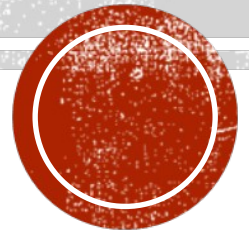
USER INTERFACE DESIGN

HCI FOUNDATION

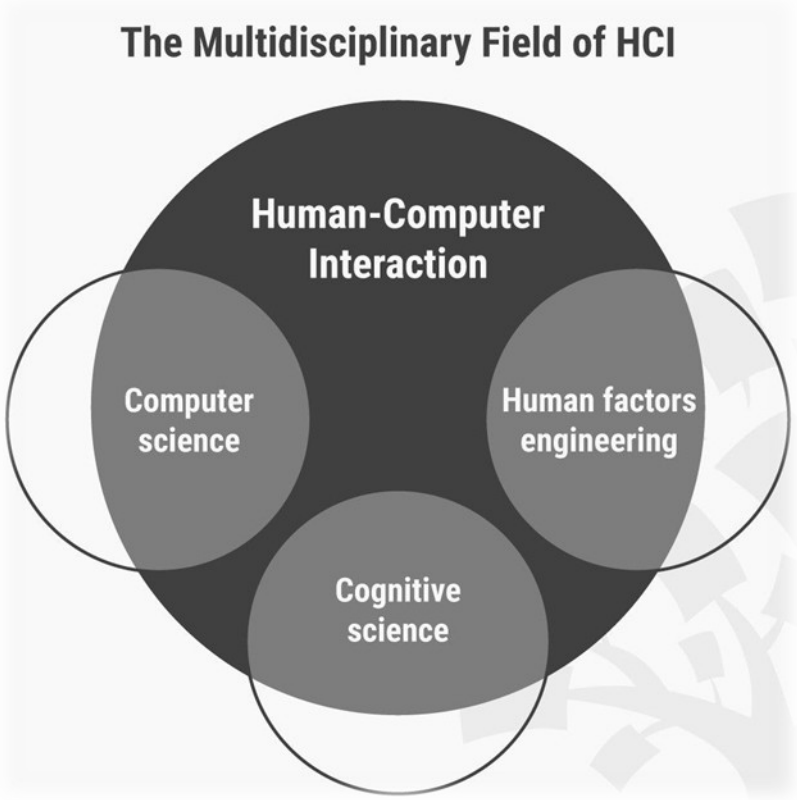


OVERVIEW

- The Human
- The Computer
- The Interaction
- Paradigms for Interaction

HUMAN-COMPUTER INTERACTION

Human-computer interaction (HCI) is a multidisciplinary field of study focusing on the design of computer technology and, in particular, the interaction between humans (the users) and computers.



EXAMPLE

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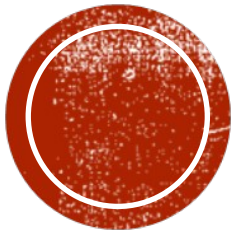

THE HUMAN

THE HUMAN

- **Information i/o …**
  - visual, auditory, haptic, movement
- **Information stored in memory**
  - sensory, short-term, long-term
- **Information processed and applied**
  - reasoning, problem solving, skill, error
- **Emotion influences human capabilities**
- **Each person is different**

INFORMATION I/O

- **Vision**
  - Two stages in vision
    - Physical reception of stimulus
    - Processing and interpretation of stimulus

PHYSICAL RECEPTION OF STIMULUS

- **EYE**
  - Mechanism for receiving light and transforming it into electrical energy
  - Light reflects from objects and images are focused upside-down on retina
  - Ganglion cells (brain!) detect pattern and movement

INTERPRETING THE SIGNAL

- Size and depth
- Brightness
- Colour
- Reading
- Hearing
- Touch
- Movement

INTERPRETING THE SIGNAL

- **Size and depth**
  - visual angle indicates how much of view object occupies
  - visual acuity is ability to perceive detail
  - familiar objects perceived as constant size
  - cues like overlapping help perception of size and depth

INTERPRETING THE SIGNAL

- **Brightness**
  - subjective reaction to levels of light
  - affected by luminance of object
  - measured by just noticeable difference
  - visual acuity increases with luminance as does flicker

INTERPRETING THE SIGNAL

- **Colour**
  - made up of hue, intensity, saturation
  - cones sensitive to colour wavelengths
  - blue acuity is lowest
  - 8% males and 1% females colour blind

INTERPRETING THE SIGNAL

- **Reading**
  - visual pattern perceived
  - decoded using internal representation of language
  - interpreted using knowledge of syntax, semantics, pragmatics
  - Word shape is important to recognition

INTERPRETING THE SIGNAL

- **Hearing**
  - Humans can hear frequencies from 20Hz to 15kHz
  - Sound
    - pitch – sound frequency
    - loudness – amplitude
    - timbre – type or quality
  - Auditory system filters sounds
    - can attend to sounds over background noise.

INTERPRETING THE SIGNAL

- **Touch**
- Provides important feedback about environment.
- May be key sense for someone who is visually impaired.
- Stimulus received via receptors in the skin:
  - thermoreceptors – heat and cold
  - nociceptors – pain
  - mechanoreceptors – pressure

INTERPRETING THE SIGNAL

- **Movement**
  - Time taken to respond to stimulus:
    Reaction time + Movement time
  - Movement time dependent on age, fitness etc.
  - Reaction time - dependent on stimulus type:
    - visual ~ 200ms
    - auditory ~ 150 ms
    - pain ~ 700ms

MEMORY

There are three types of memory function:

Sensory memories

↘ Attention

Short-term memory or working memory

↘ Rehearsal

Long-term memory

Selection of stimuli governed by level of arousal.

SENSORY MEMORY

- Sensory memory is a very brief memory that allows people to retain impressions of sensory information after the original stimulus has ceased.

- It is often thought of as the first stage of memory that involves registering a tremendous amount of information about the environment, but only for a very brief period.

- Examples
  - Stereo sound

SHORT-TERM MEMORY (STM)

- Short-term memory (STM) refers to systems which provide retention of limited amounts of material for a limited time period (seconds).

- Limited capacity - 7± 2 chunks

SHORT-TERM MEMORY (STM)

212348278493202

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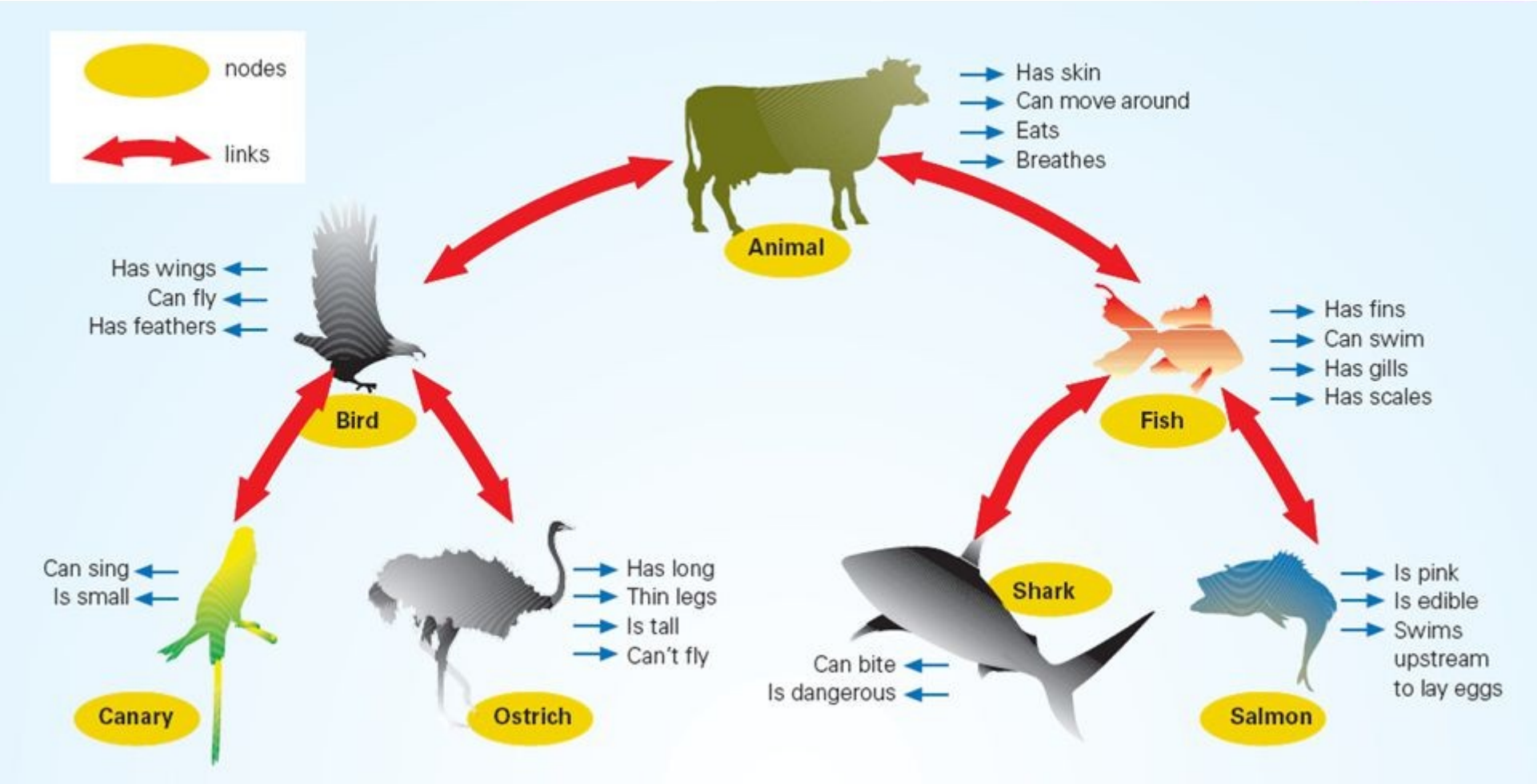
HEC ATR ANU PTH ETR EET

LONG-TERM MEMORY (LTM)

- Repository for all our knowledge
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge or unlimited capacity

- Two types
  - episodic – serial memory of events
  - semantic – structured memory of facts, concepts, skills

LONG-TERM MEMORY (LTM)



THINKING

- Reasoning
  - Deduction,
  - Induction,
  - Abduction
- Problem solving
- Errors and mental models

DEDUCTIVE REASONING

- It is the process of reasoning from one or more statements (premises) to reach a logical conclusion.

- Eg:
  1. Everyone who eats carrots is a quarterback.
  2. John eats carrots.
  3. **Therefore, John is a quarterback.**

- Logical conclusion not necessarily true:

INDUCTIVE REASONING

- Inductive reasoning is a method of reasoning in which the premises are viewed as supplying some evidence, but not full assurance, of the truth of the conclusion.

- Example:
  1. 90% of graduates from Excelsior Preparatory school go on to University.
  2. Bob is a graduate of Excelsior Preparatory school.
  3. Therefore, Bob will go on to University.

- This is a statistical syllogism. Even though one cannot be sure Bob will attend university, we can be fully assured of the exact probability for this outcome.

ABDUCTIVE REASONING

- Reasoning from event to cause

  e.g. Sam drives fast when drunk.

  If I see Sam driving fast, assume drunk.

- Unreliable:
  - can lead to false explanations

PROBLEM SOLVING

- Process of finding solution to unfamiliar task using knowledge.

ERRORS

Types of error

- slips
  - right intention, but failed to do it right
  - causes: poor physical skill,inattention etc.
  - change to aspect of skilled behaviour can cause slip
- mistakes
  - wrong intention
  - cause: incorrect understanding

    humans create mental models to explain behaviour.

    if wrong (different from actual system) errors can occur

EMOTION

- Various theories of how emotion works
  - **James-Lange:** emotion is our interpretation of a physiological response to a stimuli
  - **Cannon:** emotion is a psychological response to a stimuli
  - **Schacter-Singer:** emotion is the result of our evaluation of our physiological responses, in the light of the whole situation we are in
- Emotion clearly involves both cognitive and physical responses to stimuli

EMOTION

- The biological response to physical stimuli is called *affect*

Affect influences how we respond to situations

- positive → creative problem solving
- negative → narrow thinking

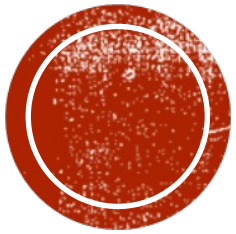
"Negative affect can make it harder to do even easy tasks; positive affect can make it easier to do difficult tasks"

(Donald Norman)

INDIVIDUAL DIFFERENCES

- long term
  - sex, physical and intellectual abilities
- short term
  - effect of stress or fatigue
- changing
  - age

Ask yourself:
will design decision exclude section of user population?



THE COMPUTER

THE COMPUTER

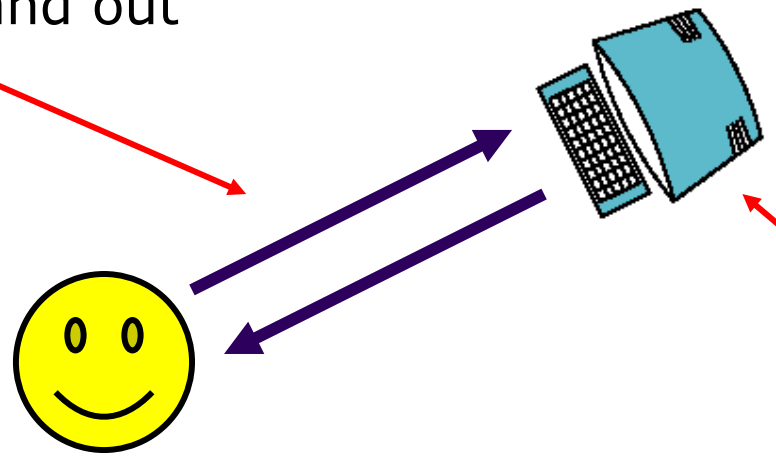
A computer system is made up of various elements each of these elements affects the interaction

- 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

INTERACTING WITH COMPUTERS

to understand human–*computer* interaction
… need to understand computers!

what goes in and out
devices, paper,
sensors, etc.



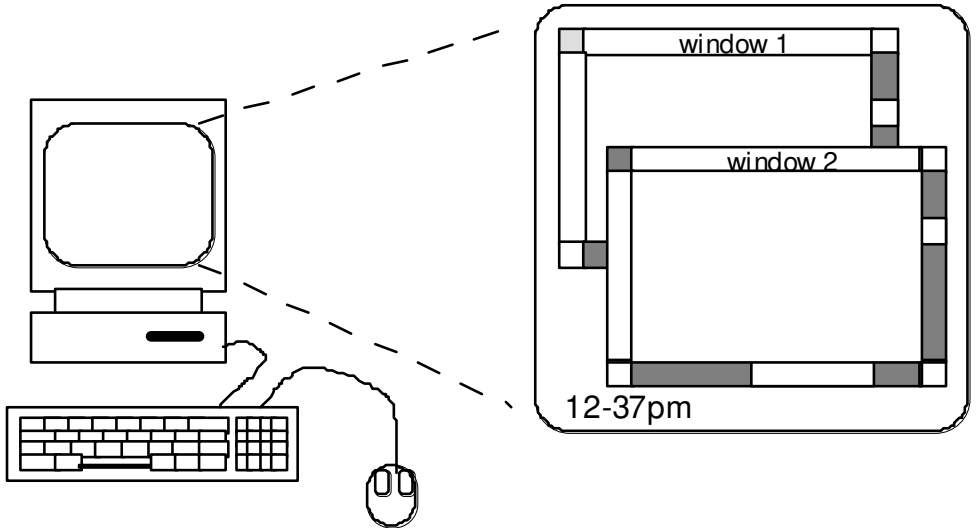
what can it do?
memory, processing,
networks

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 . . .

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?

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

- punched card stacks or large data files prepared
- long wait ….
- line printer output

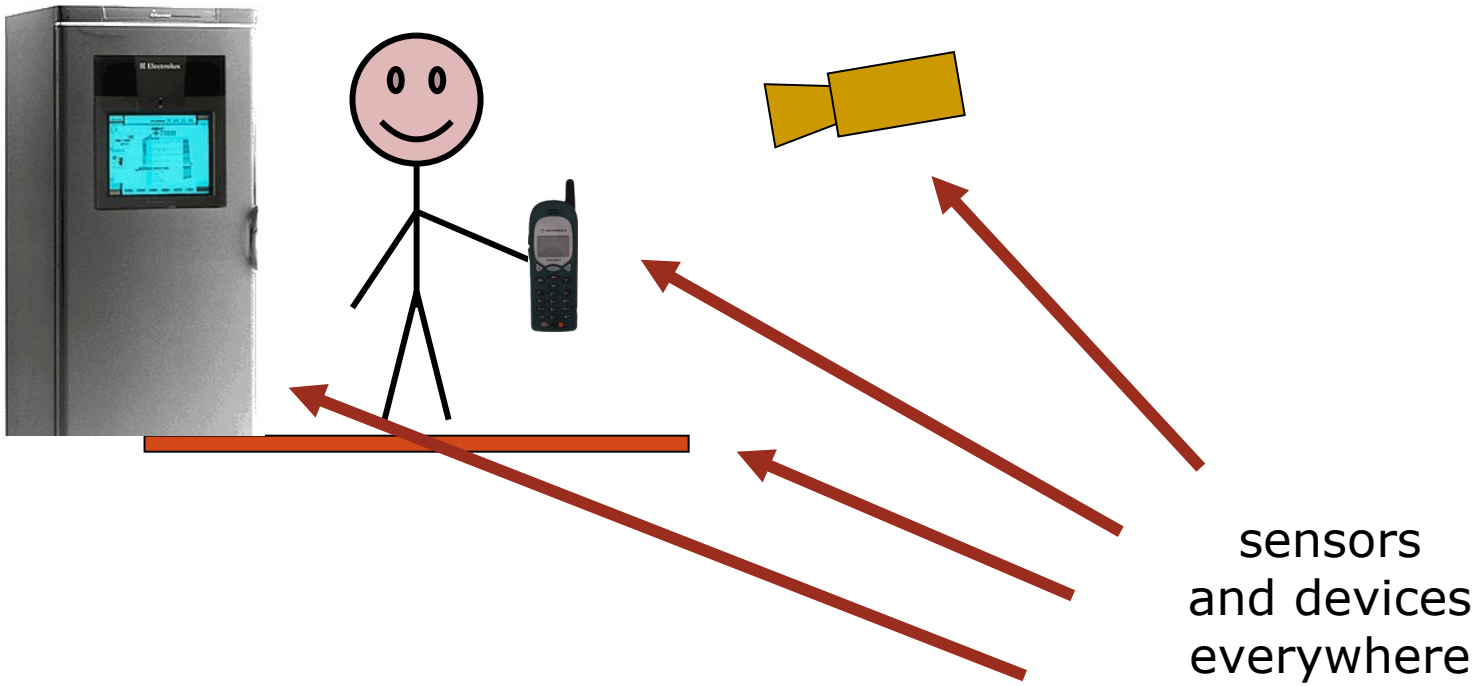
  … and if it is not right …

Now most computing is interactive

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

Is faster always better?

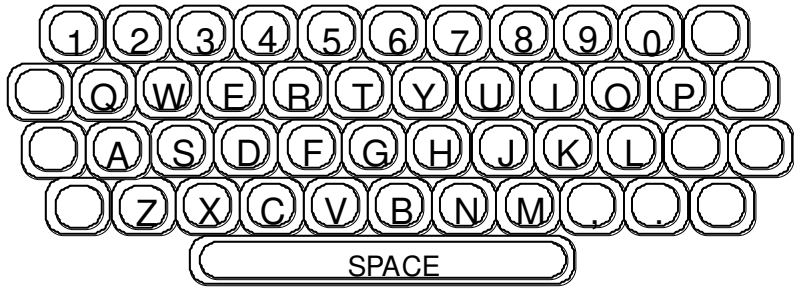
RICHER INTERACTION



TEXT ENTRY DEVICES

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

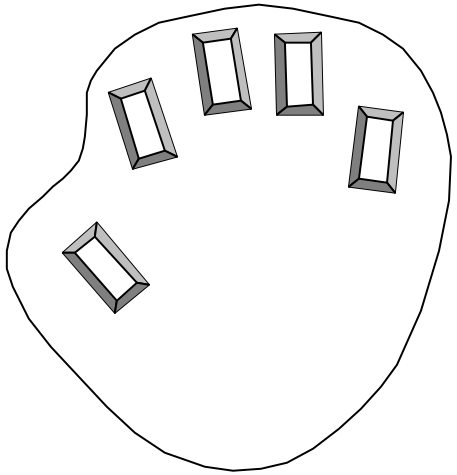
QWERTY KEYBOARD



SPECIAL KEYOARD

TEXT ENTRY DEVICES

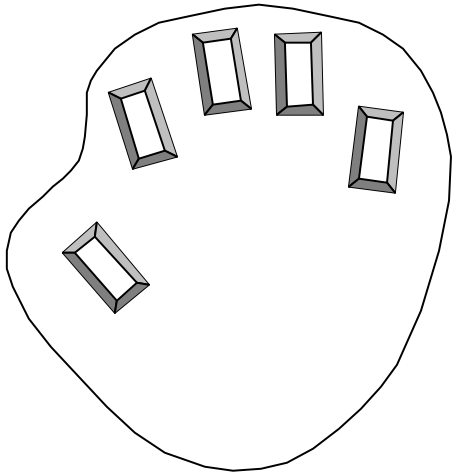
CHORD KEYBOARD



PHONE PAD

TEXT ENTRY DEVICES

CHORD KEYBOARD



PHONE PAD

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

- Improving rapidly
- 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

POSITIONING, POINTING AND DRAWING

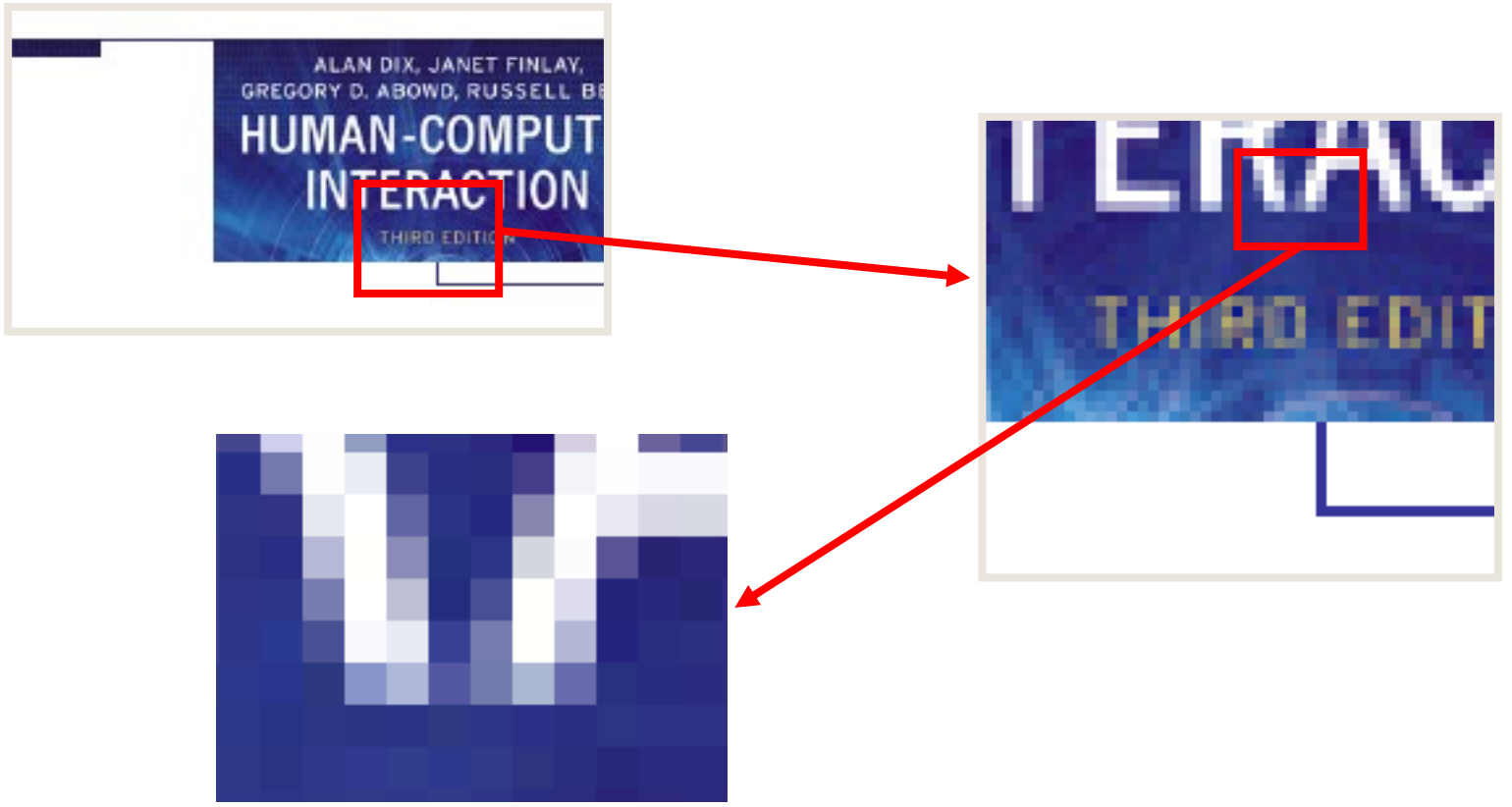
- Mouse,
- Touchpad
- Trackballs,
- Joysticks.
- Touch screens,
- Tablets
- Eyegaze.

DISPLAY DEVICES

- Bitmap screens (CRT & LCD)
- large & situated displays
- Digital paper

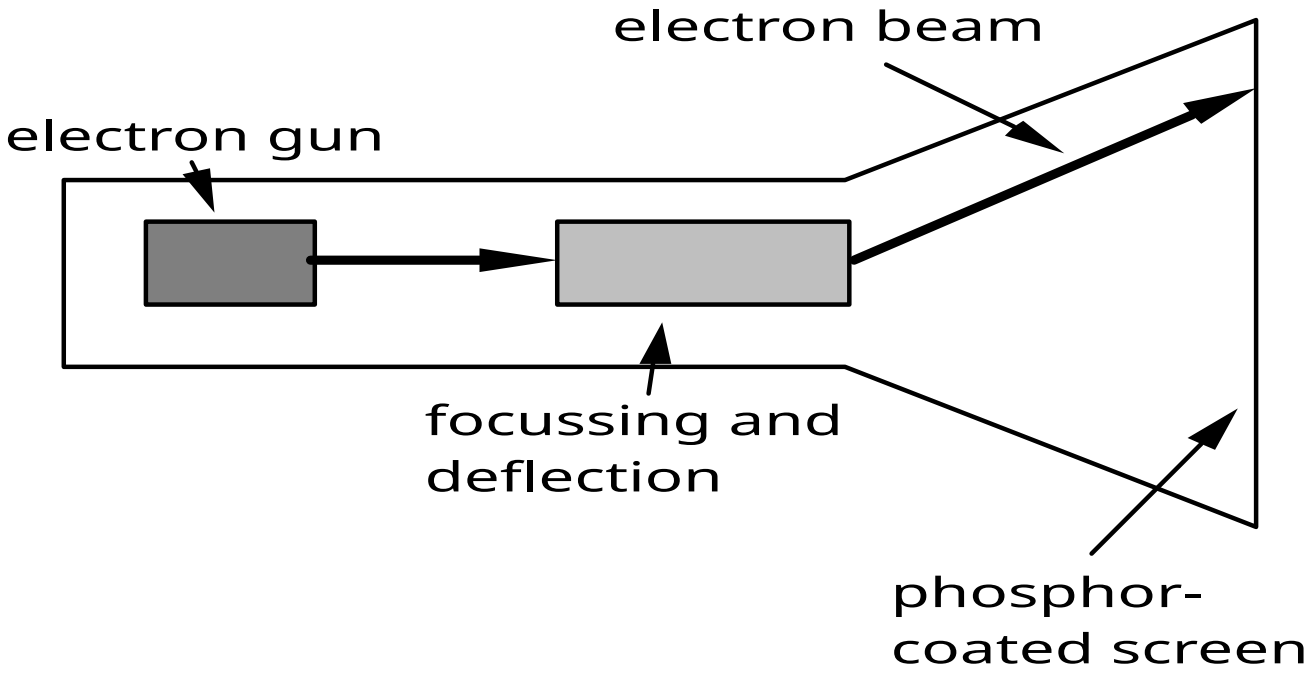
BITMAP DISPLAYS

- screen is vast number of coloured dots



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



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.

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

PHYSICAL CONTROLS, SENSORS ETC.

- Special displays and gauges
- Sound, touch, feel, smell
- Physical controls
- Environmental and bio-sensing

PHYSICAL CONTROLS

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

large buttons

clear dials

tiny buttons

easy-clean
smooth buttons

multi-function
control

ENVIRONMENT AND BIO-SENSING

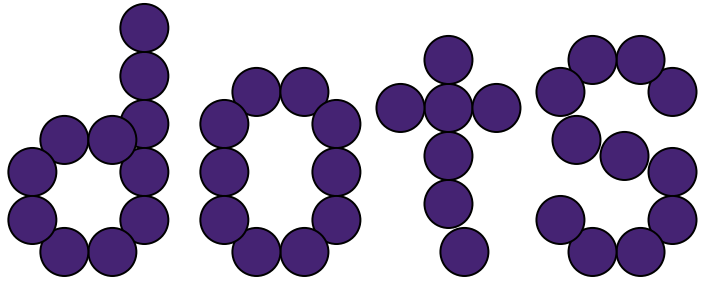
- sensors all around us
  - car courtesy light – small switch on door
  - ultrasound detectors – security, washbasins
  - RFID security tags in shops
  - temperature, weight, location

- … and even our own bodies …
  - iris scanners, body temperature, heart rate, galvanic skin response, blink rate

PAPER: PRINTING AND SCANNING

- Print technology
- Fonts,
- Page description,
- 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.

FONTS

- Font – the particular style of text

Courier font
Helvetica font
Palatino font
Times Roman font
- ♣×∝≡↵ℜ□⊗↵~□ (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
This is eighteen point
and this is twenty-four point

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

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 (RAM)
- Long term (DISC)
- Speed,
- Capacity,
- Compression
- Formats,
- Access

THE INTERACTION

THE INTERACTION

- Interaction models
  - translations between user and system
- Ergonomics
  - physical characteristics of interaction
- Interaction styles
  - the nature of user/system dialog
- Context
  - social, organizational, motivational

WHAT IS INTERACTION?

communication

user  system

MODELS OF INTERACTION

- Terms of interaction
- Norman model
- Interaction framework

SOME TERMS OF INTERACTION

domain – the area of work under study

e.g. graphic design

goal – what you want to achieve

e.g. create a solid red triangle

task – how you go about doing it
– ultimately in terms of operations or actions

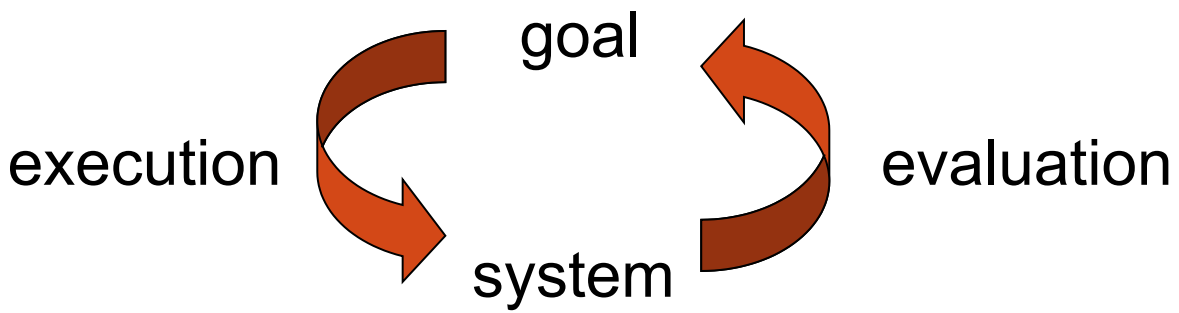
e.g. … select fill tool, click over triangle

DONALD NORMAN'S MODEL

- Seven stages
  - user establishes the goal
  - formulates intention
  - specifies actions at interface
  - executes action
  - perceives system state
  - interprets system state
  - evaluates system state with respect to goal

- Norman's model concentrates on user's view of the interface

EXECUTION/EVALUATION LOOP



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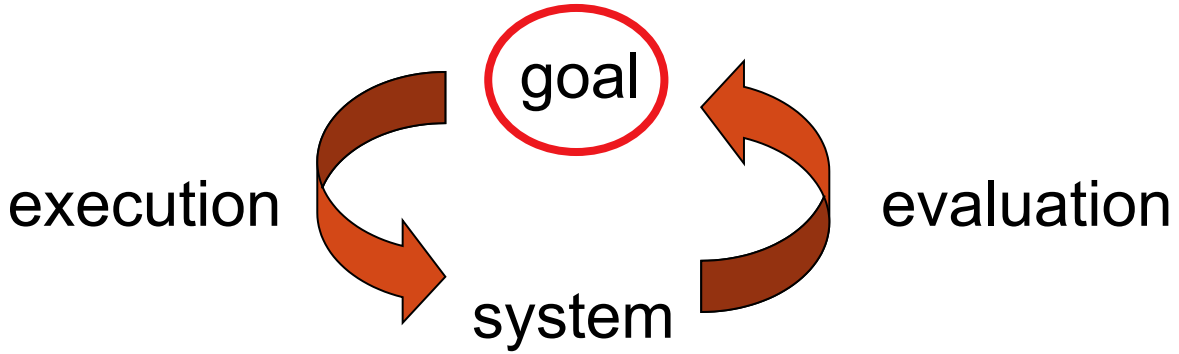

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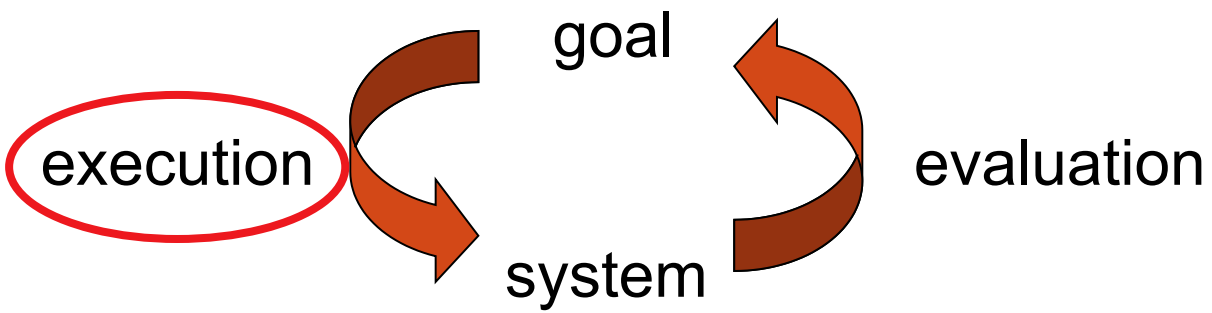

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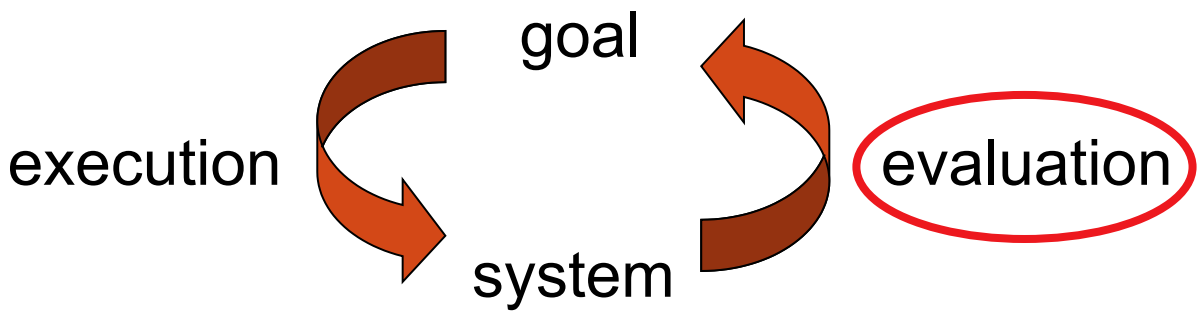

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ERGONOMICS

- Study of the physical characteristics of interaction
- Also known as human factors – but this can also be used to mean much of HCI!
- Ergonomics good at defining standards and guidelines for constraining the way we design certain aspects of systems

ERGONOMICS - EXAMPLES

- Arrangement of controls and displays
  - e.g. controls grouped according to function or frequency of use, or sequentially
- Surrounding environment
  - e.g. seating arrangements adaptable to cope with all sizes of user
- Health issues
  - e.g. physical position, environmental conditions (temperature, humidity), lighting, noise,
- Use of colour
  - e.g. use of red for warning, green for okay, awareness of colour-blindness etc.

INDUSTRIAL INTERFACES

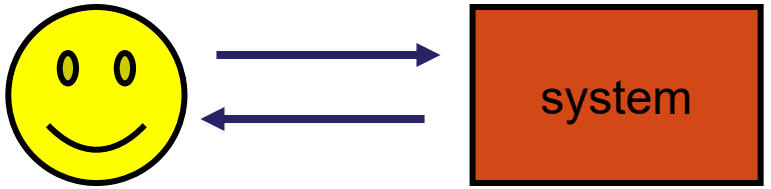
Office interface vs. industrial interface?

Context matters!

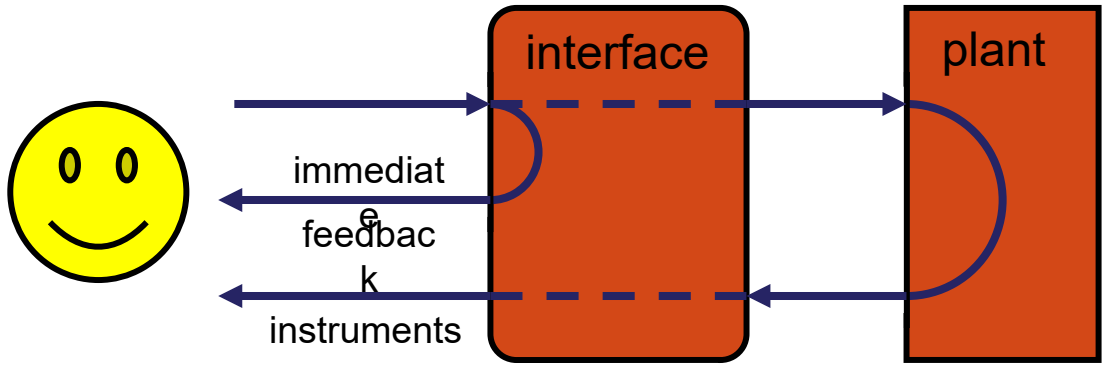
	office	industrial
type of data	textual	numeric
rate of change	slow	fast
environment	clean	dirty

INDIRECT MANIPULATION

- office– direct manipulation
  - user interacts with artificial world



- industrial – indirect manipulation
  - user interacts *with* real world *through* interface
- issues ..
  - feedback
  - delays



COMMON INTERACTION STYLES

- Command Line Interface
- Menus
- Natural Language
- Question/Answer And Query Dialogue
- Form-fills And Spreadsheets
- Wimp
- Point And Click
- Three–dimensional Interfaces

COMMAND LINE INTERFACE

- Way of expressing instructions to the computer directly
  - function keys, single characters, short abbreviations, whole words, or a combination
- Suitable for repetitive tasks
- Better for expert users than novices
- Offers direct access to system functionality
- Command names/abbreviations should be meaningful!

Typical example: the Unix system

MENUS

- Set of options displayed on the screen
- Options visible
  - less recall - easier to use
  - rely on recognition so names should be meaningful
- Selection by:
  - numbers, letters, arrow keys, mouse
  - combination (e.g. mouse plus accelerators)
- Often options hierarchically grouped
  - sensible grouping is needed
- Restricted form of full WIMP system

NATURAL LANGUAGE

- Familiar to user
- speech recognition or typed natural language
- Problems
  - vague
  - ambiguous
  - hard to do well!
- Solutions
  - try to understand a subset
  - pick on key words

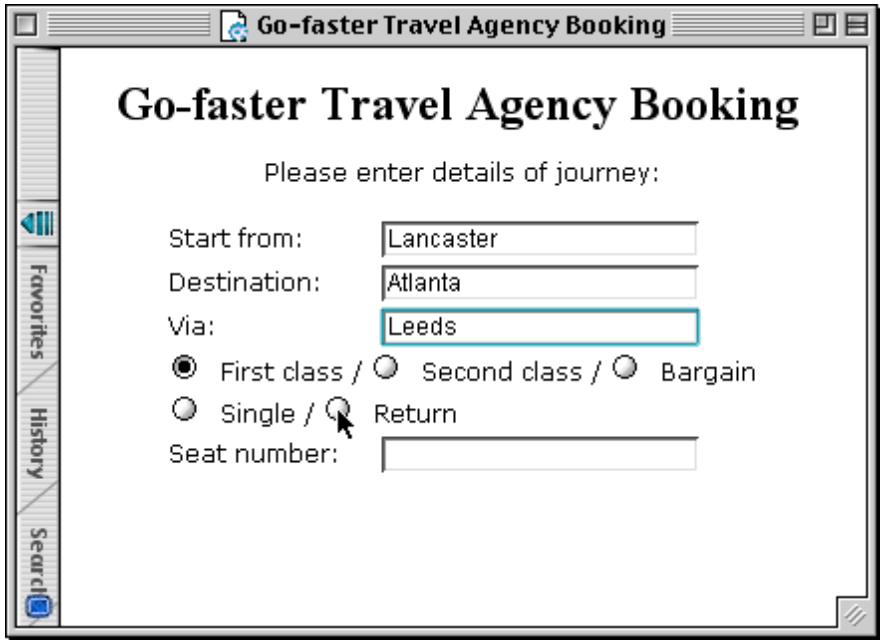
QUERY INTERFACES

- Question/answer interfaces
  - user led through interaction via series of questions
  - suitable for novice users but restricted functionality
  - often used in information systems

- Query languages (e.g. SQL)
  - used to retrieve information from database
  - requires understanding of database structure and language syntax, hence requires some expertise

FORM-FILLS

- Primarily for data entry or data retrieval
- Screen like paper form.
- Data put in relevant place
- Requires
  - good design
  - obvious correction facilities



SPREADSHEETS

- first spreadsheet VISICALC, followed by Lotus 1-2-3
- MS Excel most common today
- Sophisticated variation of form-filling.
  - grid of cells contain a value or a formula
  - formula can involve values of other cells

    e.g. sum of all cells in this column
  - user can enter and alter data spreadsheet maintains consistency

WIMP INTERFACE

Windows

Icons

Menus

Pointers

… or windows, icons, mice, and pull-down menus!

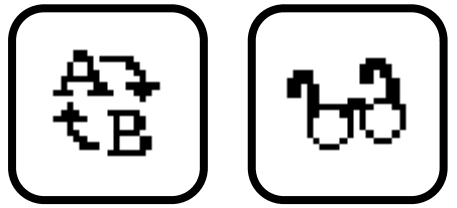
- Default style for majority of interactive computer systems, especially PCs and desktop machines

POINT AND CLICK INTERFACES

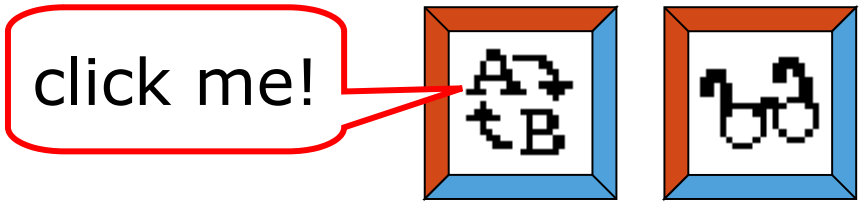
- used in ..
  - multimedia
  - web browsers
  - hypertext
- just click something!
  - icons, text links or location on map
- minimal typing

THREE DIMENSIONAL INTERFACES

- virtual reality
- ‘ordinary’ window systems
  - highlighting
  - visual affordance
  - indiscriminate use
    just confusing!
- 3D workspaces
  - use for extra virtual space
  - light and occlusion give depth
  - distance effects



flat buttons …



… or sculptured

EXPERIENCE, ENGAGEMENT AND FUN

- Designing experience
- Physical engagement
- Managing value

EXPERIENCE?

- home, entertainment, shopping
  - not enough that people can use a system
  - they must want to use it!
- psychology of experience
  - flow
  - balance between anxiety and boredom
- education
  - zone of proximal development
  - things you can just do with help
- wider …
  - literary analysis, film studies, drama

DESIGNING EXPERIENCE

- **Real crackers**
  - cheap and cheerful!
  - bad joke, plastic toy, paper hat
  - pull and bang

DESIGNING EXPERIENCE

- **virtual crackers**
  - cheap and cheerful
  - bad joke, web toy, cut-out mask
  - click and bang

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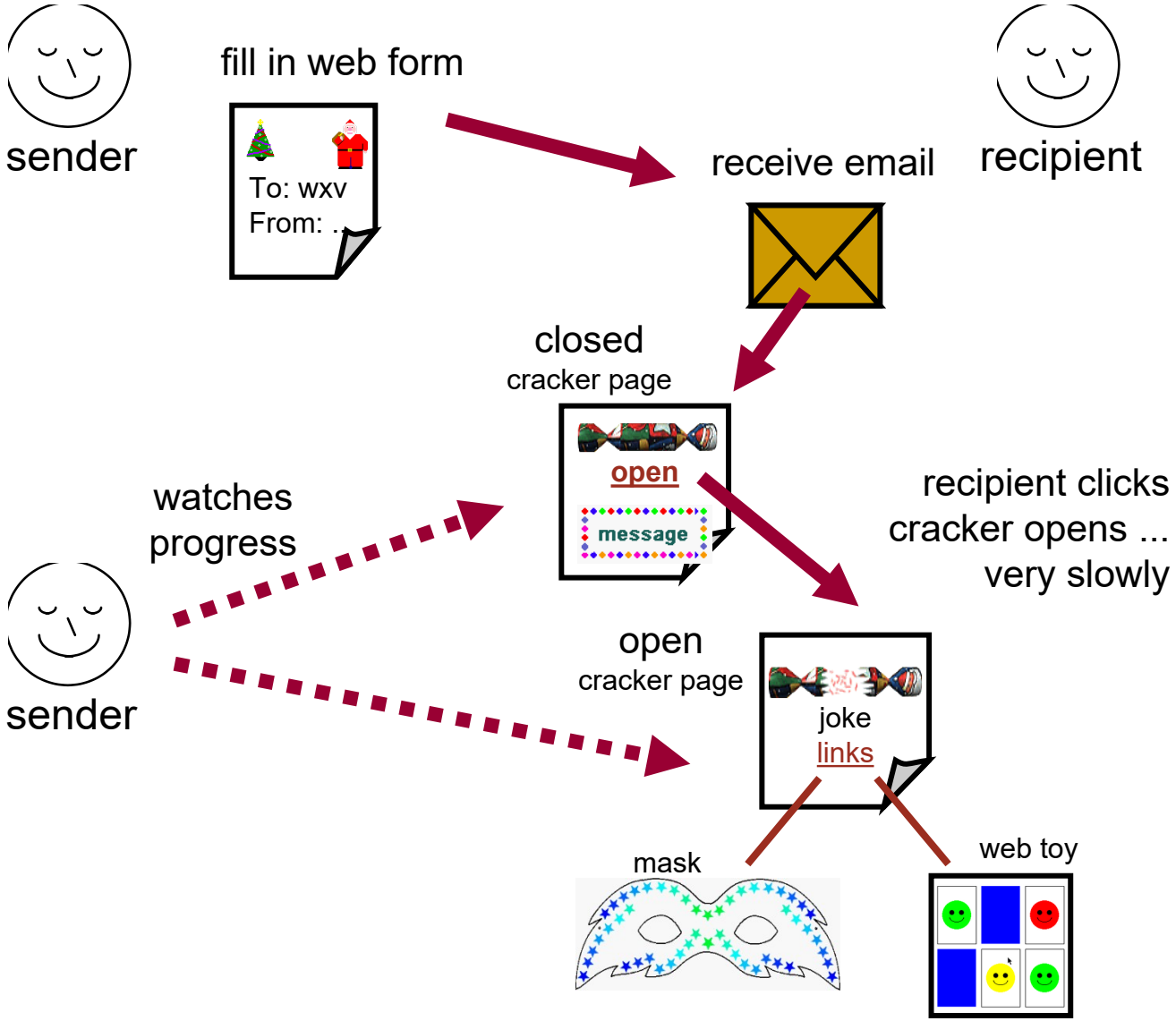
HOW CRACKERS WORK

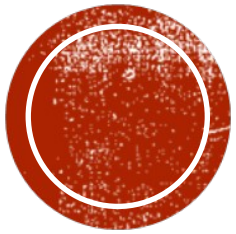


THE CRACKERS EXPERIENCE

	Real cracker	Virtual cracker
• **Surface elements**		
Design	cheap and cheerful	simple page/graphics
Play	plastic toy and joke	web toy and joke
Dressing up	paper hat	mask to cut out
• **Experienced effects**		
Shared	offered to another	sent by email message
Co-experience	pulled together	sender can't see content until opened by recipient
Excitement	cultural connotations	recruited expectation
Hiddenness	contents inside	first page - no contents
Suspense	pulling cracker	slow … page change
Surprise	bang (when it works)	WAV file (when it works)

PHYSICAL DESIGN

- Many constraints:
  - Ergonomic – minimum button size
  - Physical – high-voltage switches are big
  - Legal and safety – high cooker controls
  - Context and environment – easy to clean
  - Aesthetic – must look good
  - Economic – … and not cost too much!



PARADIGMS

WHY STUDY PARADIGMS

Concerns

- how can an interactive system be developed to ensure its usability?
- how can the usability of an interactive system be demonstrated or measured?

History of interactive system design provides paradigms for usable designs

WHAT ARE PARADIGMS

- Predominant theoretical frameworks or scientific world views
  - e.g., Aristotelian, Newtonian, Einsteinian (relativistic) paradigms in physics
- Understanding HCI history is largely about understanding a series of paradigm shifts
  - Not all listed here are necessarily "paradigm" shifts, but are at least candidates
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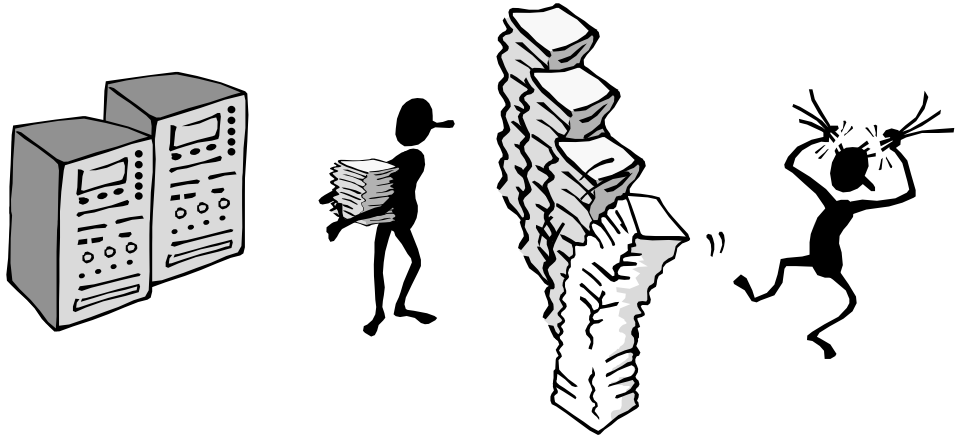

Impersonal computing

EXAMPLE PARADIGM SHIFTS

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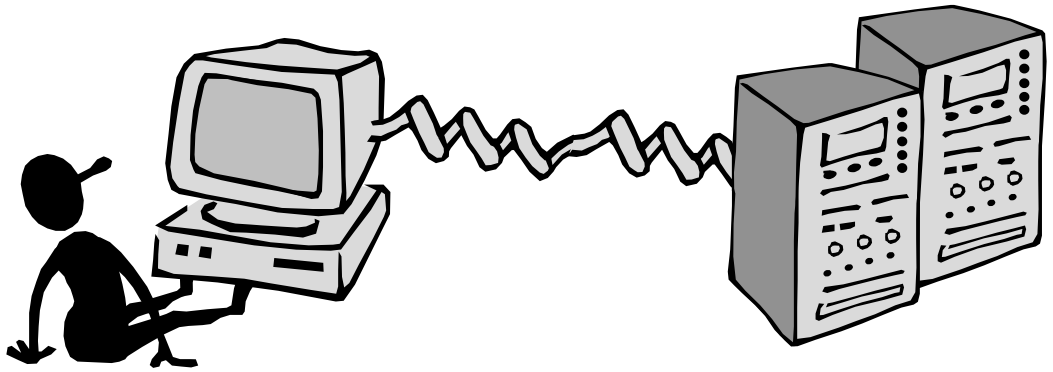

Interactive computing

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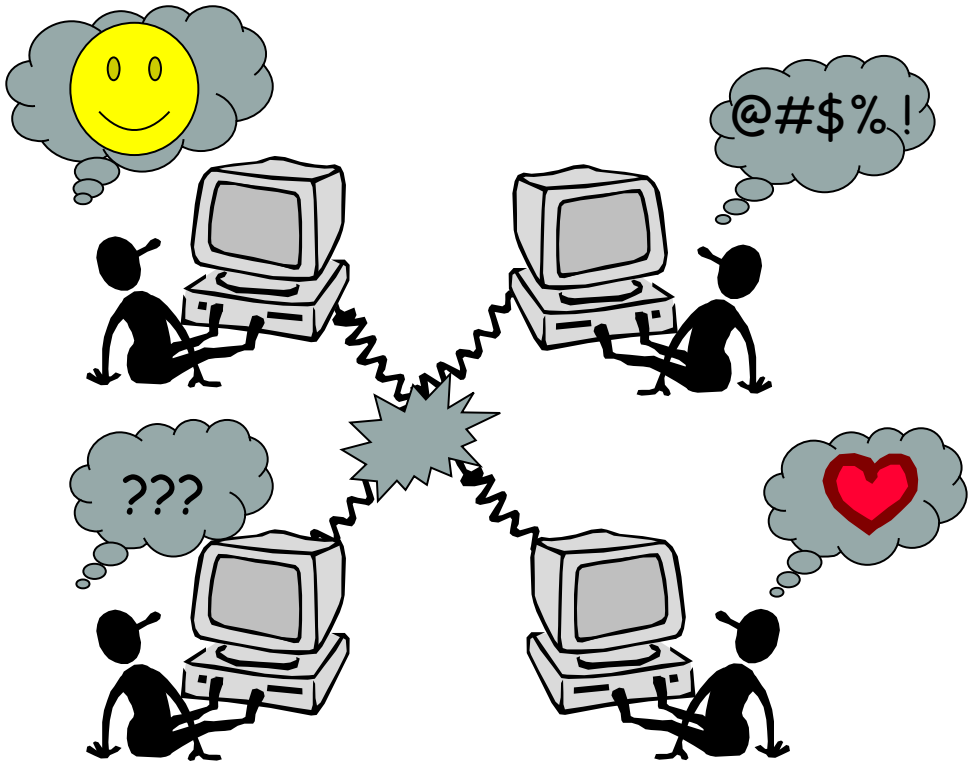

Community computing

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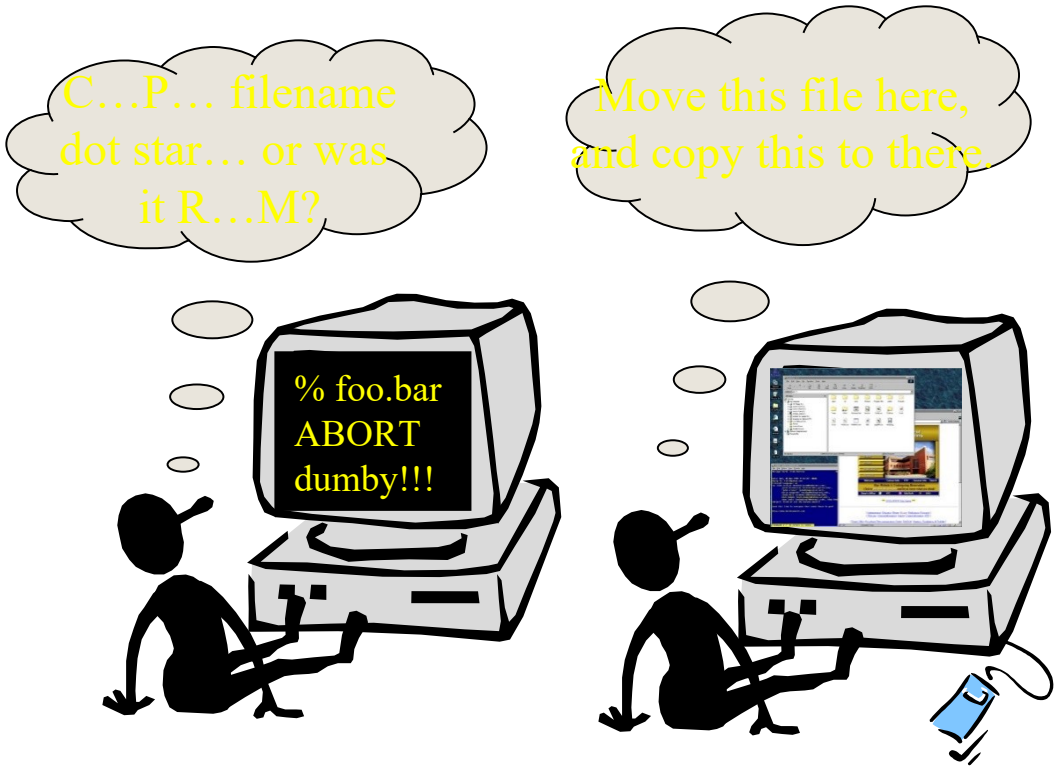

Direct manipulation

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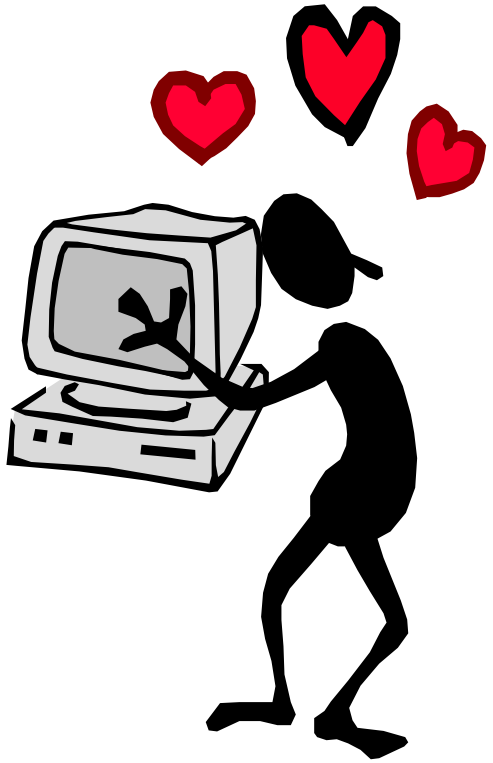

Personal computing

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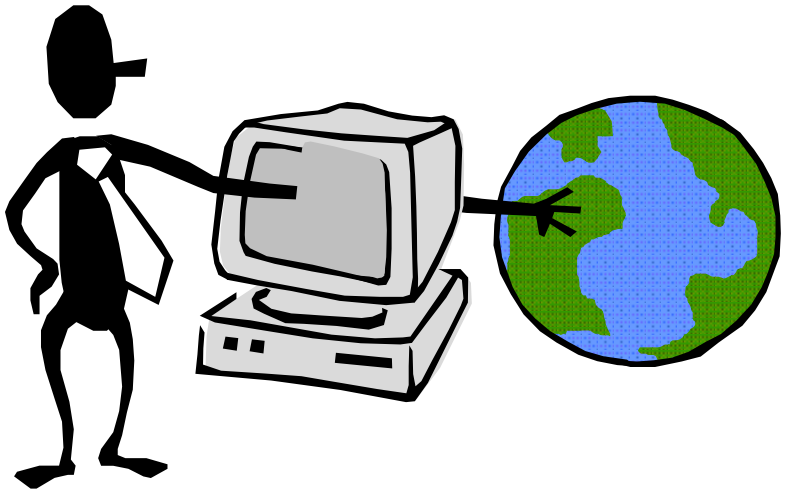

Global information

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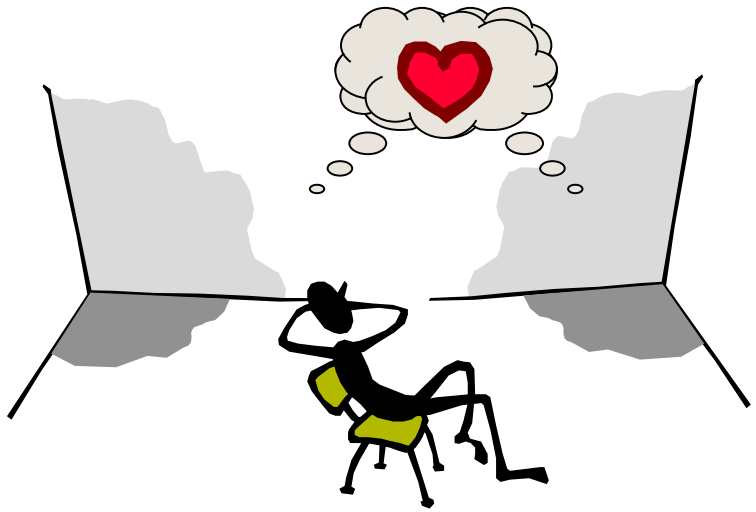

TIME-SHARING

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- 1960s – need to channel the power
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- single computer supporting multiple users

VIDEO DISPLAY UNITS

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WINDOW SYSTEMS AND THE WIMP INTERFACE

- humans can pursue more than one task at a time
- windows used for dialogue partitioning, to "change the topic"
- 1981 – Xerox Star first commercial windowing system
- windows, icons, menus and pointers now familiar interaction mechanisms

METAPHOR

- relating computing to other real-world activity is effective teaching technique
  - LOGO's turtle dragging its tail
  - file management on an office desktop
  - word processing as typing
  - financial analysis on spreadsheets
  - virtual reality – user inside the metaphor

- Problems
  - some tasks do not fit into a given metaphor
  - cultural bias

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  - reversibility encourages exploration
  - syntactic correctness of all actions
  - replace language with action

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- Nelson's Xanadu project still a dream today

MULTIMODALITY

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- emphasis on simultaneous use of multiple channels for input and output

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- Can no longer neglect the social aspects
- Electronic mail is most prominent success

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  - Language-based
- Direct Manipulation/WIMP
  - Commands performed on "world" representation
  - Action based
- Agents - return to language by instilling proactivity and "intelligence" in command processor
  - Avatars, natural language processing

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"The most profound technologies are those that disappear."

Mark Weiser, 1991

Late 1980's: computer was very apparent

How to make it disappear?

- Shrink and embed/distribute it in the physical world
- Design interactions that don't demand our intention

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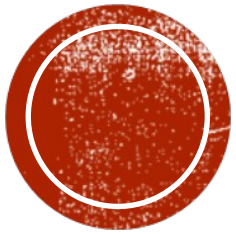

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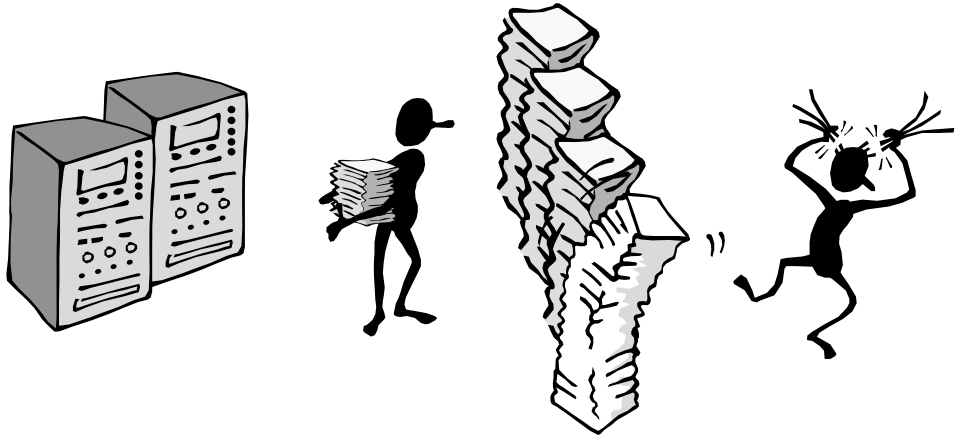

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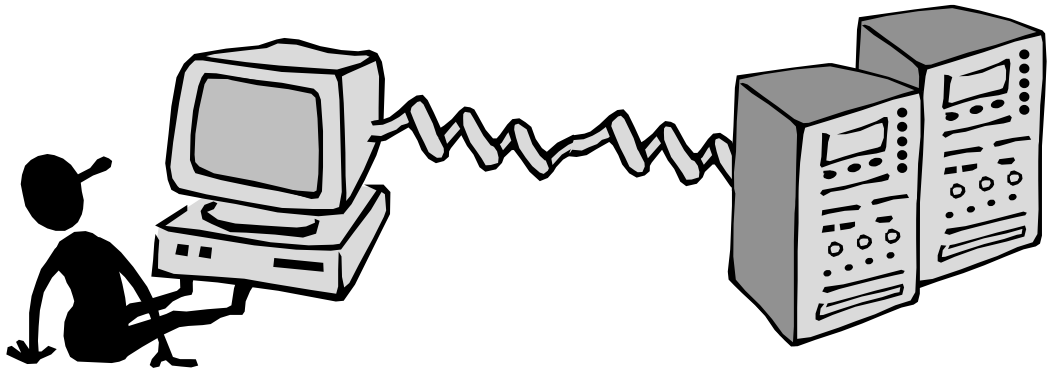

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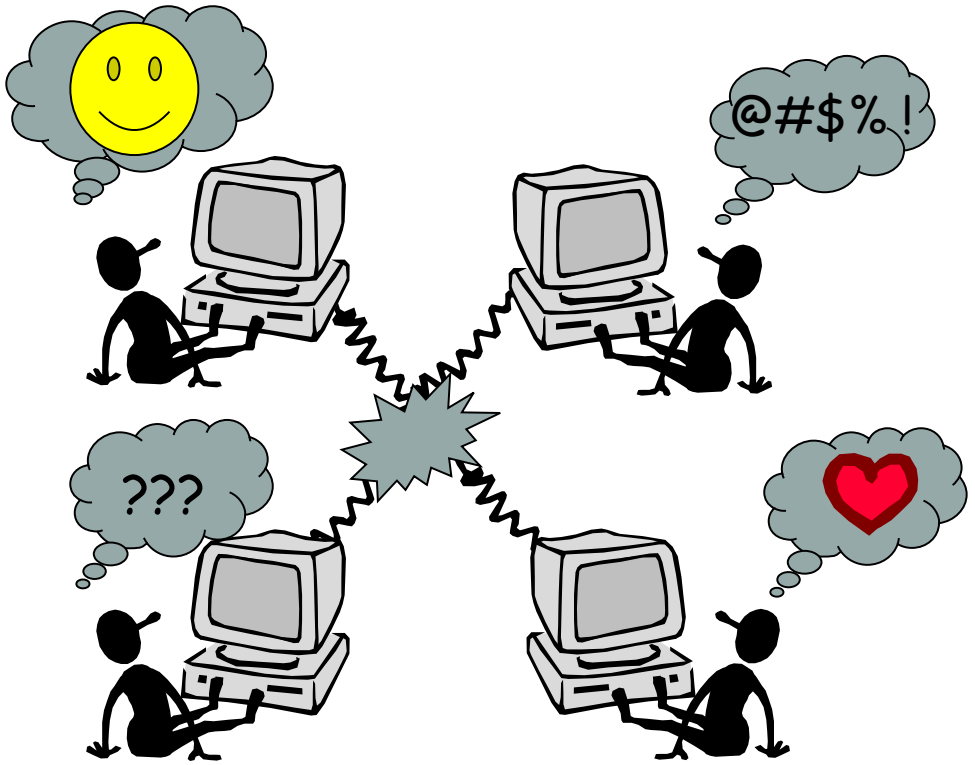

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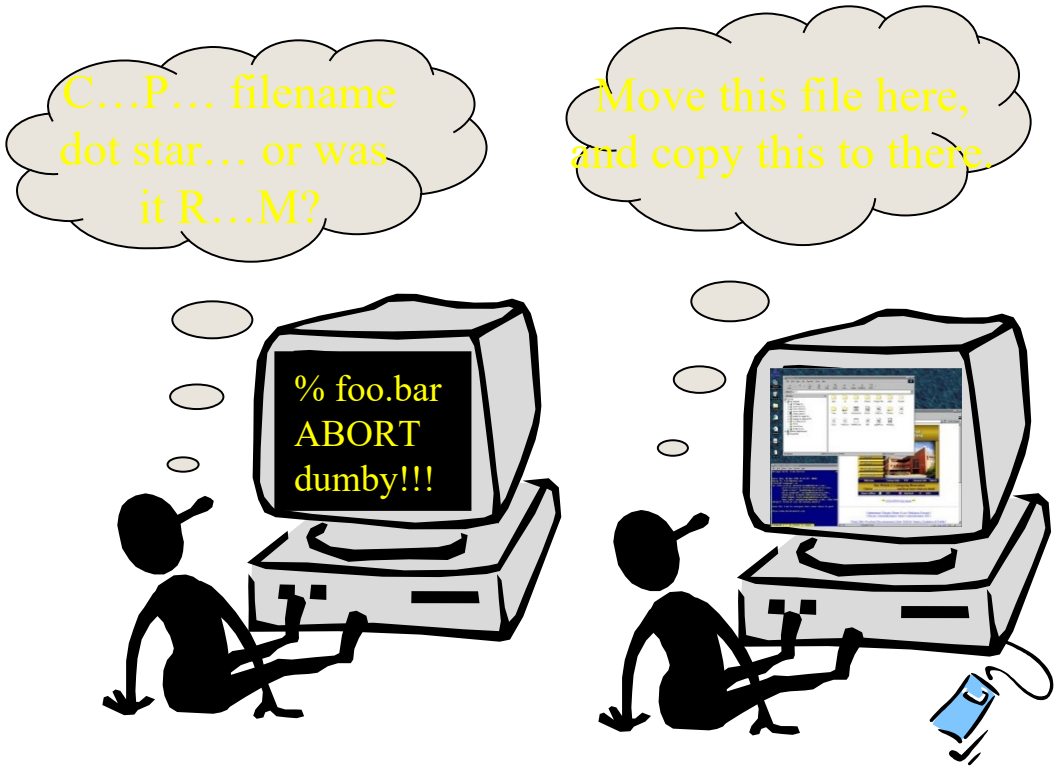

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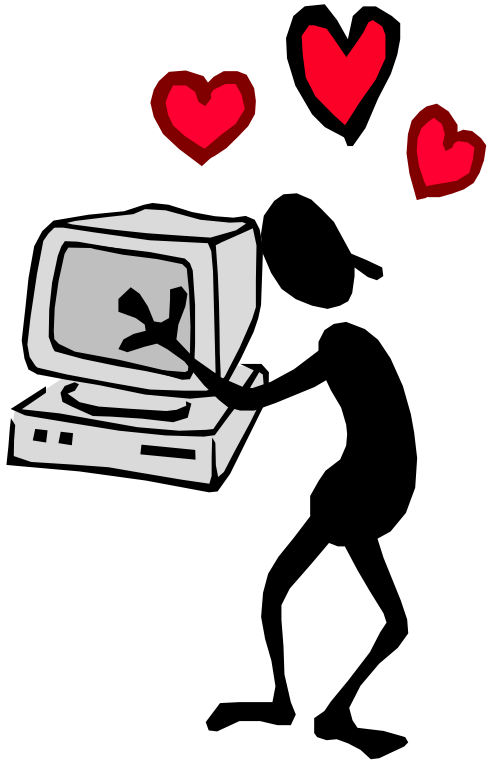

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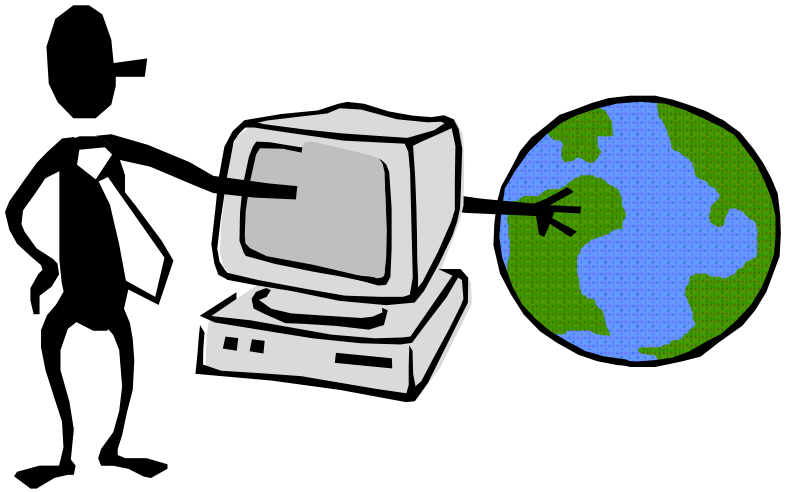

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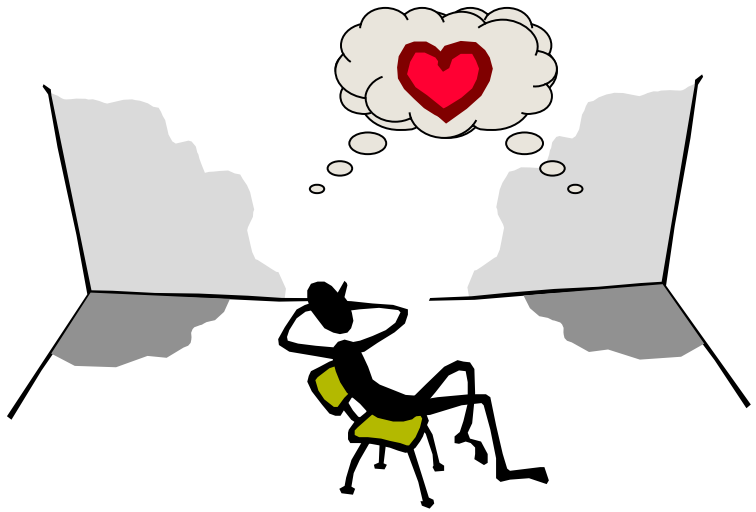

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UNIT – 1: ACTIVITY

- Individuals must select one topic on the following
  - **Human**
  - **Computer**
  - **Interaction**
  - **Interaction Paradigm**
- A report on it shall be prepared with a minimum of 2 pages.
- A presentation on the selected topic shall be made in the upcoming weeks (Maximum of 4 Slides)
- This Component will be considered for **Tutorial – 1**
- The same will be repeated for unit – 2 & the average of it will be made as tutorial -1
- **Tutorial 1 = 5 Marks (Average mark in Presentation of Unit 1 & 2)**