Computing systems and communications

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- Reference:
  - Data and computer communications, William Stallings, pages 1 – 16 ISBN 0-02-415441-5

Introduction

- Need for communications
- What is communications?
  - Communications allows us to transfer and exchange data
  - This allows access to much greater data than that available on one computer
- Where are communications used?
  - Financial systems: ATM networks, stock exchanges
  - Airlines: Reservation systems, aircraft control
  - Manufacture: Assembly line, design systems, stock control
  - Academia: Internet, sharing of ideas
  - University: Sharing computing resources

A universal machine

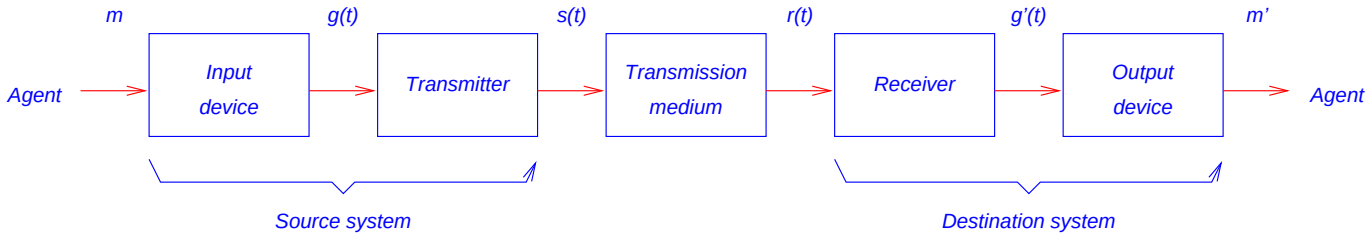
- At the center of **all** of these computing systems is the computer
- The capacity to compute arithmetic and logical operations has enabled the machine to be used in a vast array of applications
- The user of such computing systems is usually oblivious to the powerful simplicity of the computer that they rely on

Computer-communications revolution

- There is no fundamental difference between data processing (computers) and data communications (transmission and switching equipment)
- There are no fundamental differences among data, voice, graphics and video communications
- The lines between single-processor computer, multi-processor computer, local network, metropolitan network, and long-haul network have blurred

A communications model

- Exchange of information between two agents
- Data and Information:
  - **Data:** A representation of facts, concepts, or instructions in a formalised manner suitable for communication, interpretation, or processing by human beings or by arithmetic means
  - **Information:** The meaning that a human being assigns to data by means of the conventions being applied to those data [Stallings]



Example 1 – Electronic mail (1)

1 The sender composes a message, m

2 Through a keyboard, this is translated into a stream of bits, g

3 The bit stream is converted into a signal, $s(t)$, appropriate for transmission through the given medium

4 The signal $s(t)$ undergoes some degradation in transmission, the result is a potentially different received signal, $r(t)$

Example 1 – Electronic mail (2)

5 The receiver converts $r(t)$ into a bit stream, $g'(t)$, reversing the conversion used by the sender to produce $s(t)$

6 At this point, the receiving computer may examine the message for errors

7 If errors are detected, the receiving computer may cooperate with the sending computer, re-transmitting as necessary until the errors are resolved

8 The receiver eventually will receive a message m, that is usually identical to the transmitted message

Example 2 – Telephone conversation

1. Message m is generated as sound waves (by speaker's mouth)
2. Telephone converts this to an electric signal, $s(t)$
3. The signal $s(t)$ may be directly transmitted, $g(t) = s(t)$
4. The transmitted signal will suffer some distortion, so that the received signal, $r(t)$, will not be identical to the transmitted signal, $s(t)$
5. The received signal is translated directly to sound waves, with no attempt to recover errors
6. The receiver hears a distorted version of the transmitted message m', but the message is generally understandable

Communications tasks

- Reliable communication involves many different tasks

- Some are listed below:
  - Transmission system utilisation
  - Interfacing
  - Signal generation
  - Synchronisation
  - Exchange management
  - Error detection and correction
  - Addressing
  - Routing
  - Recovery
  - Message formatting
  - Protection
  - System management

Data communication networking

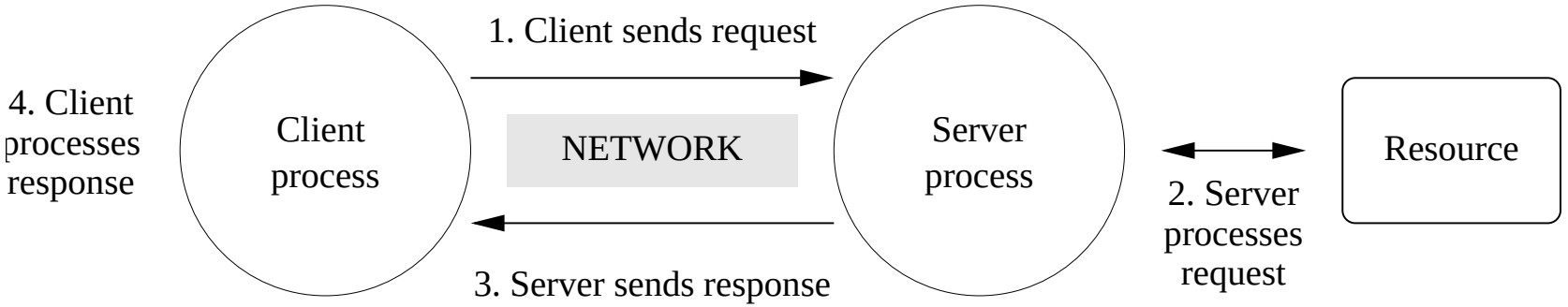
- In its simplest form, data communication takes place between two devices connected by some form of point-to-point transmission medium

- This is often impractical
  - The devices are too far apart
  - There is a set of devices, each of which require a link to many of the others at various times

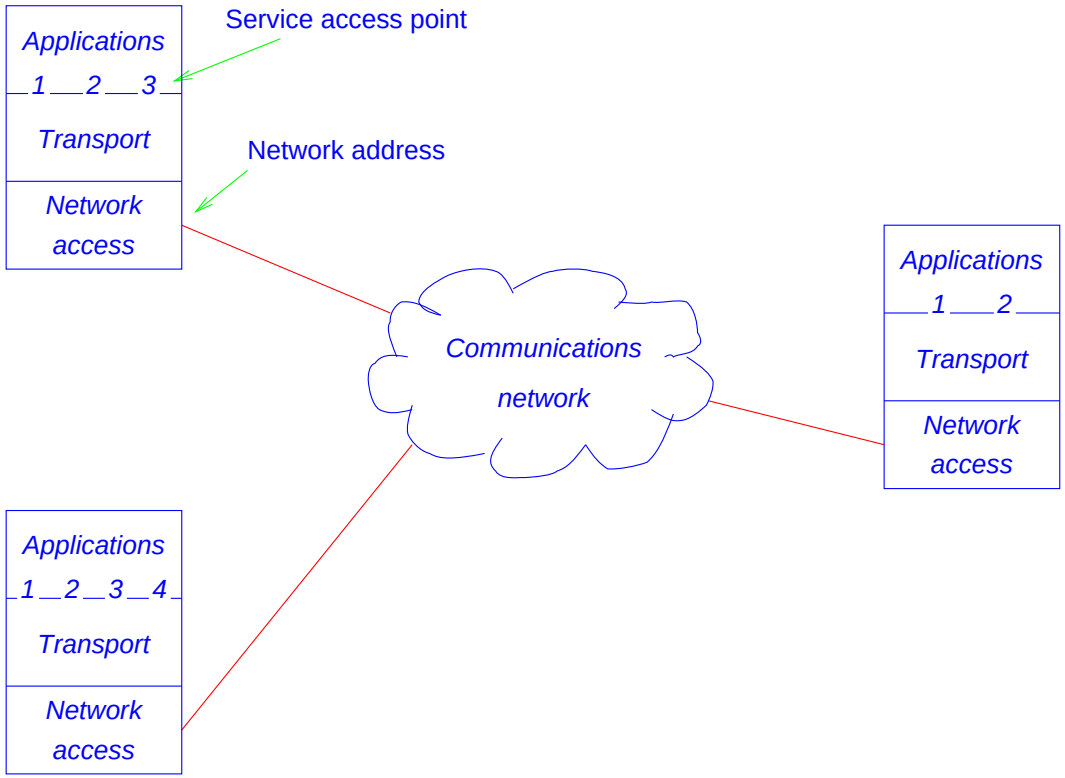
- The solution is to attach each device to a **communication network**

Client-Server Programming Model over a Network

- Every network application is based on a client-server model
- The fundamental operation in this model is the *transaction*



Computer communications architecture



Network access layer

- Concerned with the exchange of data between a computer and the network to which it is attached
- The sending computer provides the network with a destination address for every message to be communicated
- The software used at this layer depends on the sort of network used
- There are many different sorts of networks
- The transport and application layers are not concerned with the specifics of the network

Transport layer

- Due to the errors that are typically introduced during transmission, software is employed to ensure reliability
- Such error correction can be made independent of the application software and the particular network technology
- The negotiations between sender and receiver to ensure reliable transmission are often complex
- The transport layer ensures reliable transmission, hiding the details from the application layer and insulated from the hardware details by the network access layer

Application layer

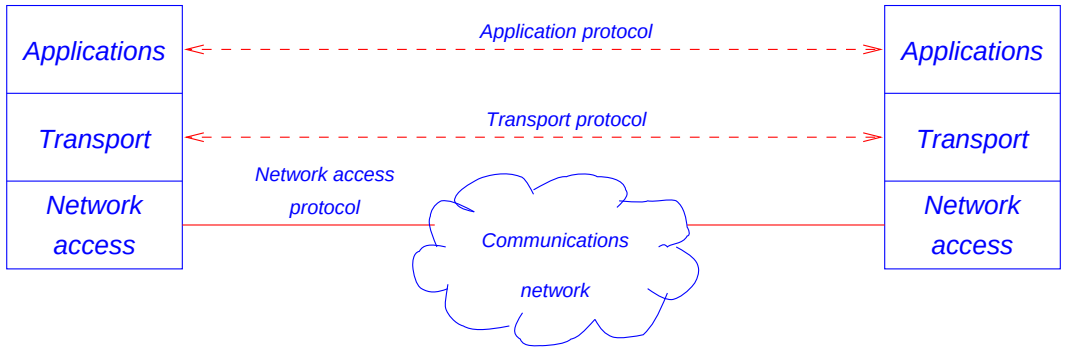
- The application layer holds the software associated with the various different network applications, such as file transfer and email

- Different applications transfer information in different ways; e.g. telnet, email, web browser, etc.

Addressing and protocols

- A single machine may be host to many applications at a time
- Each application on a machine will access the transport layer through an identifiable point called a **Service Access Point** (SAP)
- Thus, an **address** must specify a machine and a SAP
- **Protocols** are rules of communication that allow orderly, standardised communication between parties
- Protocols are used in human communication
- In machine communication, protocols help to detect errors
- A breach of protocol is viewed as an error

Protocols in a three layer architecture (1)



- Application layer
  - Data may consist of a message of **any** length
  - The data is given directly to the transport layer

Protocols in a three layer architecture (2)

- Transport layer
  - The message is typically broken into small units (**packets**)
  - Associate with each packet will be a **header**
  - The header typically contains:
    * An address
    * A sequence number
    * An error-detection code

Protocols in a three layer architecture (3)

- Network access layer
  - A network access layer header is attached to each packet
  - The header typically contains:
    - The destination computer address
    - Other information including service requirements (priorities, time-stamps, etc.)
    - A further error detection code

Illustration of the packets at each layer