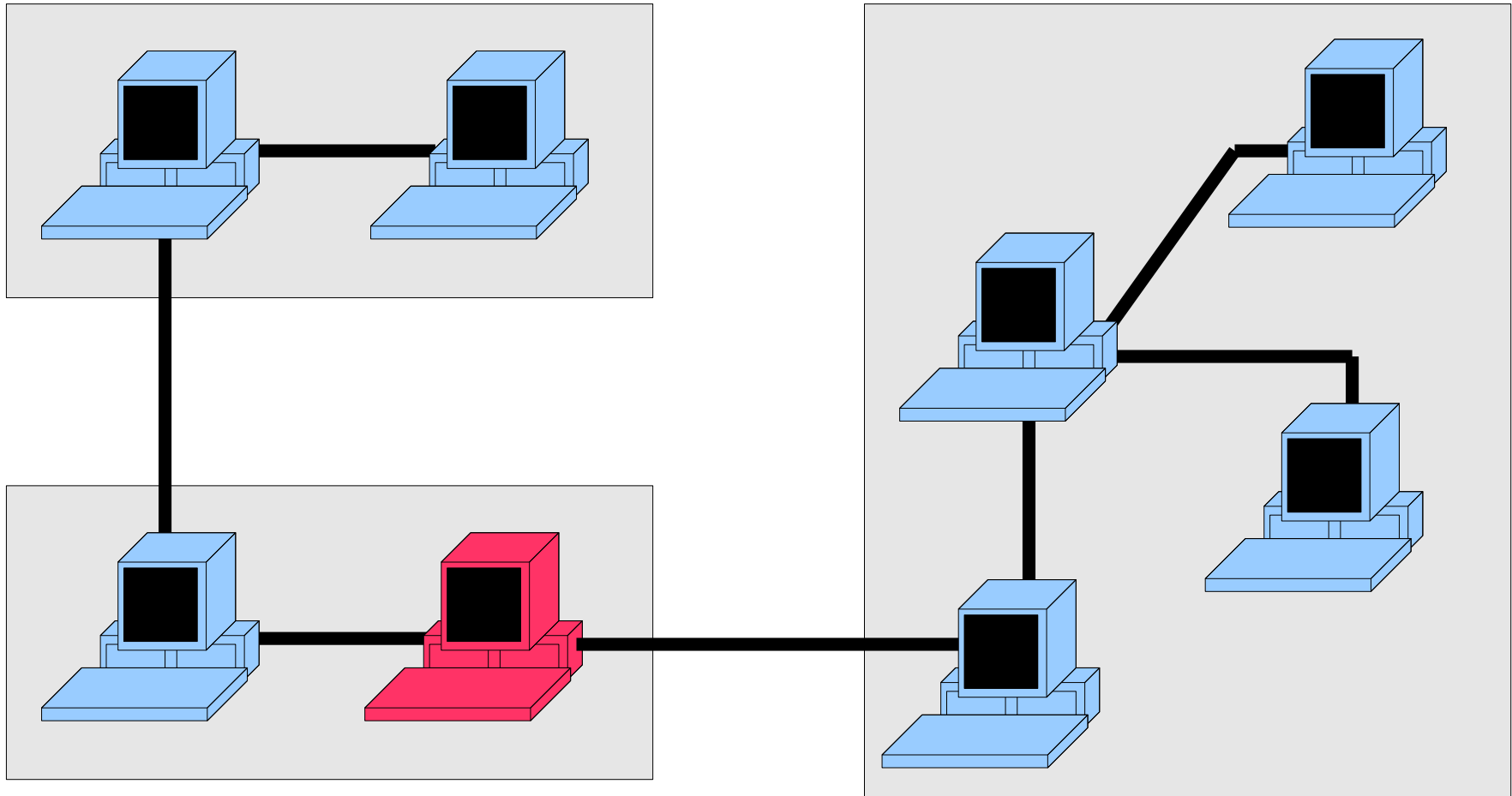
# Routing



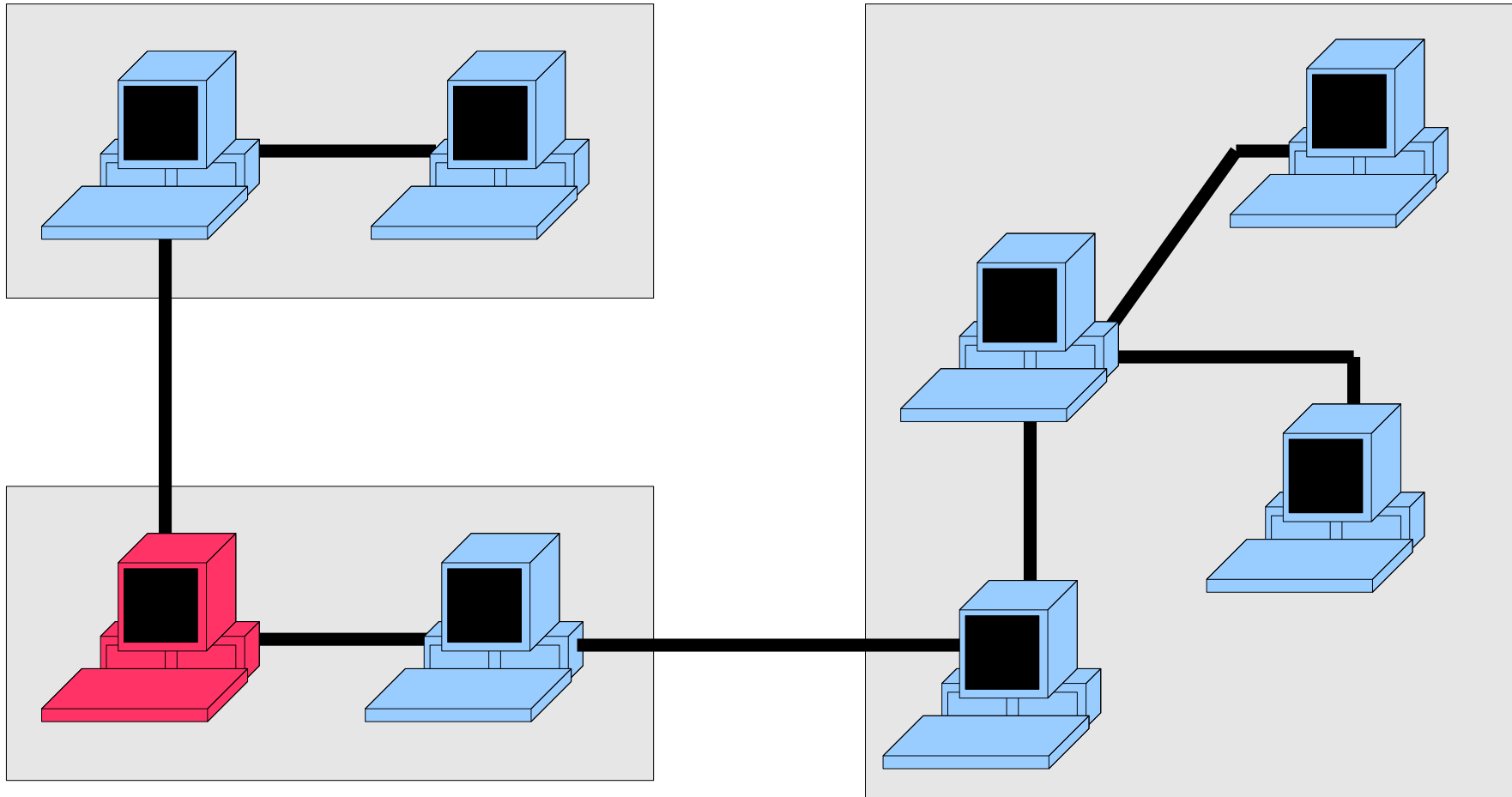
# Routing



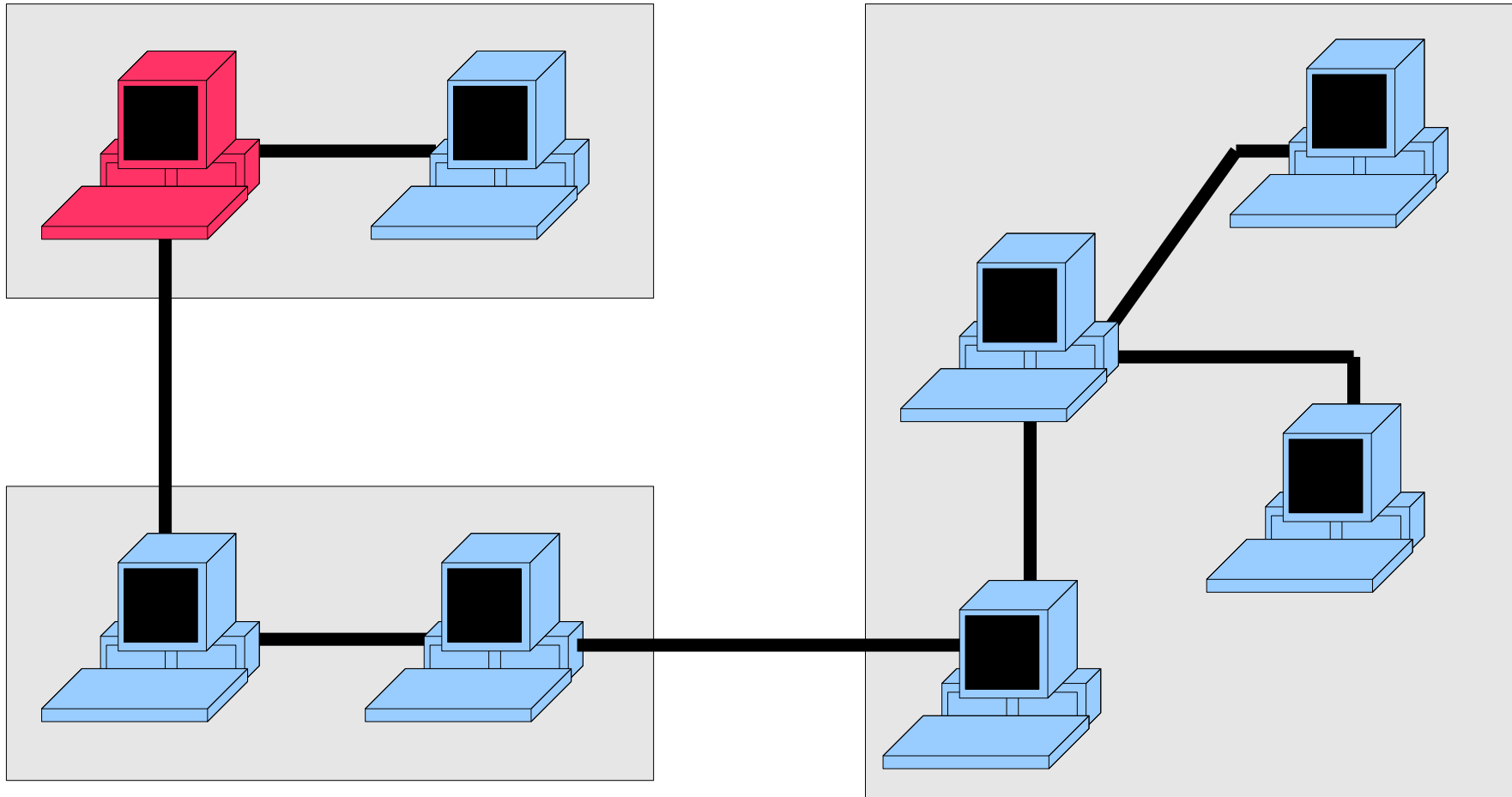
# Routing



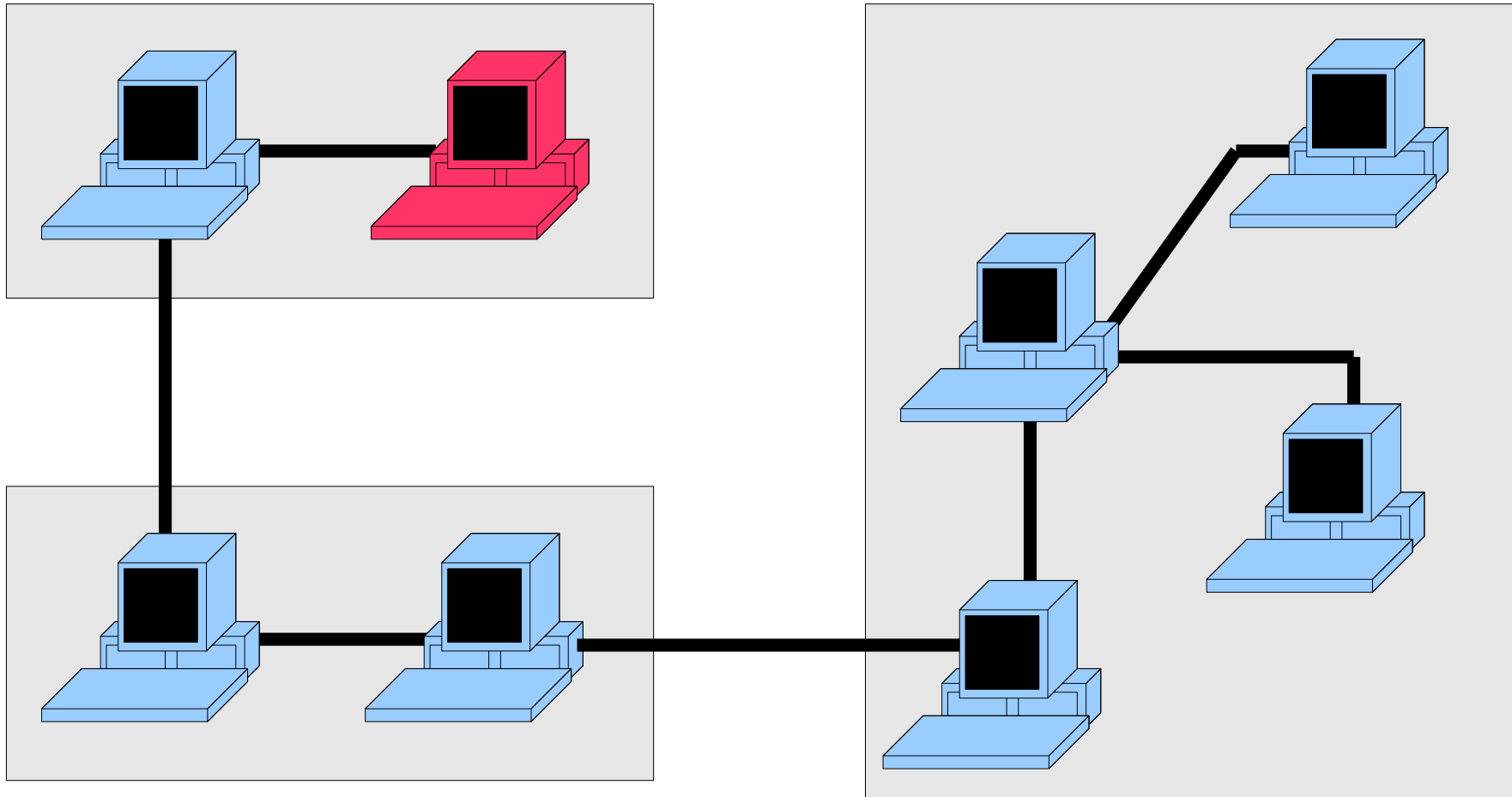
# Routing



# Routing



# Routing

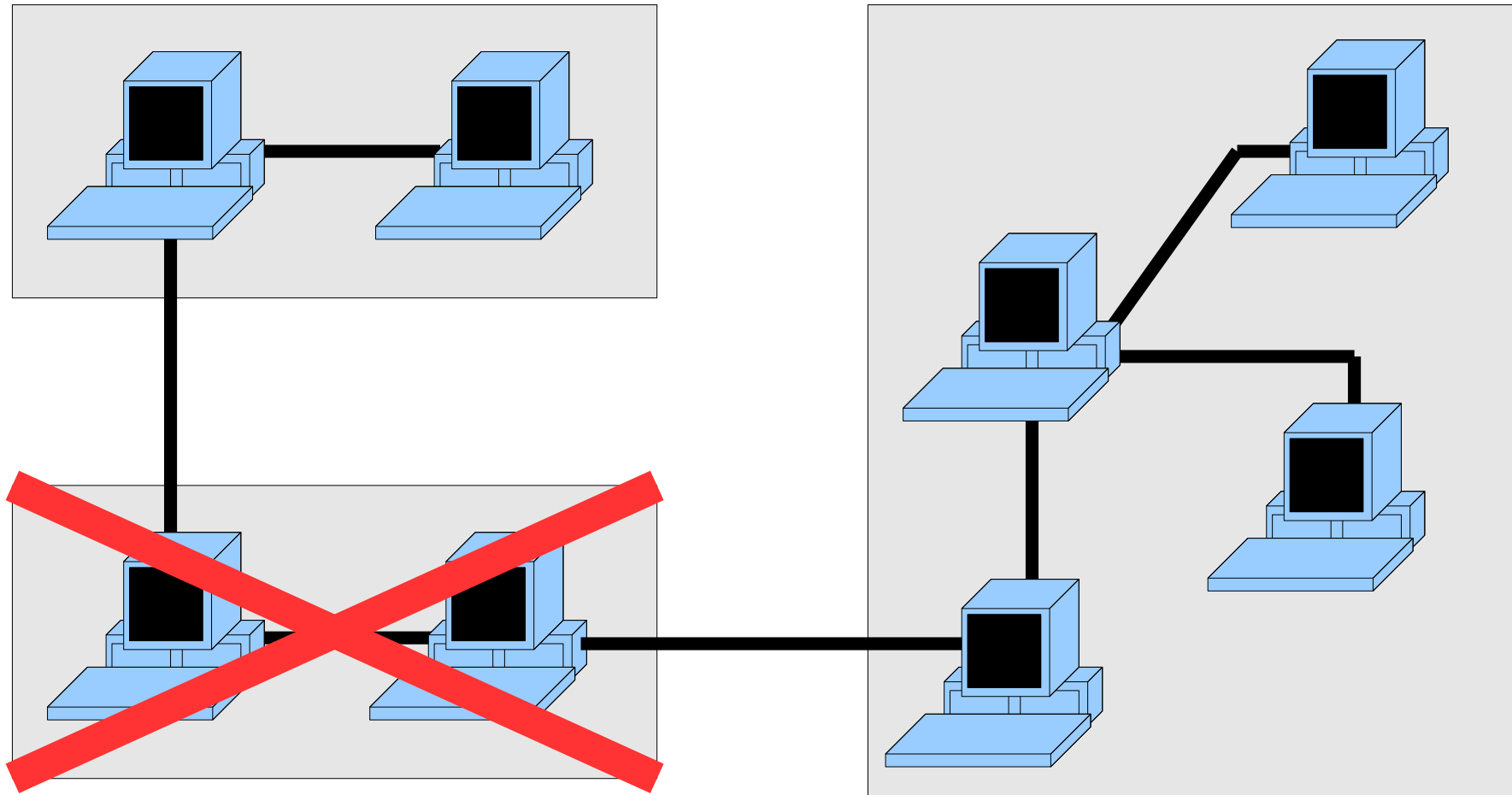




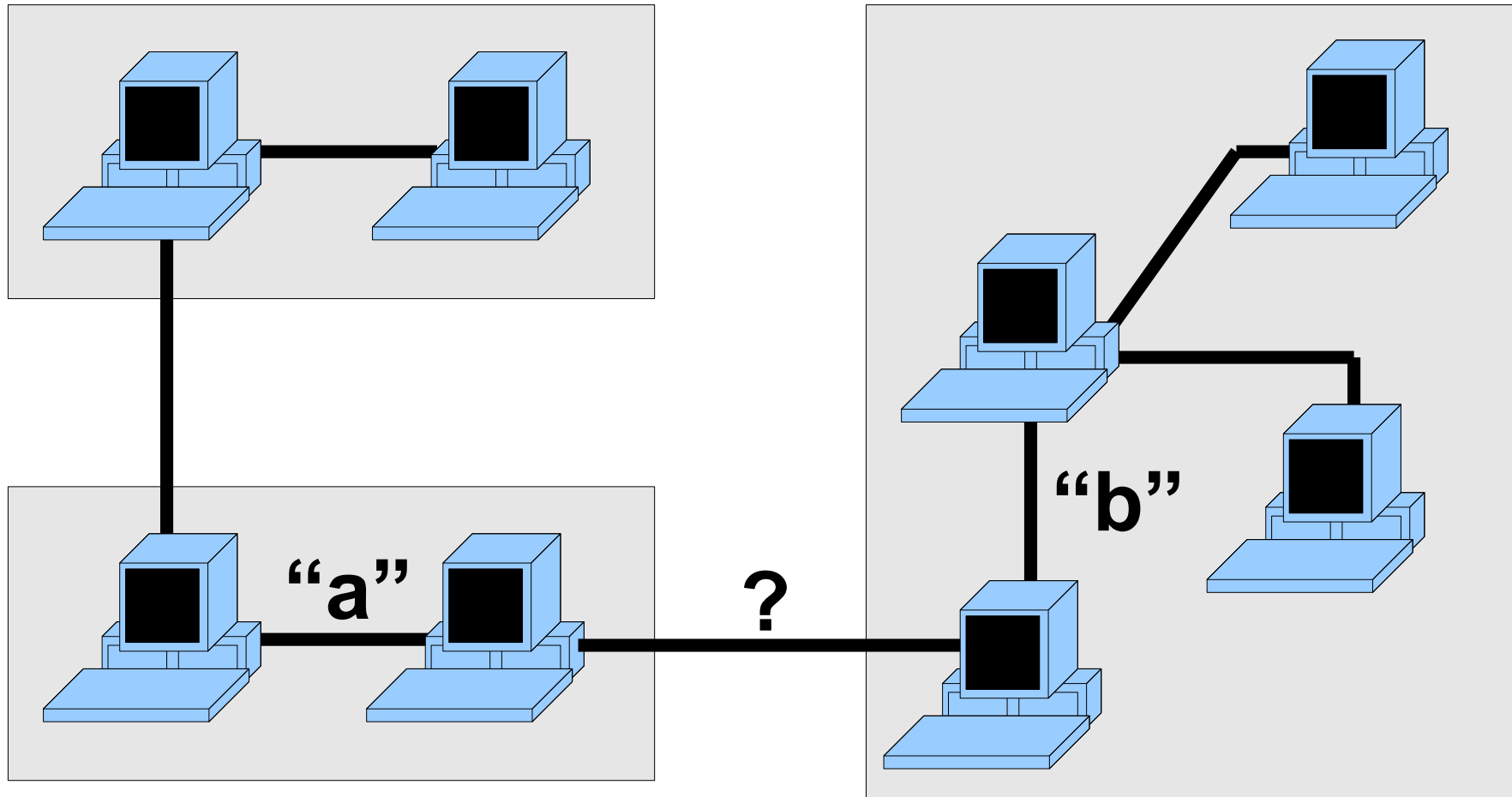
# Origins of the Internet

- 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

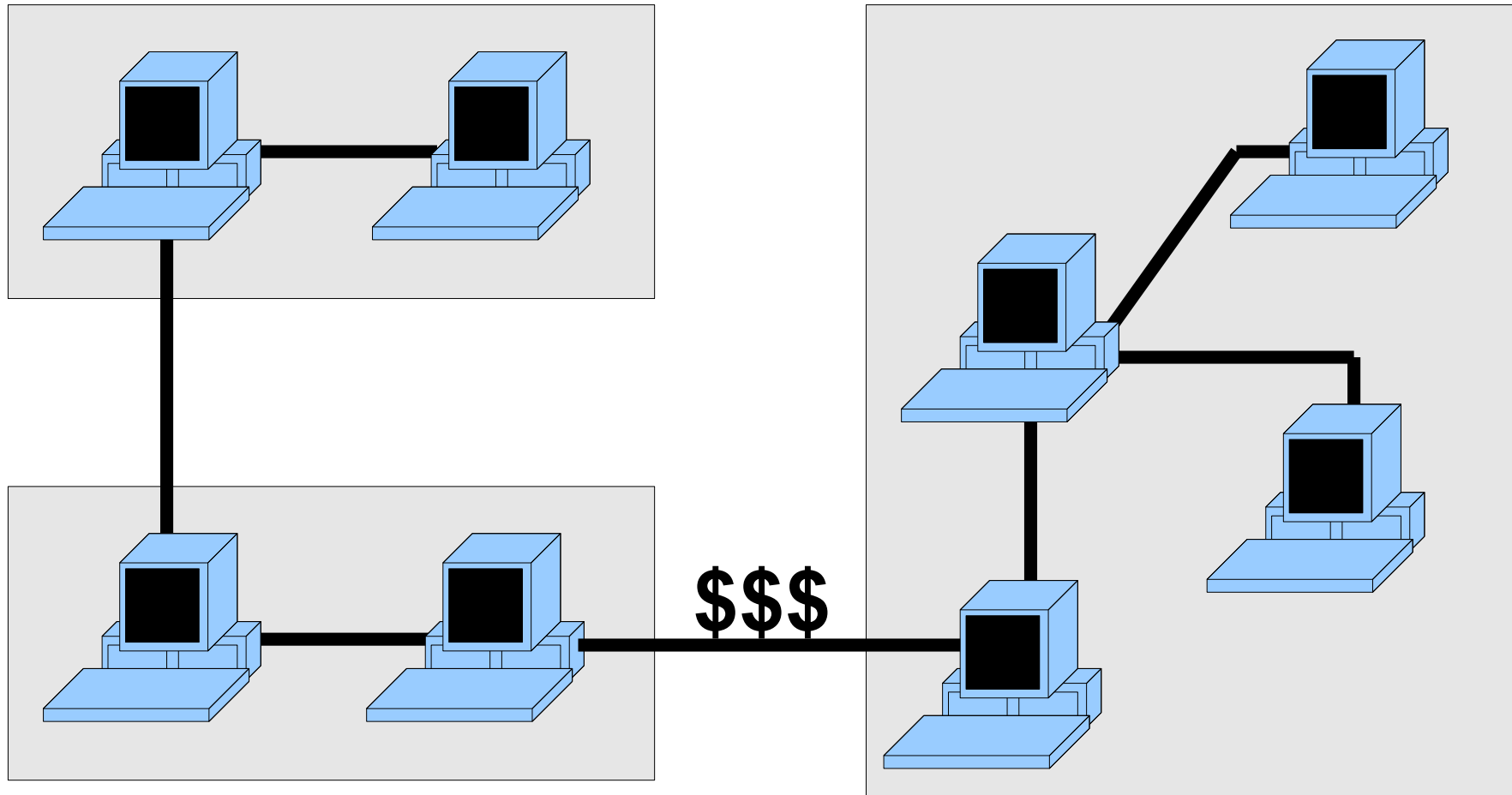
# Problems: Centralisation



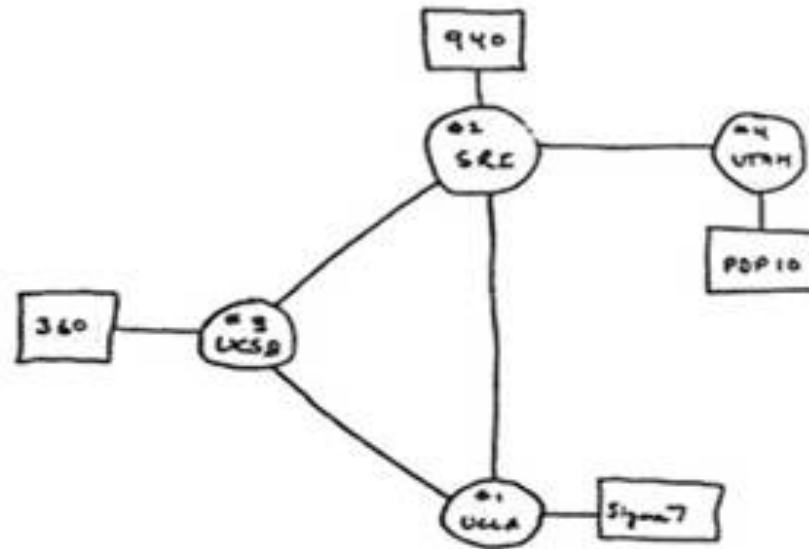
# Problems: Different Protocols



# Problems: Proprietary protocols



# 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)

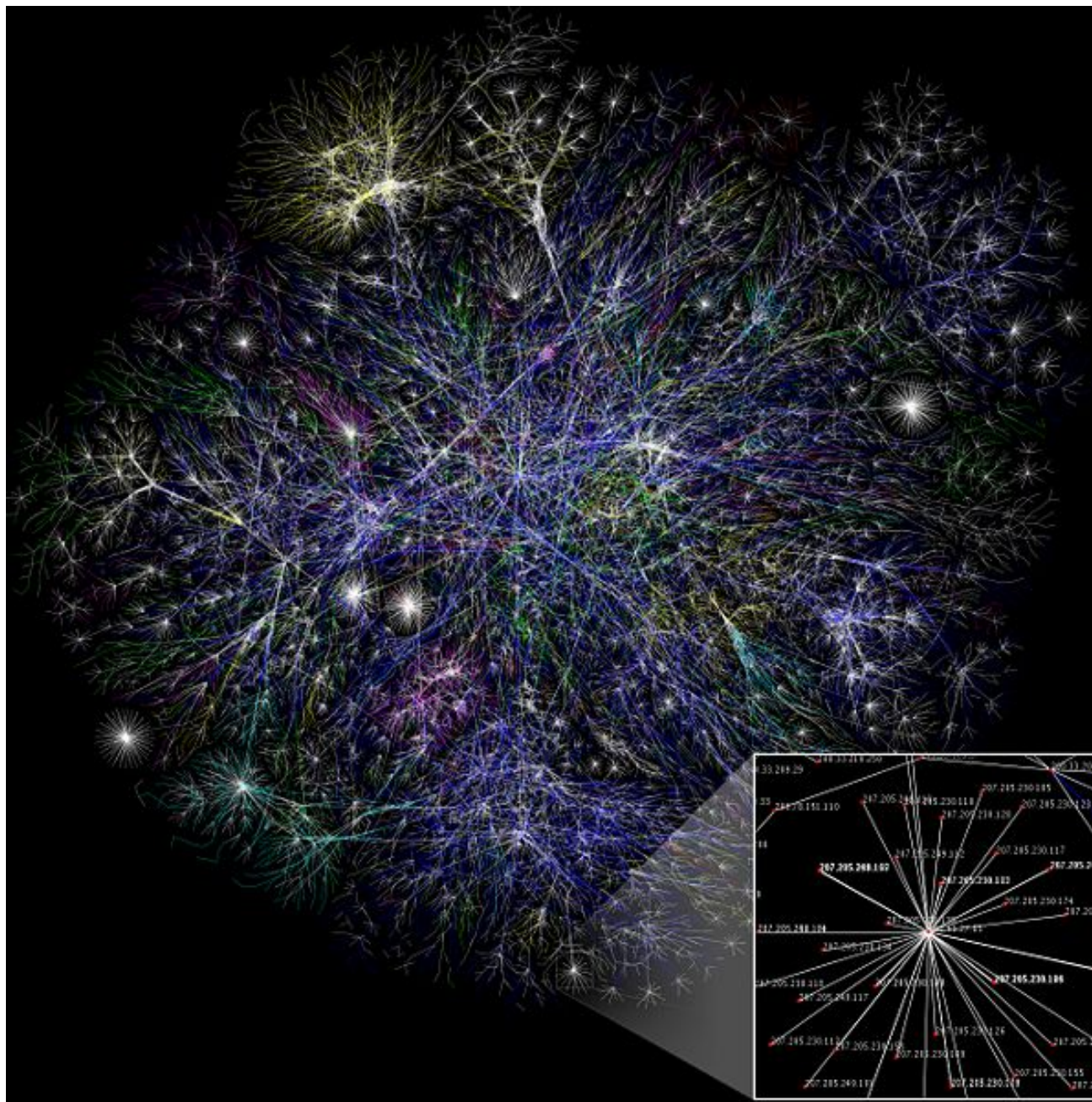
# Internet History

- 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.

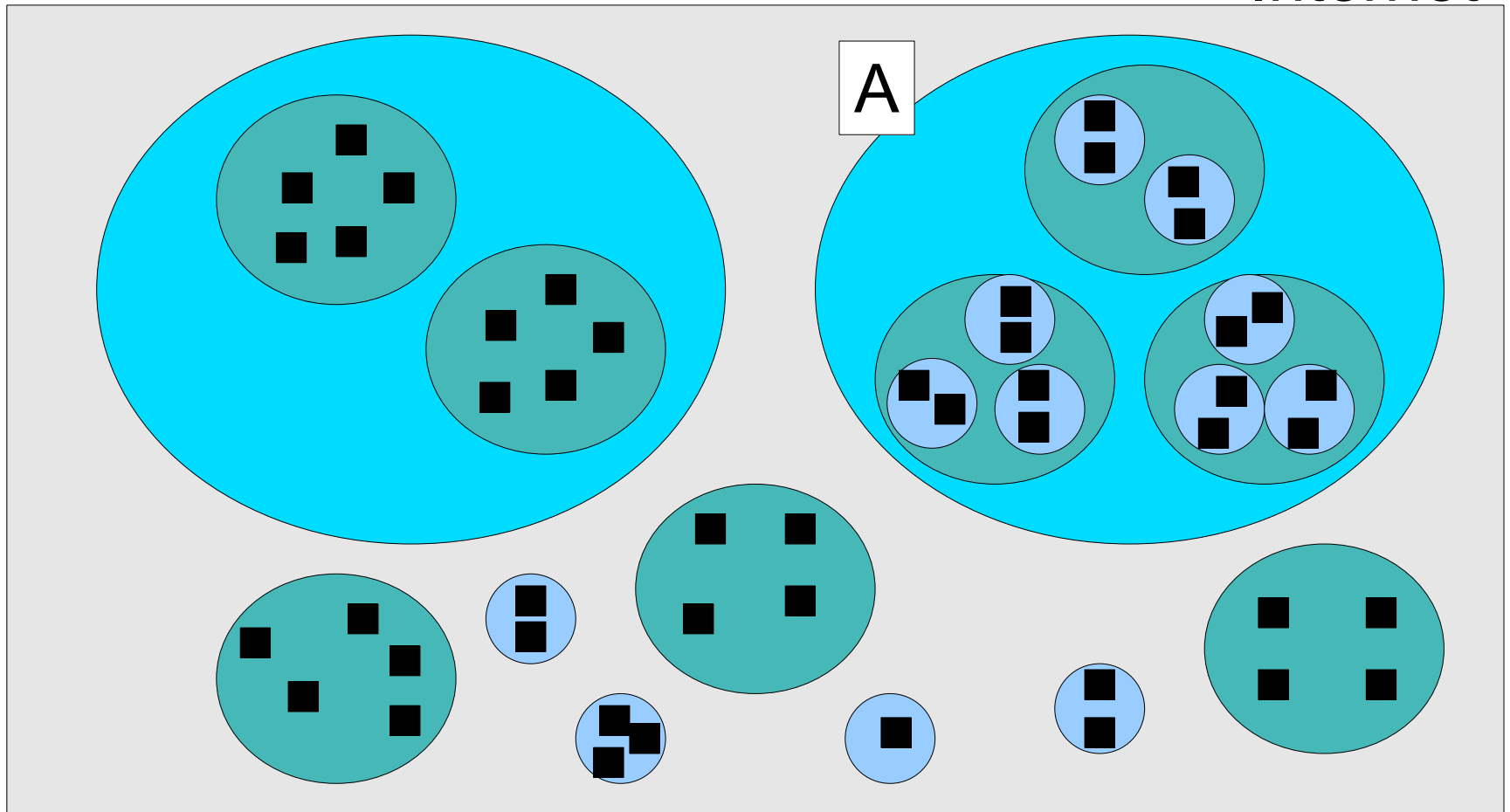
➤ Vern Paxson, "End-to-end routing behavior in the internet," *SIGCOMM Computer Communications Review*, Vol. 36, No. 5, October 2006, pp 41-56.

# Course topics

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

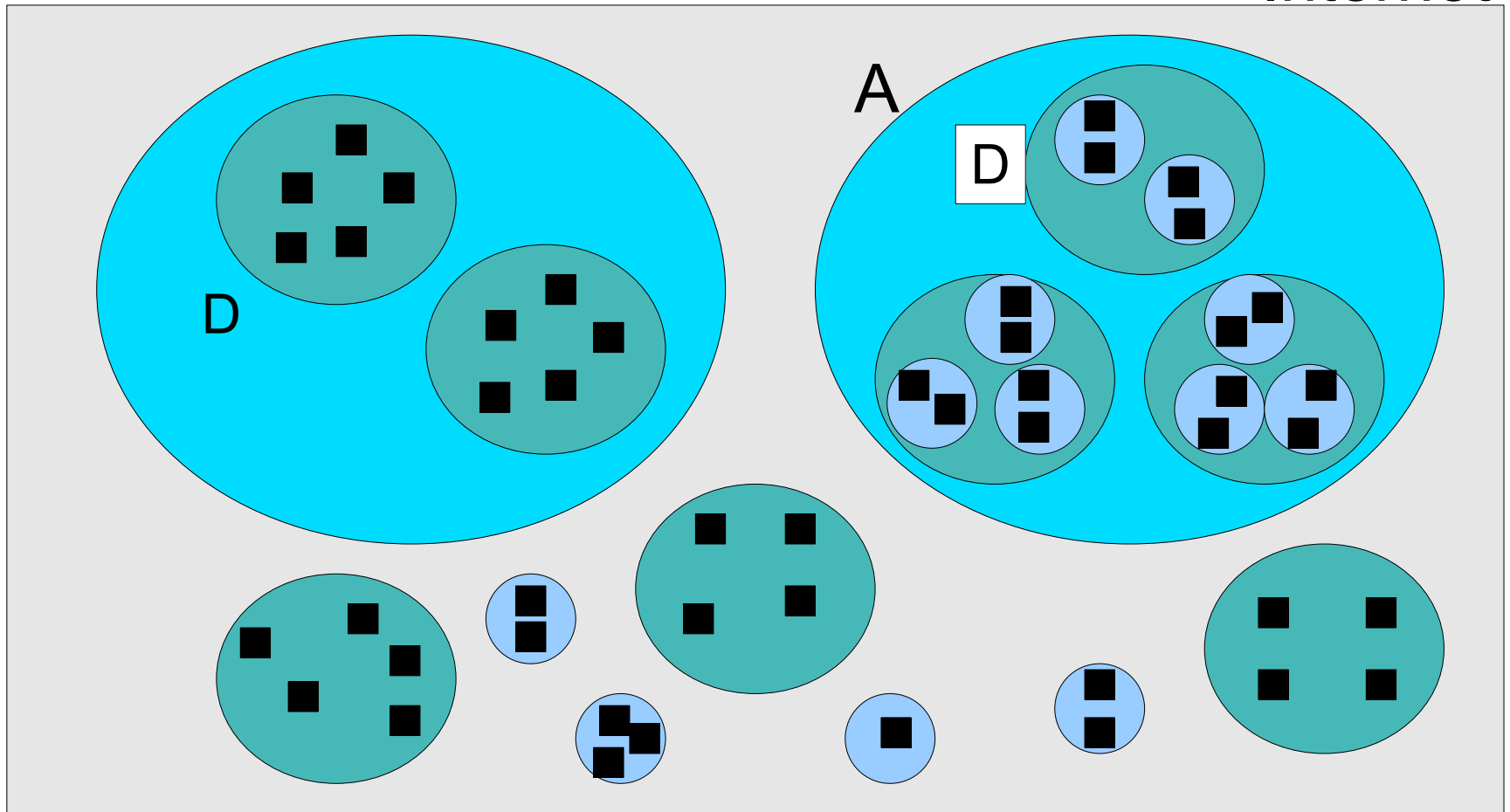
# Hierarchical addressing

Internet



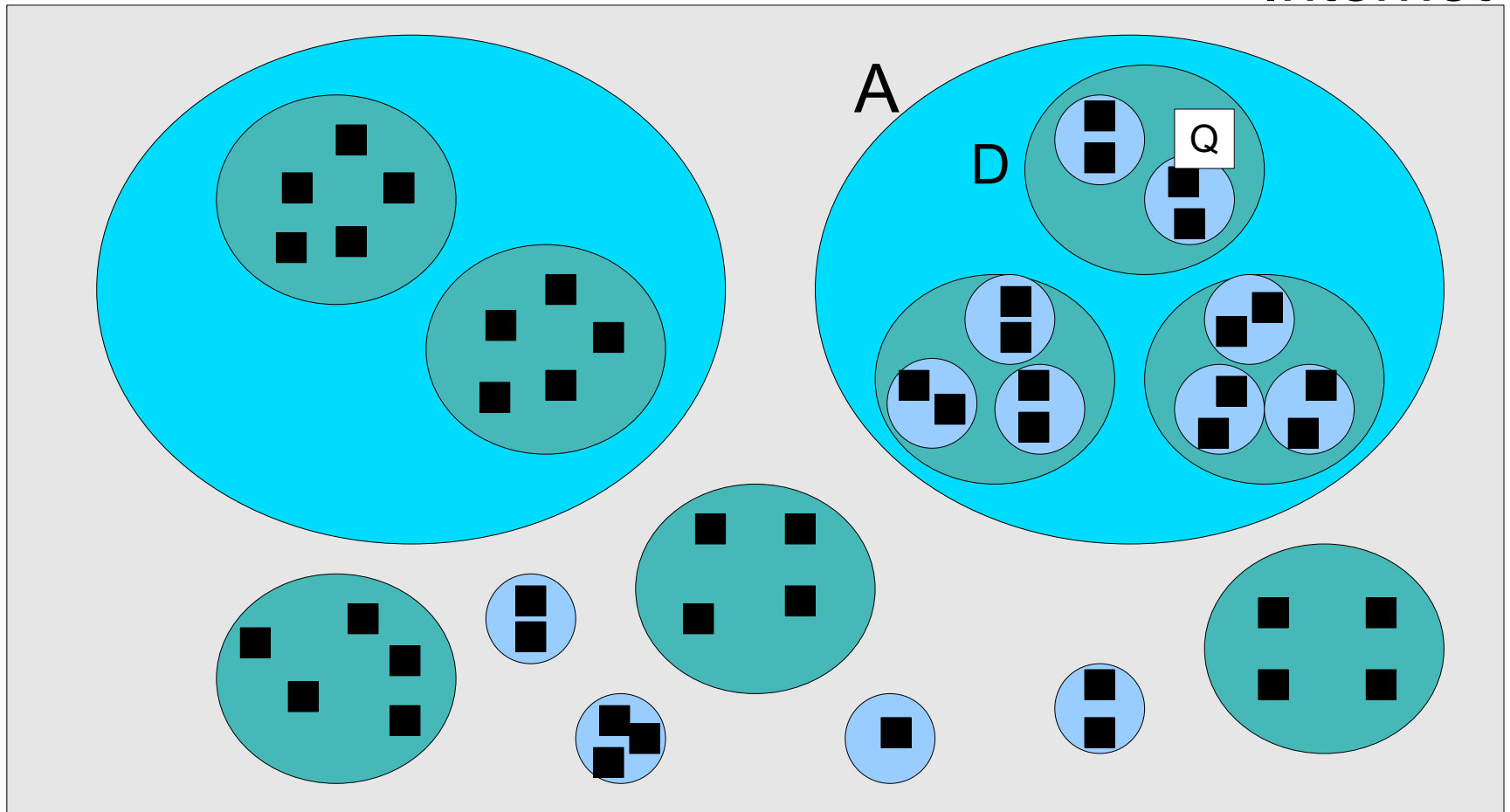
# Hierarchical addressing

Internet



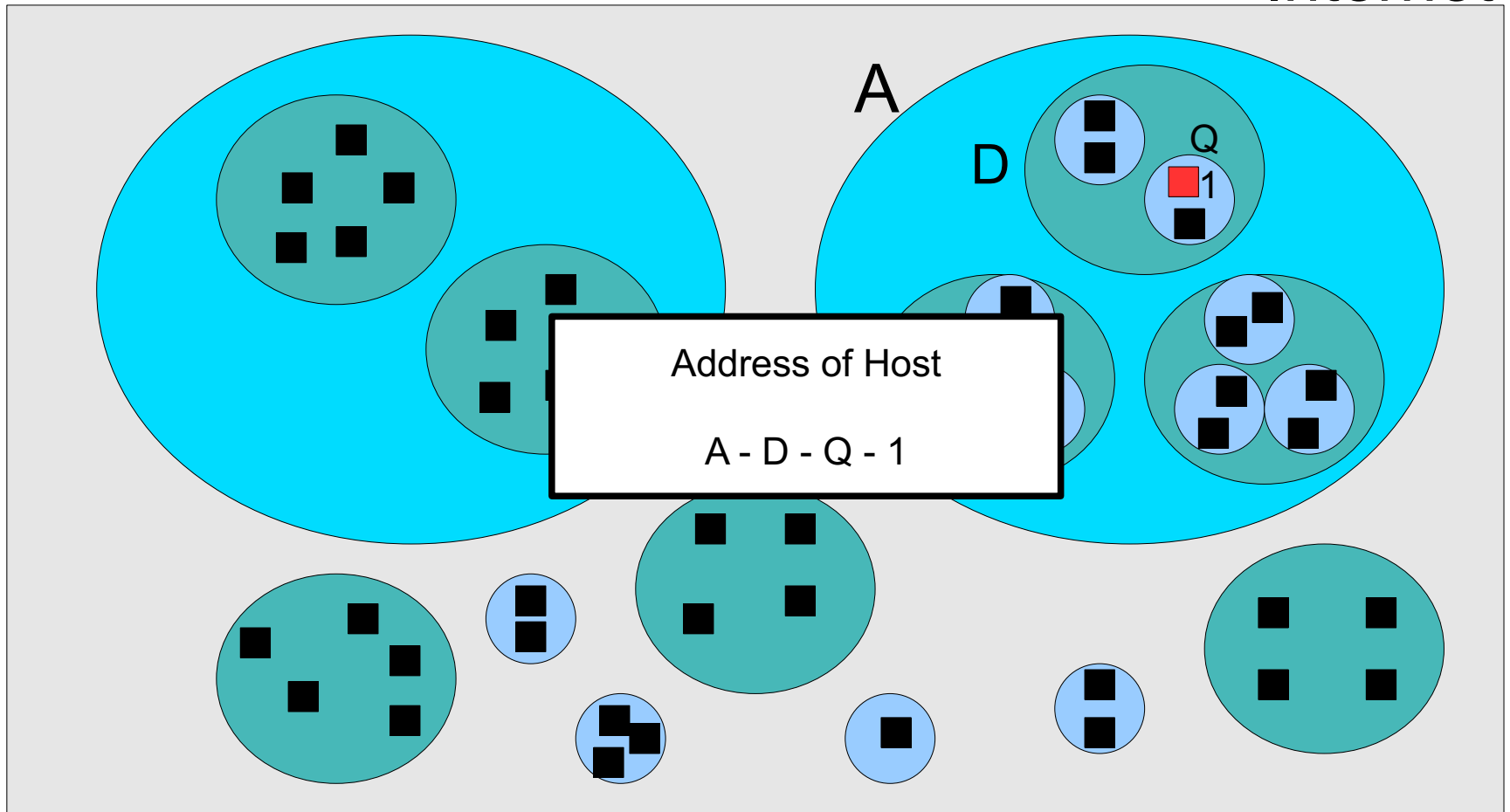
# Hierarchical addressing

Internet



# Hierarchical addressing

Internet

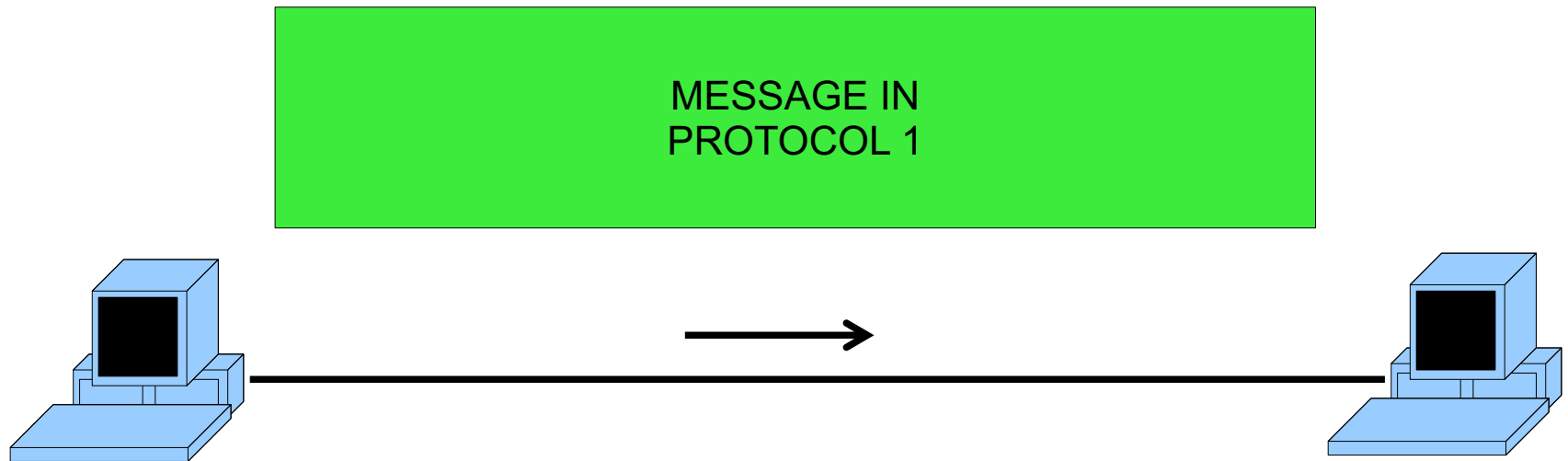


# Course topics

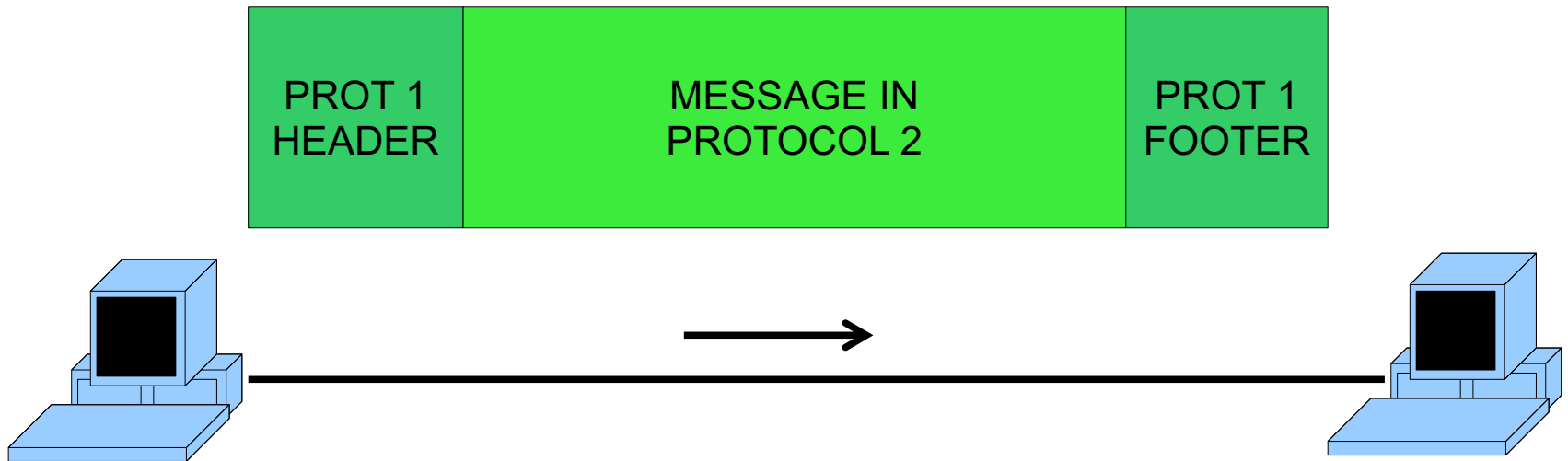
1. The architecture of the internet
2. Addressing resources on the internet
- 3. Internetwork communication (IP)**
- 4. Handling communication problems (TCP)**



# Embedded messages

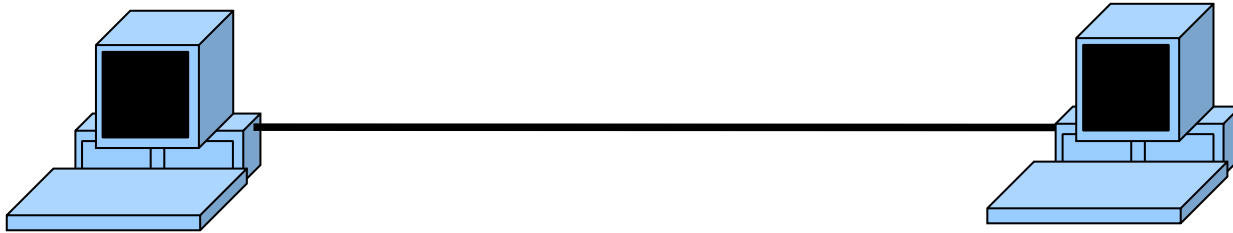


# Embedded messages



# Flow Control

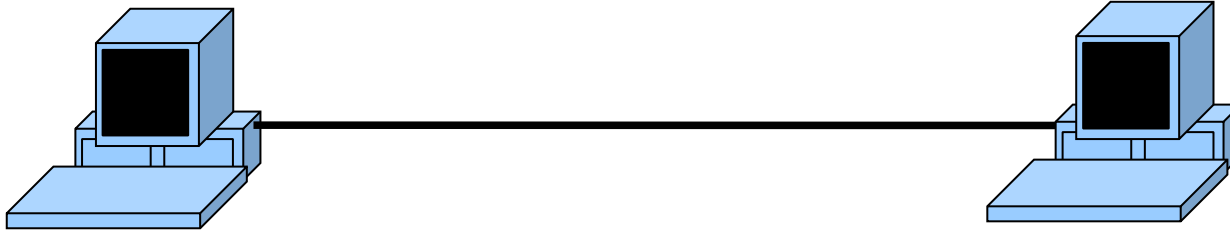
MESSAGE TO SEND



# Flow Control

MESSAGE SEGMENTS

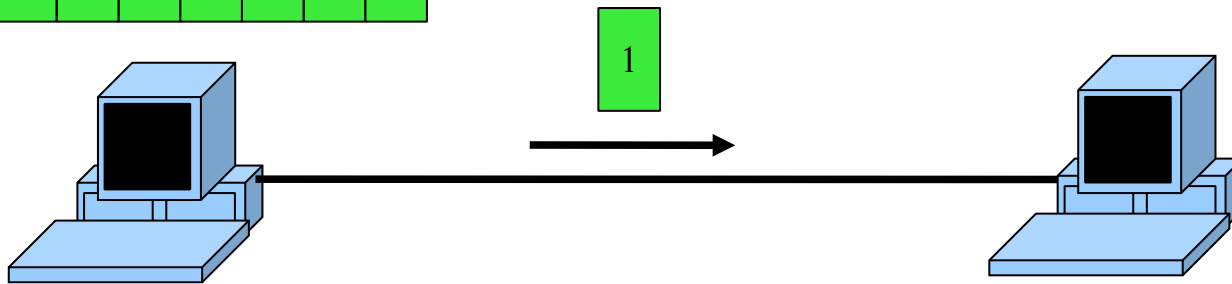
1	1	9	8	7	6	5	4	3	2	1
1	0									



# Flow Control

MESSAGE SEGMENTS

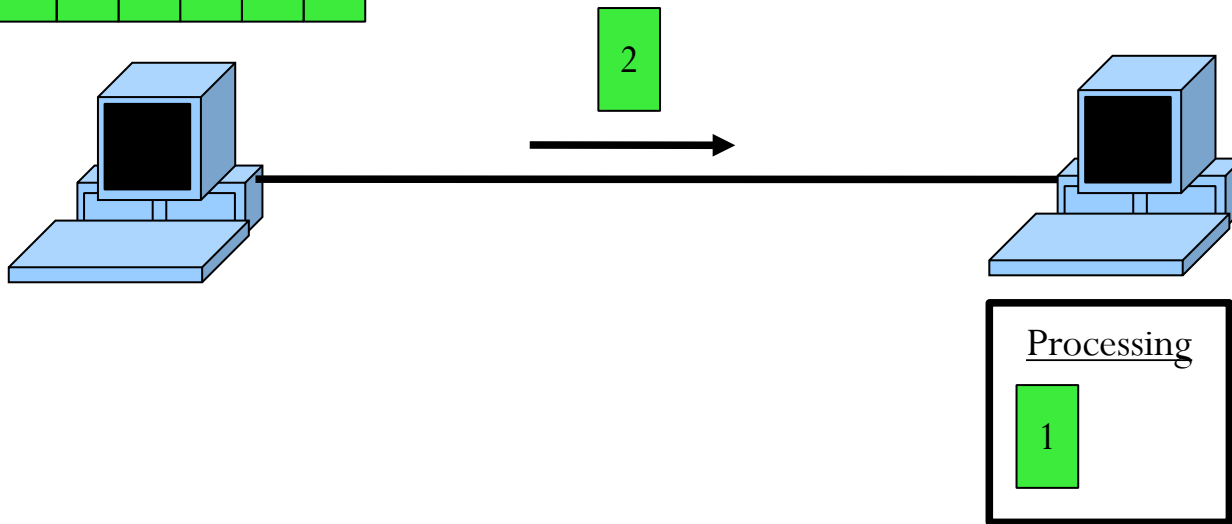
1	1	9	8	7	6	5	4	3	2
1	0								



# Flow Control

MESSAGE SEGMENTS

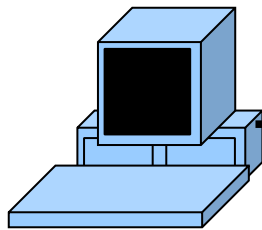
1	1	9	8	7	6	5	4	3
1	0							



# Flow Control

MESSAGE SEGMENTS

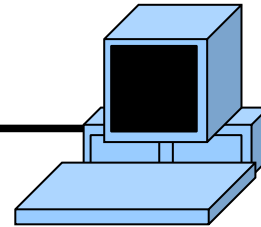
1	1	9	8	7	6	5	4
1	0						



3



Too fast!



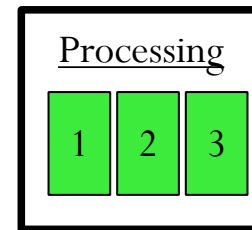
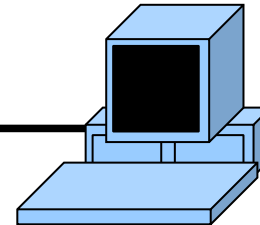
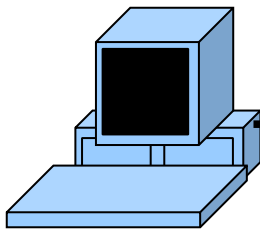
Processing

1	2
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# Flow Control

MESSAGE SEGMENTS

1	1	9	8	7	6	5	4
1	0						

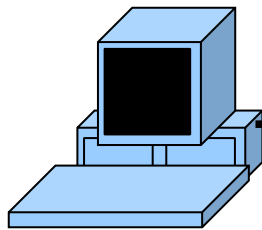




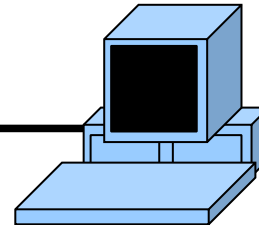
# Flow Control

MESSAGE SEGMENTS

1	1	9	8	7	6	5
1	0					



4



Processing

2	3
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# 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

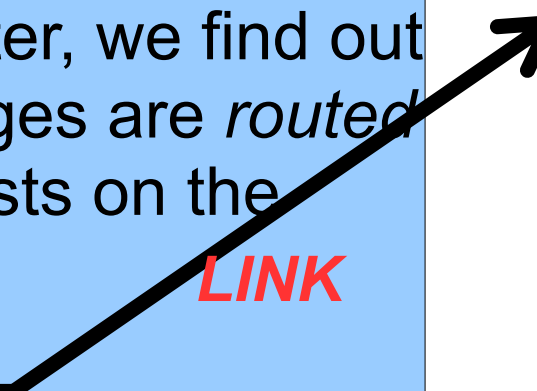
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## *LINK* Chapter 2

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# 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

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TECHNICAL  
TERM

TECHNICAL  
TERM

# Mark-up in XML

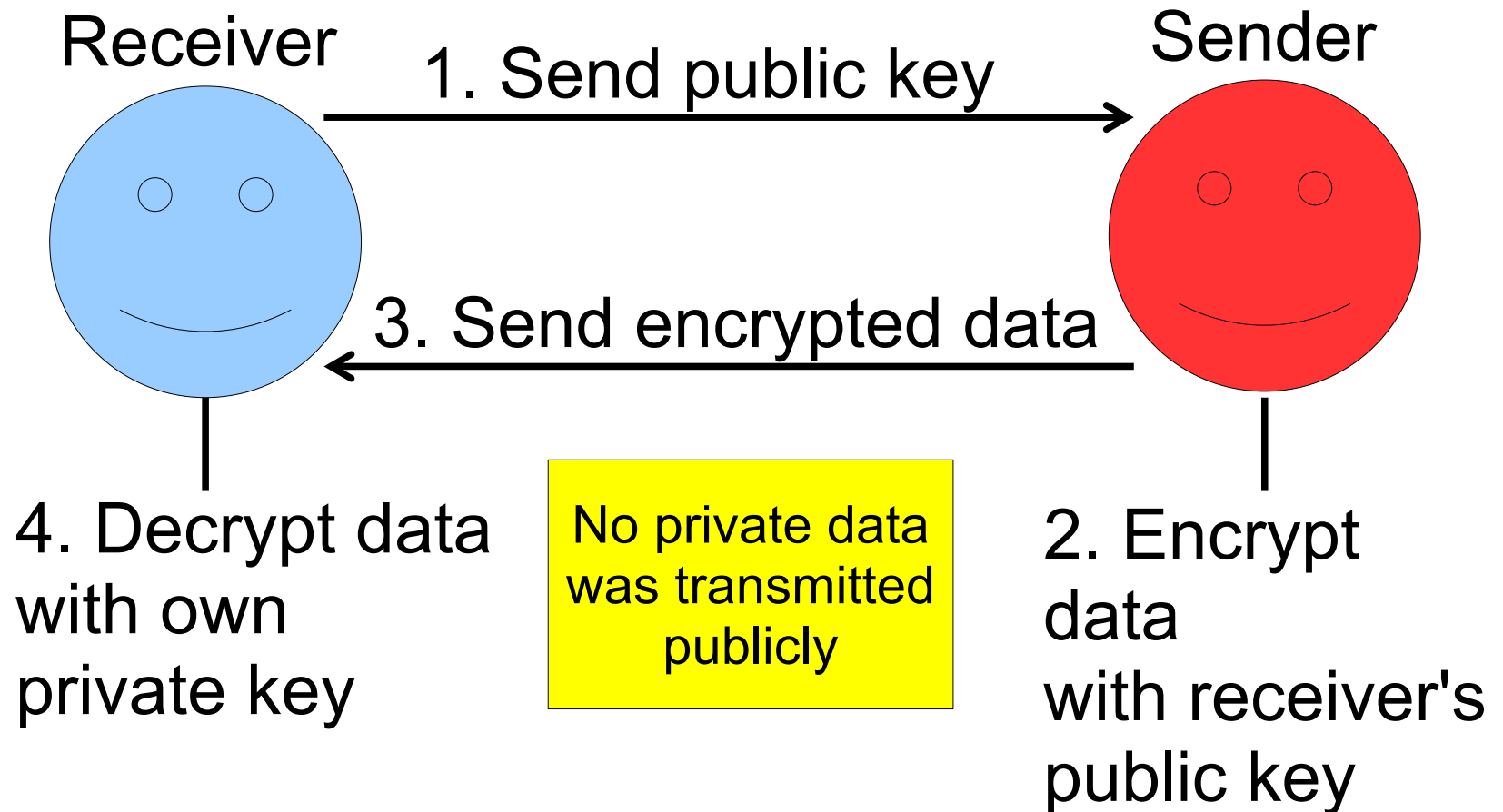
**<chapter><title>**Introduction to Mark-up**</title>**

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





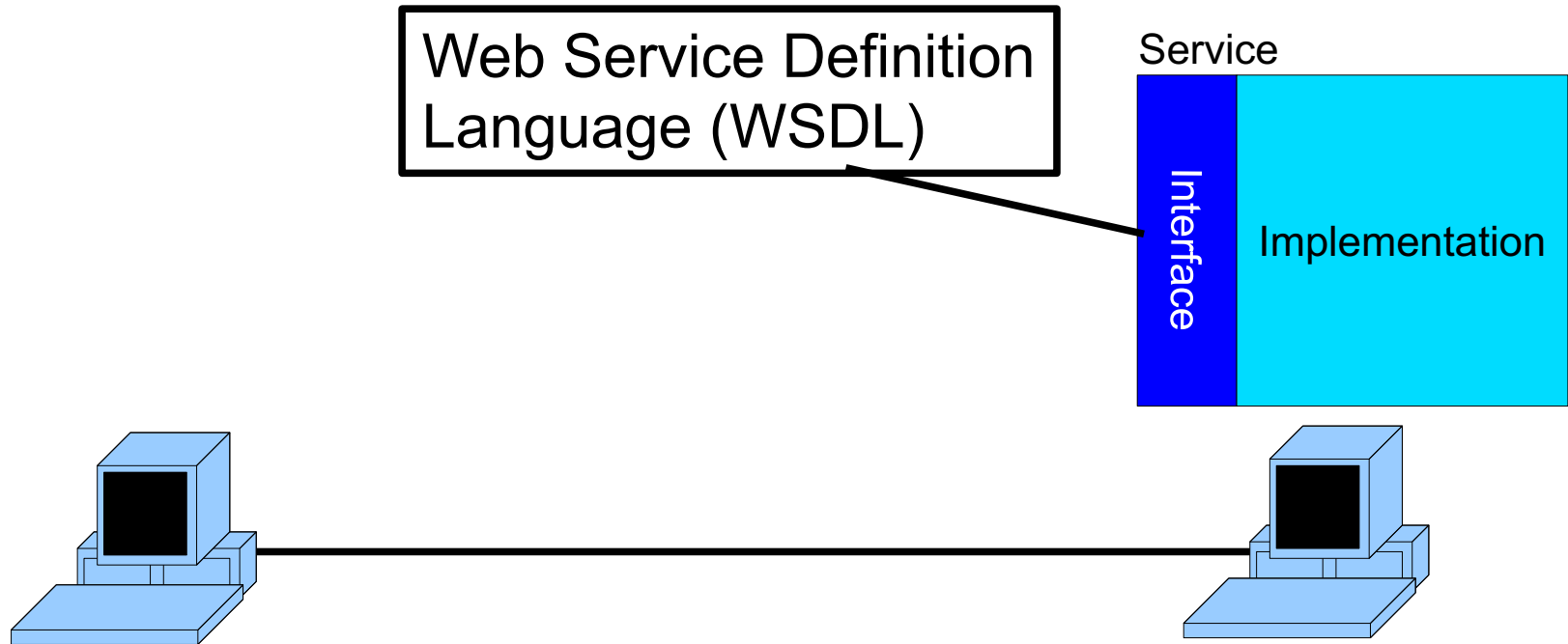
# Digital certificates

- 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

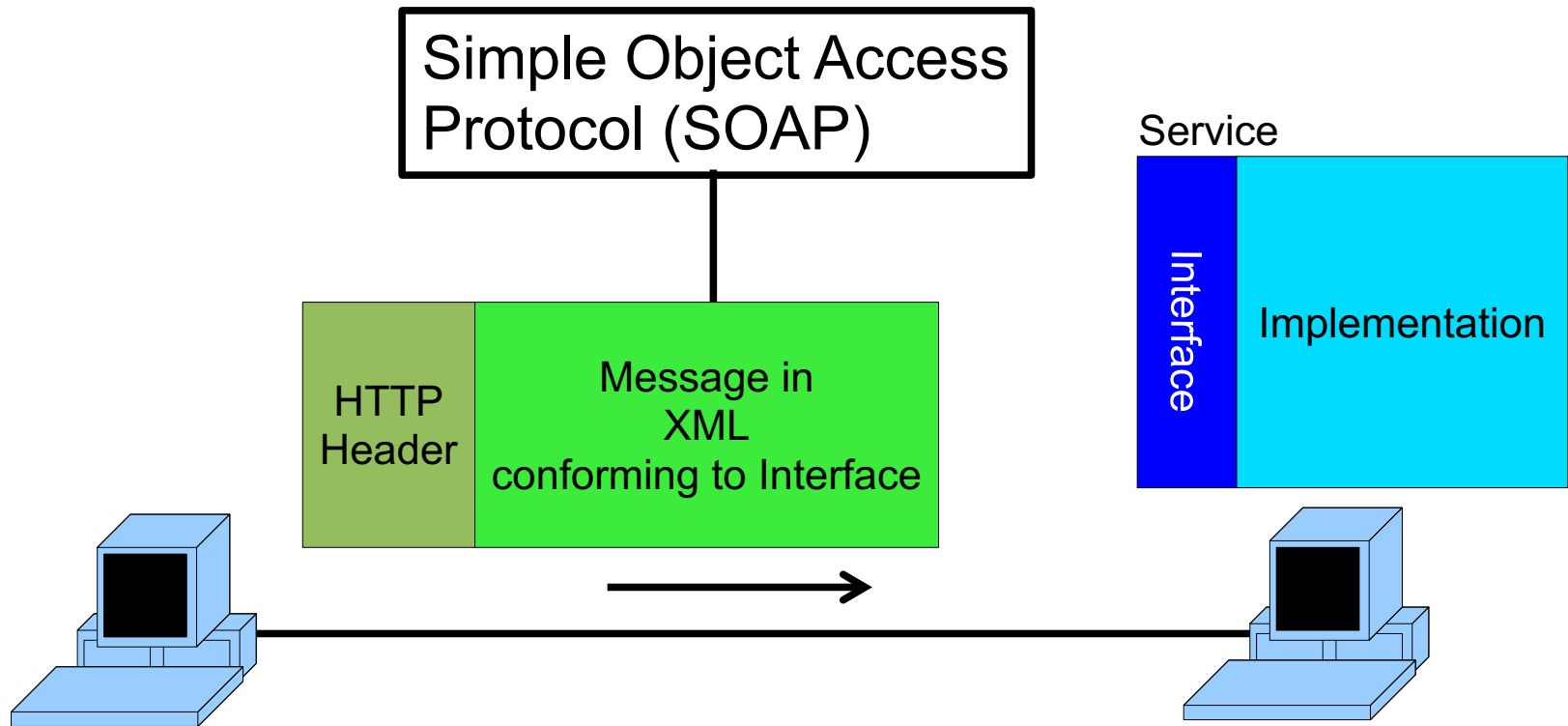
# Course Topics

1. The architecture of the internet
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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

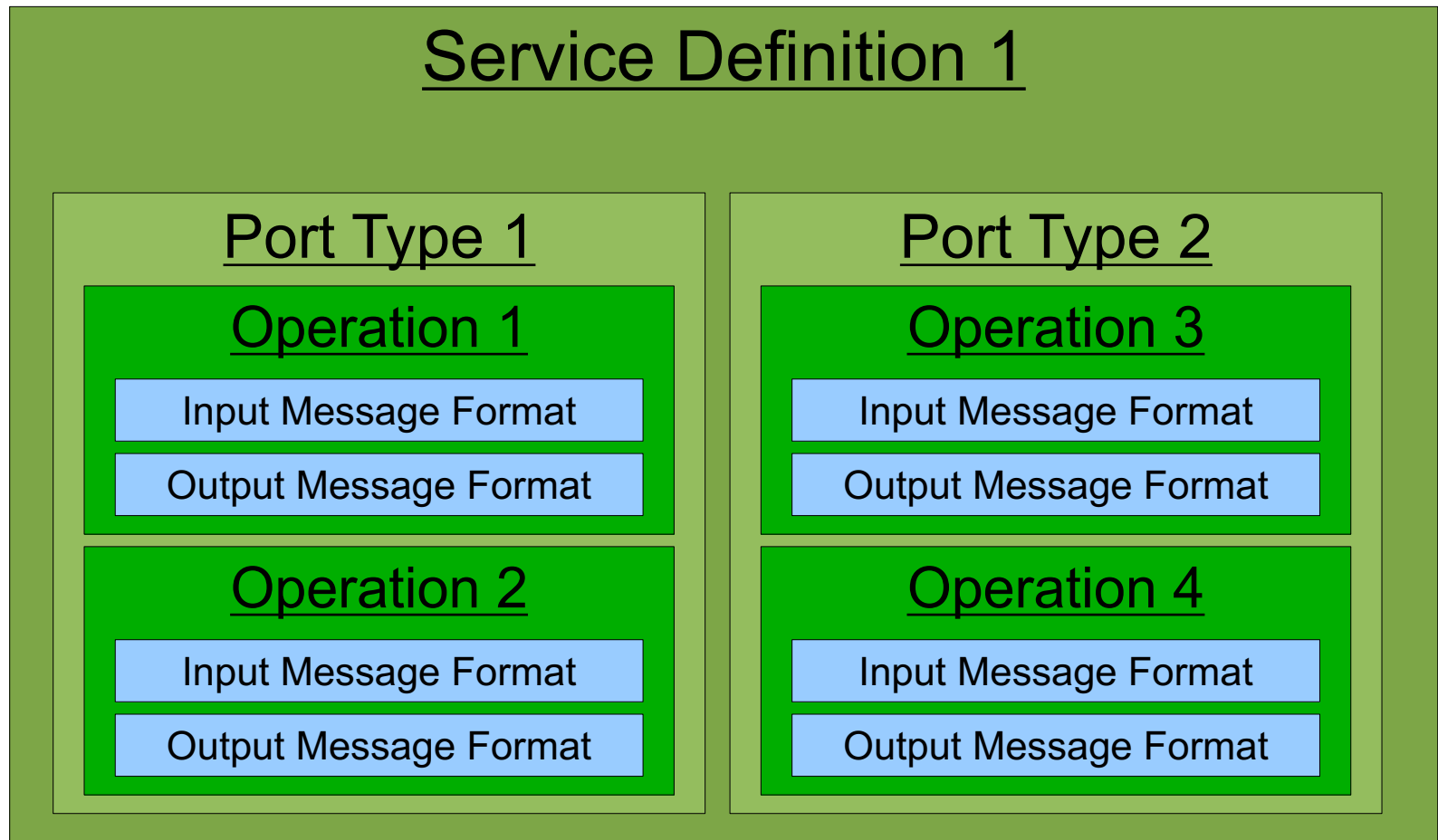
# Web Services



# Web Services



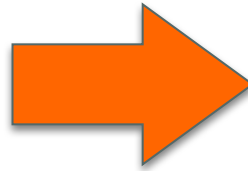
# WSDL interface



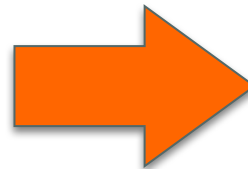
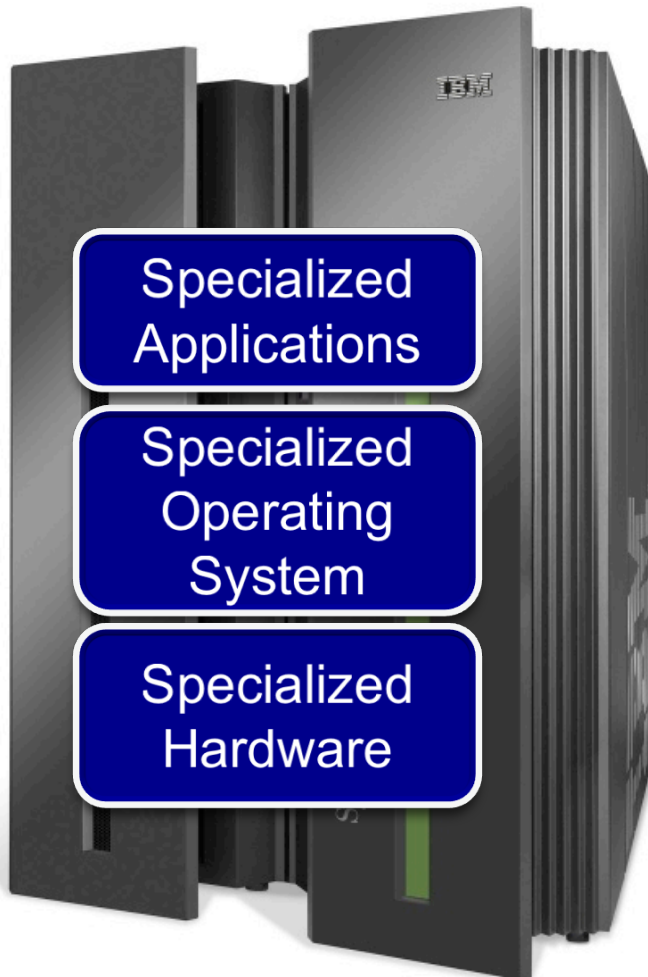
# Internet Paradigm Shift

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

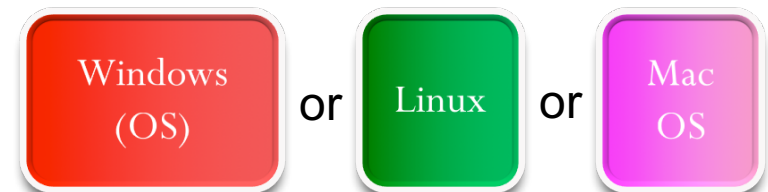
- ✓ Vertically integrated
- ✓ Closed, proprietary
- ✓ Slow innovation
- ✓ Small industry



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



— Open Interface —



— Open Interface —



# Cloud Service Models

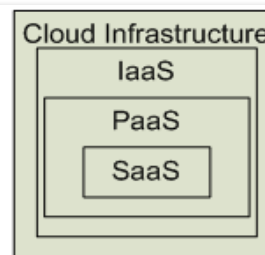
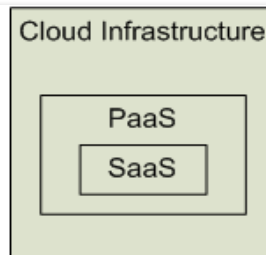
Software as a  
Service (SaaS)

Platform as a  
Service (PaaS)

Infrastructure as a  
Service (IaaS)

SalesForce CRM

LotusLive

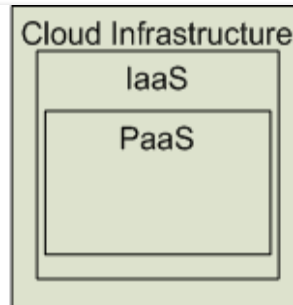
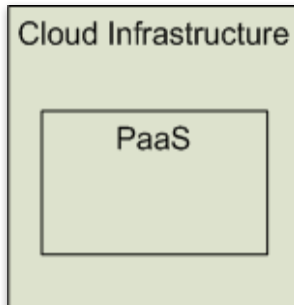


Software as a Service  
(SaaS)  
Providers  
Applications



Google  
App

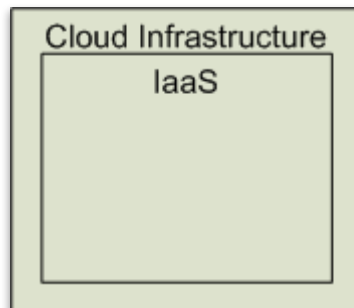
Windows Azure  
The Future Made Familiar



Platform as a Service (PaaS)  
Deploy customer  
created Applications

amazon  
web services™

rackspace  
HOSTING



Infrastructure as a Service (IaaS)

Rent Processing, storage, N/W  
capacity & computing resources



**See you next week**