HUMAN-COMPUTER INTERACTION

Lecture 2
The Computer

SK Alamgir Hossain

The Computer

A computer system is made up of various elements, each of these elements affects the interaction

- **input devices** – text entry and pointing
- **output devices** – screen (small&large), digital paper
- **virtual reality** – special interaction and display devices
- **physical interaction** – e.g. sound, haptic, bio-sensing
- **paper** – as output (print) and input (scan)
- **memory** – RAM & permanent media, capacity & access
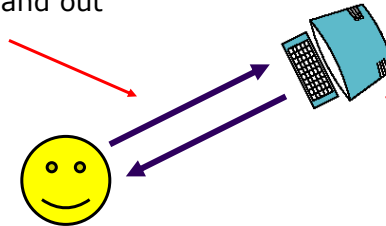- **processing** – speed of processing, networks

http://www.alamgirhossain.com/cse5503
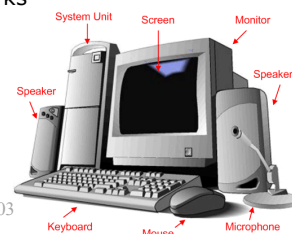
Interacting with computers

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

http://www.alamgirhossain.com/cse5503

How many computers …

1960s: Mainframe Era
One computer per many users.

1980s: Personal Computer Era
One computer per user.

2000s: Mobility Era
Several computers per user.

2020 and beyond: Ubiquity Era
Thousands of computers per user.

http://www.alamgirhossain.com/cse5503
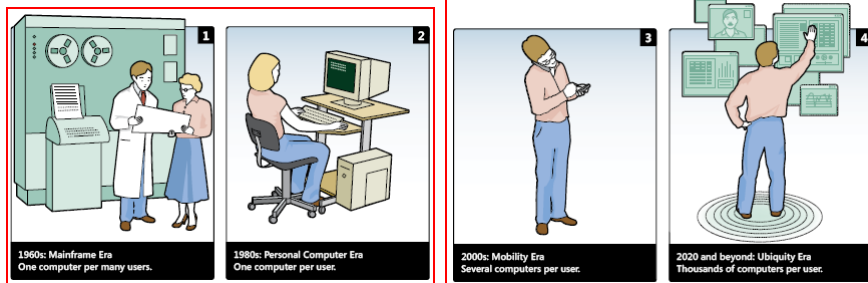
How many computers …

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

http://www.alamgirhossain.com/cse5503

Interactivity?

Long ago in a galaxy far away … *batch* processing
- 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?

http://www.alamgirhossain.com/cse5503

Text Entry Devices

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

http://www.alamgirhossain.com/cse5503

Keyboards

- Most common text input device
- Allows rapid entry of text by experienced users

- Keypress closes connection, causing a character code to be sent
- Usually connected by cable, but can be wireless

http://www.alamgirhossain.com/cse5503

layout – QWERTY

QWERTY KEYBOARD

- Standardised layout
  but …
  - non-alphanumeric keys are placed differently
  - accented symbols needed for different scripts
  - minor differences between UK and USA keyboards

- QWERTY arrangement not optimal for typing
  - layout to prevent typewriters jamming!
- Alternative designs allow faster typing but large social base of QWERTY typists produces reluctance to change.

http://www.alamgirhossain.com/cse5503

Alternative keyboard layouts

Alphabetic
  - keys arranged in alphabetic order
  - not faster for trained typists
 - not faster for beginners either!

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

http://www.alamgirhossain.com/cse5503

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
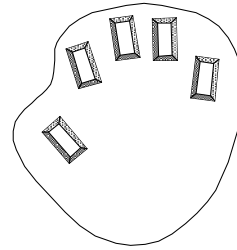
BUT - social resistance, plus fatigue after extended use
NEW – niche market for some wearables

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
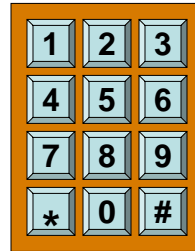   – hello = 43556 …
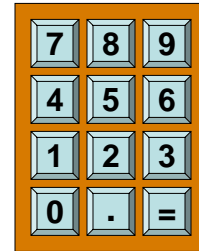   – but 26 -> menu 'am' or 'an'

Numeric keypads

- for entering numbers quickly:
  - calculator, PC keyboard
- for telephones

not the same!!

ATM like phone

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

telephone

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

calculator

Positioning, pointing and drawing

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

The Mouse

- 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.)

http://www.alamgirhossain.com/cse5503

# the mouse (ctd)

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

Relative movement only is detectable.
Movement of mouse moves screen cursor
Screen cursor oriented in (x, y) plane,
  mouse movement in (x, z) plane …

… an *indirect* manipulation device.
  - device itself doesn't obscure screen, is accurate and fast.
  - hand-eye coordination problems for novice users

http://www.alamgirhossain.com/cse5503
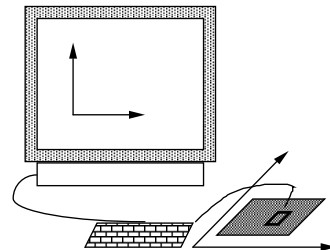
How does it work?

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

http://www.alamgirhossain.com/cse5503

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

http://www.alamgirhossain.com/cse5503

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

http://www.alamgirhossain.com/cse5503

Trackball and thumbwheels

Trackball
- ball is rotated inside static housing
  - like an upsdie 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

http://www.alamgirhossain.com/cse5503

Joystick

Joystick
- indirect
  pressure of stick = <u>velocity</u> of movement
- buttons for selection
  on top or on front like a trigger
- often used for computer games
 aircraft controls and 3D navigation

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
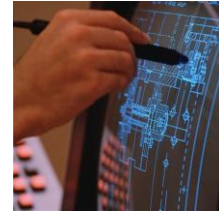
Stylus
- – small pen-like pointer to draw directly on screen
- – may use touch sensitive surface or magnetic detection
- – used in PDA, tablets PCs and drawing tables

Light Pen
- – now rarely used
- – uses light from screen to detect location

BOTH …
- – very direct and obvious to use
- – but can obscure screen

Eyegaze

- control interface by eye gaze direction
  - – e.g. look at a menu item to select it
- uses laser beam reflected off retina
  - – … a very low power laser!
- mainly used for evaluation (ch x)
- potential for hands-free control
- high accuracy requires headset
- cheaper and lower accuracy devices available
      sit under the screen like a small webcam
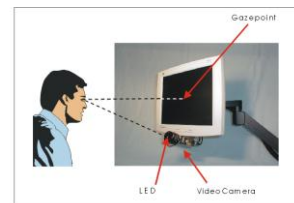
Cursor keys

- 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.
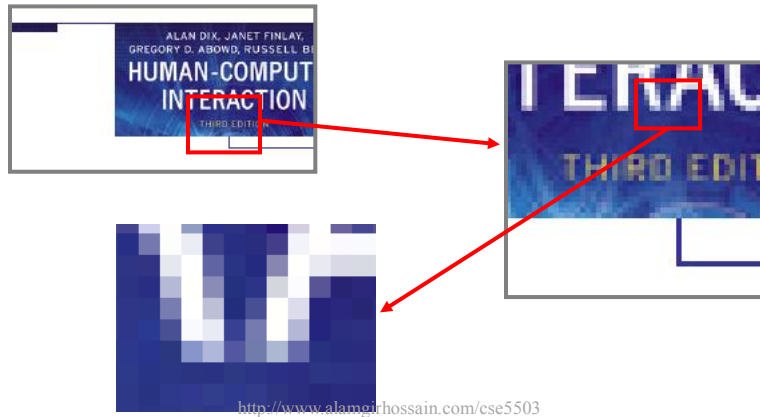- No standardised layout, but inverted "T", most common

http://www.alamgirhossain.com/cse5503
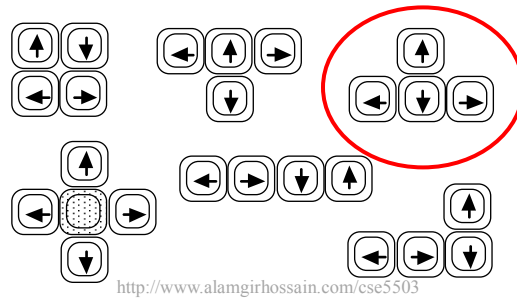
Display devices

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

Bitmap displays

- screen is vast number of coloured dots

Resolution and colour 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

640 x 480 (VGA)
800 x 600 (SVGA)
1024 x 768 (XGA)
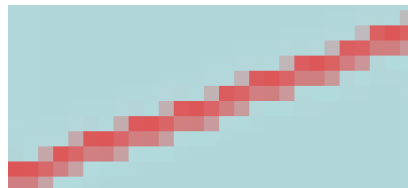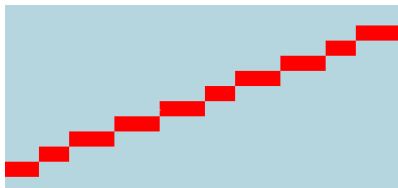1280 x 1024 (SXGA)
1600 x 1200 (UXGA)
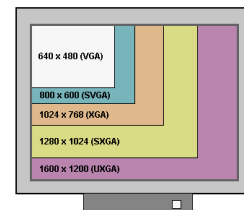
anti-aliasing

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

http://www.alamgirhossain.com/cse5503

Cathode ray tube

- 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

Electron gun (cathode) Electron beam

Metal layer
Insulating layer
Photoelectric material

Image projected through lens onto flat end of tube

Using a cathode ray tube as a television camera

http://www.alamgirhossain.com/cse5503
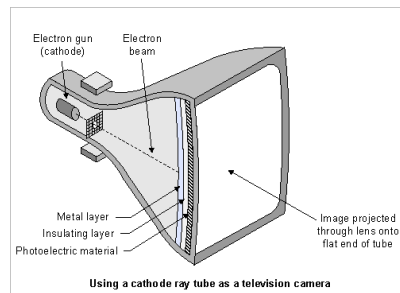
Health hazards of CRT !

- 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).

http://www.alamgirhossain.com/cse5503

Liquid crystal displays

- Smaller, lighter, and … no radiation problems.

- Found on PDAs, portables and notebooks,
      … and increasingly on desktop and even for home TV

- also used in dedicted 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

http://www.alamgirhossain.com/cse5503

16
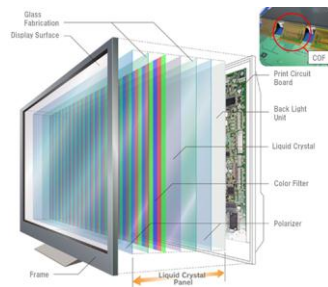
large displays

- 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
  - frosted glass + projector behind

http://www.alamgirhossain.com/cse5503

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

http://www.alamgirhossain.com/cse5503

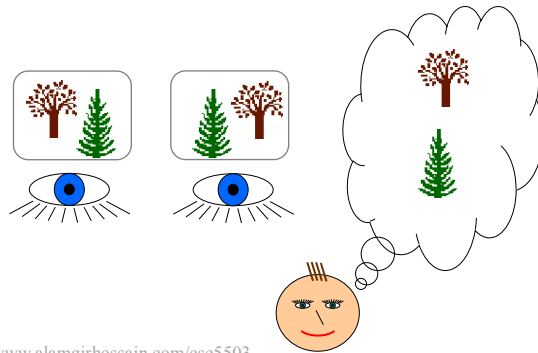# Virtual reality and 3D interaction

---

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

http://www.alamgirhossain.com/cse5503

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

http://www.alamgirhossain.com/cse5503

Simulators and VR caves

- scenes projected on walls
- realistic environment
- real controls
- other people

Physical controls, sensors etc.

special displays and gauges
sound, touch, feel, smell
physical controls
environmental and bio-sensing

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.

http://www.alamgirhossain.com/cse5503

physical controls

- specialist controls needed …
  - industrial controls, consumer products, etc.

easy-clean
smooth buttons

multi-function
control

large buttons

clear dials

tiny buttons

Environment and bio-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

http://www.alamgirhossain.com/cse5503

Paper: printing and scanning

print technology
fonts, page description, WYSIWYG
scanning, OCR

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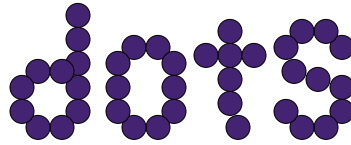
- image made from small dots
  - allows any character set or graphic to be printed,
- critical features:
  - resolution
    - size and spacing of the dots
    - measured in dots per inch (dpi)
  - speed
    - usually measured in pages per minute
  - cost!!

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.

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 (ctd)

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 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
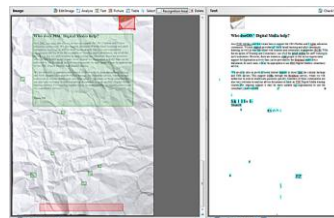
Memory

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:
    64 to 256 Mbytes RAM

http://www.alamgirhossain.com/cse5503

Long-term Memory - disks

- magnetic disks
  - floppy disks store around 1.4 Mbytes
  - hard disks typically 40 Gbytes to 100s of Gbytes
    access time ~10ms, transfer rate 100kbytes/s

- optical disks
  - use lasers to read and sometimes write
  - more robust that magnetic media
  - CD-ROM
    - same technology as home audio, ~ 600 Gbytes
  - DVD - for AV applications, or very large files

Blurring boundaries

- 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 … swopping
  - program on disk needs to run again
  - copied from disk to RAM
  - s l o w s   t h i n g s   d o w n
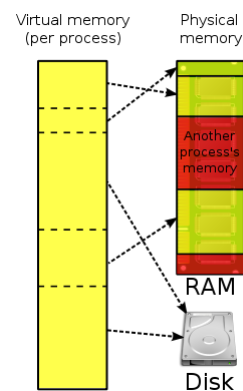
Compression

- reduce amount of storage required
- 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

- ASCII - 7-bit binary code for to each letter and character
- UTF-8 - 8-bit encoding of 16 bit character set
- RTF (rich text format)
  - text plus formatting and layout information
- SGML (standardized generalised markup language)
  - documents regarded as structured objects
- XML (extended markup language)
  - simpler version of SGML for web applications

Storage formats - media

- Images:
  - many storage formats :
    (PostScript, GIFF, JPEG, TIFF, PICT, 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

http://www.alamgirhossain.com/cse5503

Processing and networks

finite speed (but also Moore's law)
limits of interaction

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 deisgn

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

Networked computing

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

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

The internet

- history …
  - 1969: DARPANET US DoD, 4 sites
  - 1971: 23; 1984: 1000; 1989: 10000
- 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

Any Question ??