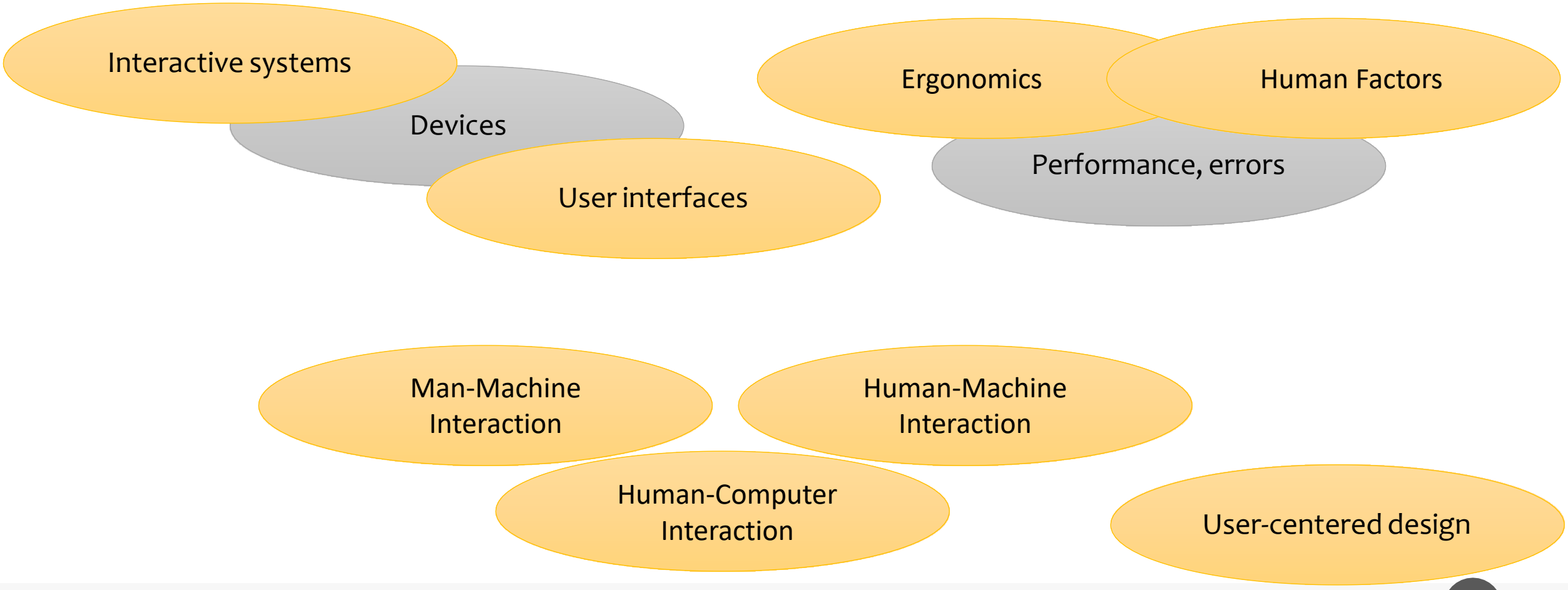
What is HCI?

Human Computer Interaction

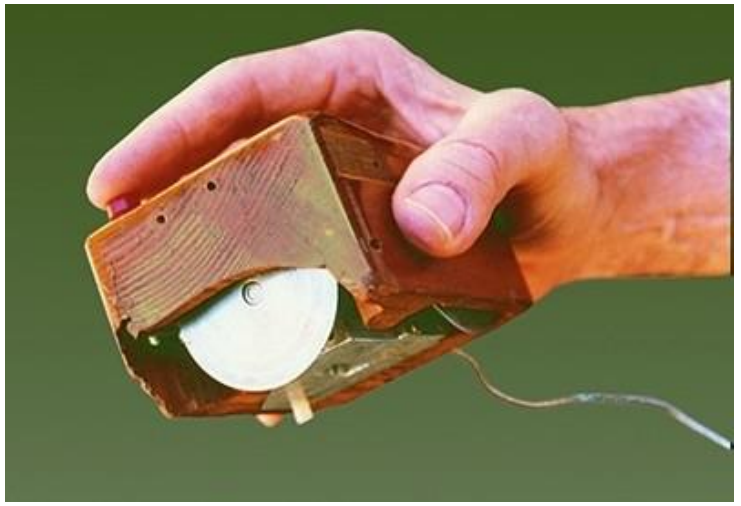
Goals

- What is HCI?
- What is usability?
- What are the Interaction Design processes, and how does they relate with Software Engineering processes?
- What is meant by User Centered Design?

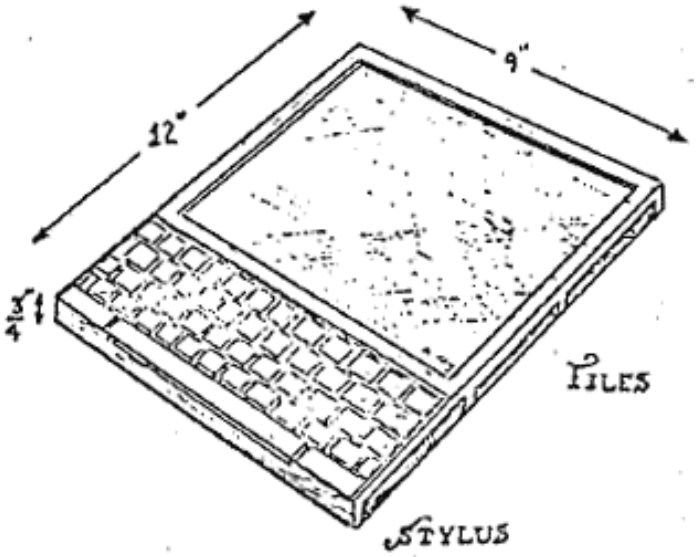
Interconnected Concepts, and Evolution



Human-Computer Interaction… In Brief

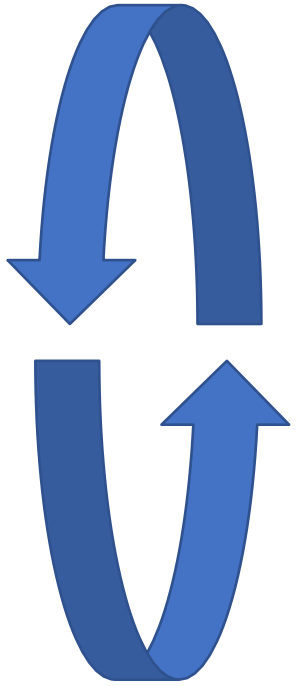


- A multi-disciplinary field
- Concerned with the **design, evaluation,** and **implementation** of interactive computing systems for human use
  - and with the study of **major phenomena** surrounding them
- Involves two *entities* (the human and the computer) that determine each other behavior over time
  - framed in terms of humans' **goals** and related **tasks/pursuits**



HCI Is Multidisciplinary

- Psychology and cognitive science
  - User perceptual, cognitive and problem-solving skills
- Ergonomics
  - User's physical capabilities
- Sociology
  - Understanding the wider context of the interaction
- **Computer Science and Computer Engineering**
  - **Building the necessary artifacts (HW, SW)**
- Business
  - Satisfying market needs
- Graphic design
  - Produce an effective interface presentation
- Technical writing
  - Documentation, manuals, on-screen content
- …



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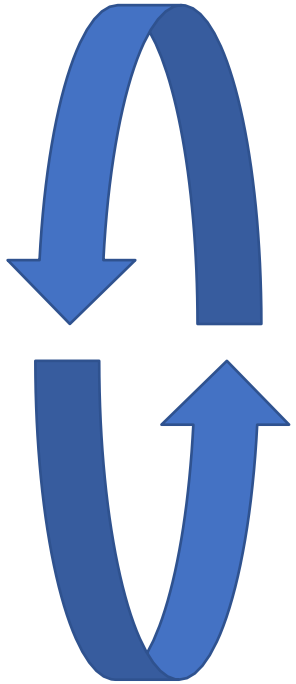


To help us in applying expertise from many different fields:

- Design methods and processes
- Models
- Heuristics
- Best practices
- Conventions
- Experiments and user studies

The Goal of HCI

Ingredients

- The **User**(s)
- The **Computer**(s)
- The **Task**(s) to be accomplished

Goal

- The system must support the user's **task,** with a focus on its **usability**
  - Useful
  - Usable
  - Used

The Ingredients

The human

- Sensory systems
  - Visual
  - Auditory
  - Haptic
  - Spatial
- Acting systems
  - Hands
  - Voice
  - Head, Body, …
- Cognitive processes
  - Perception
  - Memory

The computer

- Input peripherals
  - Keyboard, mouse
  - Trackpad, trackball
  - Touch surfaces or screens
  - Microphone
  - Sensors
  - Card readers
  - …
- Output peripherals
  - Screen
  - Audio (voice, sounds)
  - Haptics
  - VR/AR headsets
  - …

History of HCI

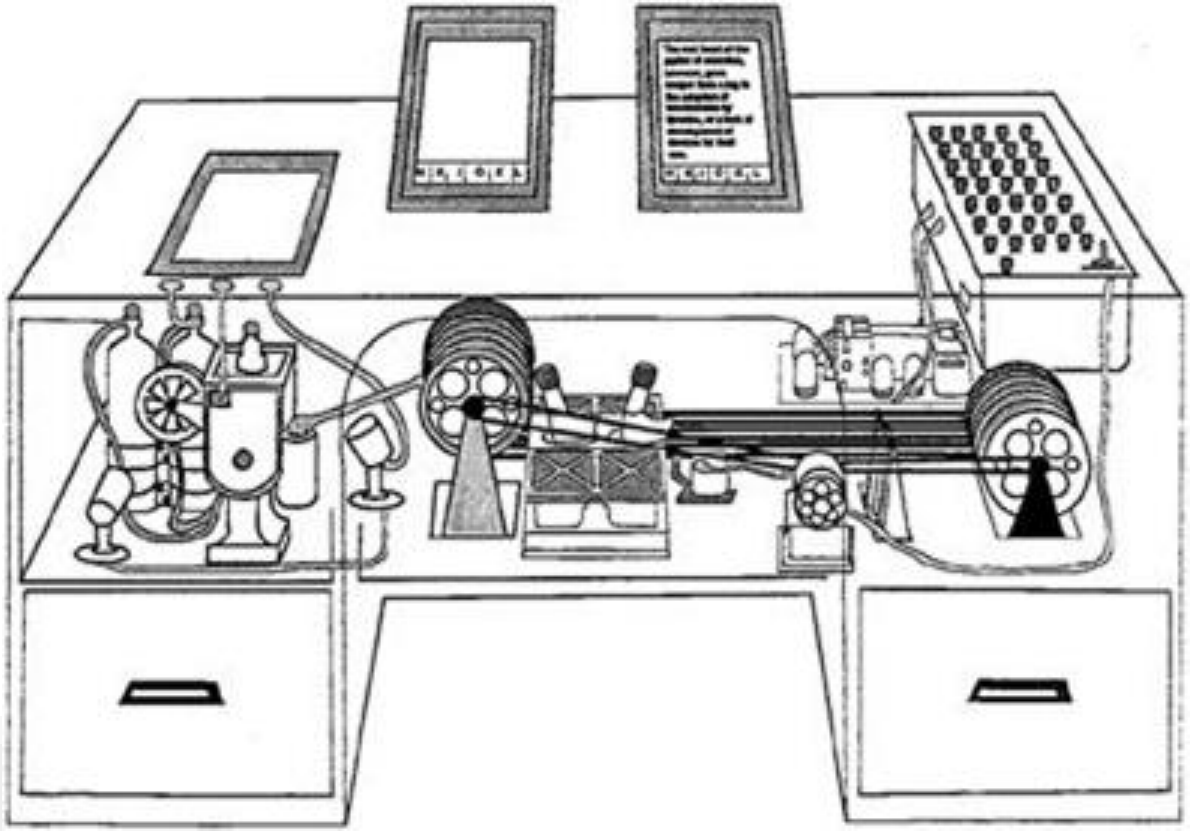
Vannevar Bush

As We May Think

The Atlantic Monthly

1945

Memex



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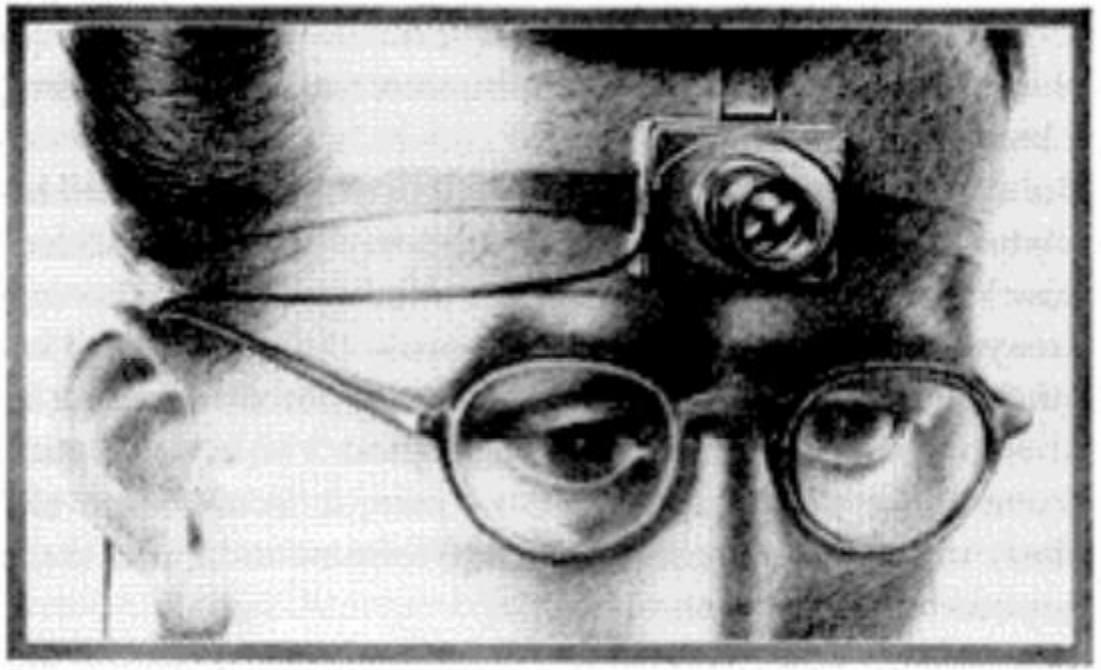
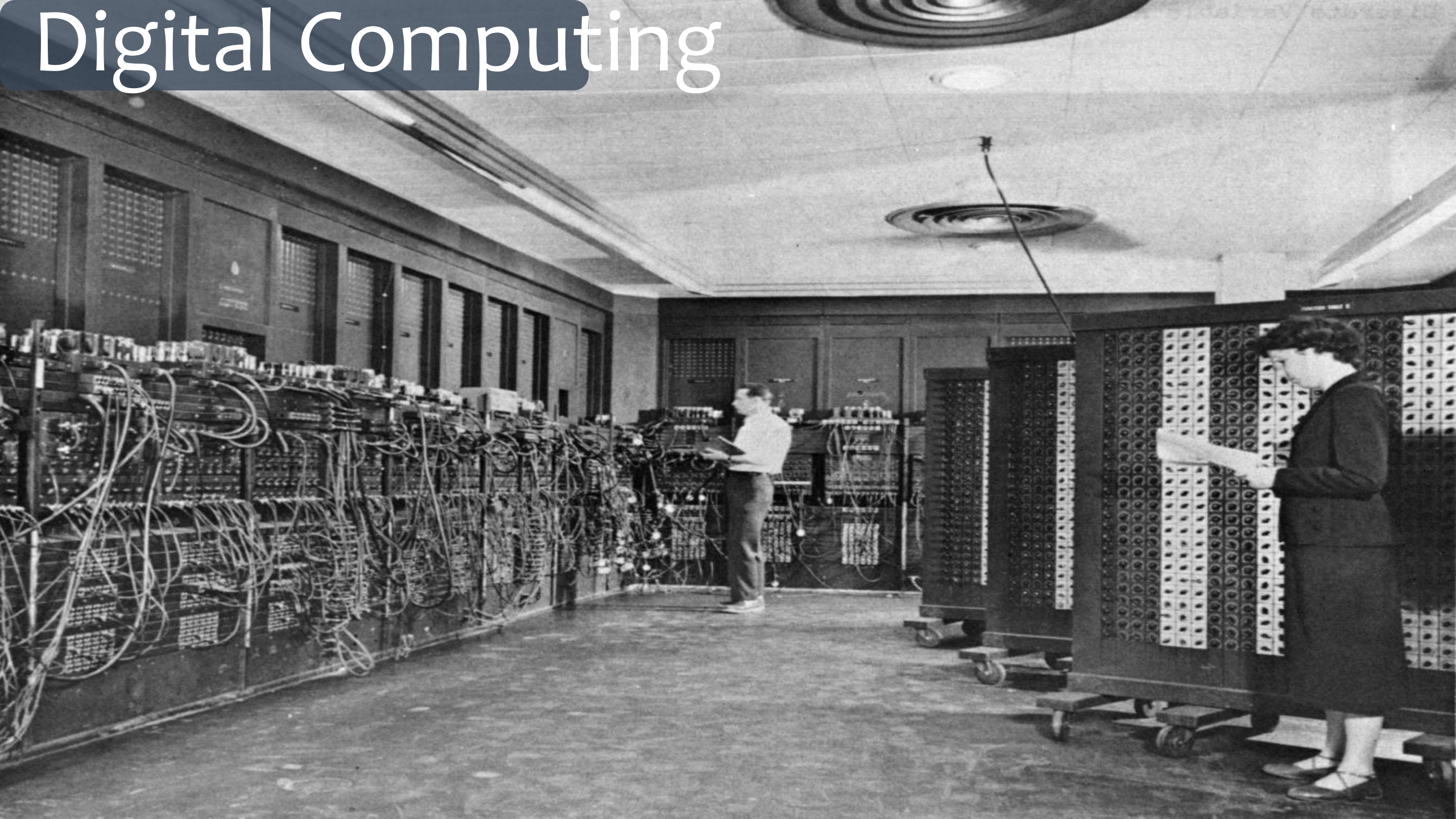


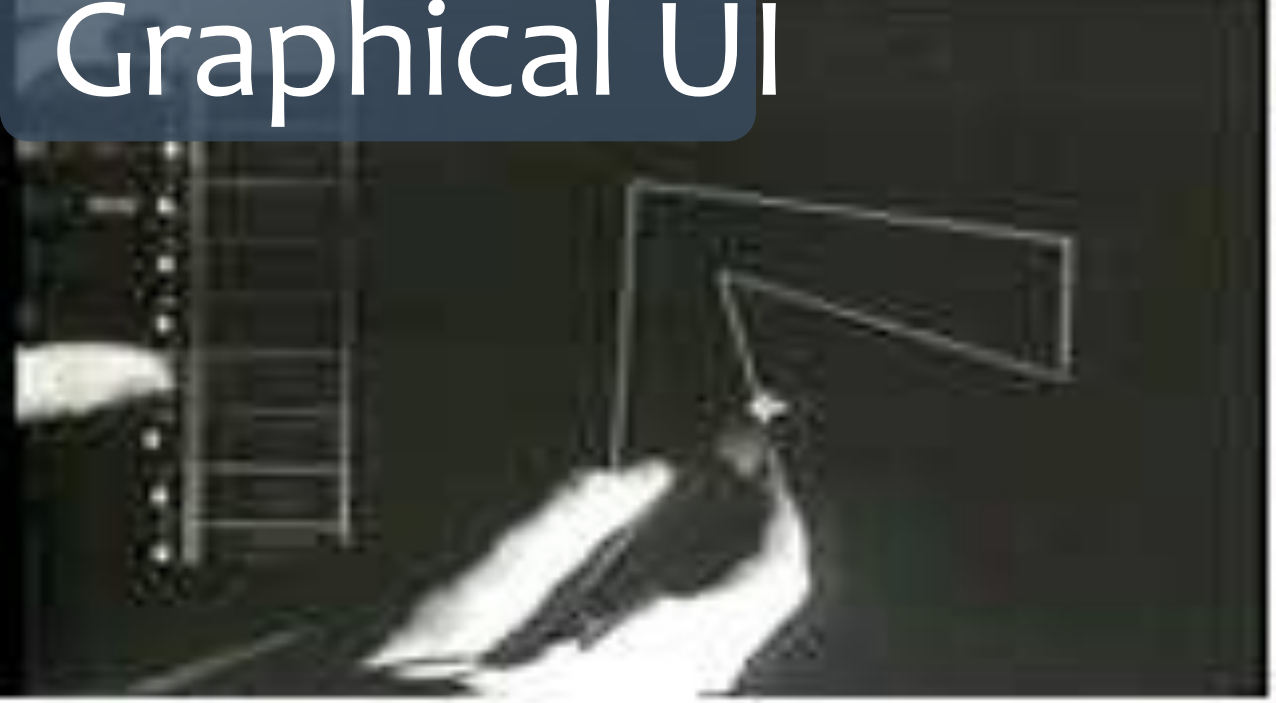
A scientist of the future records experiments with a tiny camera fitted with universal-focus lens. The small square in the eyeglass at the left sights the object (*LIFE* 19(11), p. 112).

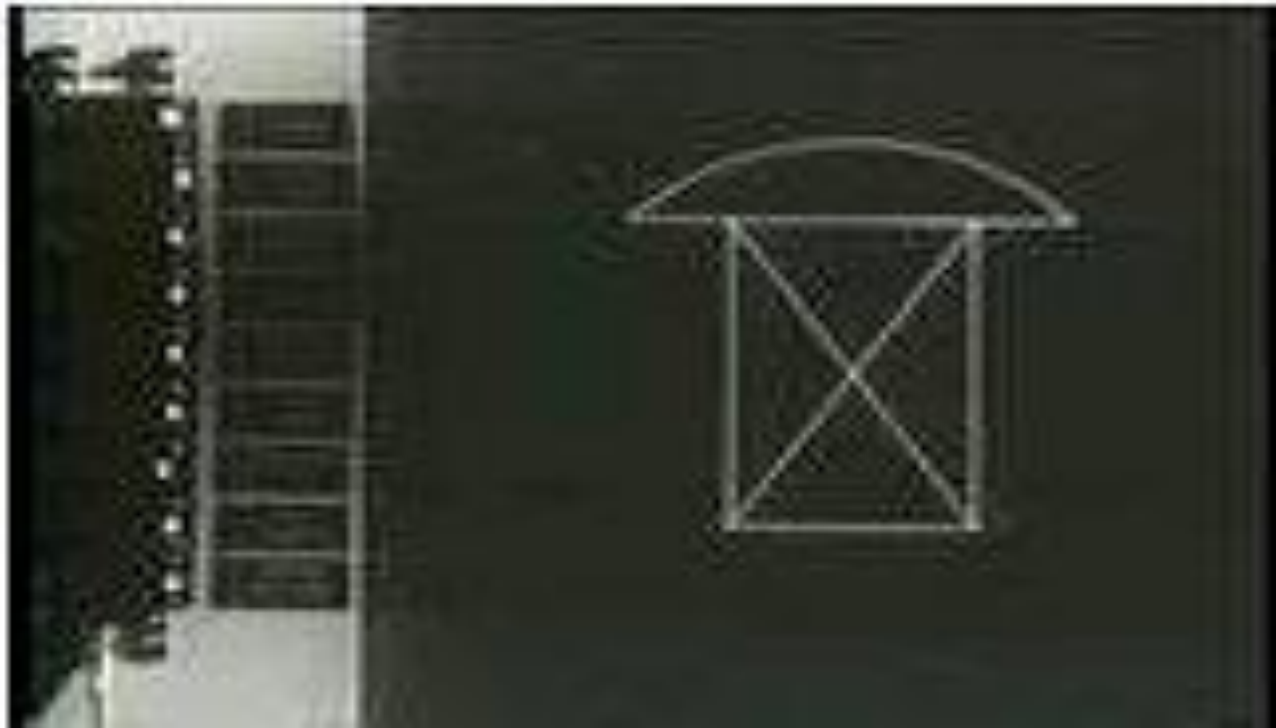
Digital Computing



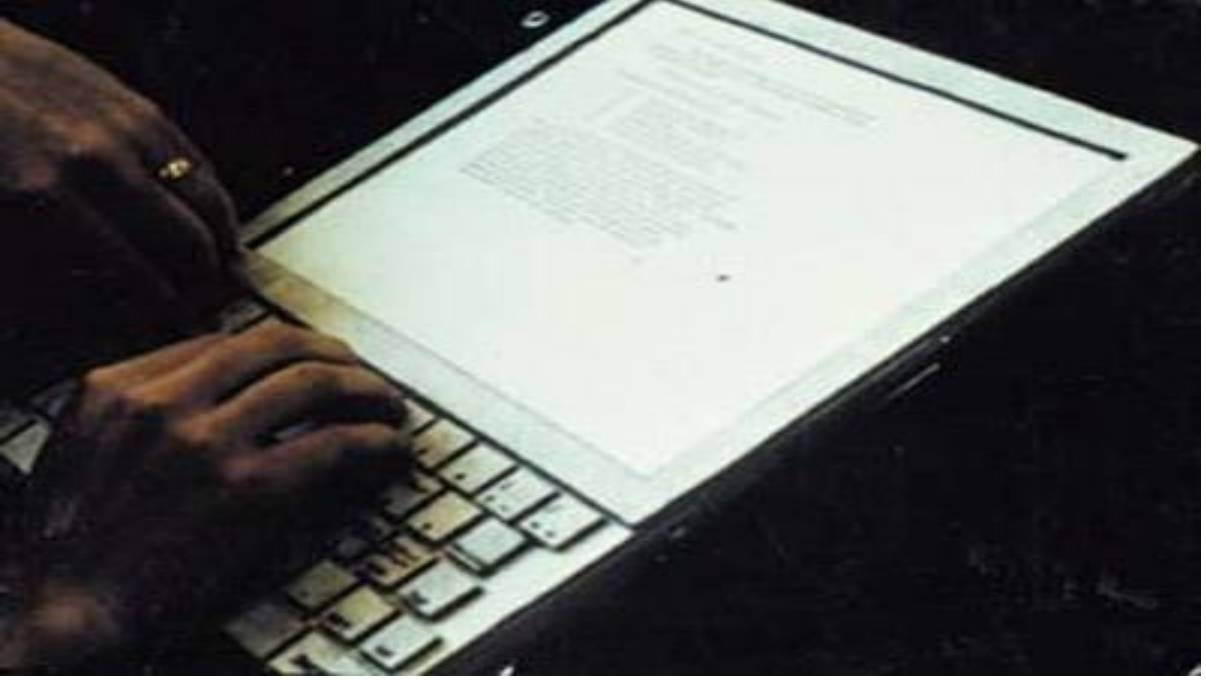
Compilers

Graphical UI



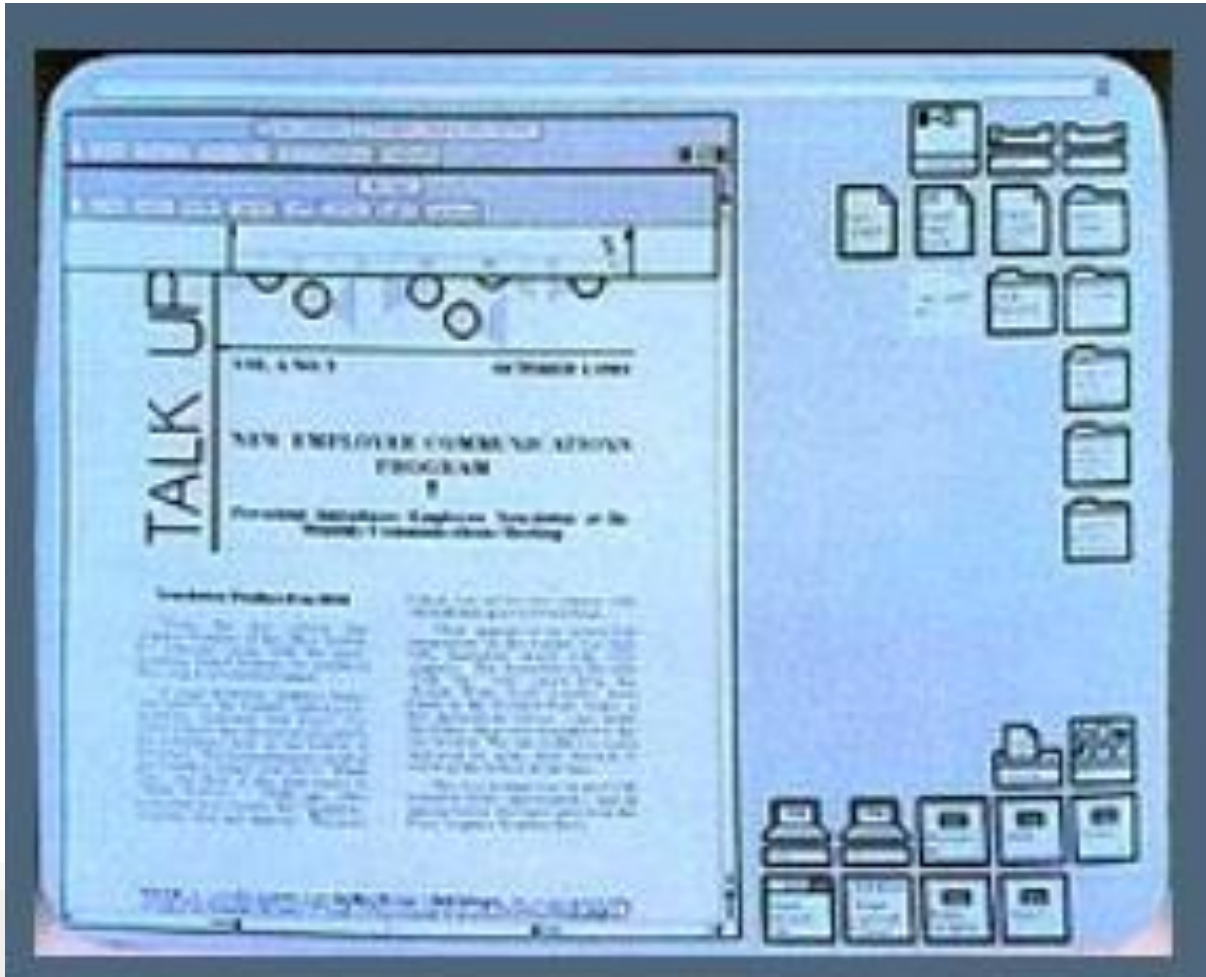


Mouse, Hypertext

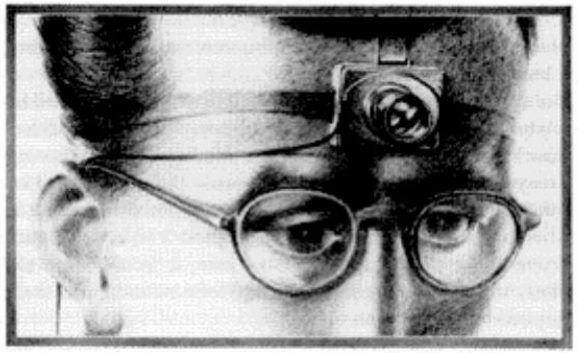


Alan Kay’s Dynabook

Xerox PARC: Alto



Why we learn history of HCI?



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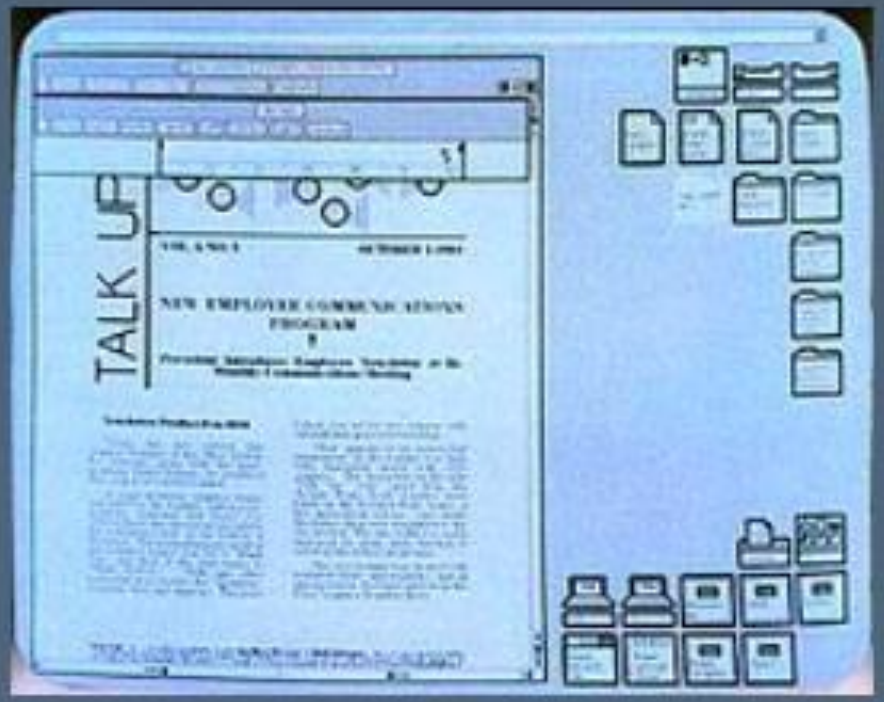


Xerox PARC: Alto

Modern MacOS desktop

Card, English and Burr: Evaluation of mouse, rate-controlled isometric joystick, step keys, and text keys for text selection on a CRT

Modern mouse

Consolvo et al.
Activity sensing

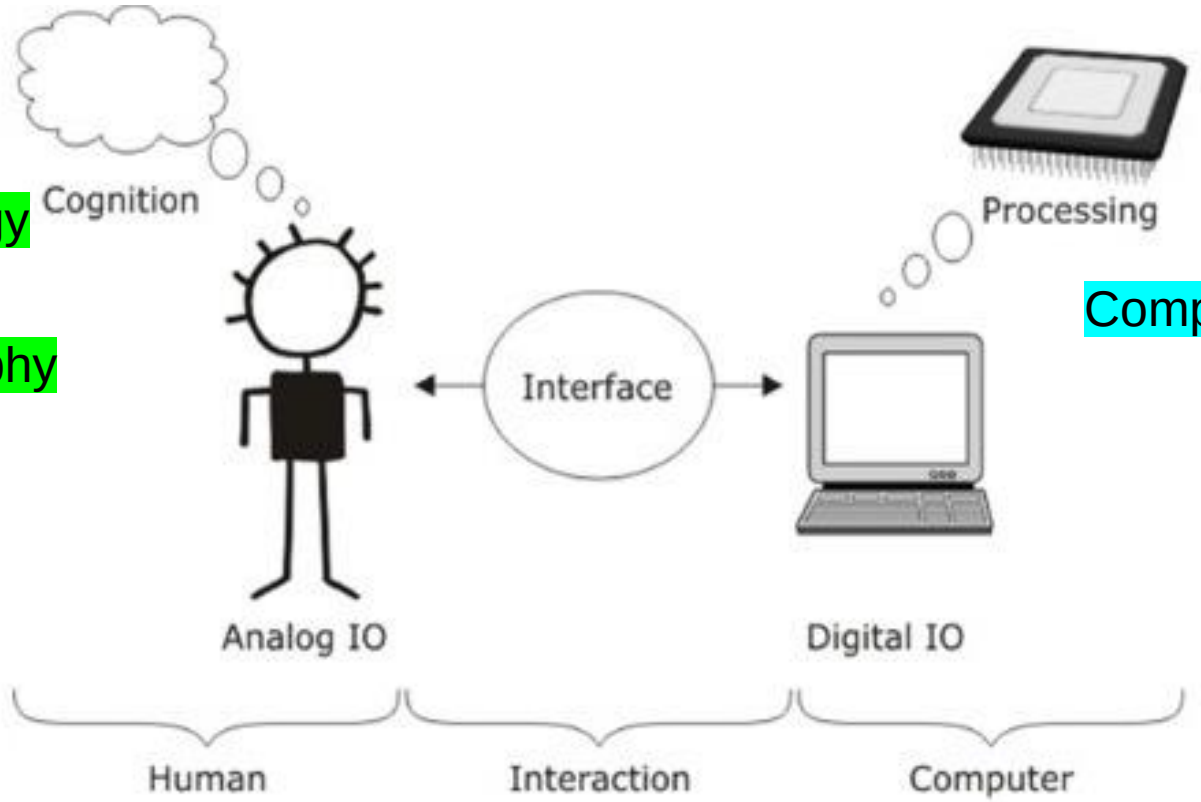
Modern fitness trackers

The multidisciplinary field of HCI

Psychology

Sociology

Ethnography



Engineering

Computer science

Design

Group Formation

Models of Interaction

A general framework to understand how User and System interact

What Is "Interaction" (in HCI)?

- Interaction is…

Concept	View of interaction	Key phenomena and constructs	Good interaction	Example support for evaluation and design
Dialogue	a cyclic process of communication acts and their interpretations	mappings between UI and intentions; feedback from the UI; turn taking	understandable; simple, natural; direct	methods/concepts for guessability, feedback, mapping; walkthroughs
Transmission	a sender sending a message over a noisy channel	messages (bits); sender and receiver; noisy channels	maximum throughput of information	metrics and models of user performance
Tool use	a human that uses tools to manipulate and act in the world	mediation by tools; directness of acting in the world; activity as a unit of analysis	useful and transparent tools; amplification of human capabilities	compatibility in instrumental interaction; break down analysis
Optimal behavior	adapting behavior to goals, task, UI, and capabilities	rationality; constraints; preferences; utility; strategies	improves or reaches maximum or satisfactory utility	models of choice, foraging, and adaptation
Embodiment	acting and being in situations of a material and social world	intentionality; context; coupling	provides resources for and supports fluent participation in the world	studies in the wild; thick description
Experience	an ongoing stream of expectations, feelings, memories	non-utilitarian quality; expectations; emotion	satisfies psychological needs; motivating	metrics of user experience; experience design methods
Control	interactive minimization of error against some reference	feedforward; feedback; reference; system; dynamics	rapid and stable convergence to target state	executable simulations of interactive control tasks

Taken from: Kasper Hornbæk & Antti Oulasvirta, What Is Interaction? In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*

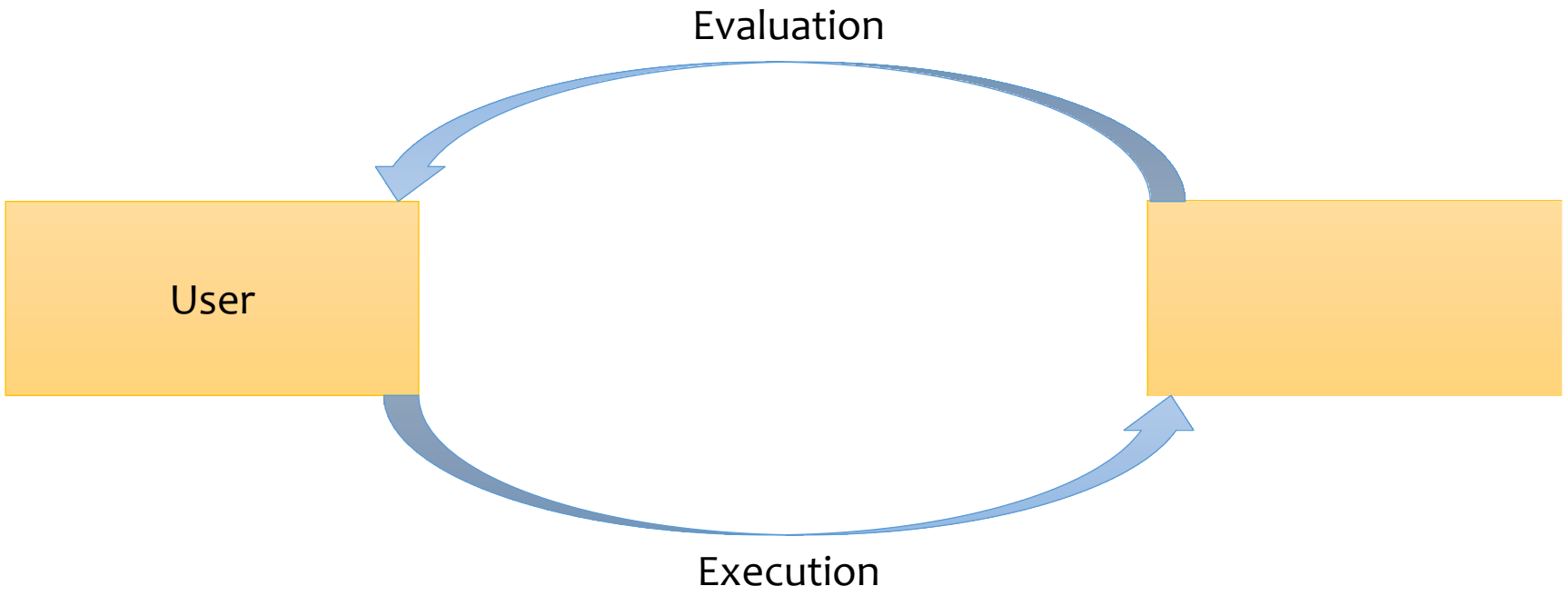
What Is Interaction (in HCI)?

- Interaction…
  - **is not** the idea promoted and repeated in folk notions that a computer and a human are engaged
  - it concerns two entities – humans and computers – that determine each other's behavior over time
    - Their mutual determination can be of many types, including statistical, mechanical, and structural
- **Users**, with their **goals** and **pursuits**, are the ultimate metric of interaction

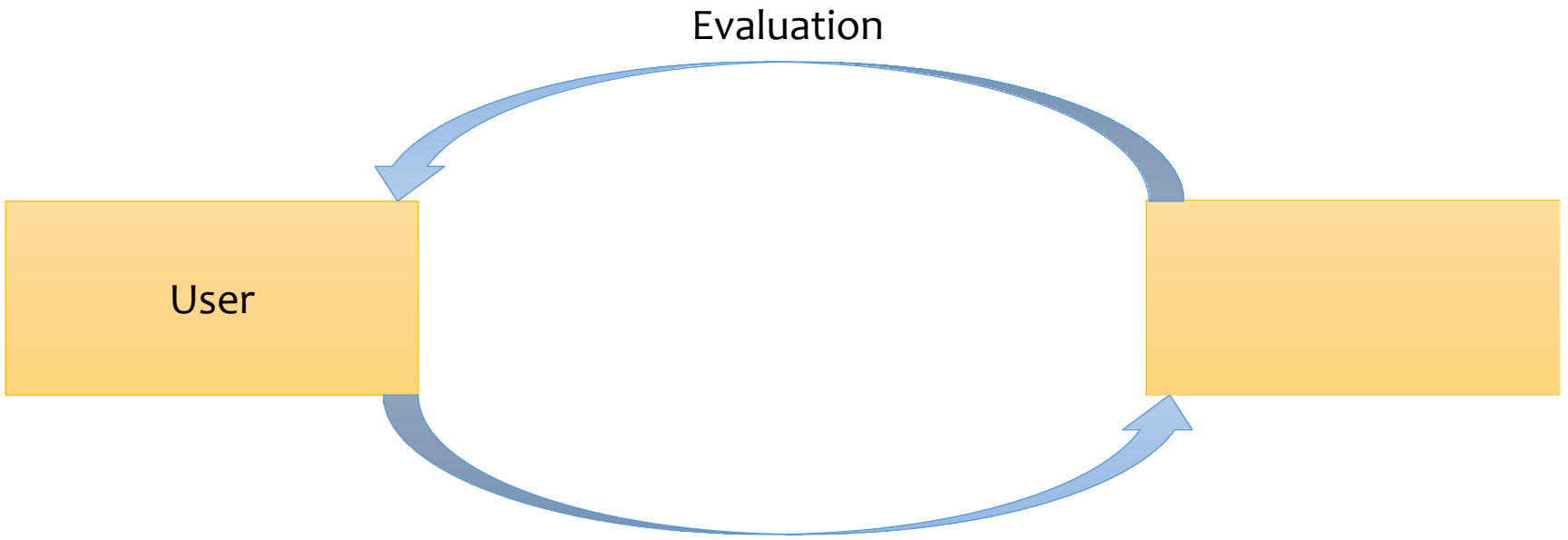
Assumptions

- The **user** wants to accomplish some **goals**, in a specific application **domain**
  - Each domain has a specific jargon, set of possible processes and goals, artifacts and building blocks, …
- **Tasks** are operations to manipulate the concepts of a domain
  - The goal is attained by performing one or more tasks
- Interaction studies the relation between User and System
  - The system possesses a **state** and "speaks" a **core language**
  - The user possesses a **state**, that includes an **understanding** of the system's state, some **intention** to perform a task, and "speaks" the **task language**

Norman's Model of Interaction

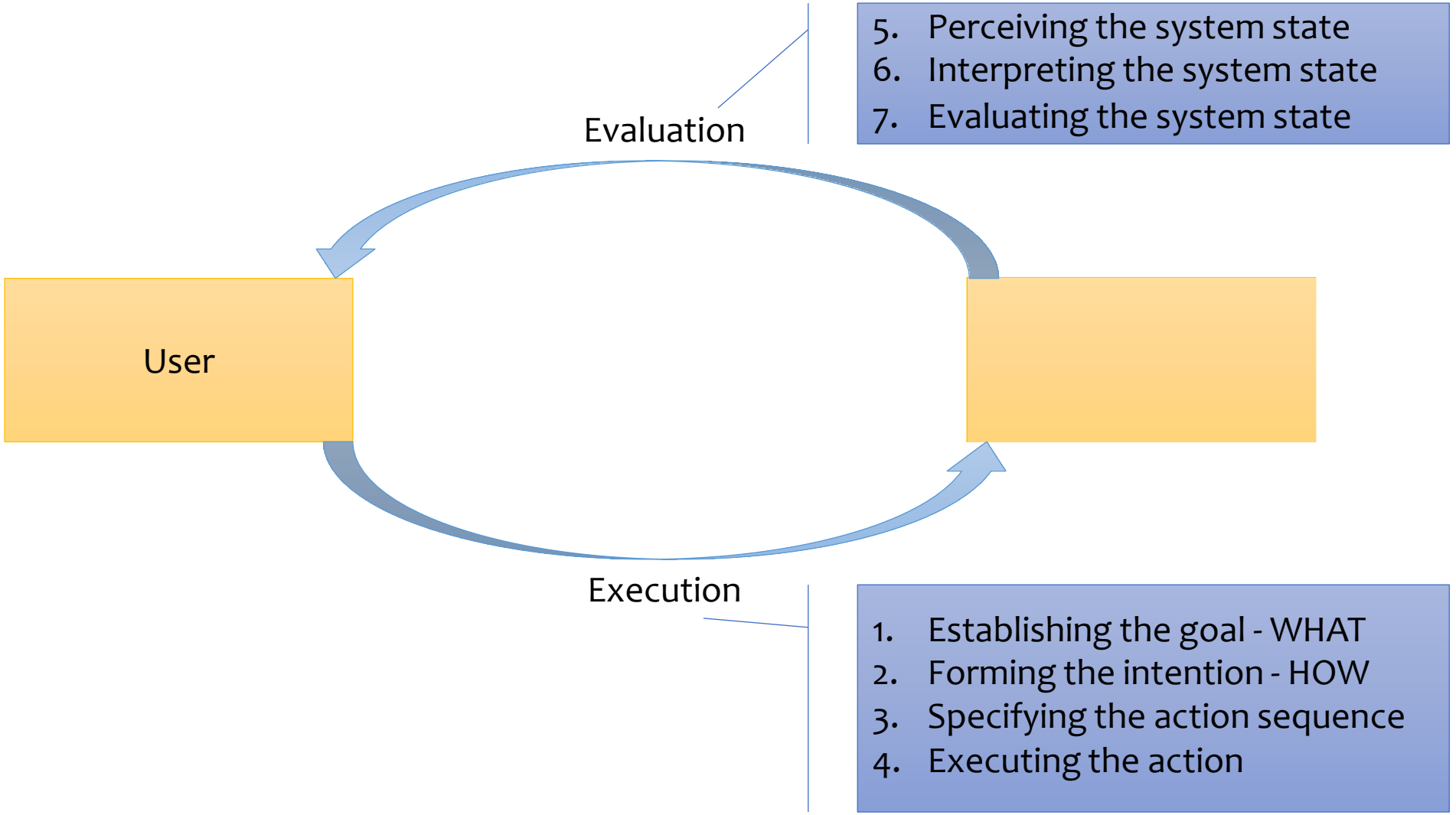


Norman's Model of Interaction



1. Establishing the goal - WHAT
2. Forming the intention - HOW
3. Specifying the action sequence
4. Executing the action

Norman's Model of Interaction



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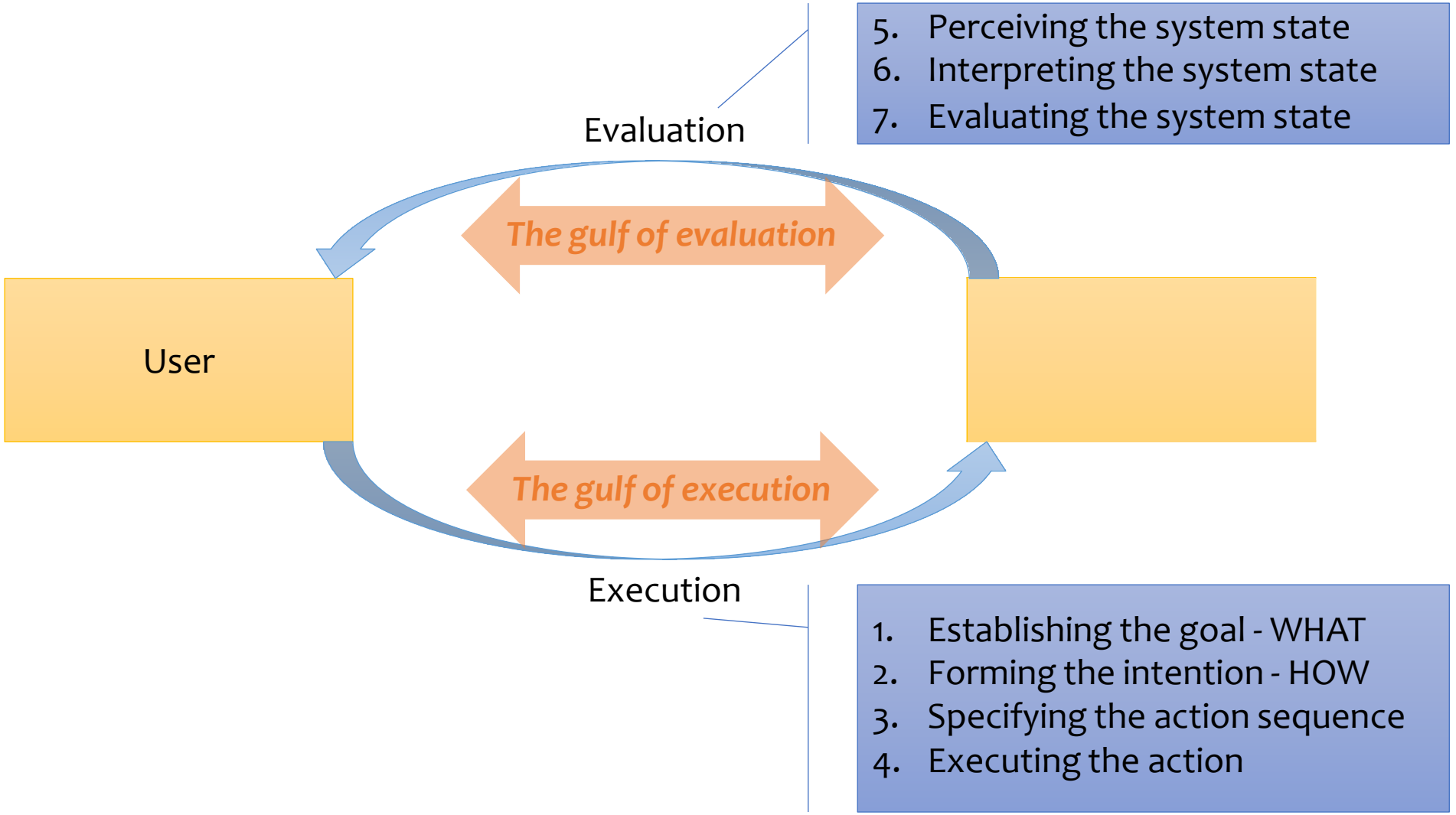
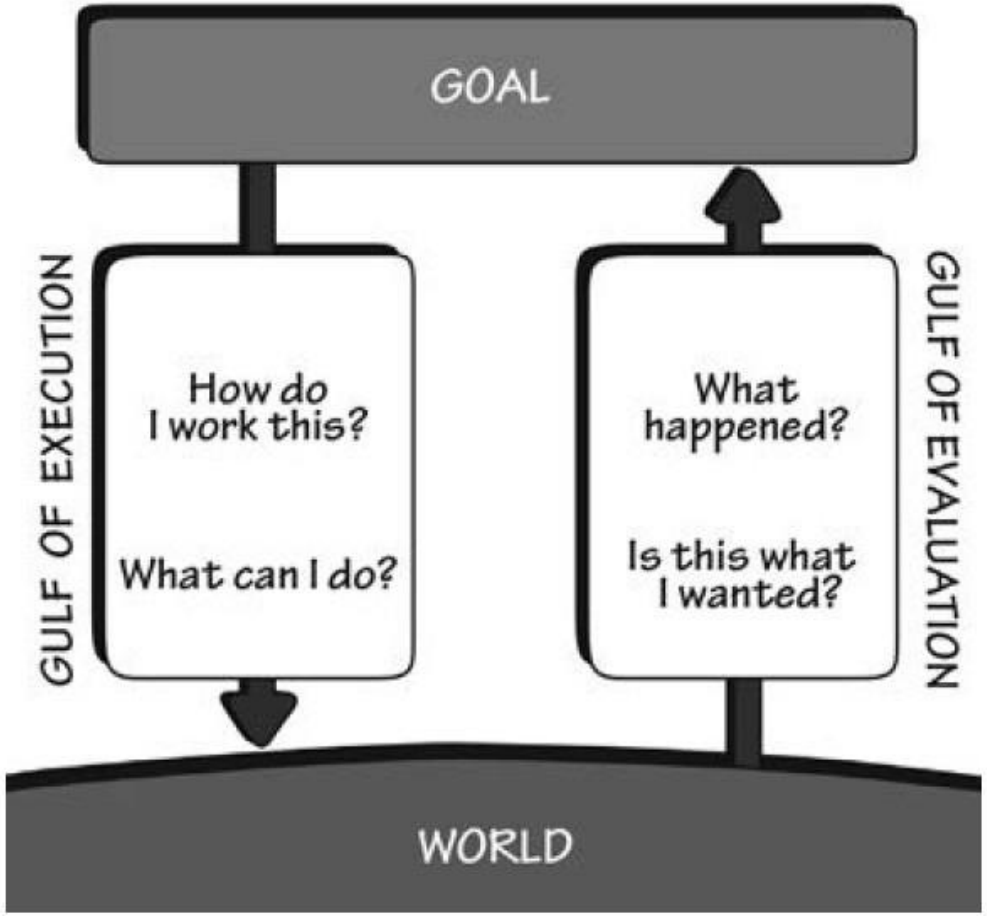
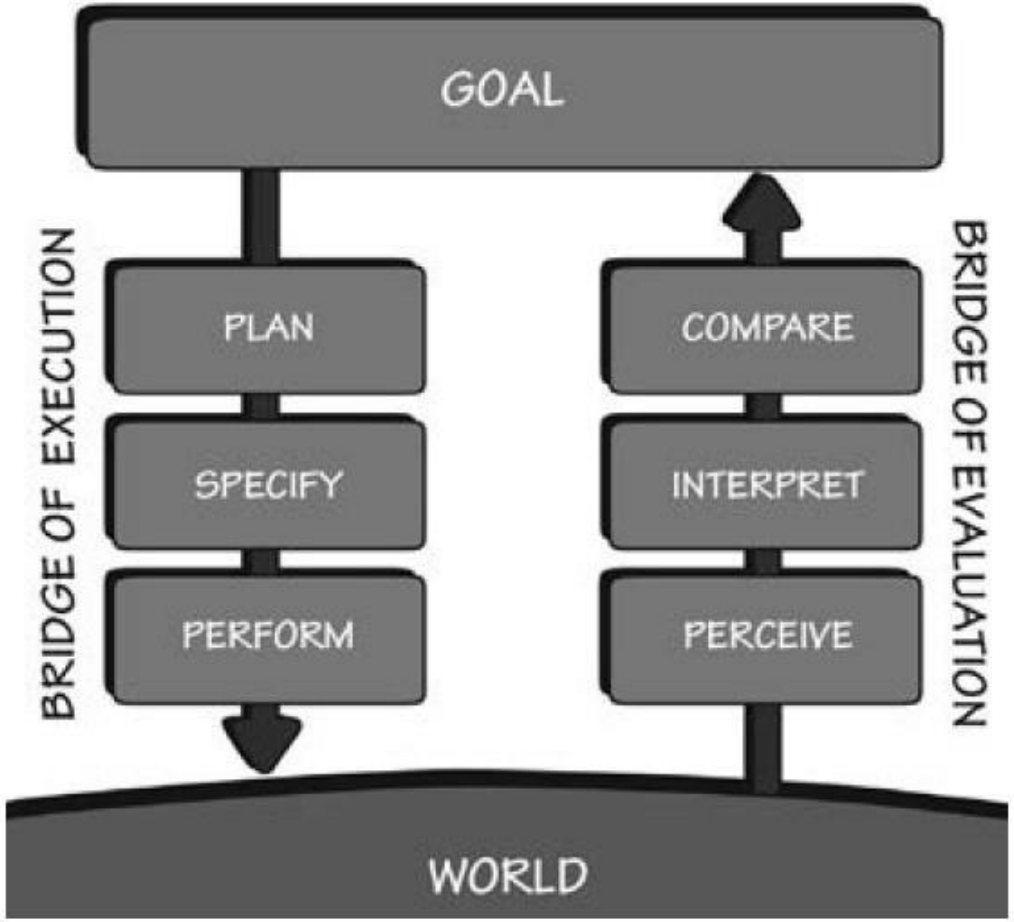


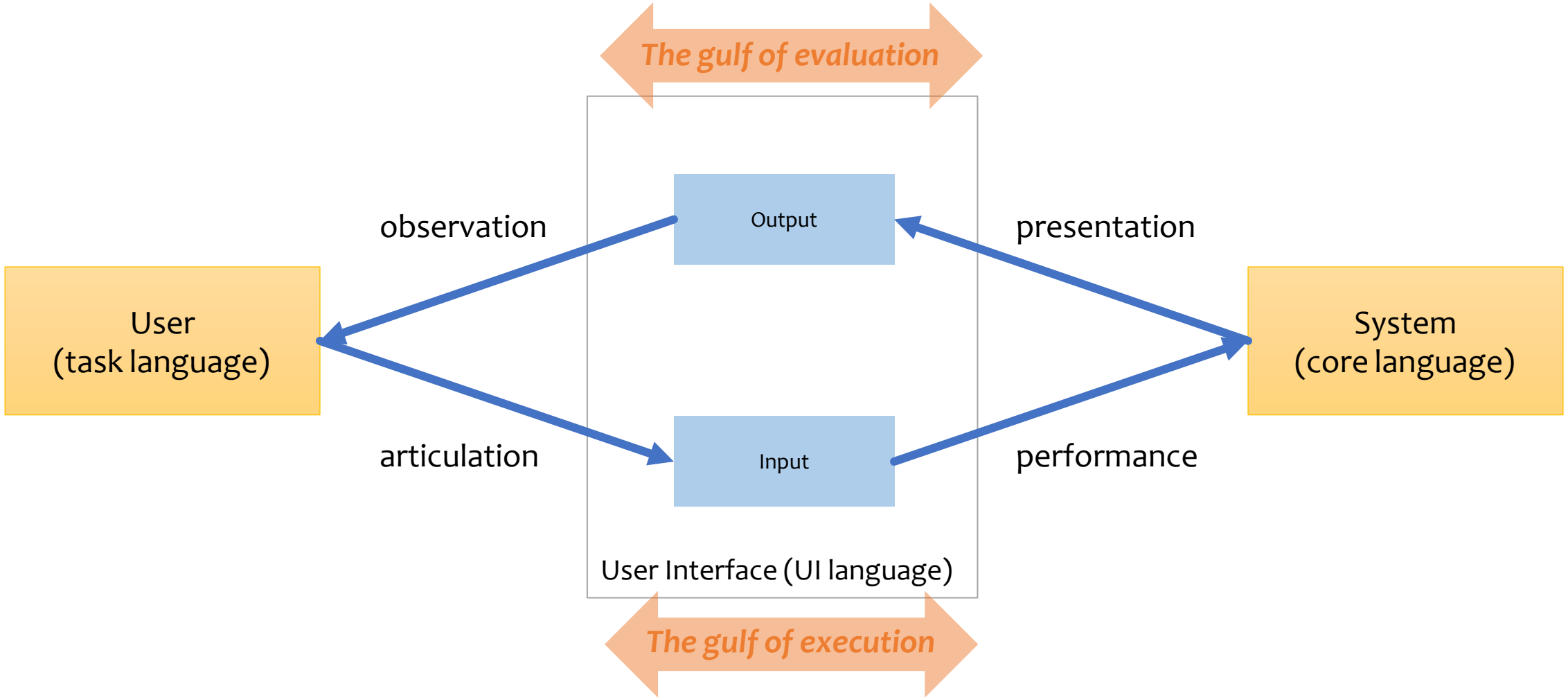
Norman's Diagrams

1. **Goal** (form the goal)
2. **Plan** (the action)
3. **Specify** (an action sequence)
4. **Perform** (the action sequence)
5. **Perceive** (the state of the world)
6. **Interpret** (the perception)
7. **Compare** (the outcome with the goal)





Abowd and Beale Model, with Explicit UI



Human Errors*
in the gulf of execution

Slip

- You have formulated the right action, but fail to execute that action correctly
  - E.g., click the wrong icon, or double-click too slow, …
- May be corrected by a better interface (spacing, layout, highlights, …)

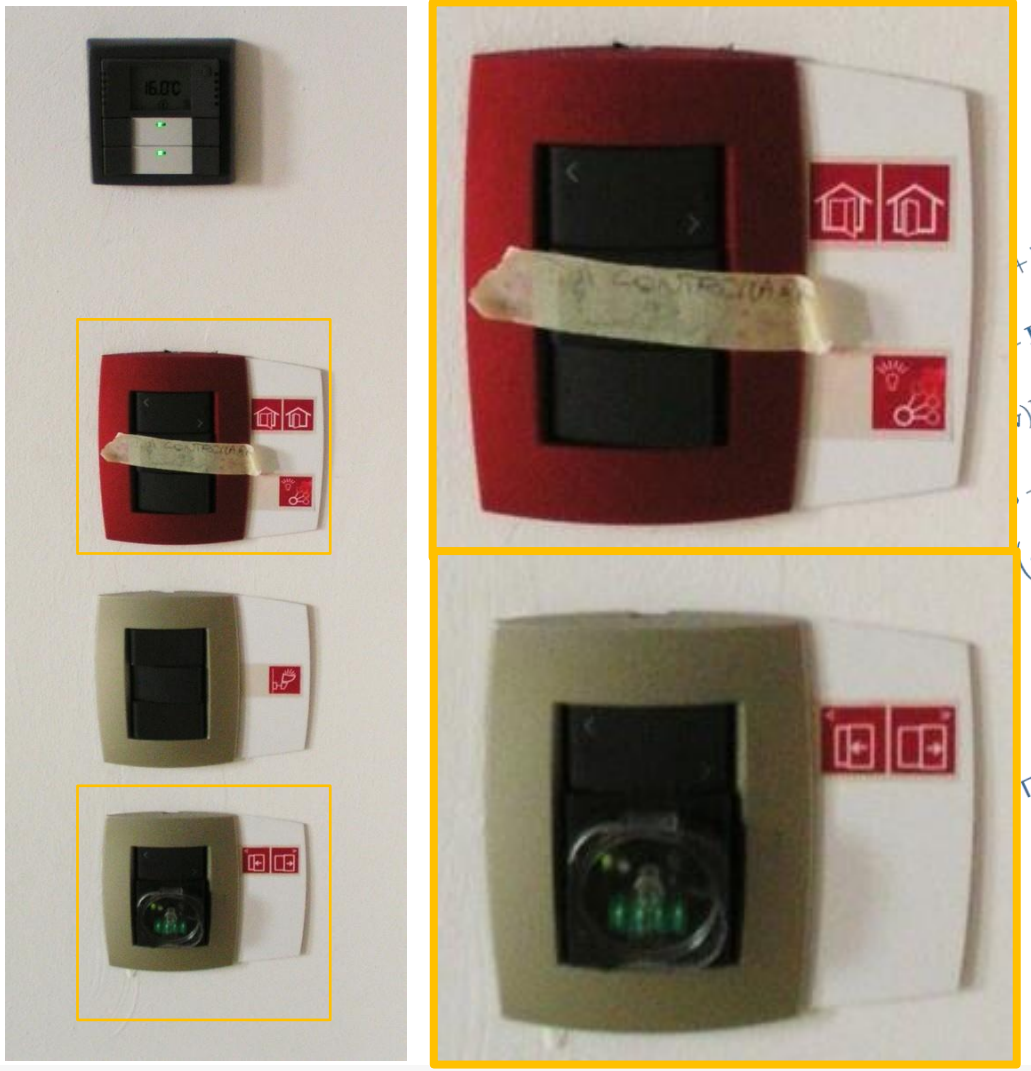
Mistake

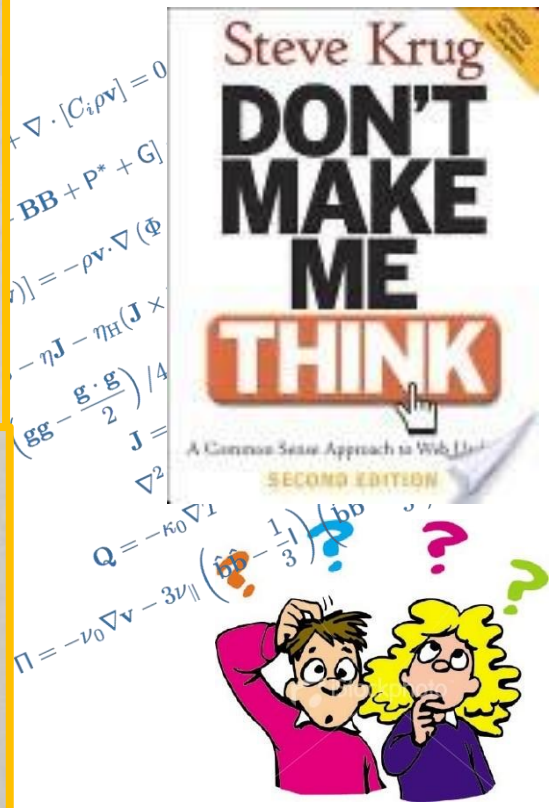
- You don't know the system well and you may not formulate the right goal
  - E.g., click for Zoom, but it means Search
- The user's mental model of the system's state is not correct
- Requires more radical redesign, or additional training

* About Human Errors

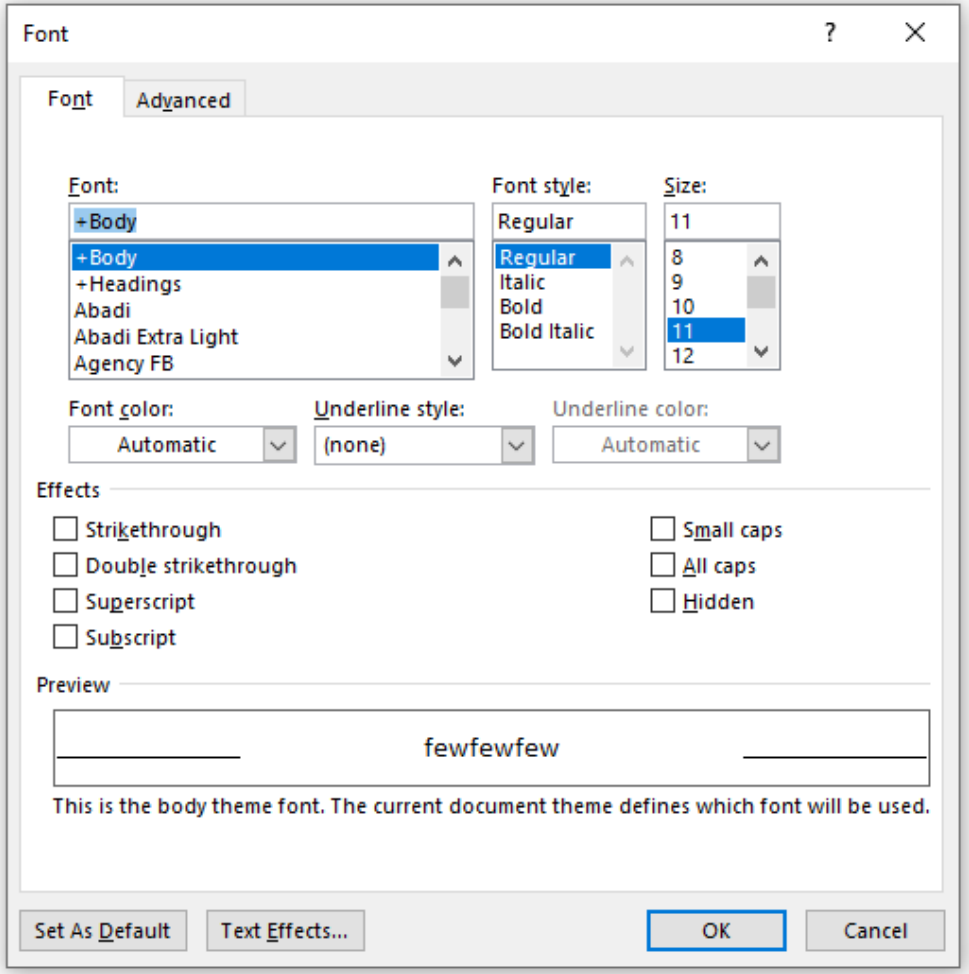
- Human errors should **never** be considered as faults of the user
- Rather, «they are usually a result of bad design» (Norman)
- Humans tend to be imprecise, distracted, not-omniscient
  - System design should anticipate this human behavior
  - Minimize the chance of inappropriate actions (evaluation)
  - Maximize the possibility of discovering and repairing an inappropriate action (execution)
  - Enable users to understand the state of the system and build an appropriate model

Example (articulation): find the right switch

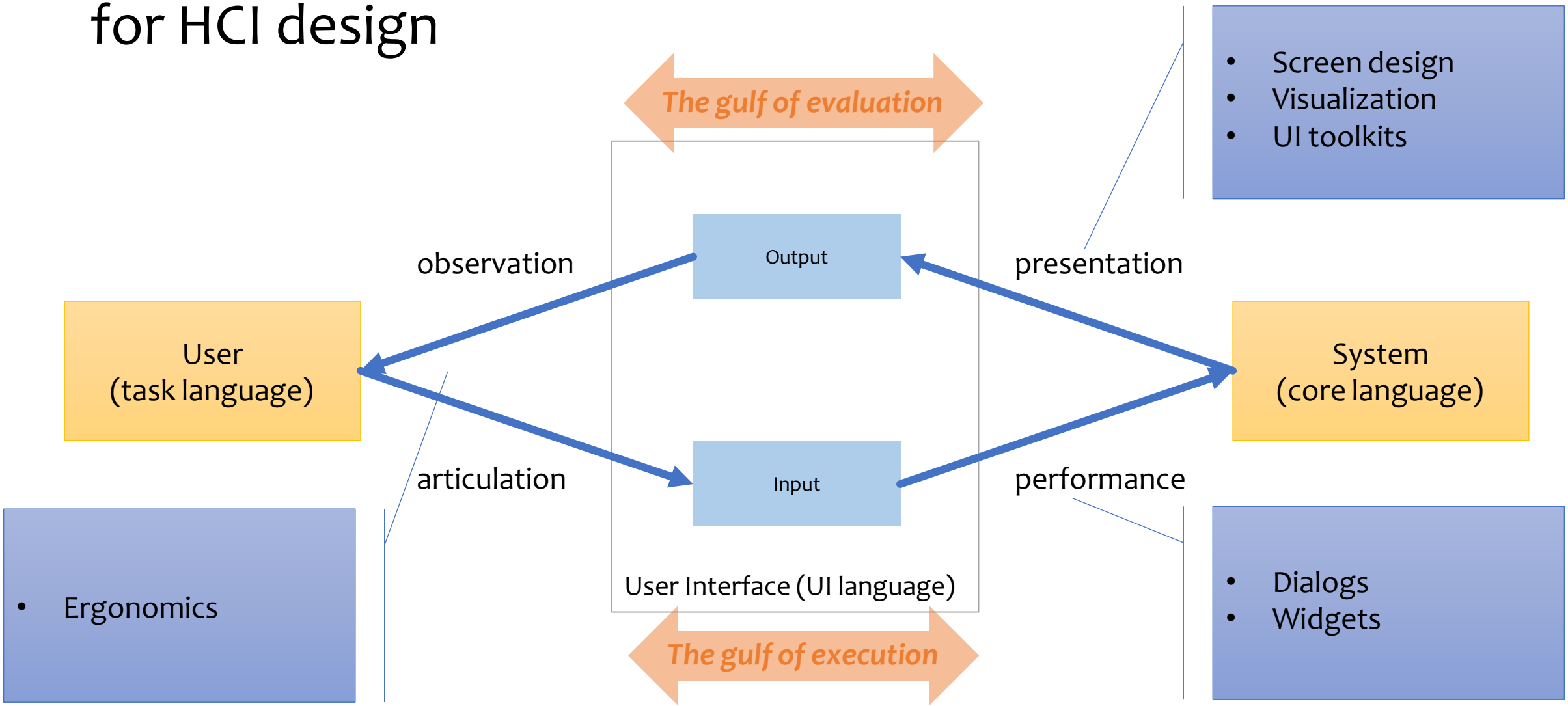




Example (presentation):
Which are the allowed combinations?



Tools, Techniques and Environments
for HCI design



Frameworks: Major UI Styles

- Command line interface
- Menus
- Natural language
- Question/answer and query dialog
- Form-fills and spreadsheets
- Windows, Icons, Menus and Pointers (WIMP)
- Mobile
- Point and click
- Three-dimensional interfaces

Design Processes and Frameworks

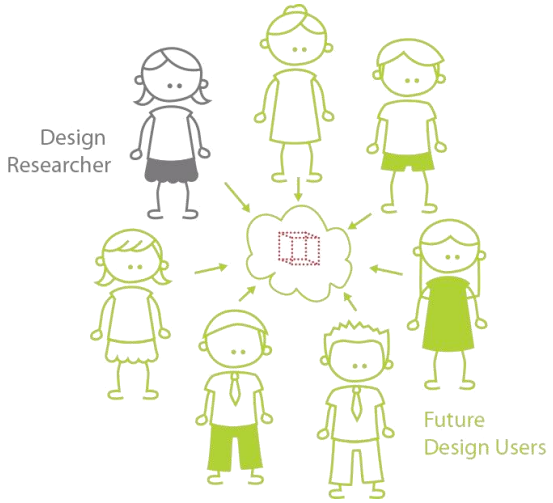
Approaches for shaping the design process

User-Centered Design (UCD)

- Avoid the risk of software project failure
  - Estimated 50% are affected by bad developer<->user/client communication
- UCD takes the needs, wants, and limitations of the **actual end users** into account **during each phase** of the design process
  - User-centered design issues are discovered during the early stages
- Benefits: systems easier to learn, with faster performance, with less human errors, encourage users to discover advanced features, and avoids "building the wrong system"
- Issues: how to find users? How many? How motivated? How to speak their language? How to extract user needs, business needs, organizational implications?

Participatory Design

- One step further than UCD, users are directly involved in the collaborative design of the things and applications they use



- Engage a group of users
  - Discussions
  - Creating scenarios, sketches, dramatizations
  - Creating and testing lo-fi prototypes
  - Continuous meetings, flexible management
  - Highly reliant on the skills of the group moderators/leaders (keep involved, filter ideas, reward participation, work around resistances, …)
  - More effective with more mature and prepared user populations (less with kids, elderly, disabled, …)

Agile Interaction Design

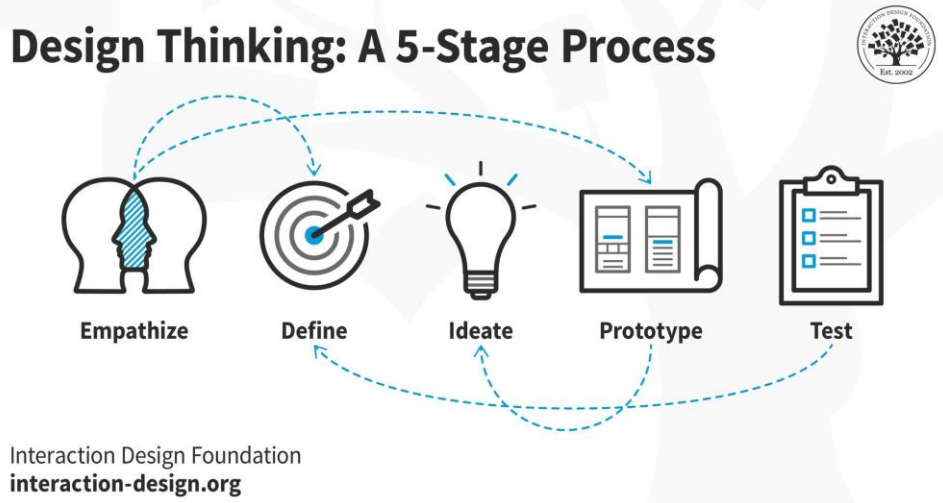
- Borrows ideas from Agile development in software engineering
- Key: evolutionary development
  - System is built incrementally in rapid release cycles
  - Rapid prototyping techniques (for hardware, software and physical objects)
- Focus on low-cost many-iterations prototypes
- Requires fast usability inspection (extreme usability, XU)
- Makers' culture (only if it involves users!)

Design Thinking

- *"A human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success."*

— Tim Brown, IDEO's Executive Chair

- A 5-stage, non-linear and iterative, process
  1. **Empathize** – research users' needs
  2. **Define** – state the found needs
  3. **Ideate** – challenge assumptions and ideate
  4. **Prototype** – create solutions
  5. **Test** – try the solutions out



Service Design

- Describe the contemporary shift from *products* (e.g., a car of a specific brand) to *services*, e.g., the car as a tool for an elderly customer that wants to take an Uber ride to visit a friend
- Focus on the complete experience, including business resources and processes
- Build upon five *key principles, a*ccording to "This is Service Design Thinking":
  1. **User-centered** – focus on all users
  2. **Co-creative** – include all relevant stakeholders
  3. **Sequencing** – break a complex service into separate processes
  4. **Evidencing** – envision service, not product, experiences
  5. **Holistic** – design across networks of users and interactions

Human-centered Design Process

A process for designing interactive systems with a focus on usability

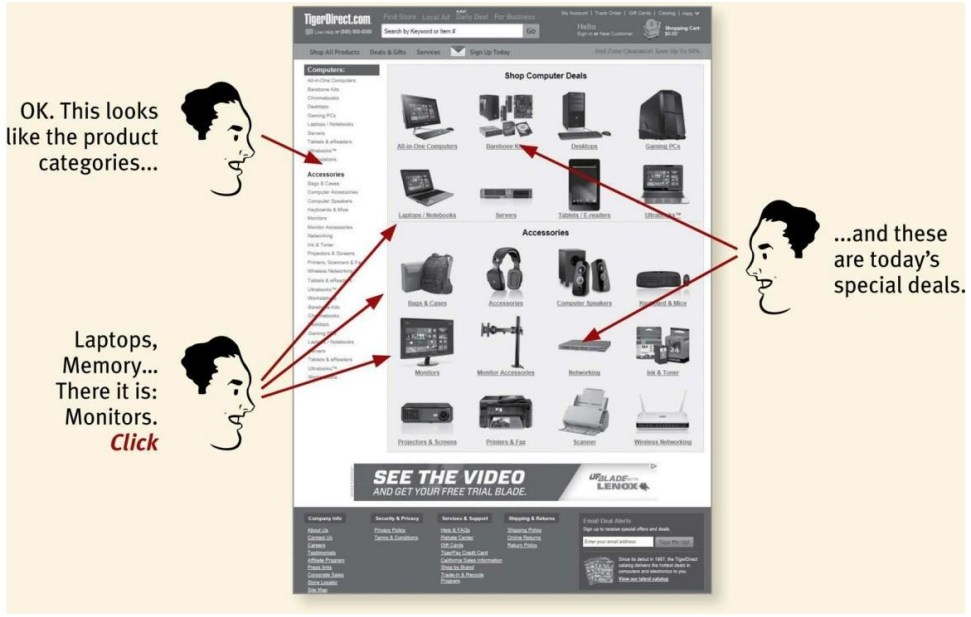
Usability (ISO standard definition)

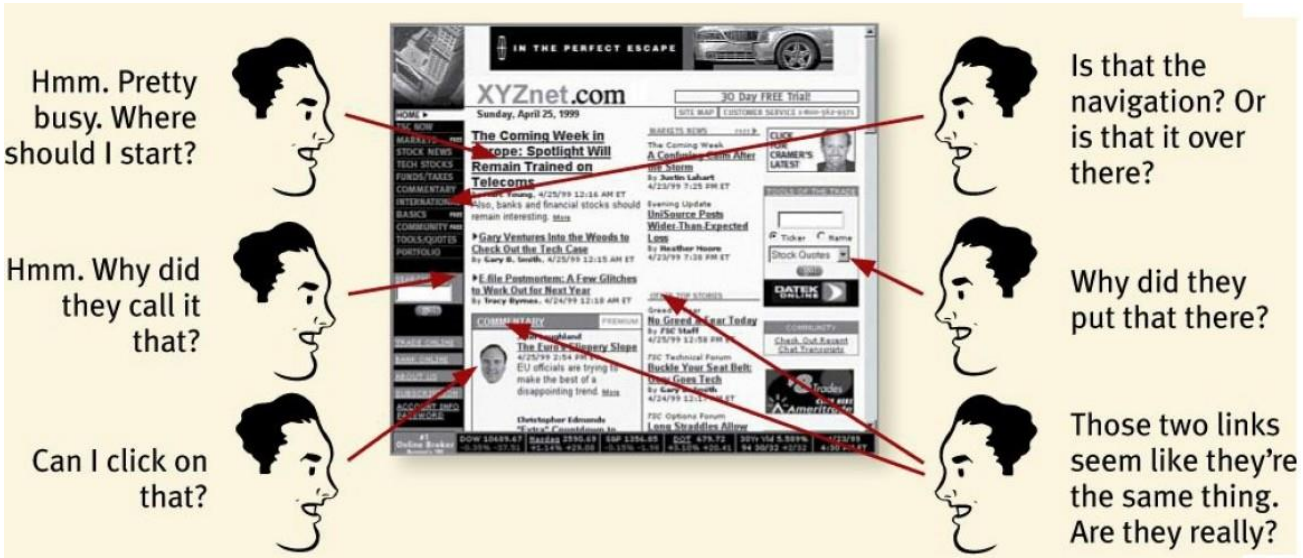
- **Usability**: "extent to which a system, product or service can be used by specified users to achieve specified goals with *effectiveness*, *efficiency* and *satisfaction* in a specified context of use"
  - Note 1: The "specified" users, goals and context of use refer to the particular combination of users, goals and context of use for which usability is being considered
  - Note 2: The word "usability" is also used as a qualifier to refer to the design knowledge, competencies, activities and design attributes that contribute to usability, such as usability expertise, usability engineering, usability testing, etc.

Usability

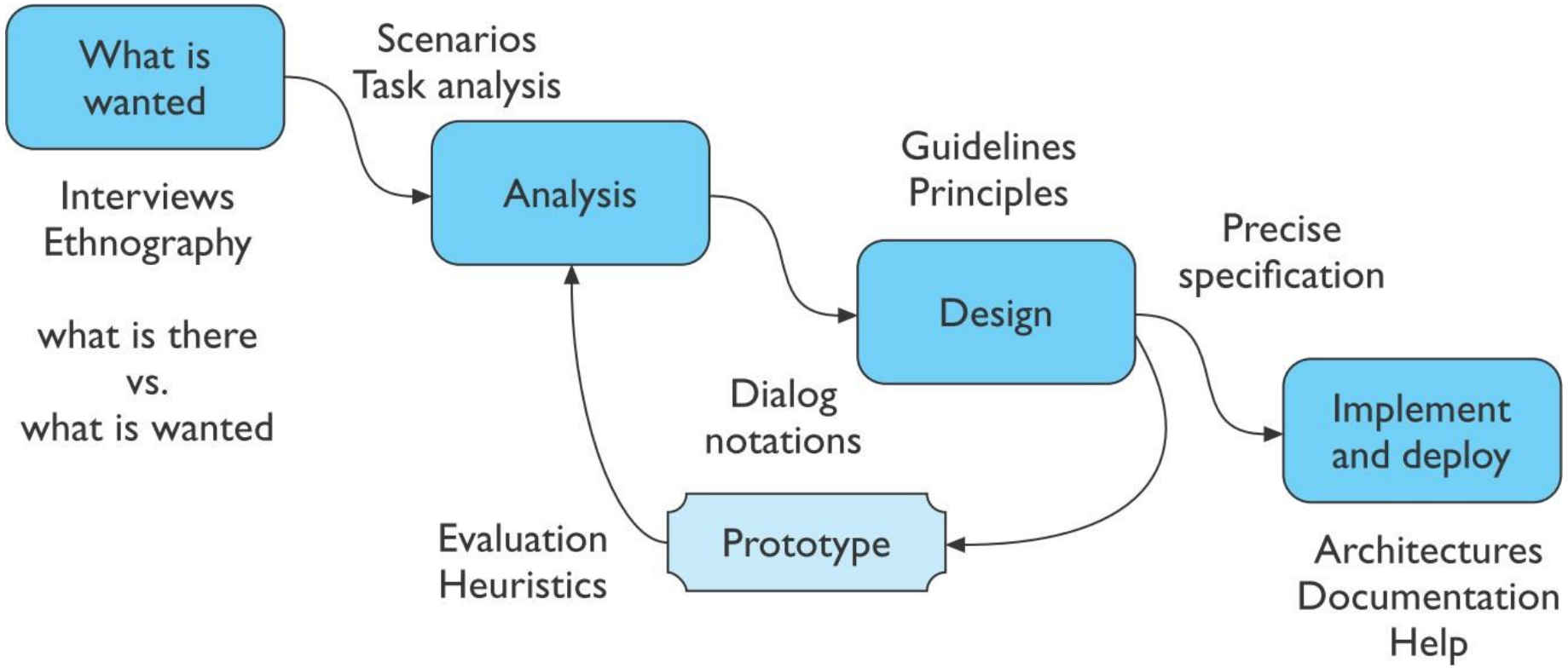
- **Usability**: how well users can use the system's functionality
- Dimensions of usability:
  - **Usefulness**: does it do something people want?
  - **Learnability**: is it easy to learn?
  - **Memorability**: one learned, is it easy to remember?
  - **Effectiveness**: does it allow reaching the goal?
  - **Efficiency**: once learned, is it fast to use?
  - **Visibility**: is the state of the system visible?
  - **Errors**: are errors few and recoverable?
  - **Satisfaction**: is it enjoyable to use?

Usability: Don’t Make Me Think



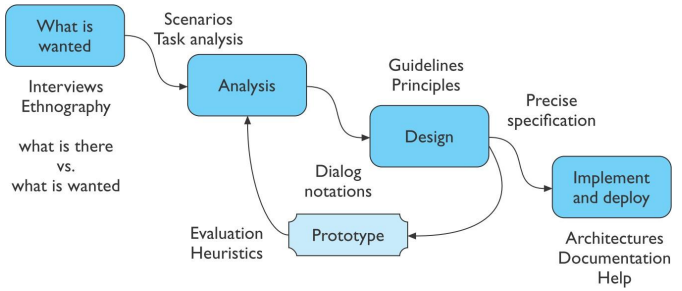


Human-Centered Design Process
(simplified and generic)



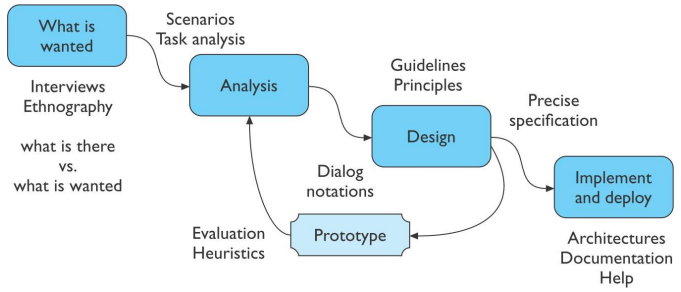
Human-Centered Design Process – The Main Steps (1)

- **Needfinding – what is needed**
  - What exactly is needed? How are people currently accomplishing the goal?
  - User observation, interviews, …
- **Analysis**
  - Formalize and structure the needs
  - Create interaction scenarios, stories, tasks
  - Compare current situation with expected new situation

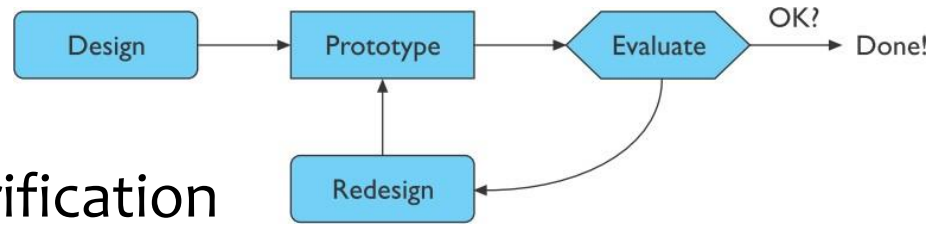


Human-Centered Design Process – The Main Steps (2)

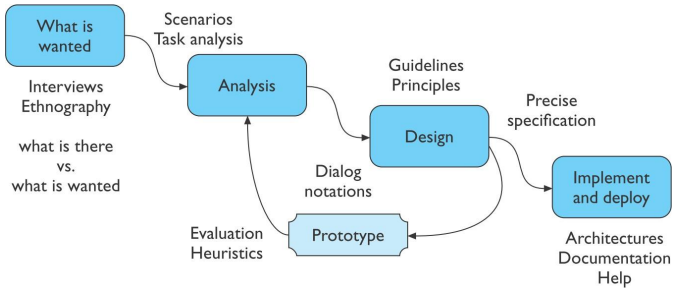
- **Design**
  - The main choices to shape the system
  - Rules, guidelines, design principles
  - Considering different types of users
  - Modeling and describing interaction
  - Visual layout
  - Consider all inputs from cognitive models, communications theories, organization issues



Human-Centered Design Process – The Main Steps (3)



- **Iteration and prototyping**
  - Design must be supported by intermediate verification
  - Evaluate the design in its partial forms:
    - Prototypes
    - Evaluation metrics
  - Involving users
- **Implementation and deployment**
  - Hardware and software implementation
  - Documentation

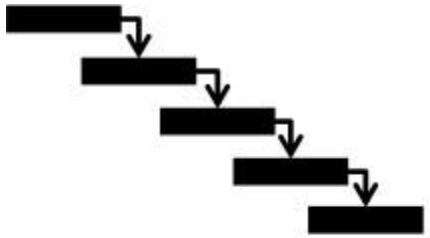


HCI in the Software Process

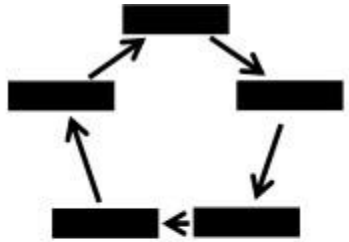
How to include Human-centered processes in Software Engineering

Software Engineering Processes

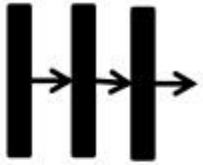
Where / how does HCI fit in?



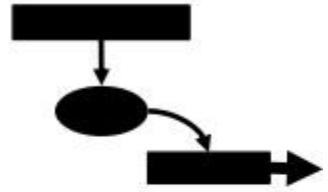
Waterfall



Iterative waterfall



Agile (scrum)

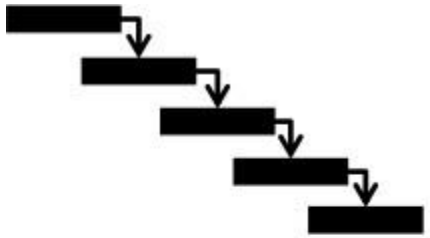


Lean

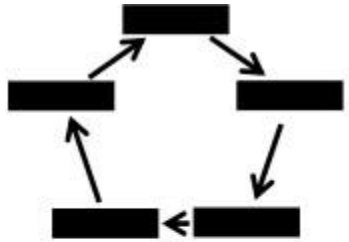
Software Engineering Processes

Where / how does HCI fit in?

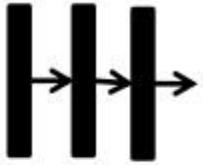
Always a step ahead!



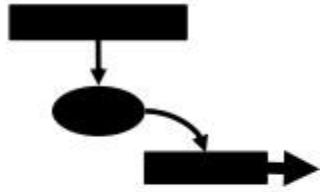
Waterfall



Iterative waterfall



Agile (scrum)



Lean

Always a Step Ahead

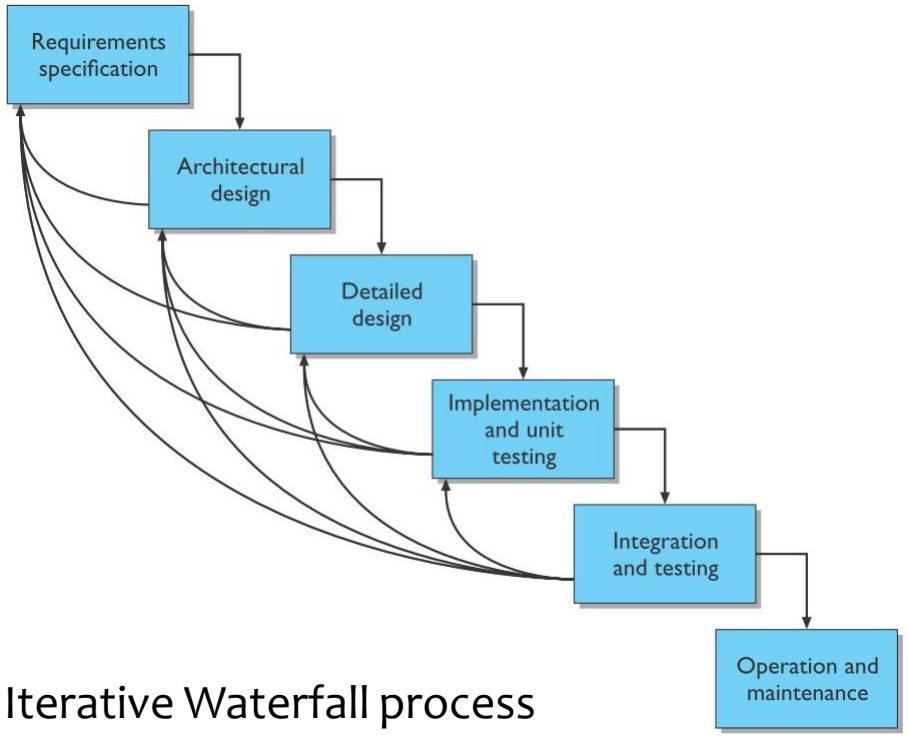
- Before
  - Every design step
  - Every implementation step
  - Any product iteration (or sprint)
  - …
- You need a user-centered step
  - Evaluate usability
  - Experiment with users
  - Evaluate alternative flows
  - Evaluate alternative layouts
  - …

- User-centered steps are cheaper than development
  - User research about users' needs to decide what to design
  - Heuristic evaluations before testing with users
  - Evaluating prototypes instead of full-fledged products
- Anticipate critical decision points later in the project

Always a Step Ahead

- Usability, Safety, Performance, are part of Non-Functional Requirements
- User-centered steps are cheaper than development
  - User research about users' needs to decide what to design
  - Heuristic evaluations before testing with users
  - Evaluating prototypes instead of full-fledged products
- Anticipate critical decision points later in the project

Example



Iterative Waterfall process

- Each step must be
  - Preceded with user evaluation of the design choices and formalized requirements
  - Followed with user evaluation of the result
- Must produce additional artifacts to allow this kind of iteration
  - Prototypes

References and Thanks

- Robert Miller, MIT Course "6.813/6.831: User Interface Design & Implementation"
  - Spring 2018 - http://web.mit.edu/6.813/www/sp18/
  - Spring 2011 - https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-831-user-interface-design-and-implementation-spring-2011/index.htm
- Dix *et al*: Human Computer Interaction
  - Chapters 3, 5
- Norman: The Design of Everyday Things
  - Chapter 2
- Krug: Don't make me think
  - Introduction
- Shneiderman: Designing the User Interface
  - Chapter 4
- Thanks to Fulvio Corno, past teacher of the course, for his work on this slides