Input and Output

Chapter 13

Input/Output Concepts And Terminology

Topics

- Introduction
- Input and Output Device
- Control of an External Device
- Data Transfer
- Serial and Parallel Data Transfers
- Self-clocking Data
- Full-duplex and Half-duplex Interaction

Topics

- Interface Latency and Throughput
- The Fundamental Idea of Multiplexing
- Multiple Devices Per External Interface
- A Processor View of I/O
- Summary

Introduction

- Previous parts covered two major components
  - processor
  - memories
- This part covers the third significant component
  - input and output (I/O)

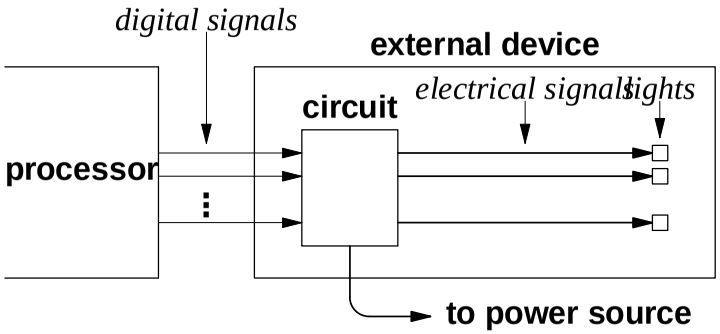
Input and Output Devices

- Examples of old interfaces
  - manual switches for input, sequence of lights for output
- Examples of current interfaces
  - keyboard, mice, monitors, disks, printers, audio speakers

Control of External Device

- Early external devices
  - separate independent units housed separately
  - received control signals from CPU
  - received separate power supply
- Modern external devices
  - these also receive control signals from the processor

Control of External Device



Example of an early external device: a set of lights controlled by a processor. The device contains circuitry that converts incoming signals into the signals needed to operate the device.

Data Transfer

- Primary function of external device is data transfer
- Questions regarding data transfer
  - how is data communicated
  - how is transfer controlled, who initiates the transfer
  - what mechanisms are needed for the highest speed transfers
- Interface controller
  - hardware that provides the interface to an external device
  - controllers are needed at both ends (processor and device)

Serial and Parallel Data Transfer

- Parallel interface
  - allows transfer of multiple bits of data simultaneously
  - interface consists of many wires
  - number of parallel wires is called interface width, e.g. 8 bit interface

- Serial interface
  - one bit transferred at a time
  - advantage: fewer wires, one for signal, one for ground
  - disadvantage: increased delay, slower transfer

Clocks

- Processors and I/O devices have own clocks which operate at different rates
- How does the interface accommodate difference in clock rates?
- Self clocking data
  - mechanism where signals sent across interface contain information that allows the receiver to determine how the sender encoded the data

Full-Duplex and Half-Duplex Interaction

- Full duplex
  - bidirectional, simultaneous transfer
  - two parallel devices with two independent set of wires.
  - one set to transfer in each direction.

- Half duplex
  - transfer in one direction at a time
  - single set of wires connecting processor and external device must be shared
  - need to negotiate direction, start and finish of transfer

Interface Latency and Throughput

- Latency
  - delay between the time a bit is sent and the time the bit is received
  - how long to transfer a single bit.
  - units is nanoseconds

- Throughput
  - number of bits that can be transferred per unit time
  - units is Megabits per second (Mbps), or Megabytes per second (MBps)

Interface Latency and Throughput

The latency of an interface is a measure of the time required to perform a transfer, the throughput of an interface is a measure of the data that can be transferred per unit time.

Multiplexing

- Wider parallel interface means more pins are needed
- More pins for interface means fewer pins for other functions
- Full-duplex uses twice the number of pins as half-duplex
- Compromise - limited parallelism
  - hardware breaks large data transfer into pieces and sends one piece at a time
  - multiplexor and demultiplexor are hardware at sending and receiving ends

Multiplexing

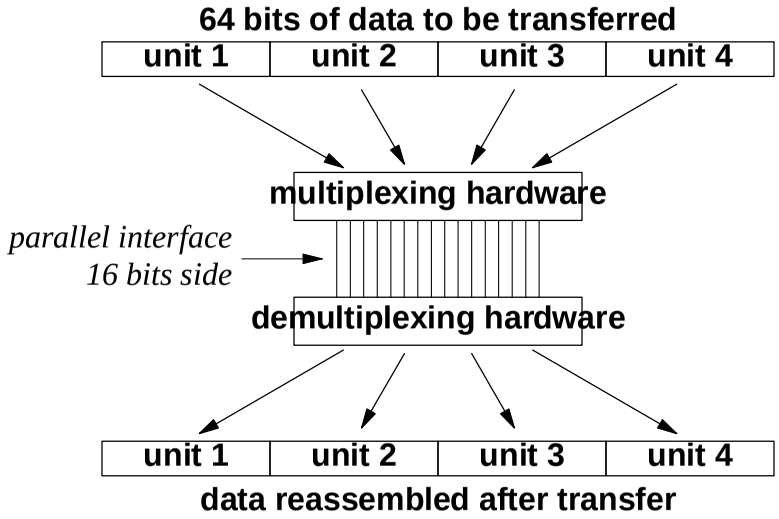


Illustration of the transfer of sixty-four bits of data over a sixteen bit interface. Multiplexing hardware divides the data into sixteen bit units and sends one unit at a time.

Multiplexing

Multiplexing is used to construct an I/O interface that can transfer arbitrary amounts of data over a fixed number of parallel wires. Multiplexing hardware divides the data into blocks and transfers each block independently.

Processor's View of I/O

A processor does not access external devices directly. Instead, the processor uses a programming interface to pass requests to an interface controller, which translates the requests into the appropriate external signals

Summary

- Computer systems interact with external devices to control or transfer data
- Interface can be serial or parallel, the number of bits in parallel that can be sent simultaneously is the width
- Latency and throughput measure interface performance, latency is the time taken to transfer a bit, while throughput is the number of bits sent per unit time
- External connections are not arbitrarily wide- this would need too many pins
- Multiple external device can attach to single external connection, interface controller handles the communication