

IPM 13/14 – T1.7

Mental Models

Licenciatura em Ciência de Computadores

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Summary

- Mental models vs. Conceptual design
- Human goal-oriented action
- Structural and functional models

Recall: Design Concepts

design concept is highest level and open to interpretation;
It is a starting point

- Affordance
 - visible constraints
- Mapping
- Feedback
 - Causality (true and false kinds)
 - Understandable action
- Visibility
- **Conceptual models**

Other factors:

- Transfer effects
- Cultural associations
- Individual differences

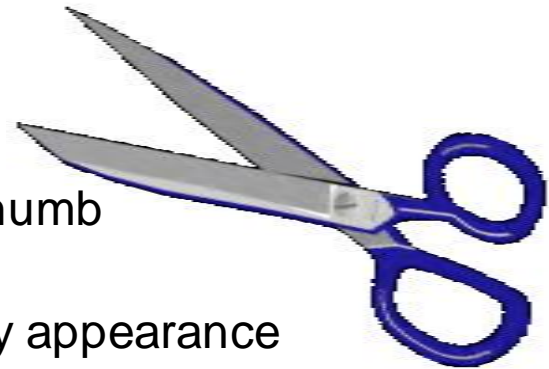
“Psychology of everyday things”,
Don Norman, 1988

Conceptual models: learning goals

- People have “**mental models**” of how things work
- We **build** our conceptual models from **many things**, inc:
 - affordances
 - causality
 - constraints
 - mapping
 - positive transfer
 - population stereotypes/cultural standards
 - instructions
 - interactions (inc. w/ other people)
 - familiarity with similar devices (positive transfer)
- Models **may be wrong**, esp. if attributes are misleading
- Models allow us to **mentally simulate** device operation
- The designer has control over the **system image**

An object that **helps** you form a conceptual model: **Scissors**

- **Affordances:**
 - Holes for something to be inserted
- **Constraints:**
 - Big hole for several fingers, small hole for thumb
- **Mapping:**
 - Holes-for-fingers suggested / constrained by appearance
- **Positive transfer and cultural idioms:**
 - Learnt when young; constant mechanism
- **Conceptual model:**
 - Physical object implies how the operating parts work

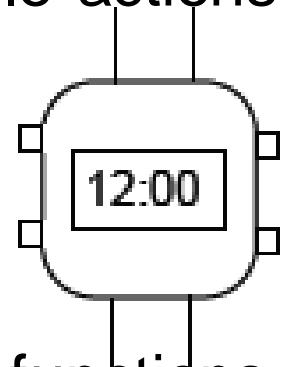


The object implies a **reasonable conceptual model**.

- Some things you don't understand you do anyway: why big blade down?
- Model's not perfect: what about "glide" style of cutting?

An object that **hinders** conceptual model formation: **Digital watch**

- **Affordances:**
 - Four buttons to push, but not clear what they will do
- **Constraints and mapping unknown:**
 - No visible relation between buttons, possible actions and end result
- **Transfer of training:**
 - Little relation to analog watches
- **Cultural idiom:**
 - Somewhat standardized core controls and functions
- **But still highly variable conceptual model:**
 - Must be taught



Mental models

"In interacting with the environment, with others, and with the artifacts of technology, **people form internal, mental models of themselves and of the things with which they are interacting.**

These models provide **predictive** and **explanatory** power for understanding the interaction."

– Norman (in Gentner & Stevens, 1983)

Mental models vs. Conceptual Design

Mental models: *something the user has (forms)*

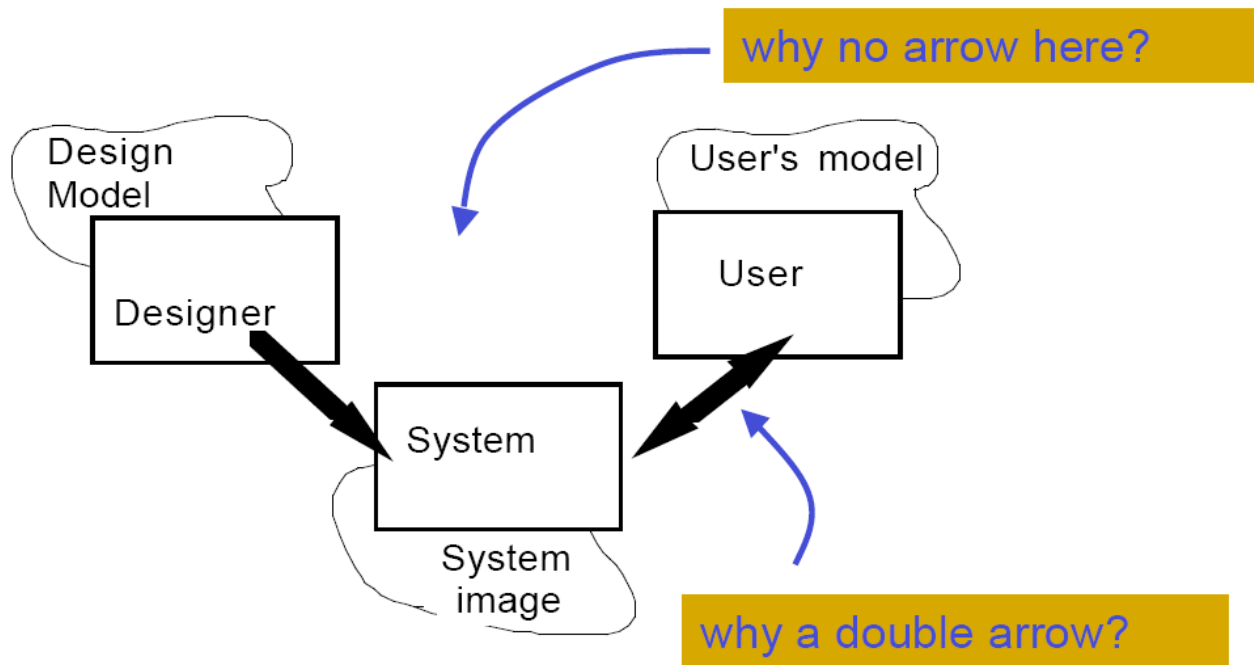
- Users “**see**” the system through mental models
- Users **rely** on mental models during usage
- There are various **forms** of mental models
- Mental models can **support** users’ interaction

Conceptual design: *something the designer does*

- **Defining** the *intended* mental model
 - Hiding the technology of the system
- **Designing** a suitable system image
 - Applying appropriate design guidelines
- **Analysis** using “walkthroughs”

Conceptual Design

- Designing systems so users can understand them
- Assisting the user to build useful mental models

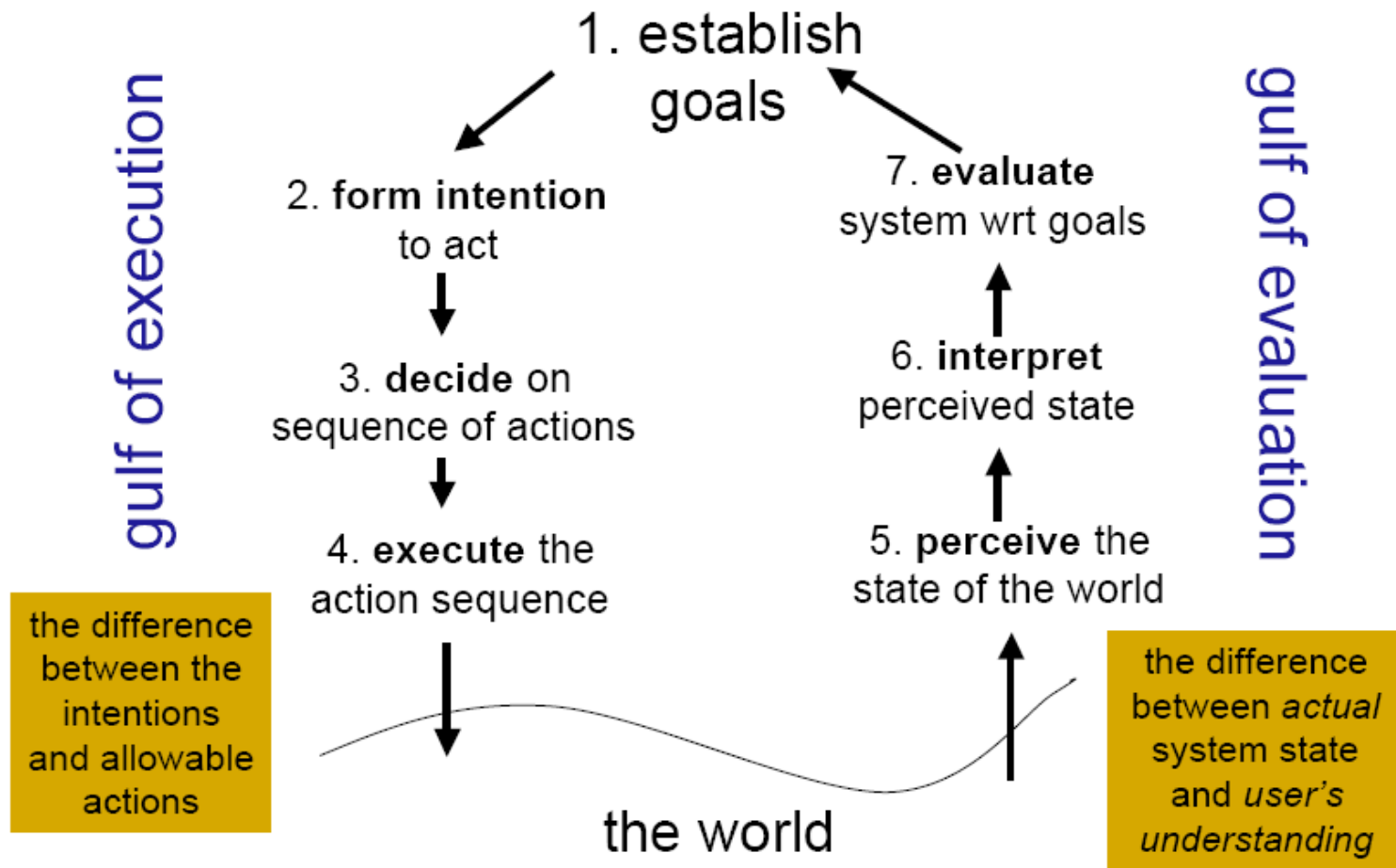


Various models

- **Design model** is the designer's conceptual model
- **System model** is a model of the way the system works
- **System image** results from the physical structure of what has been built (including documentation, instructions, labels) – it is what the user “sees”
- **User's model** is the “**mental model**” developed by the user through interaction with the system
 - User tries to match the mental model to the system model

Norman's seven-stage model

a description of human goal-oriented action



Conceptual mismatch

- **Misconceptions** happen when user's model differs from the system model
 - Document sizes measured in bytes, not pages or words
 - Sun and SGI Unix use different measures for files
 - Dates may be in non-standard formats
 - Whose birthday is 09-06-46 (what country are we in)?
 - Userids (and files) may be constrained by system design
 - userid hmitchel@cs.ubc.ca
 - Error message may use system-specific codes
 - Error 404 in HTTP

Some characteristics of mental models

- Incomplete
- Constantly evolving
- Not accurate representation
 - (contain errors and uncertainty measures)
- Provide a simple representation of a complex phenomena
- Can be represented by a set of if-then-else rules

Acquiring mental models

- **During system usage:**
 - The user's own activity leads to a mental model
 - Explanatory theory, developed by the user
 - Often used to predict future behavior of the system
 - **Observing others using the system:**
 - Casual observation of others working
 - Asking someone else to “do this for me”
 - Formal training sessions
 - **Reading about a system**
 - Documentation, help screens, “for Dummies” books
- This is done by the user (not the designer)**

Runnable models:

‘perturb’ system to figure out how it works

- These are **dynamic models**
 - Includes a notion of **causality**
 - “doing this will result in this”
- Used for **explanation**
 - To understand why the system responded as it did
 - Part of Norman’s model of behavior (interpretation)
- Used for **prediction**
 - To select an appropriate action
 - Also part of Norman’s model (intention)

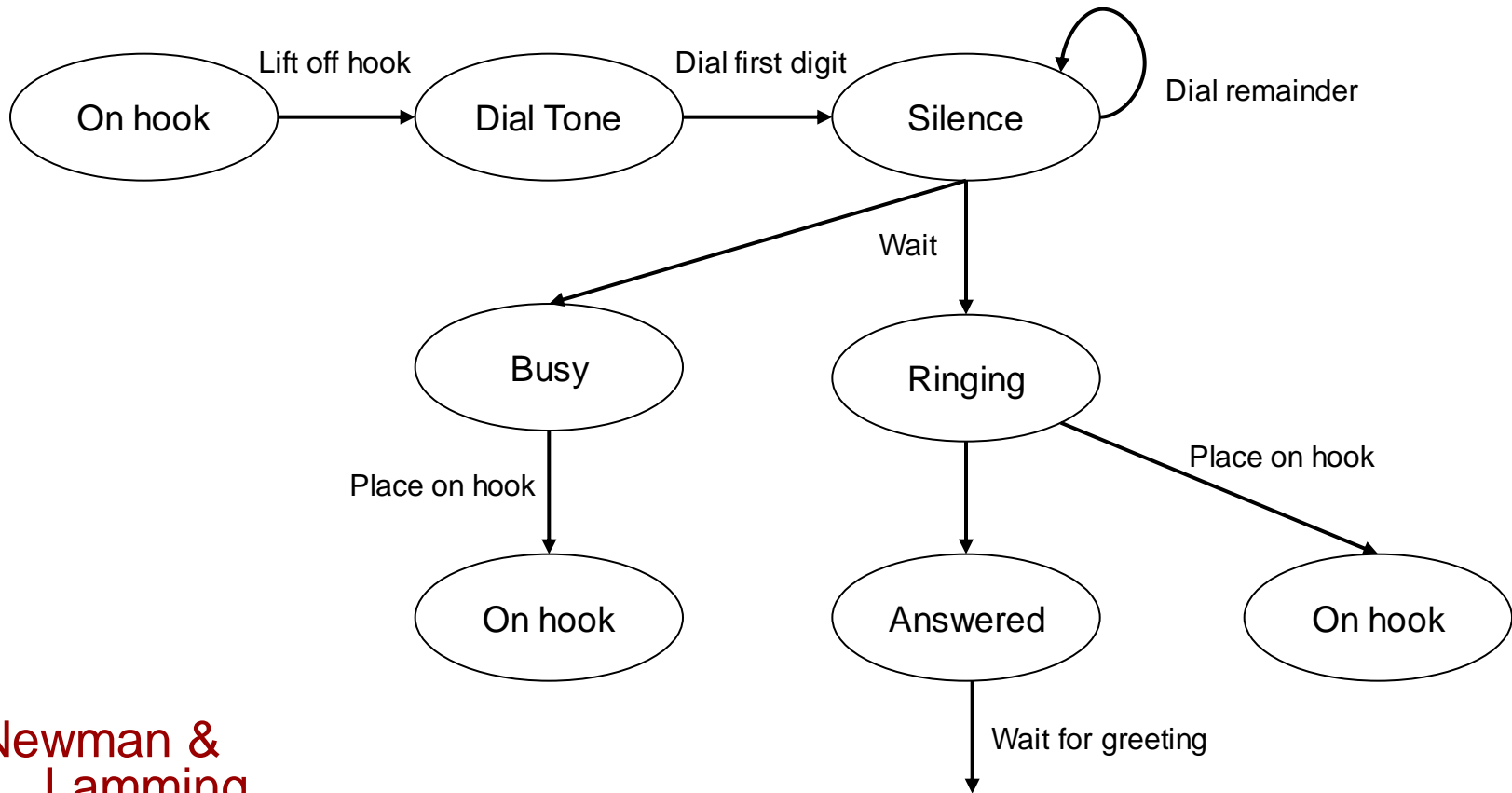
Runnable models: 'doing x will result in y '

1. **Establish the goal** to be achieved
2. **Form the intention** for action to achieve goal
3. **Specify the action** sequence corresponding to the intention
4. **Execute** the action sequence
5. **Perceive** the system state resulting from the action sequence
6. **Interpret** the perceived system state
7. **Evaluate** the system state with respect to the goal and the intentions

What would be a good x ?

Did y happen?
What does it mean?

Mental model of a telephone call



Newman &
Lamming
Fig 13.5

Common forms of mental models: Many categorizations. Very high-level.

- **Structural:** presents an image of *what the system is*
 - Descriptive (not prescriptive)
 - User may need additional knowledge to actually use it
 - Often more powerful / flexible, and often harder to use (esp. if don't have the necessary additional knowledge)
 - **Road map:** *it may show a particular type of information, but it isn't customized to your particular use of that info.*
- **Functional:** action-based; describes *how it is used*
 - Prescriptive; specific; often step-by-step
 - Does not assume global or system knowledge
 - Easier to use, but not very helpful for problem-solving or dealing with the unexpected
 - **Google directions:** *great when everything's there; need more when there's a roadblock.*

Structural models

Presents an image of ***what the system is***

- **Most maps and schematics**
 - Provide a specific view of the system; “use as needed”
 - ***Different views:*** *street, bus, bike maps of same region are customized to drivers, bus riders and bikers. All are structural models.*
- **Object-action models**
 - Users think in terms of concrete or abstract objects
 - The system supports action on the objects
 - ***Unix:*** *files are objects, commands like mv acts on them*
- **Analogies/metaphors**
 - A new system (closely) resembles an old system
 - (usually) intent is to help *transfer* existing system knowledge
 - *desktop metaphor; spreadsheet.*

Functional models

Presents an image of *how the system is used*

- Many kinds of user manuals
 - step-by-step “how-tos”.
- State transition model
 - Changes in state need to be “visible”; step through them.
 - **Telephone example**, earlier slide; **online shopping cart**
- Functional “mapping” models
 - Different from a “system map”!
 - Users learn a sequence of actions to accomplish tasks
 - The mappings need to be rote-learned; often arbitrary
 - *Hand-held calculator* maps “math” to key presses;
 - **keyboard shortcuts**

How users use mental models

e.g. State transition model

- Our view of using a telephone is as a series of **state changes**
 - e.g. represented as in telephone example (earlier)
- **MM predicts how long we wait at various points**
 - Unexpected delays or unfamiliar responses not understood
- **We try to fit what we hear into our model:**
 - international calls may encounter different delays
 - international calls may have extra steps
 - international calls may result in different signals
 - a separate device exerts control in fax calls

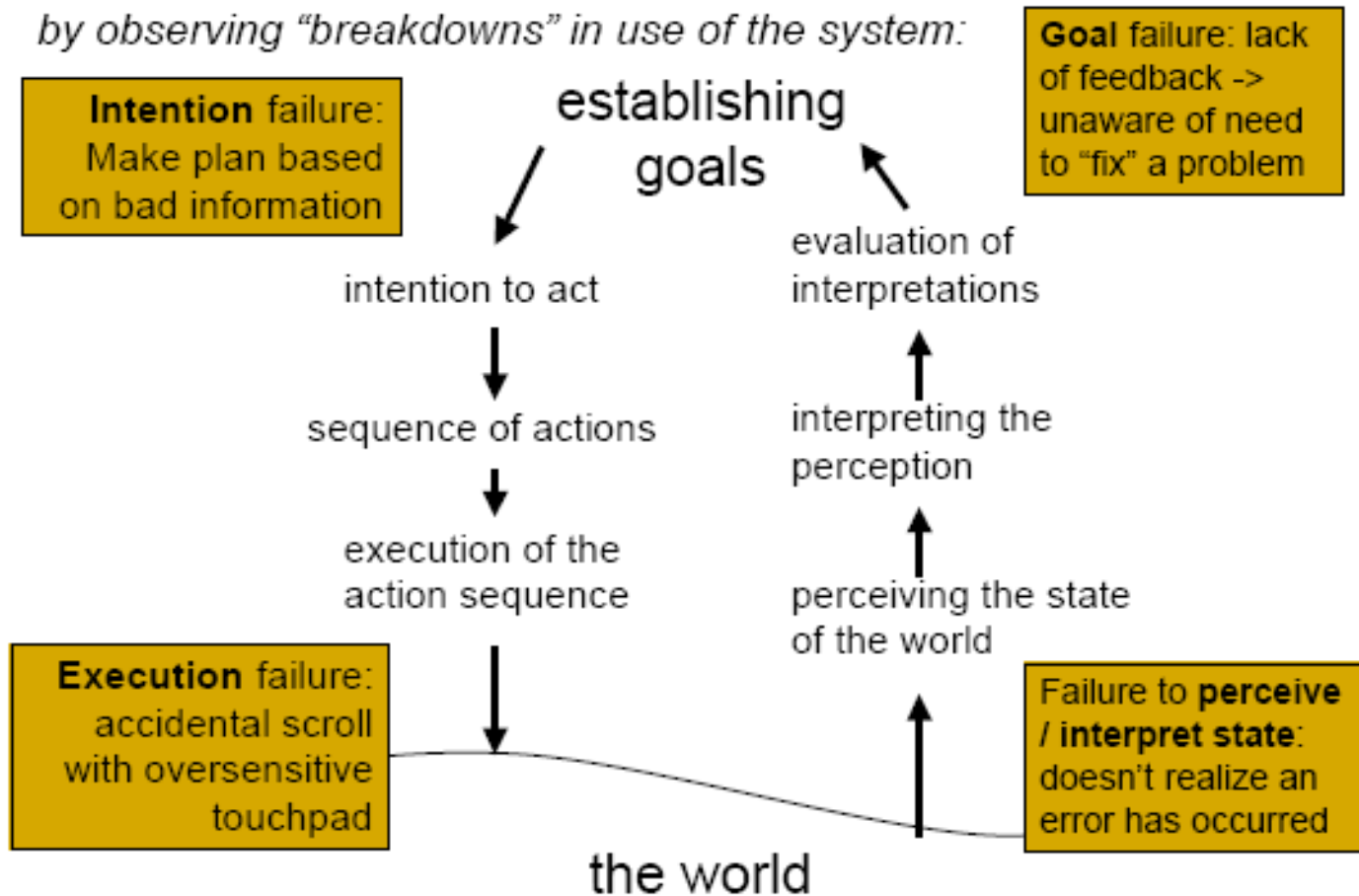
Topic: Mental models and user interaction

- Recap on previous lecture on mental models
- **Mental models and user interaction**

What mental models tell the user



How do designers identify a user's mental model?



The system image

- **We have control over what users see**
 - Responsible for turning the system model -> system image
 - Choose a system image to foster a good mental model
- **Some interfaces literally display the system model**
 - All objects and actions may be visible at all times
 - Automobile dashboard provides a system image of the car
... sensor displays, physical controls
- **Currency (up-to-date-ness) is important**
 - The system image has to reflect the actual current state
- **Consistency is important**
 - Adaptive Microsoft drop-down menus violate consistency

When a simple mental model might be better:

Hiding system complexity

- Many systems have messy low-level details
 - These may not be relevant to the user's activity
 - The full functionality of the system may not be required
- Example: MS Word has hundreds of commands
 - Many users need only a small subset of these commands
 - Users themselves can hide complexity by customization
 - IT administrators may provide macro capabilities
 - Macros bundle low-level commands into a single concept
 - Wizards allow a user to “do what's right”, skipping details
 - One approach: “**training wheels**”

Example

of where it helps to hide system complexity

- **Water faucet**

- The [real] **system model** has independent hot & cold
- The **system image** provides variable temperature
- Some taps allow separate temperature control & volume control
- Both “hot & cold” and “temperature & volume” are 2 DOF

Presenting the system image

- **Explicit representation**
 - Provide a current and consistent map of everything
- **Implicit representation**
 - Provide cues about the system model
 - Progressively expose/reinforce the system model
 - Telephone voice mail example:
 - Good: *You have three new messages. Press 2 to hear your first new message.*
 - Bad: *Press 2 to hear new message.*

Conceptual models in design

Guideline #1

Provide a good conceptual model

Allows user to predict the effects of their actions

- **Problem:**
 - *Designer's conceptual model is communicated via **system image**.*
 - Appearance, instructions, system behavior through interaction transfer, idioms and stereotypes.
 - If system image does not make model clear and consistent:
 - User will develop inconsistent conceptual model.
- “wrong” vs “simplified”?

Conceptual models in design

Guideline #2

- **Make things visible**
 - Relations between user's intentions, required actions, and results are sensible and meaningful.
 - Employ visible affordances, mappings, and constraints.
 - Use visible cultural idioms.
 - Remind person of what can be done and how to do it.
- **Narrow your gulfs!**

Good Practices for Conceptual Design

- Choose an intended mental model **early in design**
- Link choice of **mental model to style of interaction**
- **Hide system features** that conflict with user's activity
- **Exploit system image** to foster intended mental model
- Ensure that **system image is current and consistent**
- Take into account users' **existing mental models**
- Allow for both **novice and expert** mental models
- Use **simple, concrete, familiar metaphors**
- Obey "**Law of Least Astonishment**" (Occam's Razor)

Mental models & paper prototypes: Revealing a mental model to the user

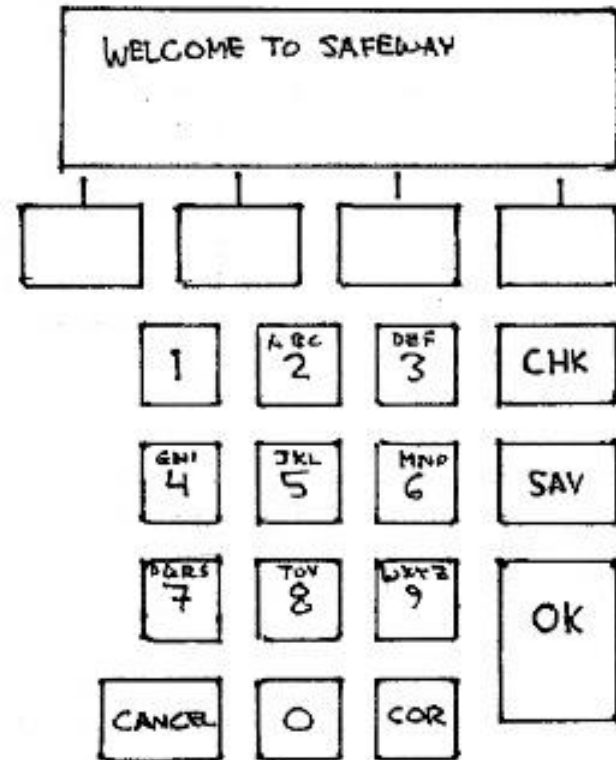
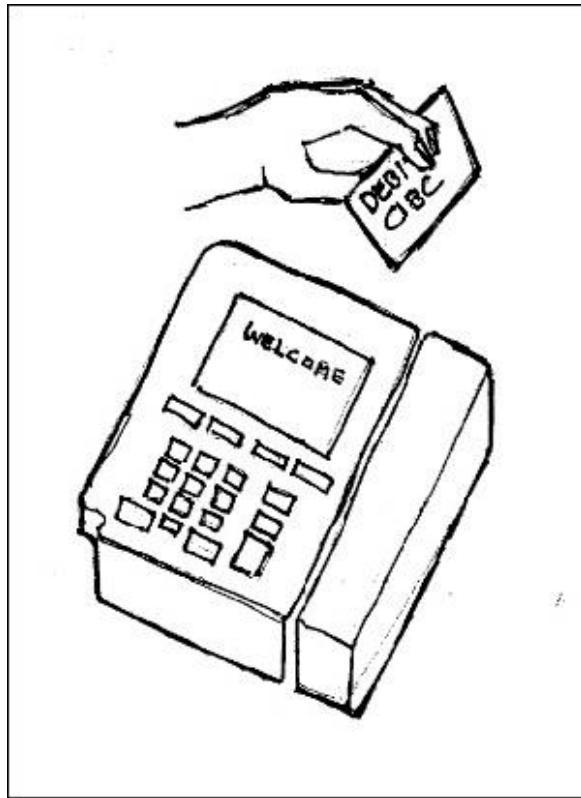
- A storyboard or paper prototype is one way of illustrating / documenting an intended or observed mental model.
- Useful for design, communication, analysis.

Interesting for your upcoming report?

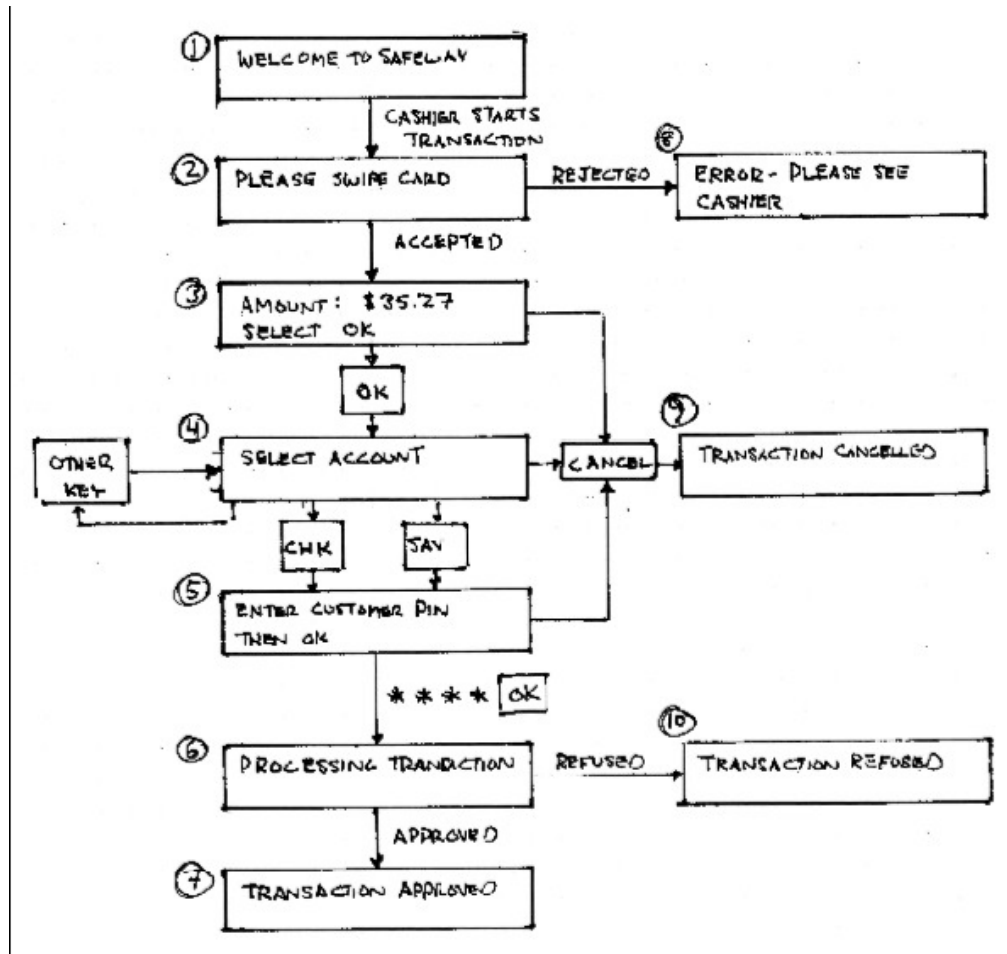
Grocery ATM

(example of a paper prototype)

First, the task:



One way to prototype the mental model



How will you prototype your project assignment?

Summary

- Designer creates **conceptual models** and **system models**.
- User models (**mental models**) are developed by the user.
- Common mental model: **object-action model**.

Resources

1. Kellogg S. Booth, Introduction to HCI Methods, University of British Columbia, Canada

<http://www.ugrad.cs.ubc.ca/~cs344/current-term/>