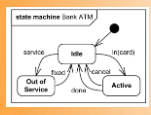
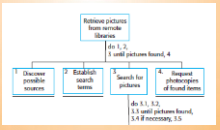
Universidade de Aveiro
Departamento de Electrónica, Telecomunicações e Informática

Models for design





Paulo Dias, Beatriz Sousa Santos

deti departamento de electrónica telecomunicações e informática
universidade de aveiro

1

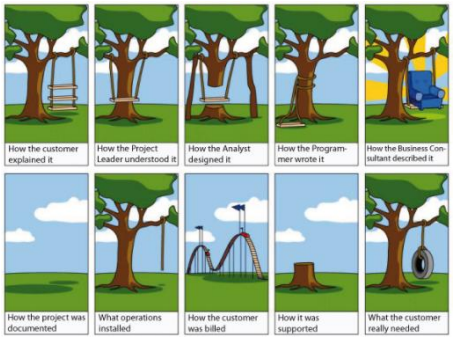
Outline

- User Models
  - Personas
  - Cognitive models
    - GOMS
    - KLM
- Task Analysis

2

2

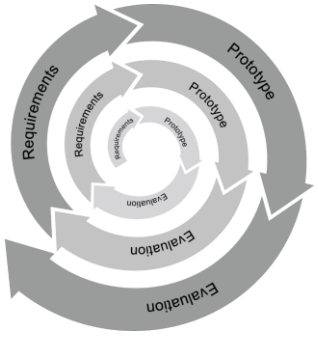
The problem of interactive systems design…



3

3

Iterative Human-Centred Design

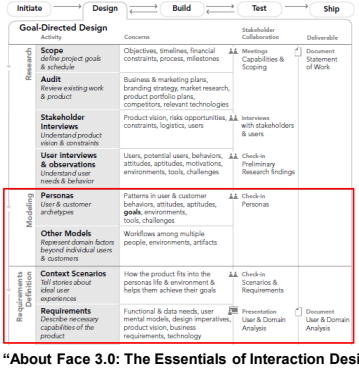


- **Requirements**
- **Prototypes**
- **Evaluation**

4

4

Requirement Analysis



Cooper et al., "About Face 3.0: The Essentials of Interaction Design", Wiley, 2007

5

5

Models used for requirement analysis

- Several types of models may be used throughout the design of user interfaces to perform requirement analysis
  - User analysis
  - Task analysis
  - Dialog notation
  - System models

6

6

I- User Models

- Models used to obtain user requirements in their social and organization context
  - Personas - fictional characters based upon research in order to represent the different types of users
  - User models - of the users' mental, perceptual and motor processes

User Models

Designing to please every possible user…

… often results in low user satisfaction, overall

User Models

We need to understand which types of users matter…

… and target their specific goals

I - User – Models - Know Your User

- Identify characteristics of target user population
  - Age, gender, culture, language
  - Education (literacy? numeracy?)
  - Physical limitations
  - Computer experience (typing?)
  - Motivation, attitude
  - Domain experience
  - Application experience
  - Work environment and other social context
  - Relationships and communication patterns
- Identify types of users
  - By role (student, teacher)
  - By characteristics (age, motivation)

How To Perform User Analysis

- Techniques
  - Questionnaires
  - Interviews
  - Observation
- Obstacles
  - Developers and users are sometimes systematically isolated from each other
    - Tech support shields developers from users
    - Marketing shields users from developers
  - Some users are expensive to talk to
    - Doctors, executives, union members

Personas

- Fictitious character used as representative of a user class
  - Nuno Rocha, a kid diagnosed with ASD
  - Bob is an IBM sysadmin in New York
- Advantages
  - Convenient handle for talking about user classes
  - Focuses on a typical user, rather than an extreme
  - Encourages empathy
- Disadvantages
  - May be misleading
  - Stereotype trap

Personas

- Based on research
- Represented as individual people
- But, represent groups of users
- Explore ranges of behaviour
- Must have motivations

16

16

Personas

- Personas depict
  - Activities – What the user does; frequency and volume
  - Attitudes – How the user thinks about the system's domain and technology
  - Aptitudes – What education and training the user has and ability to learn
  - Skills – User capabilities related to the system's domain and technology
  - Motivations – Why is the user engaged in the system's domain

17

17

Personas

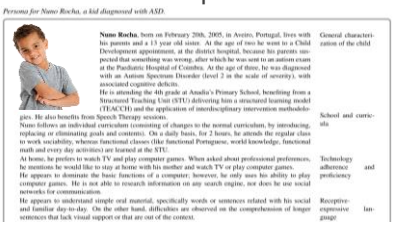
- Personas articulate this information and
  - Include biographical data
  - Are presented in narrative form
  - Have a photo

18

18

Personas

- Tools to understand and empathize with users



Persona for Nuno Rocha, a kid diagnosed with ASD.

Nuno Rocha, born on February 20th, 2005, in Aveiro, Portugal, lives with his parents and a 13 year old sister. At the age of two he went to a Child Development appointment, at the district hospital, because his parents suspected that something was wrong, after which he was sent to an autism exam at the Paediatric Hospital of Coimbra. At the age of three, he was diagnosed with an Autism Spectrum Disorder (level 2 in the scale of severity), with associated cognitive deficits.
He is attending the 4th grade at Anadia's Primary School, benefiting from a Structured Teaching Unit (STU) delivering him a structured learning model (TEACCH) and the application of interdisciplinary intervention methodologies. He also benefits from Speech Therapy sessions.
Nuno follows an individual curriculum (consisting of changes to the normal curriculum, by introducing, replacing or eliminating goals and contents). On a daily basis, for 2 hours, he attends the regular class to work sociability, whereas functional classes (like functional Portuguese, world knowledge, functional math and every day activities) are learned at the STU.
At home, he prefers to watch TV and play computer games. When asked about professional preferences, he mentions he would like to stay at home with his mother and watch TV or play computer games.
He appears to dominate the basic functions of a computer; however, he only uses his ability to play computer games. He is not able to research information on any search engine, nor does he use social networks for communication.
He appears to understand simple oral material, specifically words or sentences related with his social and familiar day-to-day. On the other hand, difficulties are observed on the comprehension of longer sentences that lack visual support or that are out of the context.

General characterization of the child

School and curricula

Technology adherence and proficiency

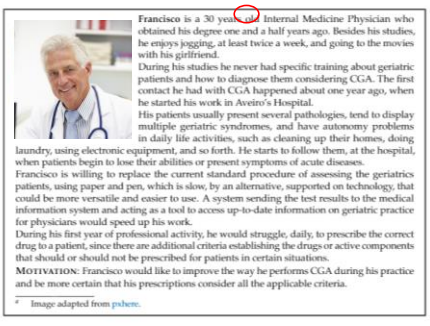
Receptive-expressive language

- They are not about technical aspects, but about behaviours and abilities

19

19

Personas



Francisco is a 30 years old Internal Medicine Physician who obtained his degree one and a half years ago. Besides his studies, he enjoys jogging, at least twice a week, and going to the movies with his girlfriend.
During his studies he never had specific training about geriatric patients and how to diagnose them considering CGA. The first contact he had with CGA happened about one year ago, when he started his work in Aveiro's Hospital.
His patients usually present several pathologies, tend to display multiple geriatric syndromes, and have autonomy problems in daily life activities, such as cleaning up their homes, doing laundry, using electronic equipment, and so forth. He starts to follow them, at the hospital, when patients begin to lose their abilities or present symptoms of acute diseases.
Francisco is willing to replace the current standard procedure of assessing the geriatrics patients, using paper and pen, which is slow, by an alternative, supported on technology, that could be more versatile and easier to use. A system sending the test results to the medical information system and acting as a tool to access up-to-date information on geriatric practice for physicians would speed up his work.
During his first year of professional activity, he would struggle, daily, to prescribe the correct drug to a patient, since there are additional criteria establishing the drugs or active components that should or should not be prescribed for patients in certain situations.
Motivation: Francisco would like to improve the way he performs CGA during his practice and be more certain that his prescriptions consider all the applicable criteria.

[4] Image adapted from pxhere.

Activities
Aptitudes

Skills

Attitudes

Motivations

- Need to be credible

20

20

Cognitive models

- Represent the user in an interaction with the system; i.e. model aspects of user knowledge, intentions or processing
- The representation level varies from model to model, from:
  High level models...→ motor activity
- There are several types of cognitive models:
  - Object and tasks hierarchies
    (GOMS- Goals, Operators, Methods and Selection) ✓
  - Linguistic models
  - Physical and device
    (KLM- Keystroke Level Model) ✓

21

21

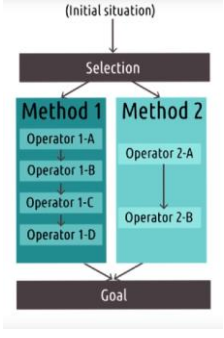
GOMS- Goals, Operators, Methods and Selections

- Human Processor information model Propose by Card, Moran and Newell, 1983
- A GOMS decomposition has the following elements:
  - ***Goals***: what the user wants to attain
  - ***Methods***: possible decompositions of the goal into sub-goals (e.g. Select an option "Save" or press "ctrl S")
  - ***Operators***: basic operations that the user has to perform to use the system; may affect the system or not (press a key or read a message)
  - ***Selections* rules:** to select the possible methods (taking into account the type of user and the system status)

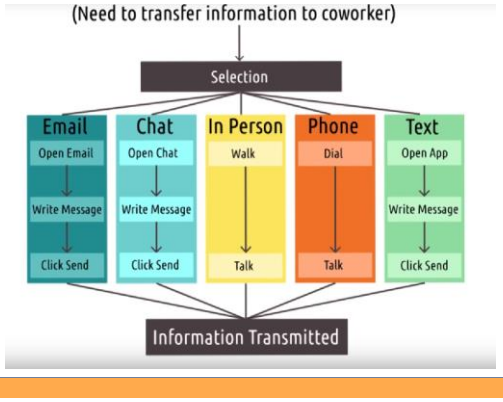
GOMS- *Goals, Operators, Methods and Selections*

- A typical GOMS analysis consists in decomposing a high level goal in a sequence of tasks (sub-goals)
- Selection rules must be adjusted to the user profile
- Analyzing the structure of the GOMS decomposition may give an **approximate** measure of :
  - Short Term Memory load (depth of the goal structure)
  - Time needed (a time for each operator)

GOMS- *Goals, Operators, Methods and Selections*

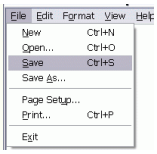


GOMS- *Goals, Operators, Methods and Selections*



Example: 'save' a file: using two common ways

- GOAL: **SAVE-A-DOCUMENT**
  - . [select GOAL: USE-SAVE-OPTION-METHOD
  - . . MOVE-MOUSE-TO-MENU-BAR
  - . . CLICK-OVER-FILE-OPTION
  - . . MOVE-MOUSE-TO-SAVE-OPTION
  - . . CLICK-SAVE-OPTION
  - . GOAL: USE-CTRLS-METHOD
  - . . PRESS-'CTRL'+'S'-KEYS]



Possible rules:

Rule 1: **USE-CTRLS-METHOD** unless other rule applies

Rule 2: If has hand on mouse **USE-SAVE-OPTION-METHOD**

Example: Make a paper copy of a paper – More in depth

- Goal: Photocopy-paper
- . Goal: Locate-article
- Goal: Photocopy-page repeat
- Goal: Orient-page
- open cover
- select-page
- position-paper
- close-cover
- Goal: Press-copy-button
- Goal: Verify-copy
- locate-out-tray
- examine-copy
- Goal: Collect-copy
- locate-out-tray
- remove-copy (outer goal satisfied)
- Goal: Retrieve-journal
- open-cover
- remove-journal
- close-cover

Closure problem

Closure problem

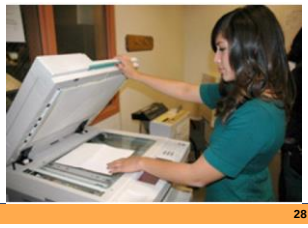
In earlier ATMs the money was given before returning the card

... many users left the card: their goal was getting money!

This was changed.

The copies usually are available to the user before they remove the original from the photocopier and walk away!

To prevent this, the overall goal should be satisfied only after removing the original



28

28

Closure problem

In stores usually these are the following steps:

- Insert the card
- Insert the pin code
- Transaction approval -> audio signal
- Remove the card
- Receipt is handled to the client

At the ATMs the money is given (goal satisfaction) only after the card is removed by the client

These procedures help not to forget the card!

29

29

GOMS- Goals, Operators, Methods and Selections

- Capacities:
  - It has been used in cognitive model research
  - It may describe adequately how **experienced users** perform **routine tasks**
  - Associated to a device model allows time estimates

Limitations:

- It does not give information concerning user knowledge to estimate training or transfer times

30

30

KLM- Keystroke-Level Model

- Proposed by Card, Moran e Newell, 1980
- Predicts user performance based on motor system characteristics
- Models unitary interaction tasks (simple command sequences <20s) (e.g. change the font of a word, use search and replace)
- These tasks have two phases:
  - Acquisition (building the mental representation of the task)
  - Execution (using the system)
- KLM only models the execution phase (the user has already decided how to use the task)

31

31

KLM- Keystroke-Level Model

- The execution phase may be decomposed in 7 operators:
  - K- *Keystroke* (varies with typing skill)
  - B- *Button press of the mouse*
  - P- *Pointing at a target* (Fitts' law)
  - H- *Homming between mouse and keyboard*
  - D- *Drawing using mouse*

  → motor

  - M- *Mentally preparing for physical action* → mental
  - R- *System Response* (often may be ignored) → system

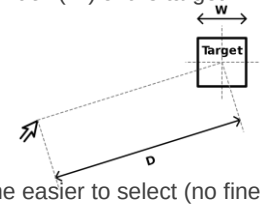
32

32

Fit's law - 1954

- Predictive model of human movement
- Estimates **time** a to select a target at **distance** (D) from the cursor given **width** (W) of the target:

$$T = a + b \log_2 \frac{D}{W}$$



- The larger the target the easier to select (no fine control needed)
- The farther the target from the cursor the longer it will take

33

33

KLM - Example

Using a mouse based editor – correct a character
Point the wrong character, delete it, write a new character, return to the original place

1- Move hand to mouse → H [mouse]
2- Place the cursor after the error → PB [left]
3- Return hand to keyboard → H [keyboard]
4- Delete wrong character → MK [delete]
5- Write correct character → K [char]
6- Replace cursor → H [mouse] MPB [left]

Adding all times:

$T_{total} = 2T_K + 2T_P + 2T_B + 3T_H + 2T_M$

This is an **estimate of the total time** the user will take to perform the task

Times for KLM operators:
(empirically established)

Operator	Remarks	Time (s)
K	Press key	
	good typist (90 wpm)	0.12
	poor typist (40 wpm)	0.28
	non-typist	1.20
B	Mouse button press	
	down or up	0.10
	click	0.20
P	Point with mouse	
	Fitts' law	0.1 $\log_2(D/S + 0.5)$
	average movement	1.10
H	Home hands to and from keyboard	0.40
D	Drawing – domain dependent	–
M	Mentally prepare	1.35
R	Response from system – measure	–

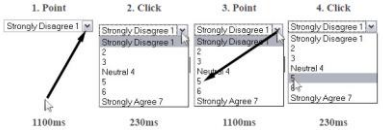
wpm = words per minute

Another example: which survey alternative takes less time?

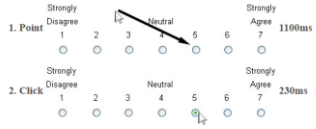
- Drop down list

  or

- Radio buttons?



- The radio button option will probably take ~**half the time**



- **If a task is done repeatedly small changes to an interface can save a lot of time!**

https://measuringu.com/predicted-times/

Another example: delete file

More examples:

Design A: drag the file into the trash can[29]	Design B: use the short cut "control + T"[30]
method encoding (operator sequence)[31]	method encoding (operator sequence)[32]
1. initiate the deletion (M) 2. find the file icon (M) 3. point to file icon (P) 4. press and hold mouse button (B) 5. drag file icon to trash can icon (P) 6. release mouse button (B) 7. point to original window (P)	1. initiate the deletion (M) 2. find the icon for the to-be-deleted file (M) 3. point to file icon (P) 4. press mouse button (B) 5. release mouse button (B) 6. move hand to keyboard (H) 7. press control key (K) 8. press T key (K) 9. move hand back to mouse (H)
Total time	Total time
3P + 2B + 2M = 3*1.1 sec + 2*.1 sec+ 2*1.35 sec = 6.2 sec	P + 2B + 2H + 2K + 2M = 1.1 sec + 2*.1 sec + 2*.4 sec + 2*.2 sec + 2*1.35 sec = 5.2 sec

This shows that Design B is 1 second faster than Design A, although it contains more operations.

https://en.wikipedia.org/wiki/Keystroke-level_model

KLM- Keystroke-Level Model

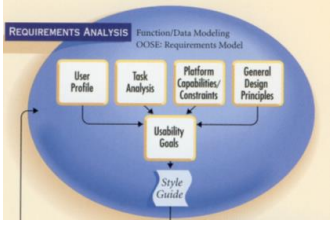
- This model has an applicability limited to micro-dialog
- **It allows only approximate results**; thus reasonable estimates concerning the user are enough
- Can predict a skilled user's task time (error-free) to within10-20% of the actual time.
- Its main application is **alternative comparison**

http://www.measuringusability.com/predicted-times.php

II- Task analysis

- What it is and how it is different from other methods
- Techniques
- Sources of information
- How to use it

(Mayhew, 1999)



Task analysis

- It is the analysis of how people perform their work
  - what they do
  - what they use
  - what they need to know
- Example: vacuum cleaning a house
  - Get the vacuum cleaner
  - Choose the adequate attachment
  - Clean the rooms
  - Empty the bag when it is full
  - Put the vacuum cleaner and attachments away
- Users have to know about vacuum cleaners, rooms, …

Differences between Task Analysis (TA) and GOMs

- The scope of Task Analysis is very wide
- TA models also aspects of the real world not part of the system (example: feeding paper into a printer; getting paper documents)
- TA describes the tasks users perform from an external point of view and has more detail
- GOMS aims at understanding the user's cognitive processes while performing the task
- TA is more used in early phases of the S/W lifecycle and GOMS for evaluation

Differences between Task Analysis (TA) and GOMS

	Task Analysis	GOMS
models:	real world aspects not part of the system	user cognitive processes while performing task
Point of view:	external	internal
S/W lifecycle:	early phases	evaluation

Task Decomposition

- Hierarchical Task Analysis (HTA) is one of the most used task analysis techniques and produces:
  - a task and sub-task hierarchy
  - plans with a sequence and execution conditions

HTA Simple example: vacuum cleaning the house

0. in order to clean the house
   1. get the vacuum cleaner
   2. fix the appropriate attachment
   3. clean the rooms
      - 3.1. clean the hall
      - 3.2. clean the bedrooms
   4. empty the dust bag
   5. put the vacuum cleaner and attachments away

Plan 0: do 1 – 2 – 3 – 5 in that order
when the dust bag gets full do 4

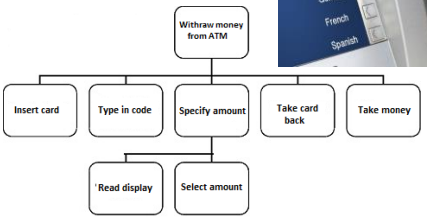
Plan 3: do any of 3.1, 3.2, or 3.3 in any order depending on which rooms need cleaning

Plan 3 could be more specific; what if it were varnishing the house?

Withdraw money from an ATM

Withdraw money from an ATM

Can you fix and complete it?



52

52

HTA: Preparing a cup of tea

Can you do a HTA describing this task?

53

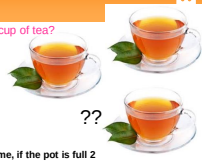
53

HTA- Preparing a cup of tea
(graphical representation of first approach)

54

54

HTA- Preparing a cup of tea
(analysis of the of first approach)



55

55

HTA- Prepare several cups of tea (a new hierarchy

56

56

Plan types in HTA

- Fixed sequence (plan 3 – prepare the teapot)
- Optional tasks (5.3 sugar?)
- Waiting for events (4- wait 4 or 5 minutes)
- Cycles (plan 5 – serve tea)
- Time sharing (1 and 2 prepare teapot, boil water)
- Random (vacuum cleaning rooms)
- Mix of several types

57

57

HTA

- The result of the analysis depends a lot on the experience of the analyst
- **Different analysts usually produce different results** (mainly at the detail level) varying with the goal of the analyst

Task analysis information sources

- The quality of task analysis results cannot be better than the original data

  "*garbage in garbage out*"
- The process of analysis in general triggers new questions, thus several phases of data collection and analysis are needed
- There are several types of information sources:
  - Documentation
  - Observation → (expensive)
  - Interviews

Using Task Analysis

- May be used in:

  - Manuals and teaching materials

  - High-level system design

  - Detailed design of the system user interface
- In the first case users are observed while performing tasks using the system
- In the other cases task analysis contributes to the design of the new system

III- Dialog notation

- Dialog is the syntatic level of human-computer interaction
- But it is related to:

  - the system semantic – what it does
  - the system presentation – how it looks
- Formal dialog descriptions may be analysed as to:
  - Incoherent actions
  - Difficult in reverting actions
  - Lacking items
  - Potential errors

Main bibliography

- Alan Dix, J. Finley, G. Abowd, R. Beale, *Human-Computer Interaction*, 3rd ed., Prentice Hall, 2004
- Cooper et al., "About Face 3.0: The Essentials of Interaction Design", Wiley, 2007
- Dan Diaper, Neville Stanton, *The Handbook of Task Analysis for Human-Computer Interaction*, CRC Press, 2003
- Ian Sommerville, *Software Engineering*, 9th ed., Addison Wesley, 2010
- Lene Nielsen, "Personas" In: Soegaard, Mads and Dam, Rikke Friis (eds.). *The Encyclopedia of Human-Computer Interaction*, 2nd Ed. Aarhus, Denmark: The Interaction Design Foundation, 2014
- https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/personas
- Alan Dix, "Formal Methods". In: Soegaard, Mads and Dam, Rikke Friis (eds.). *The Encyclopedia of Human-Computer Interaction*, 2nd Ed. Aarhus, Denmark: The Interaction Design Foundation, 2014
  https://www.interaction-design.org/encyclopedia/formal_methods.html