The Computer
From Dix, Finlay, Abowd & Beale's *Human-Computer Interaction (Chapter 2)*

A computer system is made up of various elements
- **Input & Output**
  - Input devices – text entry and pointing
  - Output devices – screen (small & large), digital paper
  - Physical interaction – e.g. sound, haptics, physiological sensing
- **Memory**
  - RAM & Permanent media, capacity & access
- **Processing**
  - Speed of processing, networks

Interacting with Computers

to understand human–computer interaction
... need to understand computers!

- what goes in and out devices, paper, sensors, etc.
- what can it do? memory, processing, networks

A ‘Typical’ Computer System
- Screen, or monitor, on which there are windows
- Keyboard
- Mouse/trackpad
- Variations
  - desktop
  - laptop
  - PDA
- The devices dictate the styles of interaction that the system supports
- If we use different devices, then the interface will support a different style of interaction
How many computers do you have...

- in your house?
  - PC
  - TV, VCR, DVD, HiFi, cable/satellite TV
  - microwave, cooker, washing machine
  - central heating
  - security system
  - can you think of more?

- in your pockets?
  - PDA
  - phone, camera
  - smart card, card with magnetic strip?
  - electronic car key
  - USB memory
  - try your pockets and bags

Interactivity?

- No interactivity in the early age of computing
  - punched card stacks or large data files prepared
  - long wait …
  - line printer output … and if it is not right …

- Now most computing is interactive
  - rapid feedback
  - the user in control (most of the time)
  - doing rather than thinking …

- Is faster always better?
- Immature technologies can benefit from interactivity
  - vision, speech recognition, …
  - human speech recognition is not perfect, but is usable because...
  - human-human interaction is inherently interactive

Richer Interaction

Text Entry Devices

keyboards (QWERTY et al.)
- chord keyboards, phone pads
- handwriting, speech

Sensors and devices everywhere
Keyboards

- Most common text input device
- Allows rapid entry of text by experienced users
- Faster than writing, sometimes faster than speaking!
- Keypress closes connection, causing a character code to be sent
- Usually connected by cable, but can be wireless

QWERTY Keyboard

- Standardised layout
  - keys arranged in alphabetic order
  - not faster for trained typists
  - not faster for beginners either!
  - Often used in pocket electronic organizers

- Dvorak
  - common letters under dominant fingers
  - biased towards right hand
  - common combinations of letters alternate between hands
  - 10-15% improvement in speed and reduction in fatigue
  - But - large social base of QWERTY typists produce market pressures not to change

Alternative keyboard layouts
**DVORAK Keyboard**

**Design objectives:**
- The majority of keystrokes should alternate between hands.
- Place commonly used keys on the middle row.
- Minimize keystrokes made with stretching too far.
- Minimize keystrokes made with weak fingers.
- 56% of keystrokes are made with the right hand
  - Probably, not an objective but a side-effect.
  - Biased towards right-handed people

Experiments have shown a speed improvement of between 10 and 15%.

**Special Keyboards**

- **Designs to reduce fatigue for RSI (Repetitive Strain Injury)**
- For one handed use
  - e.g. the Maltron left-handed keyboard

**Chord Keyboards**

- Only a few keys - four or 5
- Letters typed as **combination of keypresses**
- Compact size
  - ideal for portable applications
- Short learning time
  - keypresses reflect letter shape
- Fast
  - once you have trained

- BUT – social resistance, plus fatigue after extended use
- NEW – niche market for some wearables
Phone pad and T9 entry

- Use numeric keys with multiple presses:
  2 - a b c  6 - m n o
  3 - d e f  7 - p q r s
  4 - g h i  8 - t u v
  5 - j k l  9 - w x y z
- hello = 4433555[pause]555666
- surprisingly fast!

- T9 predictive entry:
  - type as if single key for each letter
  - use dictionary to ‘guess’ the right word
  - hello = 43556 ...
  - but 26 -> menu ‘am’ or ‘an’

Handwriting Recognition

- Text can be input into the computer, using a pen and a digesting tablet:
  - natural interaction
- Technical problems:
  - capturing all useful information - stroke path, pressure, etc. in a natural manner
  - segmenting joined up writing into individual letters
  - interpreting individual letters
  - coping with different styles of handwriting
- Used in PDAs, and tablet computers ...
  ... leave the keyboard on the desk!

Speech Recognition

- Most successful when:
  - single user – initial training and learns peculiarities
  - limited vocabulary systems
- Problems with
  - external noise interfering
  - imprecision of pronunciation
  - large vocabularies
  - different speakers
- Recognition rate of 97% means...
  - A letter in error in every 30 letters.
  - A spelling mistake every six or so words.
- Imagine everybody in an office is talking
  - Noisy environment makes speech recognition even harder.
  - Unsuitable when privacy and confidentiality are important.

Numeric Keypads

- for entering numbers quickly:
  - calculator, PC keyboard
- for telephones
  - not the same!!
  - ATM like phone
Positioning, Pointing and Drawing

- mouse, touchpad
- trackballs, joysticks etc.
- touch screens, tablets
- eyegaze, cursors

Mouse

- First introduced by Douglas C. Engelbart in 1964
- Handheld pointing device
  - very common
  - easy to use
- Two characteristics
  - planar movement
  - buttons
    (usually from 1 to 3 buttons on top, used for making a selection, indicating an option, or to initiate drawing etc.)

Mouse

- Mouse located on desktop
  - requires physical space
  - no arm fatigue

- Relative movement only is detectable.
  - Movement of mouse (i.e., displacement, not an absolute position) moves screen cursor
  - Screen cursor oriented in (x, y) plane, mouse movement in (x, z) plane ... (A mental transformation is required)
- ... an indirect manipulation device.
  - device itself doesn't obscure screen, is accurate and fast.
  - hand-eye coordination problems for novice users

How does it work?

Two methods for detecting motion

- Mechanical
  - Ball on underside of mouse turns as mouse is moved
  - Rotates orthogonal potentiometers
  - Can be used on almost any flat surface

- Optical
  - light emitting diode on underside of mouse
  - may use special grid-like pad or just on desk
  - less susceptible to dust and dirt
  - detects fluctuating alterations in reflected light intensity to calculate relative motion in (x, z) plane
Even by Foot ...

- Some experiments with the *footmouse*
  - controlling mouse movement with feet ...
  - not very common
- But foot controls are common elsewhere:
  - car pedals
  - sewing machine speed control
  - organ and piano pedals

Touchpad

- small touch sensitive tablets
- 'stroke' to move mouse pointer
- used mainly in laptop computers
- good 'acceleration' settings important
  - fast stroke
    - lots of pixels per inch moved
    - initial movement to the target
  - slow stroke
    - less pixels per inch
    - for accurate positioning

Trackball and thumbwheels

- Trackball
  - ball is rotated inside static housing
  - like an upside down mouse!
  - relative motion moves cursor
  - indirect device, fairly accurate
  - separate buttons for picking
  - very fast for gaming
  - used in some portable and notebook computers
- Thumbwheels ...
  - for accurate CAD – two dials for X-Y cursor position
  - for fast scrolling – single dial on mouse

Joystick and Keyboard Nipple

- Joystick
  - indirect
  - pressure of stick = *velocity* of movement
  - buttons for selection
    - on top or on front like a trigger
  - often used for computer games
    - aircraft controls and 3D navigation
- Keyboard nipple
  - for laptop computers
  - miniature joystick in the middle of the keyboard
Touch-Sensitive Screen

- Detect the presence of finger or stylus on the screen.
  - works by interrupting matrix of light beams, capacitance changes or ultrasonic reflections
  - direct pointing device
- Advantages:
  - fast, and requires no specialised pointer
  - good for menu selection
  - suitable for use in hostile environment: clean and safe from damage.
- Disadvantages:
  - finger can mark screen
  - imprecise (finger is a fairly blunt instrument!)
    - difficult to select small regions or perform accurate drawing
  - lifting arm can be tiring

Stylus and Light Pen

- Stylus
  - small pen-like pointer to draw directly on screen
  - may use touch sensitive surface or magnetic detection
  - used in PDA, tablets PCs and drawing tables
- Light Pen
  - now rarely used
  - uses light from screen to detect location
- BOTH ...
  - very direct and obvious to use
  - but can obscure screen

Digitizing tablet

- Mouse like-device with cross hairs
- used on special surface
  - rather like stylus
- very accurate
  - used for digitizing maps

Eyegaze

- Control interface by eye gaze direction
  - e.g. look at a menu item to select it
- Many different technologies
  - Uses laser beam reflected off retina .. A very low power laser
  - OEG
  - Machine vision
- Often used for evaluation
- Potential for hands-free control
  - When do you need hands-free control?
- High accuracy requires headset
- Cheaper and lower accuracy devices available
  - sit under the screen like a small webcam
Cursor Keys

- Four keys (up, down, left, right) on keyboard.
- Very, very cheap, but slow.
- Useful for not much more than basic motion for text-editing tasks.
- No standardised layout, but inverted “T”, most common

Discrete Positioning Controls

- In phones, TV controls etc.
  - cursor pads or mini-joysticks
  - discrete left-right, up-down
  - mainly for menu selection

- Many, many keys...
  - What are the advantages?
  - And disadvantages?

Displays

- bitmap screens (CRT & LCD)
- large & situated displays
- digital paper

Bitmap Displays

- Screen is vast number of coloured dots
Resolution and Color Depth

- Resolution ... used (inconsistently) for
  - number of pixels on screen (width x height)
    - e.g. SVGA 1024 x 768, PDA perhaps 240x400
  - density of pixels (in pixels or dots per inch - dpi)
    - typically between 72 and 96 dpi

- Aspect ratio
  - ration between width and height
  - 4:3 for most screens, 16:9 for wide-screen TV

- Colour depth:
  - how many different colours for each pixel?
    - black/white or greys only
    - 256 from a pallete
    - 8 bits each for red/green/blue = millions of colours

Anti-Aliasing

- Jaggies
  - diagonal lines that have discontinuities in due to horizontal raster scan process.

- Anti-aliasing
  - softens edges by using shades of line colour
  - also used for text

Cathode Ray Tube (CRT)

- Stream of electrons emitted from electron gun, focused and directed by magnetic fields, hit phosphor-coated screen which glows
- Used in TVs and computer monitors

Health Hazards of CRT!

- X-rays: largely absorbed by screen (but not at rear!)
- UV- and IR-radiation from phosphors: insignificant levels
- Radio frequency emissions, plus ultrasound (~16kHz)
- Electrostatic field leaks out through tube to user.
  - Intensity dependant on distance and humidity. Can cause rashes.
- Electromagnetic fields (50Hz-0.5MHz).
  - Create induction currents in conductive materials, including the human body. Two types of effects attributed to this: visual system - high incidence of cataracts in VDU operators, and concern over reproductive disorders (miscarriages and birth defects).
Health Hints ...

- Do not sit too close to the screen
- Do not use very small fonts
- Do not look at the screen for long periods without a break
- Do not place the screen directly in front of a bright window
- Work in well-lit surroundings

* Take extra care if pregnant, but also posture, ergonomics, stress

Liquid Crystal Displays (LCD)

- Smaller, lighter, and ... no radiation problems.
- Found on PDAs, portables and notebooks, ... and increasingly on desktop and even for home TV
- Also used in dedicated displays: digital watches, mobile phones, HiFi controls
- How it works ...
  - Top plate transparent and polarised, bottom plate reflecting.
  - Light passes through top plate and crystal, and reflects back to eye.
  - Voltage applied to crystal changes polarisation and hence colour.
  - N.B. light reflected not emitted => less eye strain

Liquid Crystal Display

- Liquid crystal
  - Long polymer molecules in an orderly arrangement, but not as orderly as a crystal
  - A molecule has a polarity so that it can align to an electric field.

Special Displays

- Random Scan (Directed-beam refresh, vector display)
  - Draw the lines to be displayed directly
  - No jaggies
  - Lines need to be constantly redrawn
  - Rarely used except in special instruments

- Direct view storage tube (DVST)
  - Similar to random scan but persistent => no flicker
  - Can be incrementally updated but not selectively erased
  - Used in analogue storage oscilloscopes
Large Displays
- Used for meetings, lectures, etc.
- Technology
  - Plasma – usually wide screen
  - Video walls – lots of small screens together
  - Projected – RGB lights or LCD projector
    - hand/body obscures screen
    - may be solved by 2 projectors + clever software
  - Back-projected projector
    - frosted glass + projector behind

Situated Displays
- Displays in ‘public’ places
  - large or small
  - very public or for small group
- Display only for information relevant to location
- or interactive
  - use stylus, touch sensitive screen
- in all cases ... *the location matters*
  - meaning of information or interaction is related to the location
  - Display on my office door
    - If it say “available”, what does this mean?
    - If it has a space for writing, what is it for?

Hermes a Situated Display
- Small displays beside office doors
  - handwritten notes left using stylus
  - office owner reads notes using web interface

Digital Paper
- What?
  - thin flexible sheets
  - updated electronically
  - but retain display
- How?
  - small spheres turned
  - or channels with coloured liquid and contrasting spheres
  - rapidly developing area
Virtual Reality and 3D Interaction
positioning in 3D space
moving and grasping
seeing 3D (helmets and caves)

Positioning in 3D space

- Cockpit and virtual controls
  - steering wheels, knobs and dials ... just like real!
- 3D mouse
  - six-degrees of movement: x, y, z + roll, pitch, yaw
- Data glove
  - fibre optics used to detect finger position
- VR helmets
  - detect head motion and possibly eye gaze
- Whole body tracking
  - accelerometers strapped to limbs or reflective dots and video processing

Yaw, Pitch and Roll

yaw
pitch
roll
3D Displays

- Desktop VR
  - ordinary screen, mouse or keyboard control
  - perspective and motion give 3D effect
- Seeing in 3D
  - use stereoscopic vision
  - VR helmets
  - screen plus shuttered specs, etc.

VR headsets

- Small TV screen for each eye
- Slightly different angles
- 3D effect

Simulators and VR Caves

- scenes projected on walls
- realistic environment
- hydraulic rams!
- real controls
- other people

VR Motion Sickness

- Time delay
  - move head ... lag ... display moves
  - conflict: head movement vs. eyes
- Depth perception
  - headset gives different stereo distance
  - but all focused in same plane
  - conflict: eye angle vs. focus
- Conflicting cues => sickness
  - helps motivate improvements in technology
Physical Controls, Sensors etc.
special displays and gauges
sound, touch, feel, smell
physical controls
environmental and bio-sensing

Dedicated Displays
- Analogue representations:
  - dials, gauges, lights, etc.
- Digital displays:
  - small LCD screens, LED lights, etc.
- Head-up displays
  - found in aircraft cockpits
  - show most important controls
    ... depending on context

Sounds
- beeps, bongs, clonks, whistles and whirrs
- used for error indications
- confirmation of actions e.g. keyclick

Touch, feel, smell
- Touch and feeling important
  - in games ... vibration, force feedback
  - in simulation ... feel of surgical instruments
    - called haptic devices
- Texture, smell, taste
  - current technology very limited
**BMW iDrive**
- For controlling menus
- Feel small ‘bumps’ for each item
- Makes it easier to select options by feel
- Uses haptic technology from Immersion Corp.

**Physical Controls**
- Specialist controls needed ...
  - industrial controls, consumer products, etc.

**Environment and Physiological Sensing**
- Sensors all around us
  - car courtesy light – small switch on door
  - ultrasound detectors – security, washbasins
  - RFID security tags in shops
  - temperature, weight, location
- ... and even our own bodies ...
  - iris scanners, body temperature, heart rate, galvanic skin response, blink rate

**Paper: Printing and Scanning**
print technology
- fonts, page description, WYSIWYG
- scanning, OCR
Printing

- Image made from small dots
  - allows any character set or graphic to be printed,
- Critical features:
  - resolution
    - size and spacing of the dots
    - measured in dots per inch (dpi)
  - speed
    - usually measured in pages per minute
  - cost!!

Types of Dot-based Printers

- Dot-matrix printers
  - use inked ribbon (like a typewriter)
  - line of pins that can strike the ribbon, dotting the paper.
  - typical resolution 80-120 dpi
- Ink-jet and Bubble-jet printers
  - tiny blobs of ink sent from print head to paper
  - typically 300 dpi or better.
- Laser printer
  - like photocopier: dots of electrostatic charge deposited on drum, which picks up toner (black powder form of ink) rolled onto paper which is then fixed with heat
  - typically 600 dpi or better.

Printing in the workplace

- Shop tills
  - dot matrix
  - same print head used for several paper rolls
  - may also print cheques
- Thermal printers
  - special heat-sensitive paper
  - paper heated by pins makes a dot
  - poor quality, but simple & low maintenance
  - used in some fax machines

Fonts

- Font – the particular style of text
  - Courier font
  - Helvetica font
  - Palatino font
  - Times Roman font
  - §£≈ŒŒ·~ (special symbol)
- Size of a font measured in points (1 pt about 1/72") (vaguely) related to its height
  - This is ten point Helvetica
  - This is twelve point
  - This is fourteen point
  - and this is twenty-four point
Fonts

- **Pitch**
  - fixed-pitch – every character has the same width
    - e.g. Courier
  - variable-pitched – some characters wider
    - e.g. Times Roman – compare the ‘i’ and the “m”

- **Serif or Sans-serif**
  - sans-serif – square-ended strokes
    - e.g. Helvetica
  - serif – with splayed ends (such as)
    - e.g. Times Roman or Palatino

Readability of Text

- **lowercase**
  - easy to read shape of words

- **UPPERCASE**
  - better for individual letters and non-words
    - e.g. flight numbers: BA793 vs. ba793

- **Serif fonts**
  - helps your eye on long lines of printed text
  - but sans serif often better on screen

Page Description Languages

- Pages very complex
  - different fonts, bitmaps, lines, digitised photos, etc.
- Can convert it all into a bitmap and send to the printer
  - ... but often huge!
- Alternatively Use a page description language
  - sends a *description* of the page can be sent,
    - instructions for curves, lines, text in different styles, etc.
  - like a programming language for printing!
- PostScript is the most common

PostScript Example

- %!
- %% Draws a one square inch box and inch in from the bottom left
- /inch {72 mul} def % Convert inches->points (1/72 inch)
- newpath % Start a new path
- 1 inch 1 inch moveto % an inch in from the lower left
- 2 inch 1 inch lineto % bottom side
- 2 inch 2 inch lineto % right side
- 1 inch 2 inch lineto % top side
- closepath % Automatically add left side to close path
- stroke % Draw the box on the paper
- showpage % We’re done... eject the page
Screen and Page

- WYSIWYG
  - What You See Is What You Get
  - aim of word processing, etc.

- but ...
  - screen: 72 dpi, landscape image
  - print: 600+ dpi, portrait

- Can try to make them similar
  - but never quite the same

- So ... need different designs, graphics etc, for screen and print

Scanners

- Take paper and convert it into a bitmap

- Two sorts of scanner
  - flat-bed: paper placed on a glass plate, whole page converted into bitmap
  - hand-held: scanner passed over paper, digitising strip typically 3-4" wide

- Shines light at paper and note intensity of reflection
  - colour or greyscale

- Typical resolutions from 600–2400 dpi

Scanners

- Used in
  - desktop publishing for incorporating photographs and other images
  - document storage and retrieval systems, doing away with paper storage
  - special scanners for slides and photographic negatives

Optical Character Recognition (OCR)

- OCR converts bitmap back into text

- Different fonts
  - create problems for simple “template matching” algorithms
  - more complex systems segment text, decompose it into lines and arcs, and decipher characters that way

- Page format
  - columns, pictures, headers and footers
**Paper-based interaction**

- Paper usually regarded as output only
- Can be input too – OCR, scanning, etc.
- Xerox PaperWorks
  - Glyphs – small patterns of /\//\//
    - Used to identify forms etc.
    - Used with scanner and fax to control applications
- More recently
  - Papers micro printed - like watermarks
    - Identify which sheet and where you are
  - Special ‘pen’ can read locations
    - Know where they are writing

**Memory**
short term and long term
speed, capacity, compression
formats, access

**Short-Term Memory - RAM**

- Random access memory (RAM)
  - On silicon chips
  - 100 nano-second access time
  - Usually volatile (lose information if power turned off)
  - Data transferred at around 100 Mbytes/sec
- Some non-volatile RAM used to store basic set-up information
- Typical desktop computers (in 2018):
  - 4 GB RAM on most not-too-old desktops
  - 8~16 GB RAM for gaming computers

**Long-Term Memory - Disks**

- Magnetic disks
  - Floppy disks store around 1.4 Mbytes
  - Hard disk drive (in 2018) typically 2 TB on most not-too-old desktops
    - Typically it spins at 5,400 to 15,000 RPM
    - Most hard drives operate on high speed interfaces using serial ATA (SATA) or serial attached technology
    - With the advent of solid-state drives (SSDs) (transfer rate is 5~10 times faster than HDD), magnetic disks are no longer considered the only option, but are still commonly used.
- Optical disks
  - Use lasers to read and sometimes write
  - More robust than magnetic media
  - CD-ROM
    - Same technology as home audio, ~ 600 Gbytes
  - DVD - for AV applications, or very large files
  - Blu-Ray
Blurring Boundaries

- PDAs
  - often use RAM for their main memory
- Flash-Memory
  - used in PDAs, cameras etc.
  - silicon based but persistent
  - plug-in USB devices for data transfer

Speed and Capacity

- What do the numbers mean?
- Some sizes (all uncompressed) ...
  - this book, text only ~ 320,000 words, 2Mb
  - the Bible ~ 4.5 Mbytes
  - scanned page ~ 128 Mbytes
    - (11x8 inches, 1200 dpi, 8bit greyscale)
  - digital photo ~ 10 Mbytes
    - (2–4 mega pixels, 24 bit colour)
  - video ~ 10 Mbytes per second
    - (512x512, 12 bit colour, 25 frames per sec)

Virtual Memory

- Problem:
  - running lots of programs + each program large
  - not enough RAM
- Solution - Virtual memory :
  - store some programs temporarily on disk
  - makes RAM appear bigger
- But ... swapping
  - program on disk needs to run again
  - copied from disk to RAM
  - slows things down

Compression

- Reduce amount of storage required
- Techniques
  - Run-length encoding
  - Huffman encoding
  - Predictive encoding
  - Perceptual encoding, ...
- Data is not always serial!
  - 1-D: Text, audio, ...
  - 2-D: Still image
  - 3-D: Motion picture
  - Difference methods for different dimensional data
Compression

- **Lossless**
  - recover exact text or image – e.g. GIF, ZIP
  - look for commonalities:
    - text: AAAAAAAAAABBBBBCCCCCCCC → 10A5B8C
    - video: compare successive frames and store change

- **Lossy**
  - recover something like original – e.g. JPEG, MP3
  - exploit perception
    - JPEG: lose rapid changes and some colour
    - MP3: reduce accuracy of drowned out notes

Storage Formats - Text

- **Character formats**
  - ASCII - 7-bit binary code for each letter and character
  - Unicode - 8-bit encoding of 16 bit character set

- **Document formats**
  - Rich Text Format (RTF) text plus formatting and layout information
  - Standard Generalized Markup Language (SGML) documents regarded as structured objects
  - Extended Markup Language (XML) simpler version of SGML for web applications

Storage Formats - Media

- **Images**
  - many storage formats:
    - (PostScript, GIF, JPEG, TIFF, PICT, BMP, RGB, etc.)
  - plus different compression techniques
    - to reduce their storage requirements

- **Audio/Video**
  - again lots of formats:
    - (QuickTime, MPEG, WAV, etc.)
  - compression even more important
  - also ‘streaming’ formats for network delivery

Methods of Access

- **Large information store**
  - long time to search => use index
  - what you index => what you can access

- **Simple index needs exact match**

- **Forgiving systems:**
  - Xerox "do what I mean" (DWIM)
  - SOUNDEX – McCloud ~ MacLeod

- **Access without structure ...**
  - free text indexing (all the words in a document)
  - needs lots of space!!
Processing and Networks
finite speed (but also Moore’s law)
limits of interaction
networked computing

Finite Processing Speed
- Designers tend to assume fast processors, and make interfaces more and more complicated
- But problems occur, because processing cannot keep up with all the tasks it needs to do
  - cursor overshooting because system has buffered keypresses
  - icon wars - user clicks on icon, nothing happens, clicks on another, then system responds and windows fly everywhere
- Also problems if system is too fast - e.g. help screens may scroll through text much too rapidly to be read

Moore’s law
- Computers get faster and faster!
- 1965 ...
  - Gordon Moore, co-founder of Intel, noticed a pattern
  - processor speed doubles every 18 months
  - PC ... 1987: 1.5 Mhz, 2002: 1.5 GHz
- Similar pattern for memory
  - but doubles every 12 months!!
  - hard disk ... 1991: 20Mbyte : 2002: 30 Gbyte
- Baby born today
  - record all sound and vision
  - by 70 all life's memories stored in a grain of dust!

The Myth of the Infinitely Fast Machine
- Implicit assumption ... no delays an infinitely fast machine
- What is good design for real machines?
- Good example ... the telephone :
  - type keys too fast
  - hear tones as numbers sent down the line
  - actually an accident of implementation
  - emulate in design

/e3/online/moores-law/
If processor is slower than is expected...

- Functional faults - Ex: Drawing a line with a mouse
  - Program detects depressing of a button, and then reads the current cursor position
  - If there is a time delay between the detection of button depression and reading of cursor position, a line will not begin at the point of button click.
  - The result does not conform to the user intention → functional faults

- Delayed feedback - Ex: Cursor tracking, icon wars, ..
  - Sometimes, a program is too busy to respond to inputs.
  - Nevertheless, the input module can receive input messages and stores them in a queue.
  - A program, now free from a busy task, starts to handle the input messages.
  - A user, without a prompt feedback, can issue the same command repeatedly, will receive an unexpected burst of delayed responses.

If processor is faster than is expected...

- Flashing feedback
  - A user need time to perceive appearing, moving, and disappearing of GUI objects
  - Ex: Game programs relying on a delay loop for timing
  - Run an old Tetris program on your PC. A shower of blocks even in level 0.
  - Ex: A new browser window of the same size and position as an existing browser window
  - It is hard to tell if the current window is showing a new page or a new browser window was created for the new page.

- One should not assume about the speed of a processor.
  - Sometimes, an intentional delay is useful in order to allow a user to be prepared and have time to perceive changes.
  - Animation is one of the most common and effective ways to provide a proper feedback to a user.

Limitations on Interactive Performance

- Computation bound
  - Computation takes ages, causing frustration for the user

- Storage channel bound
  - Bottleneck in transference of data from disk to memory

- Graphics bound
  - Common bottleneck: updating displays requires a lot of effort - sometimes helped by adding a graphics co-processor optimised to take on the burden

- Network capacity
  - Many computers networked - shared resources and files, access to printers etc. - but interactive performance can be reduced by slow network speed

- All these bounds are not a serious problem for a modern PC. However, remember there are other kinds of computers, e.g., PDAs and phones.

Networked Computing

- Networks allow access to ...
  - large memory and processing
  - other people (groupware, email)
  - shared resources – esp. the web

- Networked computing means...
  - Computing resources are distributed.
  - Many users can access the same resource at the same time.
  - Channels between computing resources are not homogeneous and reliable.
  - Ideals of consistency, informative feedback and predictable response are violated.

- Issues
  - network delays – slow feedback
  - conflicts - many people update data
  - unpredictability
Internet

- History ...
  - 1969: DARPANET US DoD, 4 sites

- Common language (protocols):
  - TCP – Transmission Control Protocol
    - lower level, packets (like letters) between machines
  - IP – Internet Protocol
    - reliable channel (like phone call) between programs on machines
  - email, HTTP, all build on top of these

Reference

- Dix, Finlay, Abowd & Beale, Human-Computer Interaction (Ch2)
- http://www.hcibook.com/e3-docs/slides/ppt/e3-chap-02.ppt