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Human Computer Interaction
interaction design

Lecture No. 4

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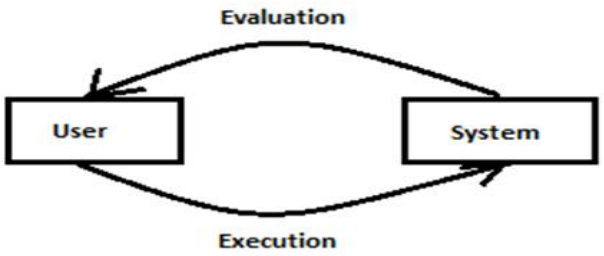
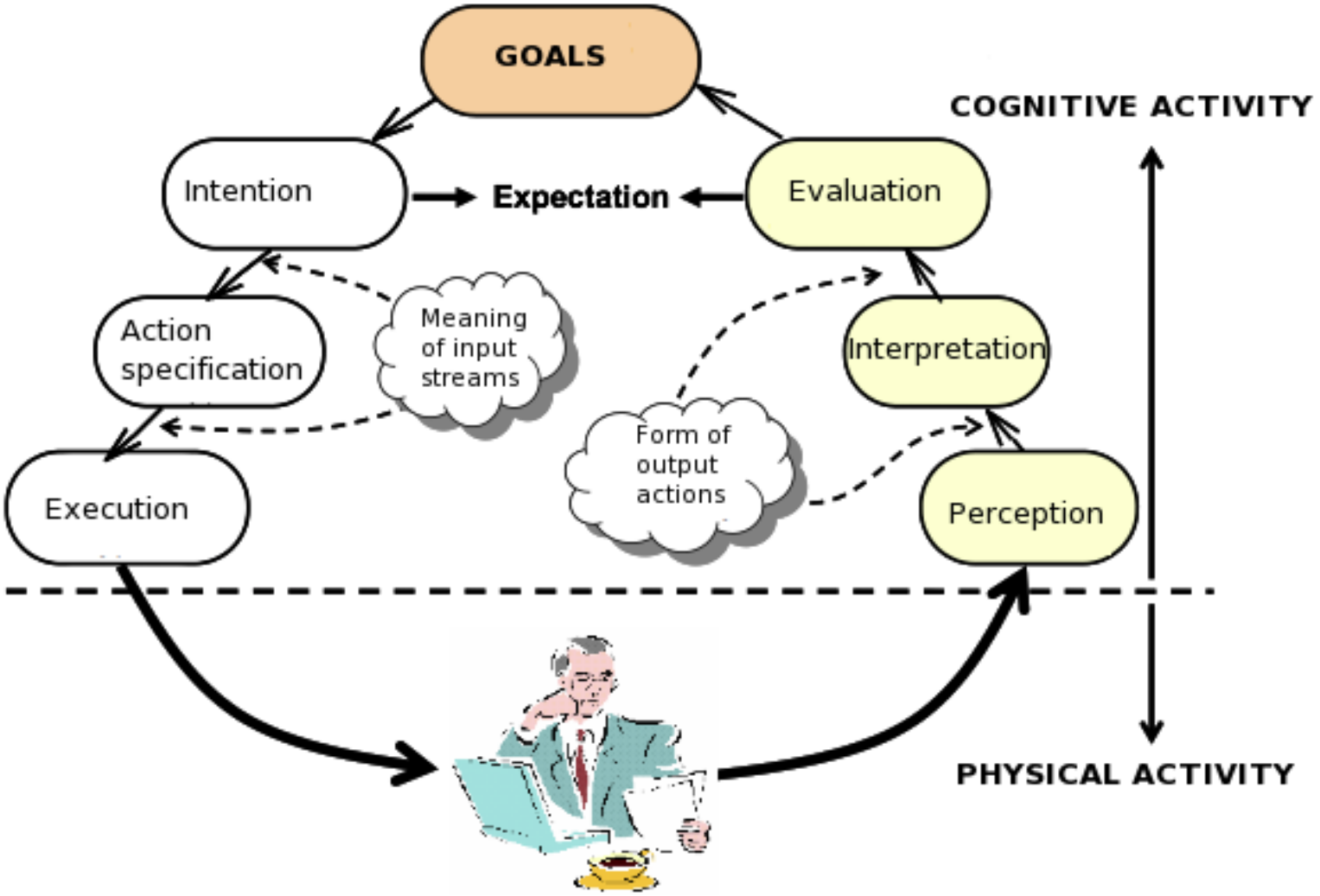
Theoretical Models
& approaches
part B: Human Centered Design

Norman's Model *(1/2)*

- The use and implementation of Norman's model:
  - Compares design solutions
  - Develops new design solutions with less **cognitive load**



Norman's Model *(2/2)*



Derivative Models

- Based on the success of Norman's model, many derivative systems emerged simulating the way in which we can quantify and thus "measure" Interaction.
- Some of these models deploying User Interface Analysis Techniques are:
  - The Keystroke Level Model
  - GOMS
  - CCT
  - TAGs
  - KLM
  - TAKD
  - …

GOMS (Goals, Operators, Methods, Selection rules) *1/5*

- The new, augmented reality in which we are heading to, is quite complex in interactivity terms and some times it is difficult to describe.
- That is why classic problem solving methods may fail to properly conceptualize Interaction.
- Example: Facebook
  - This new “metaphor” for social media communication has created a new situation in terms of Interaction. However, in HCI terms it essentially introduces a new “paradigm”, rather than a new “metaphor”, which “iconifies” user interactivity with very specifically designed tasks (“idioms”).

GOMS (Goals, Operators, Methods, Selection rules) *2/5*

- Goals, Operators, Methods, Selection Rules:
  - Goals: What do I want to do?
  - Operators: Basic cognitive functions
  - Methods: Problem solving processes
  - Selection Rules: “if-then” rules specifying the human decision processes
- User modeling approach
  - The interaction with the system should provide solutions to the problem

GOMS (Goals, Operators, Methods, Selection rules) *3/5*

- Example: minimize a window
  - **GOAL** : MINIMIZE-WINDOW
  - . [**select GOAL** : USE-METHOD-MENU-DRIVEN-MINIMAZATION
  - . . MOVE-MOUSE-CURSOR-TO-MENU-BAR
  - . . SELECT-MENU-WITH-RIGHT-CLICK
  - . . SELECT-MINIMIZE
  - . **GOAL** : USE-FUNCTION-KEY-METHOD
  - . . PRESS-KEY-F5]

  - **Selection Rule 1** : Select USE-METHOD-MENU-DRIVEN-MINIMAZATION unless the USE-FUNCTION-KEY-METHOD is in use.

GOMS (Goals, Operators, Methods, Selection rules) *4/5*

- However, the steps of the GOMS method to minimize a window no longer have global value or scope as movements described in a programming language or algorithm, since they are quite different when performed on a portable device.
- Mobile interfaces have eliminated the use of of the buttons, and in many cases there is no exact one-to-one correspondence.
- The same situation is met with the exact steps of input or output actions (e.g. make a copy, scan an image, etc.) according to the GOMS model.

GOMS (Goals, Operators, Methods, Selection rules) *5/5*

- So far, variants of the GOMS model have appeared
  - e.g. NGOMSL
- In addition, improvements of the model over time have been introduced
- These methods were mingled with self-activating cognitive objects and have created the first coupling with Cognitive Complexity Theory

Cognitive Complexity Theory

- Uses inference rules
  - *If - Then* decision trees
  - Complexly linked operations
- Competence and capability
  - Comparison of task completion with those of functional working systems
- Performance
  - It measures cognitive load and mental processing requirements

NGOMSL

- NGOMSL is a structured natural language notation for representing GOMS models and procedures.
- E.g.: Give a sequence of selection rules in HCI predicates for completing the task "**Highlight text**"

Selection rule set for goal: Highlight text

If text-is word, then accomplish goal: Highlight-Word

If text-is arbitrary, then accomplish goal: Highlight-Arb-Text

Method for goal: Highlight-Arb-Text

Step 1. Determine position of beginning of text

Step 2: Move cursor to beginning of text

Step 3: Click mouse button

Step 4: Determine position of end of text.

Step 5. Move cursor to end of text

Step 6. Shift-click mouse button

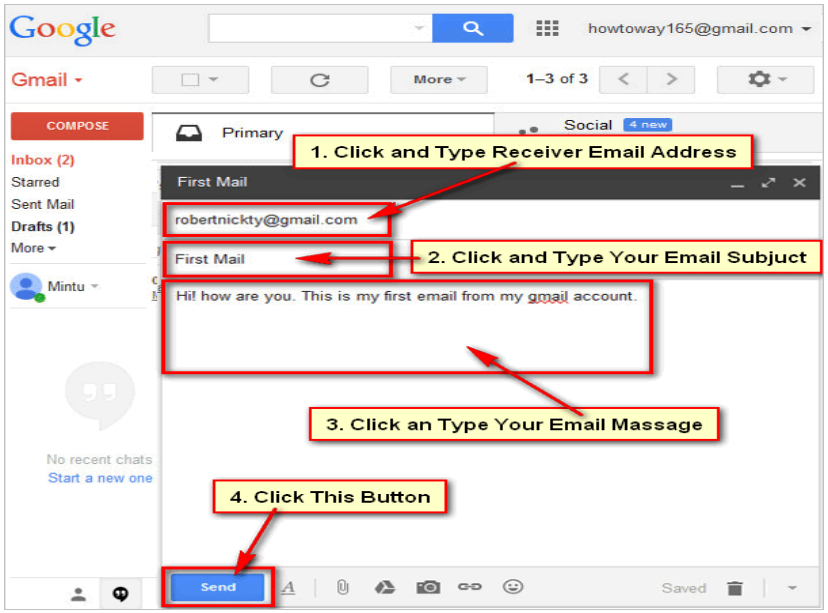
Step 7. Verify that correct text is highlighted

Step 8: Return with goal accomplished

Actions & Run-time

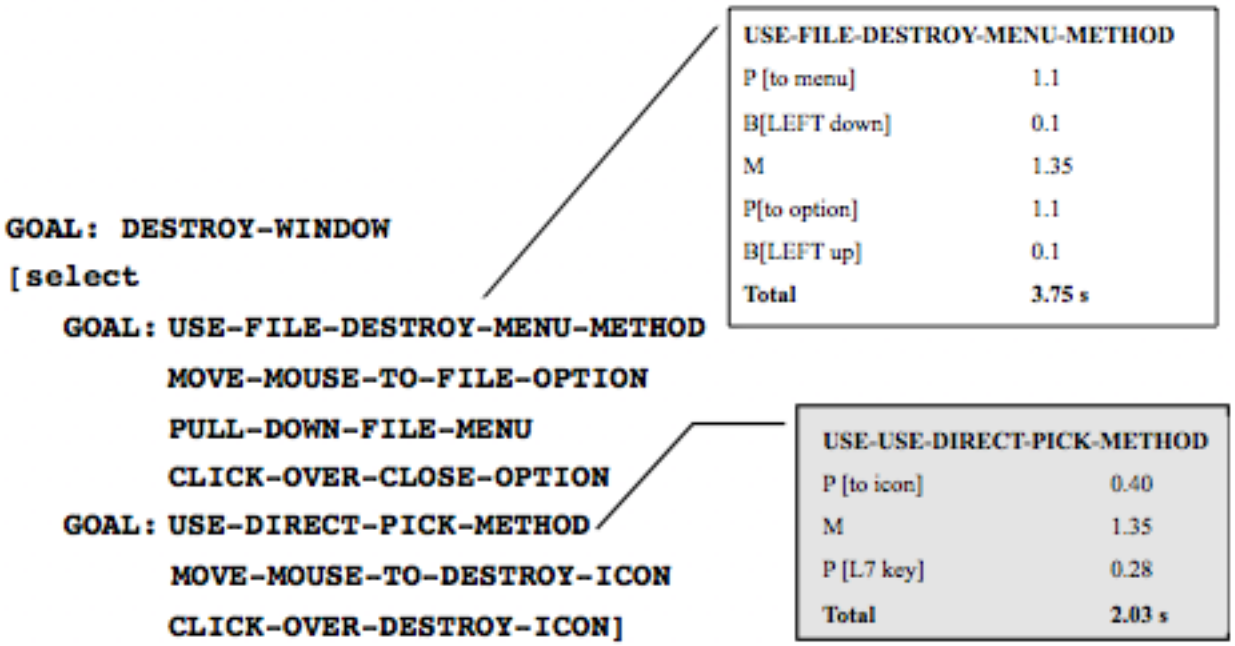
- The natural movements used for performing tasks are constantly radically shifting paradigms and idioms, and have thus created a difficulty in efficiently calculating operation time.
- We begin to identify the sequence of interactions we have to perform within a certain GUI and compare them with what we really want to do.
- In this sense, we introduce the concept of modular, manipulative virtual objects while interacting with the Operating System (Windows, Android, iOS, Linux, OSX etc.) or the working environment (e.g. Gmail).

- e.g. Steps for sending an email via a web-interface



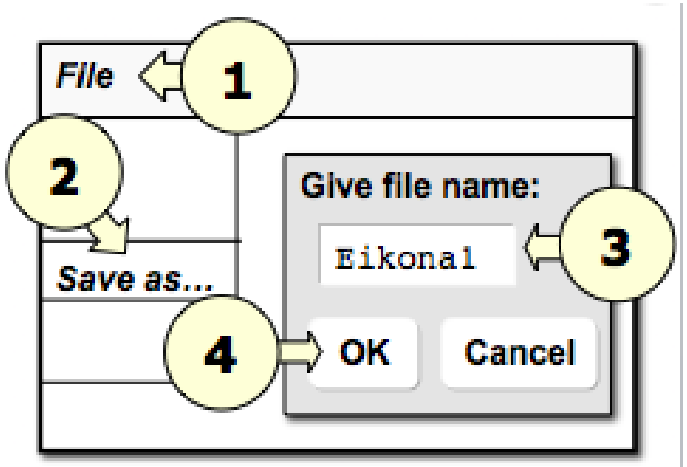
Run-time Evaluation

- Example, in a classic PC Operating System estimate operating time in seconds for destroying a window:



Run-time Evaluation: an example

- The user grabs the pointing device (T_H)
- He mentally prepares himself for action (T_M)
- He moves the cursor upon menu bar item "***File***" (T_P) and launches the menu (T_K)
- He chooses from the menu (choose == quick mental calculation + movement of the cursor upon "***Save as***" + press on the button $T_M + T_P + T_K$)
- …



$$T_0 = T_H + T_M + T_P + T_K + (T_M + T_P + T_K) + T_R + T_M + T_H + 8 * T_K + T_H + T_P + T_K =$$
$$0{,}40 + 1{,}35 + 1{,}10 + 0{,}28 + (1{,}35 + 1{,}10 + 0{,}28) + 0 + 1{,}35 + 0{,}40 + 8 * 0{,}28 + 0{,}40 + 1{,}10 + 0{,}28 \text{ sec} = 11{,}36 \text{ sec.}$$

TAKD

- Example: Describing interaction with kitchen objects using TAKD (Task Analysis for Knowledge Description)

```
kitchen object XOR
|__  preparation XOR
|     |__  pre-preparation XOR
|     |     |__  opening
|     |     |          tin opener, cork screw
|     |     |__  measuring
|     |                scales, (measuring) jug
|     |__  'proper' preparation XOR
|          |__  active
|          |          rolling pin, cook's knife, (cook's)
spoon
|          |__  passive
|                     mixing bowl, chopping board
|__  cooking XOR
|     |__  passive
|     |          teapot
|     |__  active XOR
|          |__  external power
|          |          saucepan, frying pan, casserole, baking
tray
|          |__  internal power
|                     (electric) kettle
|__  serving XOR
      |__  serving
      |          fish slice, (serving) jug, ladle
      |__  eating XOR
           |__  active
           |          spoon, fork, knife}
           |__  passive XOR
                |__  food
                |          egg cup, soup bowl, plate
                |__  drink
   |      mug, glass
```

Language Models & Grammars

Languages & Grammars

- Their use primarily concerns the description of Interaction using sets of productive rules.
- The “grammar” in use defines which sequence of events is valid or correct within a certain language
- Variants of this model:
  - Cognitive Grammars

    They help in understanding the creation of new metaphors

  - Task Action Grammars (TAGs)

Languages & Grammars, too

- The new era of mobile devices brings into consideration the flaws of the cognitive approach.
- At the implementation level Languages and Grammars were somehow lacking practical applications for the world of mobile devices.
- It is possible however to transfer the old model, somewhat altered, to portable devices.

Cognitive Complexity Theory

- Use inference rules
  - *If - Then* decision trees
  - Complexly linked operations
- Competence and capability
  - Comparison with functional working systems
- Performance
  - It measures cognitive load and mental processing requirements

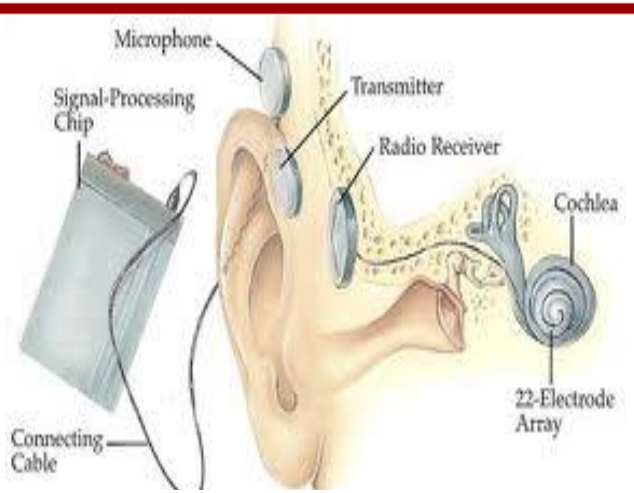
Alternate Models

Alternate Models Theory *(1/2)*

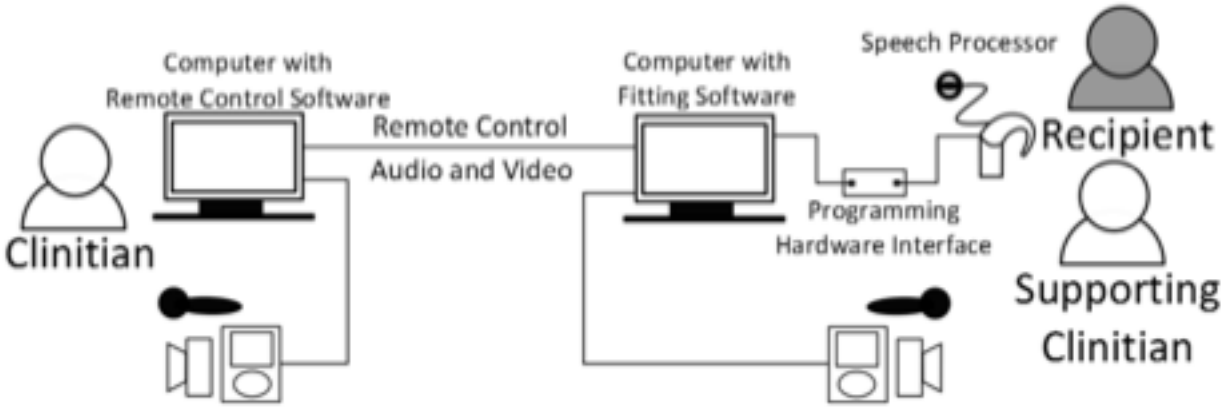
- Theories concurrent with the desktop metaphor evolution that adopt approximations from the field of social sciences
  - Activity Theory (Bodker, 1989 & 1991)
  - Distributed cognition (Hutchins, 1995)
  - Situated action models (Shuchman, 1987)
- Their common substrate is **context**
  - i.e., the broader social environment influencing the interaction of users with systems.
- They emerged as a response to:
  - the shortcomings of traditional approaches
  - understanding new phenomena (mobile devices)
- They are based on developmental social sciences like
  - Anthropology , sociology ... .
- The user interaction with a computer system obtains a degree of complexity
- They promote the the comparative study of human societies and cultures trying to correlate social phenomena with the massive technological transfer that boosts the Interaction profile of the average user.

Alternate Models Theory *(2/2)*

- Distributed cognitive models:
  - Thus far, the Interaction Models used focused on the Interaction of a sole user with the computing system in front of him.
  - These models are enhanced to include “cloud” and mobile structures over the Internet.
  - There coexist multiple cooperating actors with broadband communication.

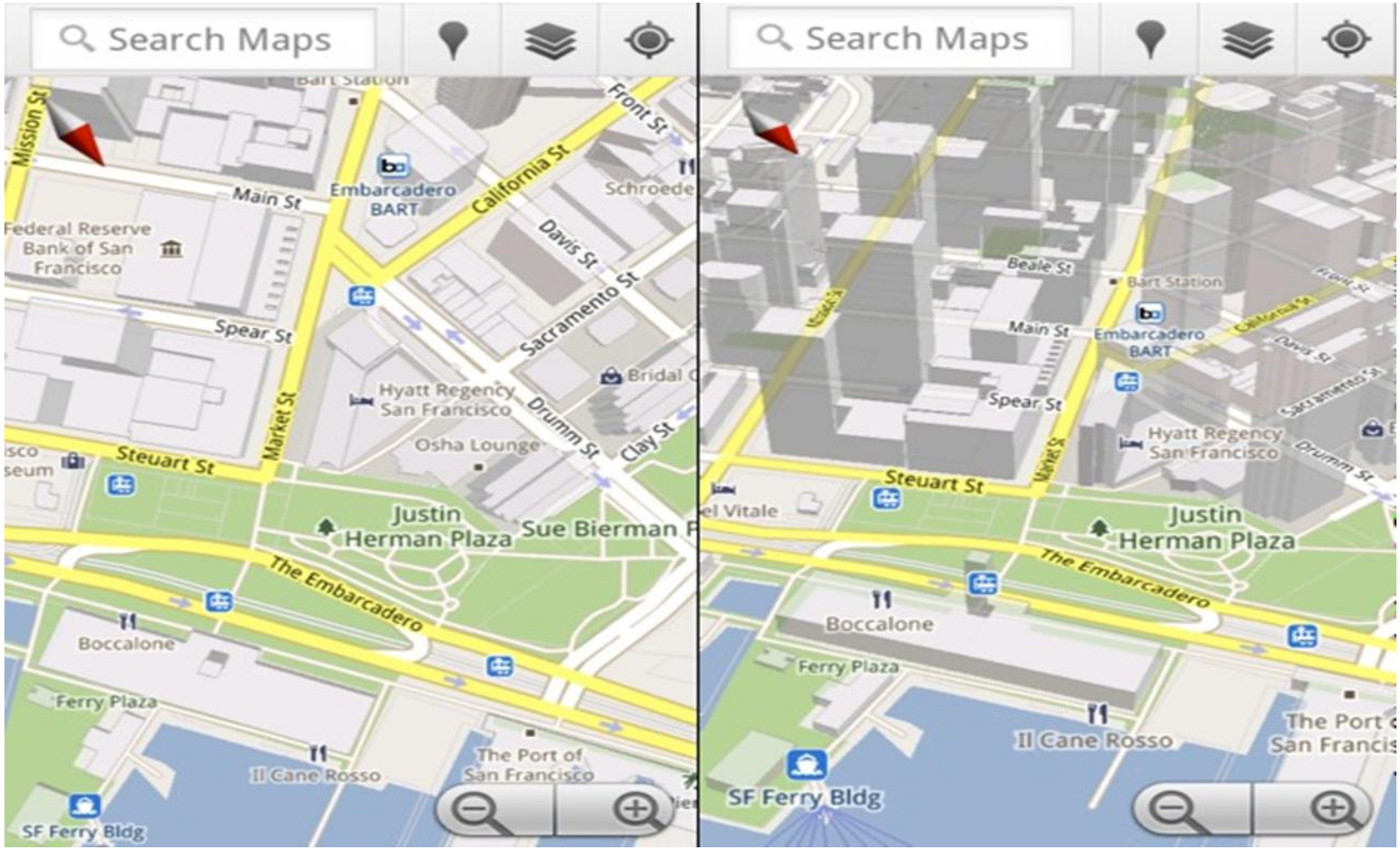


. *Remote cochlear implant programming setup*



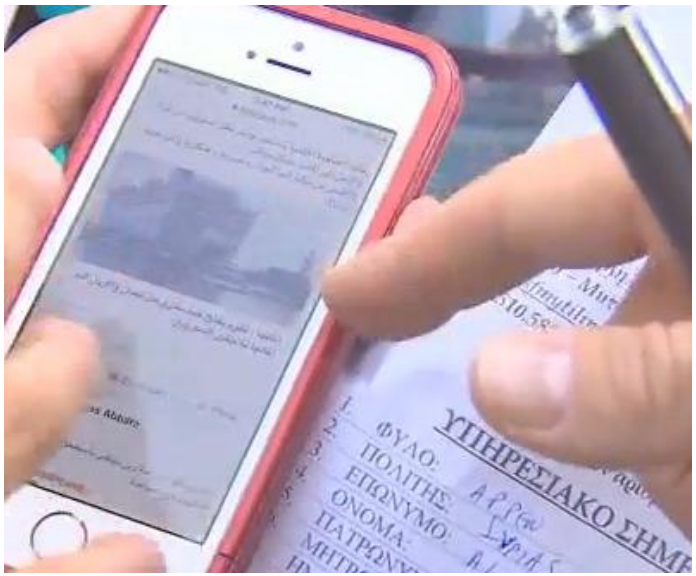
Google 3D maps

- Context oriented models, applicable with remarkable success especially in the mobile world…



Maps in general …

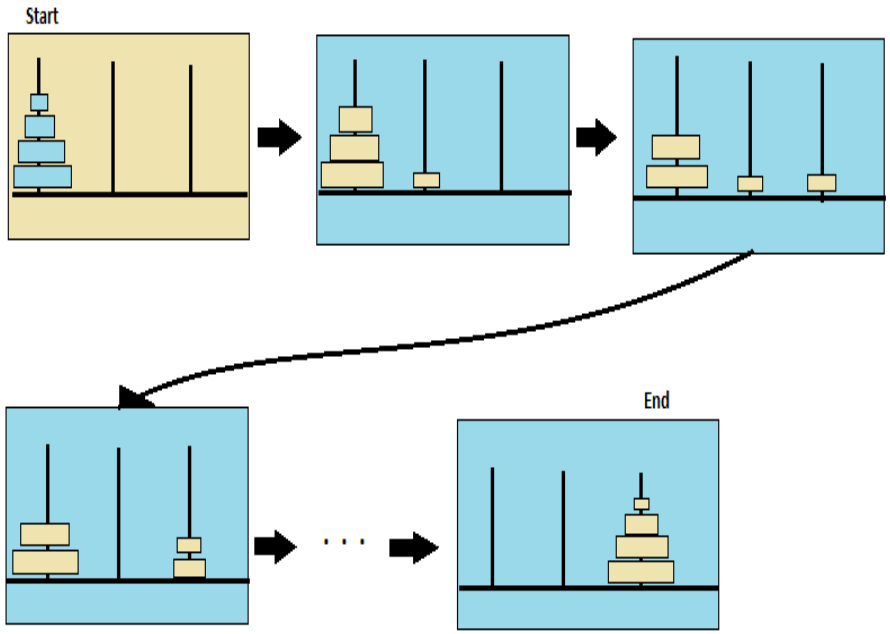
- Context oriented models, applicable with remarkable success especially in the mobile world…



How all these convey to Human-Centered Learning?

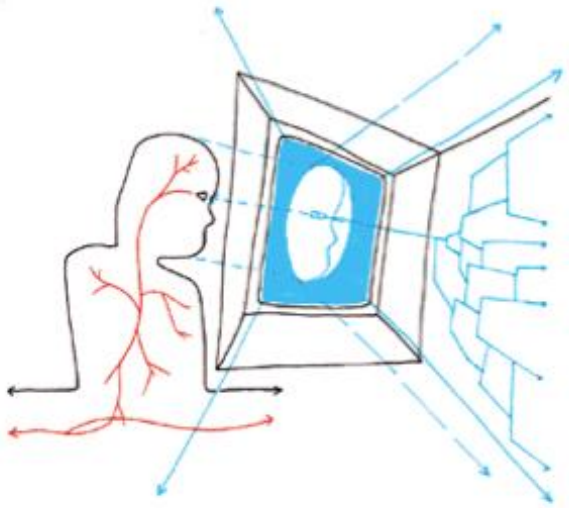
Hanoi towers

- HCI promotes descriptive multimedia explanations of the encountered problems in an attempt to stimulate algorithmic problem solving operations.



Knowledge distribution

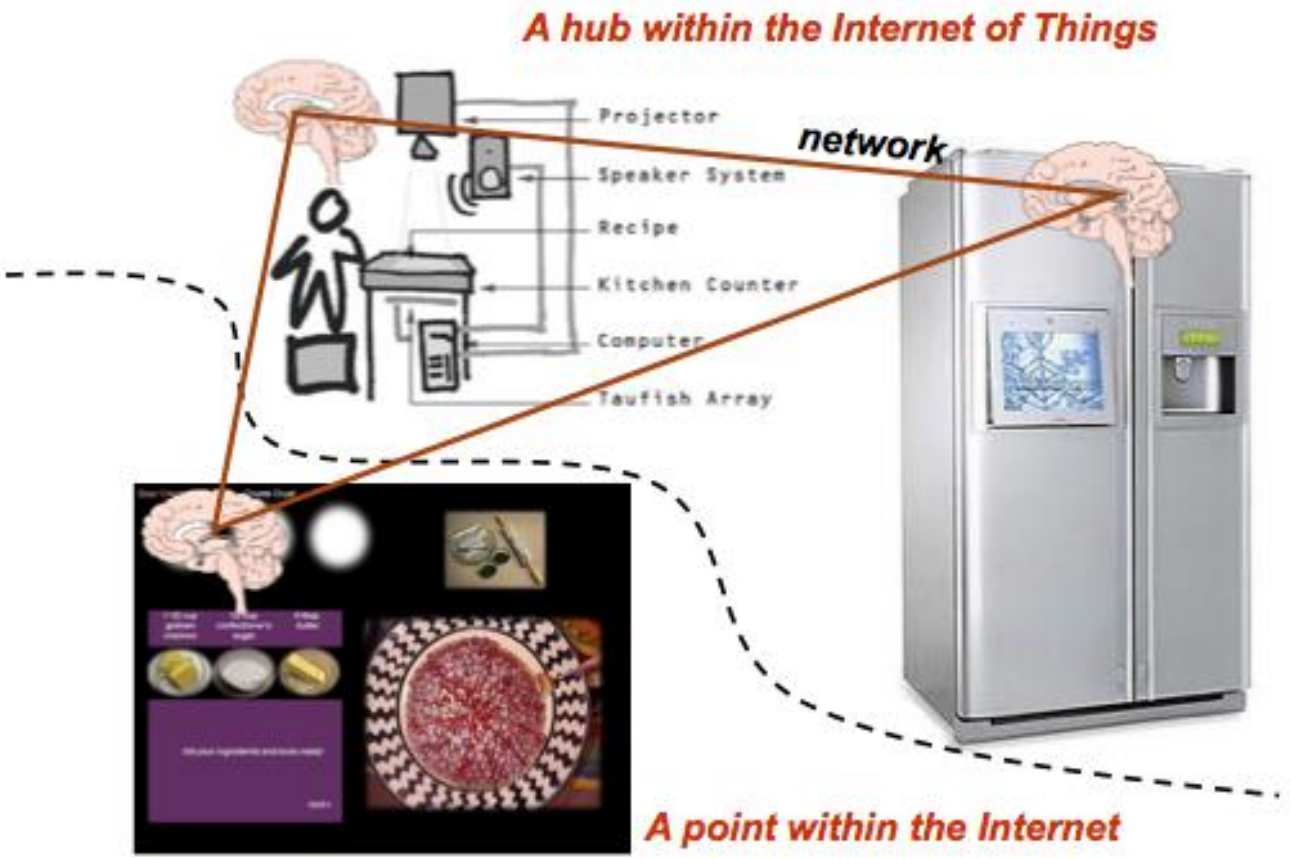
- Web 3.x development and ubiquitous penetration creates a conceptual network of three spaces that manipulate information and create constantly new knowledge:
  - ❖ The physical space
  - ❖ The conceptual space
  - ❖ Cyberspace



- Cyberspace outweighs the other two areas, having though a serious drawback:
  - It is not always easy to assess the wealth of knowledge provided by the billions of interconnected clients, servers, computer networks and Internet of Things hubs.

A Worldwide Spread Cognitive System

- A decisive step towards a knowledge society.



TAKD *(revisited)*

- Recall the example: Describing interaction with kitchen objects using TAKD (Task Analysis for Knowledge Description)

```
kitchen object XOR
|__  preparation XOR
|     |__  pre-preparation XOR
|     |     |__  opening
|     |     |          tin opener, cork screw
|     |     |__  measuring
|     |                scales, (measuring) jug
|     |__  'proper' preparation XOR
|           |__  active
|           |          rolling pin, cook's knife, (cook's)
spoon
|           |__  passive
|                      mixing bowl, chopping board
|__  cooking XOR
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|     |          teapot
|     |__  active XOR
|           |__  external power
|           |          saucepan, frying pan, casserole, baking
tray
|           |__  internal power
|                      (electric) kettle
|__  serving XOR
      |__  serving
      |          fish slice, (serving) jug, ladle
      |__  eating XOR
            |__  active
            |          spoon, fork, knife}
            |__  passive XOR
                  |__  food
                  |          egg cup, soup bowl, plate
                  |__  drink
                     |      mug, glass
```
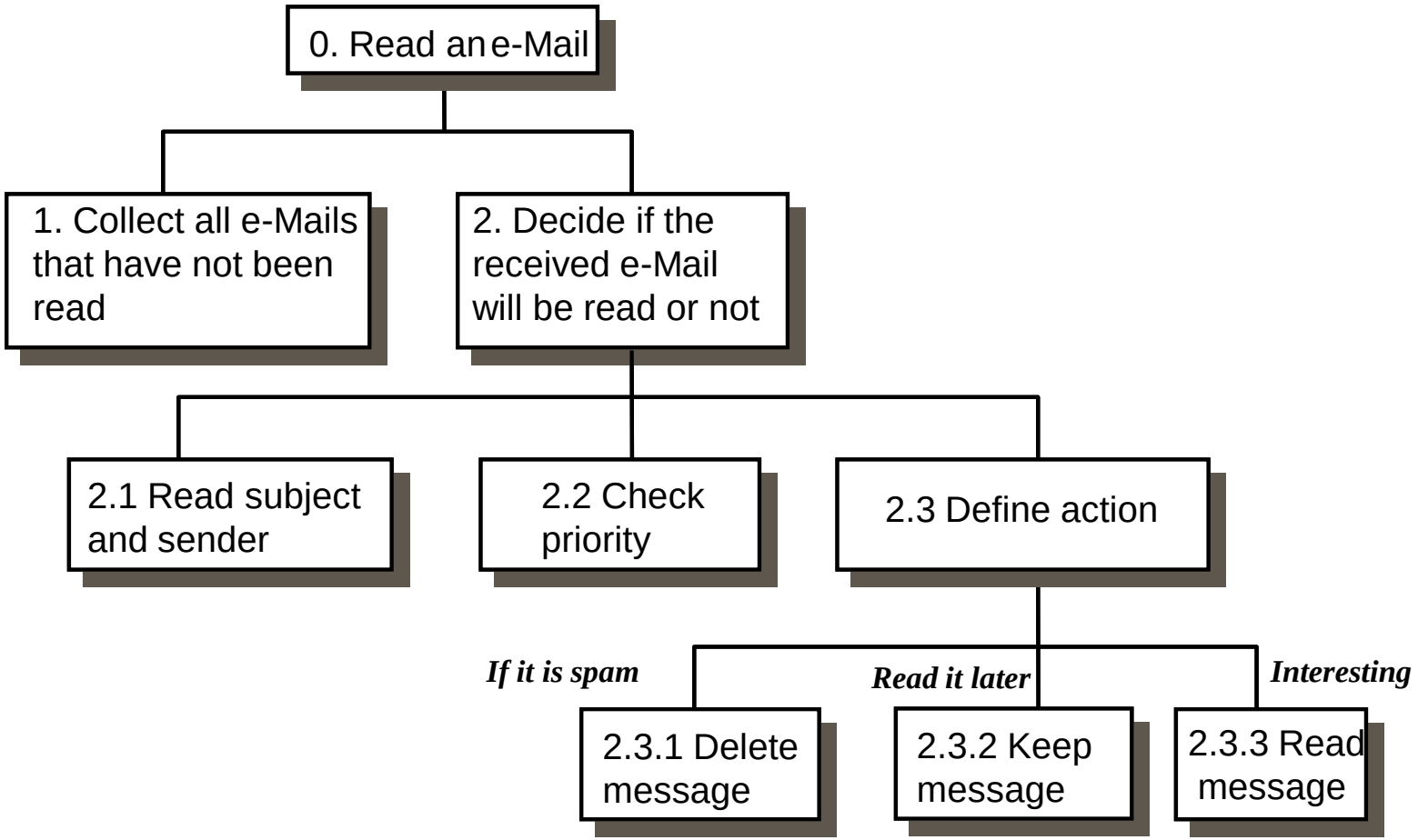
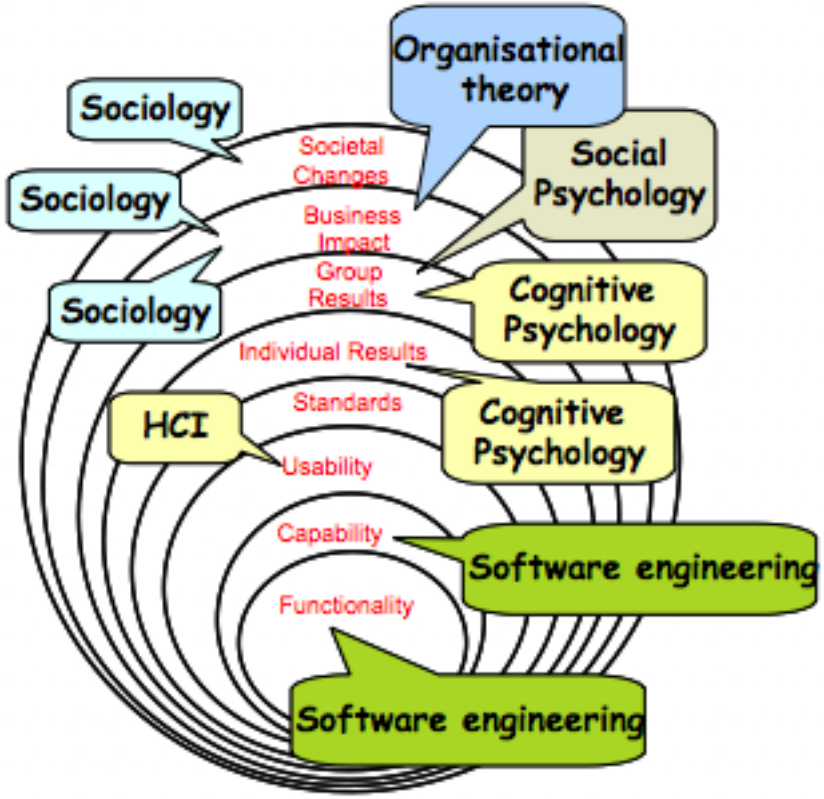

A Model for an e-Mail Application

- Applying Hierarchical Task Analysis (HTA) for reading e-Mail



From Interfaces to Interactions

- As Cyberspace gets bigger and bigger both in physical dimensions and notional, cognitive load…
- HCI methods, procedures and techniques are redesigned …
- We decisively move ahead "**From Interfaces to Interaction**"



In practice, in action …

New requirements are set for designers

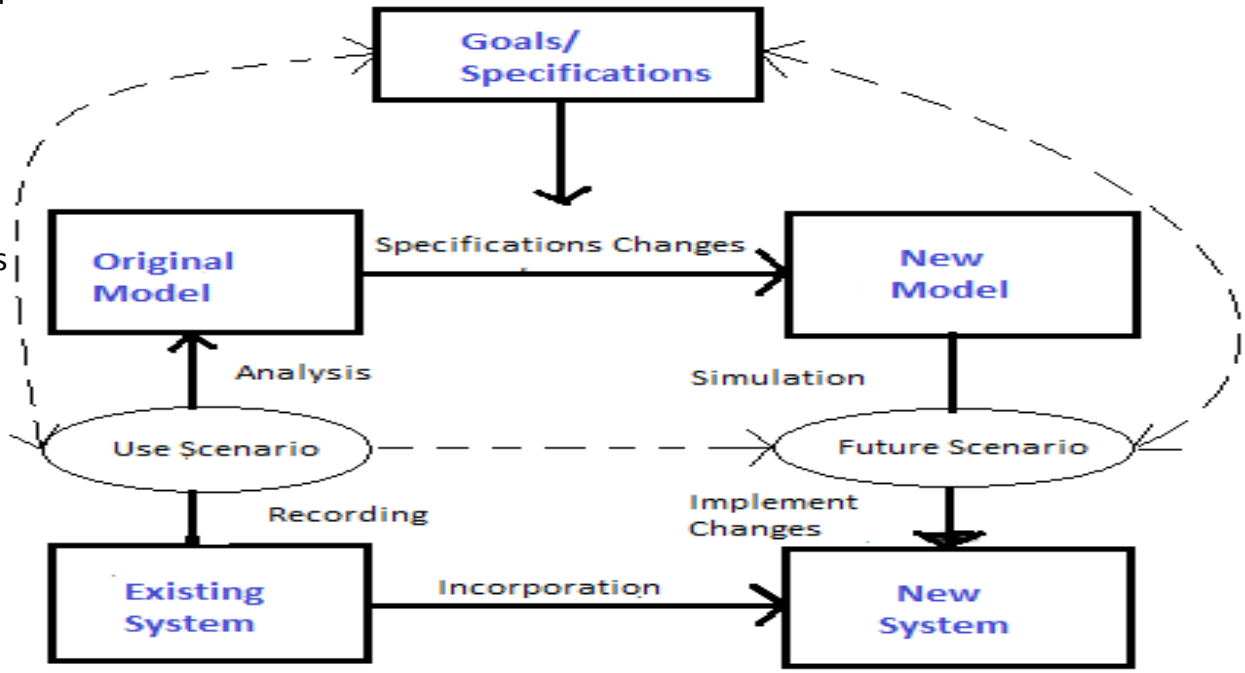
- From the laboratory to the actual workplace
- From monitoring instead of guided, passive users, independent or active users
- From studying standalone users to monitoring groups and online communities

Goals and objectives change

- Research focuses on user systems adaptability instead of merely monitoring how users adjust to new conditions
- The industry targets user satisfaction and not only increased user productivity

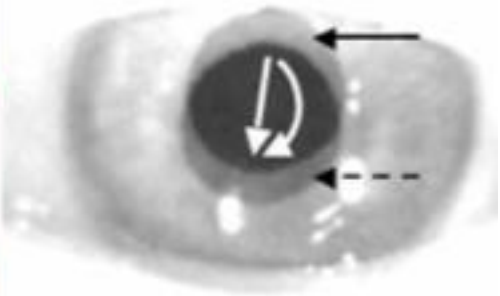
Participatory Design

- It includes a set of procedures through which different groups (social partners - public) and stakeholders work together to reach a formulation of visions and projects and in their implementation.
- Participatory planning processes can have multiple targets with various modes of communication, and actions for decision.
- Those involved in a planning process have their own targets based on political, cultural and economic factors.
- Individual partners should exchange information , explore common areas and reconciled in a joint effort to find ways to reduce the extent and intensity of disputes.



Goals

- Qualitative improvement of the working space which involves the extended use of new technological tools
  - E.g. Improvement of university courses using video recordings
- Consolidation of infrastructure and services by:
  - cooperation
  - co-decision
  - shared responsibility
  - application in high value-added learning spaces
- E.g., medical training and instruction



Tools & Techniques

- Abstract Scenarios:

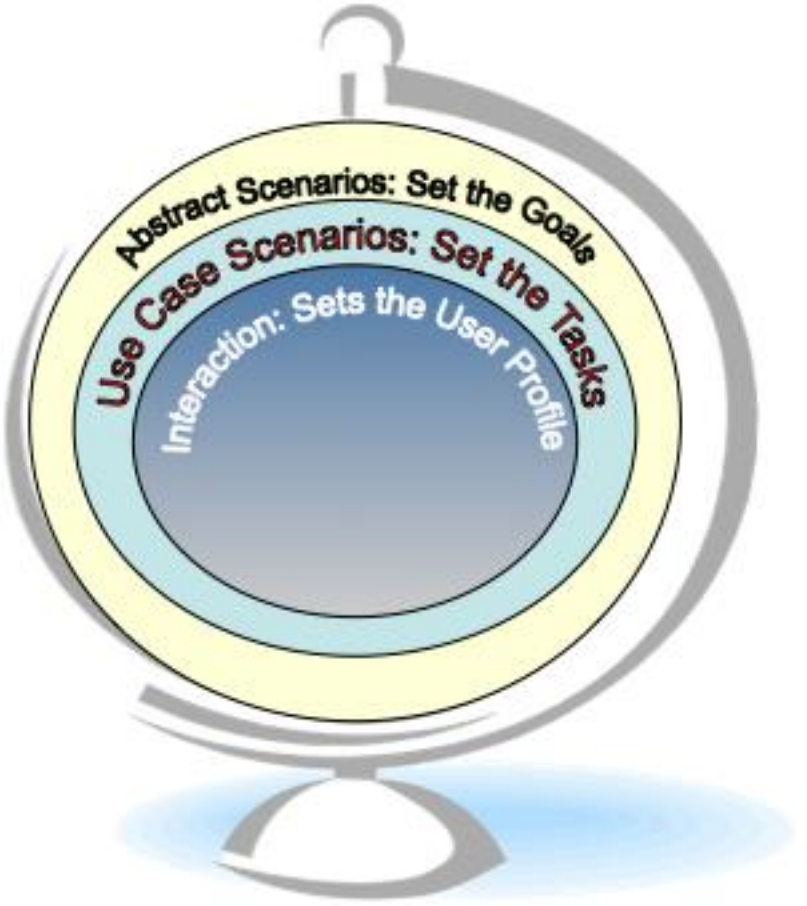
  Task analysis using data from ethnography, interviews with users, mutual sharing of experiences via recordings, prototypes and prototypes and mock-ups.

- Use Case Scenarios:

  A detailed list of actions or steps that define the interaction between the user and the system, typically using UML or some other modeling language.

- User Interaction Profiles:

  Sets the user profile in an attempt to establish a policy within the user community. Very particularly timely for the Android market, etc.



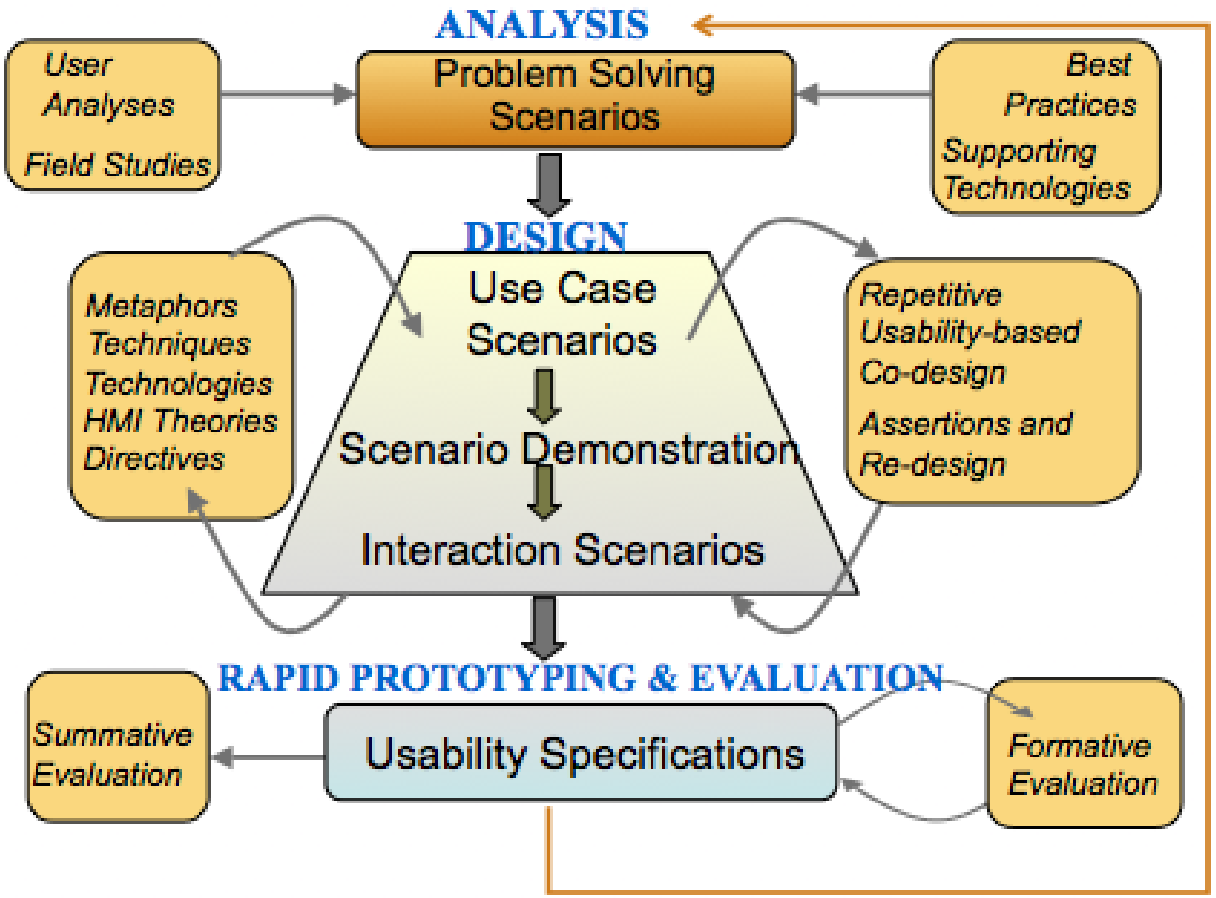
Empirical and Analytical scenario approach

- Combining analytical and empirical approaches
  - Inventory and mapping of existing conditions (problems) use
  - Study of new practices resulting from new or improved system .

Scenario Types

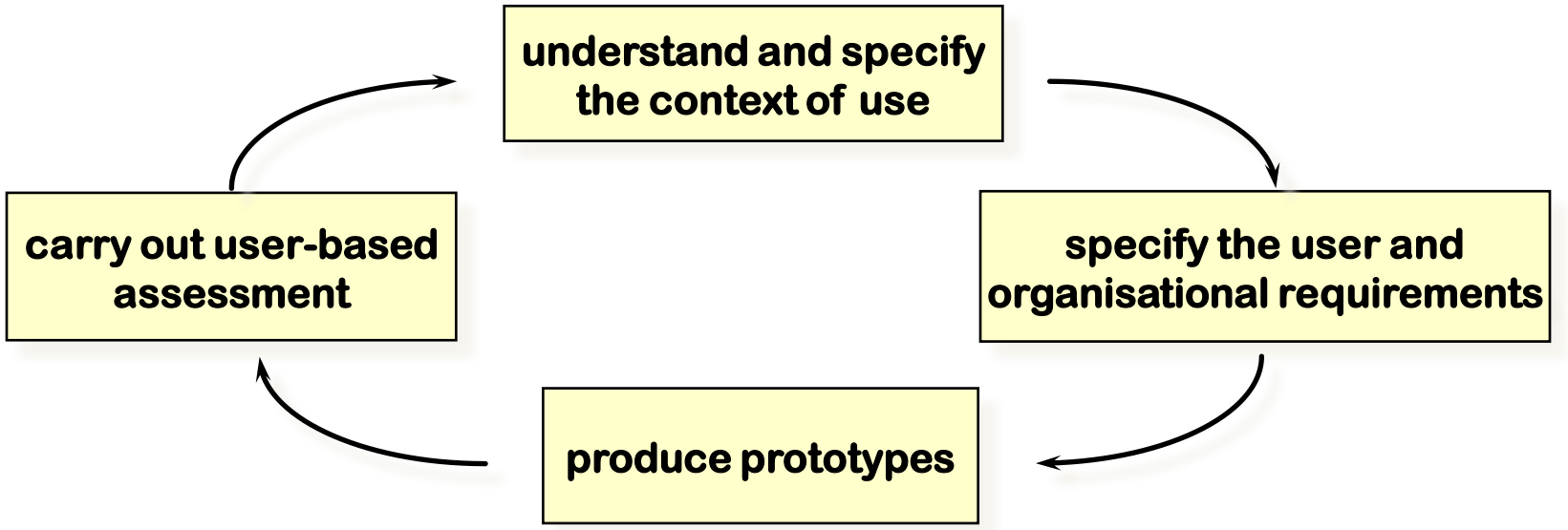
- Abstract scenario
  - Objectives of the system is asked to implement
- Use case scenario
  - Functionality required
  - Users encountered
- Interaction scenario
  - Using system by certain operators under certain conditions

A model proposed by Carol et al.



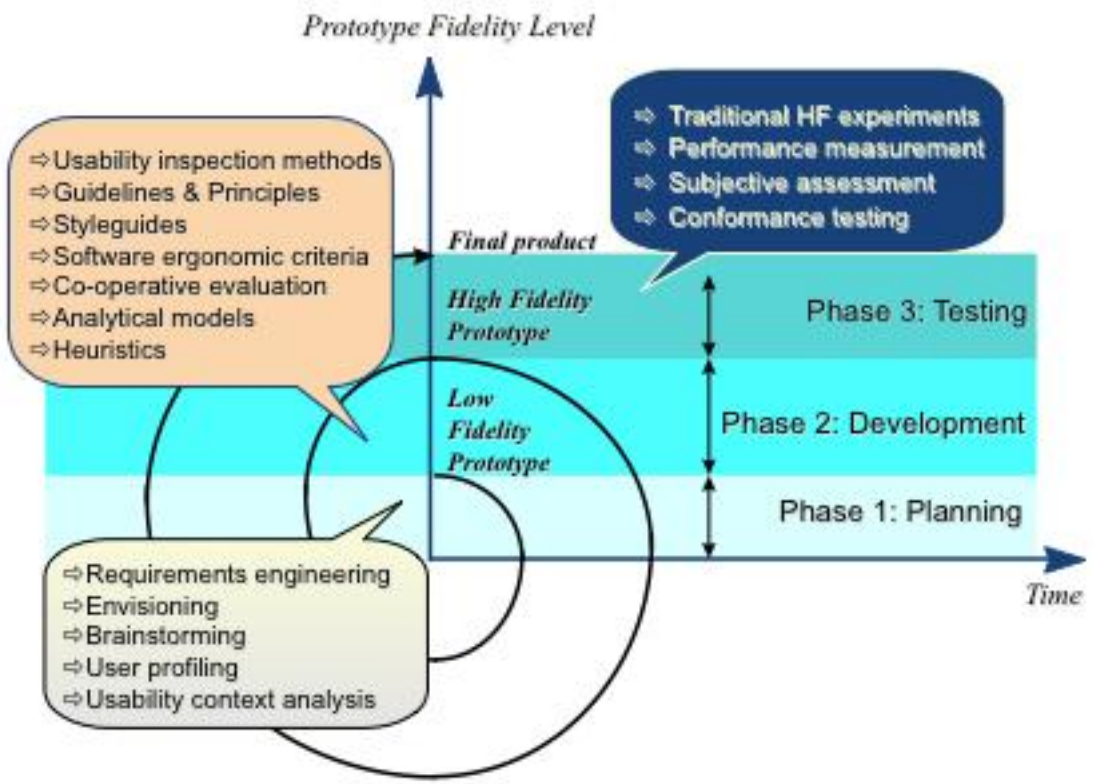
Human Centered Design

- The system focuses on the users of the system and the tasks they perform from the early phases of System Design and Development.
- In all design phases, User Interaction is evaluated, based on virtualizations, simulations and comparisons with existing prototypes.
- Evaluation is performed over repeated exposures.



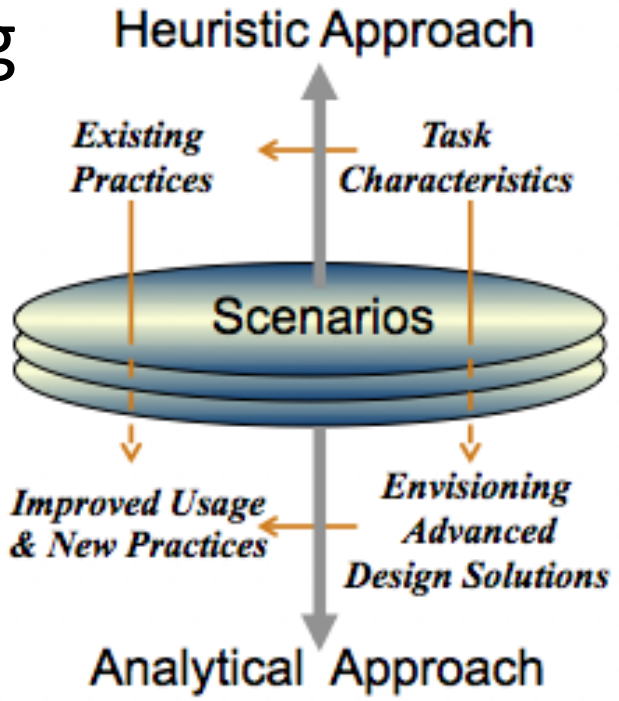
Model development scenarios

Human centered design in a nutshell:



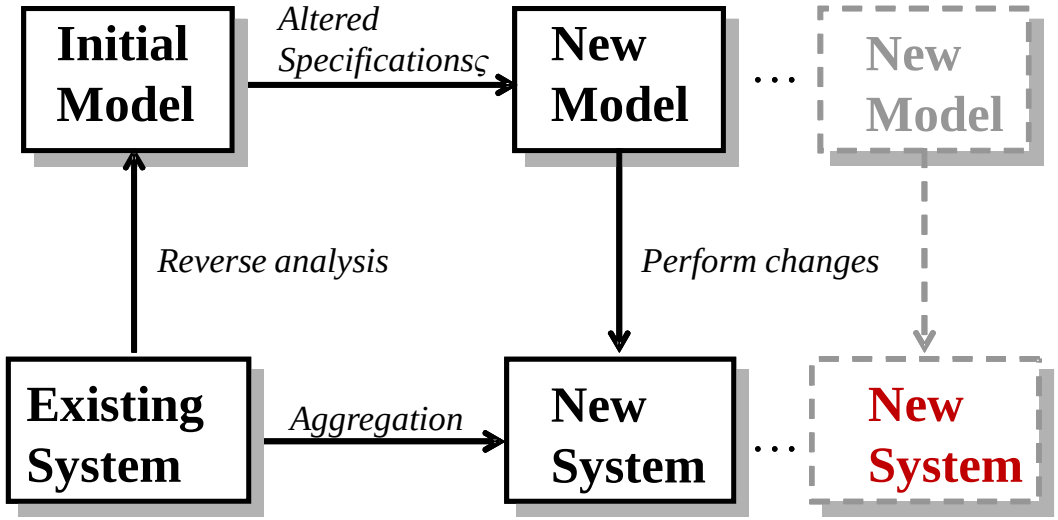
Life cycle scenario

- Lifecycle software engineering involves:
  - Requirements analysis
  - Information design (according to the scenarios used)
  - Interaction design



Overall: Life Cycles

- For human-centered design. Scenarios give the evolutionary phases of the development of a system:
  - They record
    - The existing system
    - Its use
    - Its problems
  - They define the new system's requirements
  - They aggregate design solutions, rapid prototyping and development as we move towards the new system.

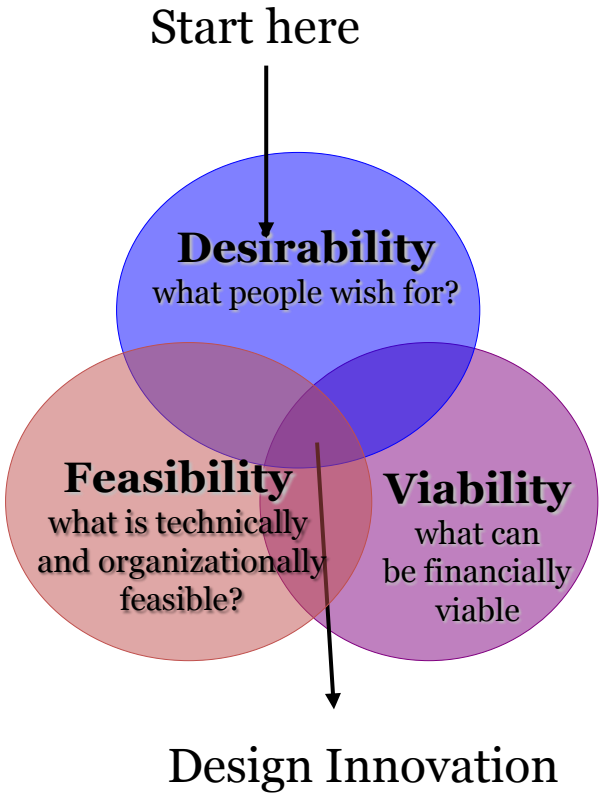


Human-Centric Models

- Overall: Human-centric models enjoy wide acceptance
- They affect the design processes and development stages of systems by providing technological, cognitive and organizational flexibility.
- Within this “anthropomorphic” approach:
  - Designing interactive products involves giving them human-like qualities
  - The design of interactions may be performed:
    - By cooperative design, which involves both the programmers and users of a system
    - By participatory design, which relies on cooperative design giving emphasis somehow on the user’s point of view
    - By contextual design, which pays great attention on user characteristics like ethnographic data, cultural data, social data etc.
  - Programmers are expected to design the complete flow of user interaction with the device
    - In practice: Task Organization; Task Content; Task Details; Communication and Coordination between Task Flows, etc

Human-centered design

- The solutions that emerge from human-centered design offer design innovation that promotes characteristics based on user experience and emotional connections, technological feasibility, and marketplace orientation.



Measurable Usability Factors

- Effectiveness
  - What is the completion of a task, i.e. the extent of integration of the HCI activities.
  - What is the quality effect of interaction.
- Efficiency
  - The ratio of useful work to resources used
  - In HCI the error rate is important, i.e. the completeness of the goals achieved.
- Subjective satisfaction
  - Qualitative analysis of user attitudes and opinions.
  - Gives a human bias over different interfaces, approaches and materials. It is emphatically timely in the mobile computing market.

Conclusions

- The human-centric design is the most renowned design process in HCI.
  - It focuses on usability.
  - It helps programmers understand how people will use systems or products, thus, orienting the production design lines to trace universal human needs and learning principles.

End of the 4th Lecture

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