Vorlesung
Mensch-Maschine-Interaktion

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Chapter 4
Analyzing the Requirements and Understanding the Design Space

- 3.1 Factors that Influence the User Interface
- 3.2 Analyzing work processes and interaction
- 3.3 Conceptual Models – How the users see it
- 3.4 Analyzing existing systems
- 3.5 Describing the results of the Analysis
- 3.6 Understanding the Solution Space
- 3.7 Design Space for Input/Output
- 3.8 Technology Overview

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  - 3.2.2 Contextual enquiry
  - **3.2.3 Observational Studies and Video Analysis (cont.)**
  - 3.2.4 Task Analysis
  - 3.2.5 Object-Action-Interface Model
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Adapted From
www.id-book.com

Participant observation & ethnography

- Participant observation is key component of ethnography
- Must get co-operation of people observed
- Informants are useful
- Data analysis is continuous
- Questions get refined as understanding grows
- Reports usually contain examples

From
www.id-book.com

Data analysis

- *Qualitative data* - *interpreted* & used to tell the 'story' about what was observed.
- *Qualitative data* - *categorized* using techniques such as content analysis.
- *Quantitative data* - collected from interaction & video logs. Presented as values, tables, charts, graphs and treated statistically.

Adapted From
www.id-book.com

Interpretive data analysis

- Look for key events that drive the group's activity
- Look for patterns of behavior
  - Critical incident analysis
  - Content analysis
  - Quantitative analysis - i.e., statistics
- Test data sources against each other - triangulate
- Report findings in a convincing and honest way
- Produce 'rich' or 'thick descriptions'
- Include quotes, pictures, and anecdotes
- Software tools can be useful

What do you think?

From www.id-book.com

Key points

- Observe from outside or as a participant
- Analyzing video and data logs can be time-consuming.
- In participant observation collections of comments, incidents, and artifacts are made. Ethnography is a philosophy with a set of techniques that include participant observation and interviews.
- Ethnographers immerse themselves in the culture that they study.

Ethnographic Observation in HCI

- Traditional ethnographers immerse into other cultures over a extended period (weeks, month, years) and thereby study and understand the culture
- Ethnographic observations in HCI are a means of data collection
- Usually observing potential users (typical users) over a period of hours, days, or weeks. Include critical times (e.g. shift change)
- Goal
  - Acquire information that is required to create user interfaces and interaction mechanisms suitable
- Risk
  - Misinterpretation of observations (often due to a luck of insight)
  - Changing peoples behavior, disrupt processes
  - Overlooking / missing important facts
- Some problems occur infrequently – if you can not observe them conduct interviews

Guidelines for Ethnographic Observation in HCI (Shneiderman, chapter 3)

- Preparation
  - Understand the current system in the context of the organization and culture – don't be ignorant!
  - Describe the goals of the observation and prepare questions
  - Get permissions for observations and interviews
- Field Study
  - Establish contact, talk to people
  - Observe, interview, and collected data in situ
  - Document observations
- Analysis
  - Compile data, summaries and quantify
  - Provide interpretation of the data
  - Refine the goals and record issues about the process
- Reporting
  - Describe findings – possibly for different audiences

Observations & Protocols

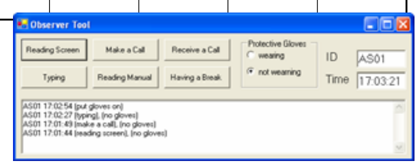
- Paper and pencil
  - Cheap and easy but unreliable
  - Make structured observations sheets / tool
- Audio/video recording
  - Cheap and easy
  - Creates lots of data, potentially expensive to analyze
  - Good for review/discussion with the user
- Computer logging
  - Reliable and accurate
  - Limited to actions on the computer
  - Include functionality in the prototype / product
- User notebook
  - Request to user to keep a diary style protocol

Structured observations

- Observation sheet

time	typing	reading screen	consulting manual	phoning	…
14:00		X		X	
14:01	X		X		
14:02	X				
14:03	X				
14:04				X	
…					

- Electronic version



Observations and Protocols

- What are observations and Protocols good for?
  - Demonstrating that a product improves productivity
  - Basis for qualitative and quantitative findings
- Hint
  - Minimize the chance for human error in observation and protocols
  - Most people are pretty bad at doing manual protocols
  - Combine with computer logging
    - Log what you get from the system
    - Observer makes a protocol on external events

Ethnographic Observation in HCI Video Observation

- Capture work practices on video (consider legal and ethical issues)
- User's view often provides significant insight
- Asking user's to talk (to describe) while doing a task provides generally a lot of useful information
- Raw material alone is of little value – need for analysis
- Analyzing video observations is hard and time consuming!
- Users may not like it! If they agree a person observing them they still may disagree to be videoed

Video Observation (1)

Camwear from
http://www.mydejaview.com

- Observation is done with one or more cameras
- Cameras provide pictures of regions important to the task
- Camera attached to the user may be use
  - Camera embedded into glasses
  - Allow the observer to see "through the eyes" of the user
- Different view points simultaneously
  - Camera overlooking the workplace
  - Camera looking from the screen to the user
  - Camera capturing what the user sees

Video Observation (2)

- Can be used
  - When only the user can be present
  - In dangerous environments
  - When many users interact and tasks are complex
  - When only selective data is required
  - For tasks that are done very quickly or hard to observe
- To speed up analysis the captured video material should be time stamped and correlated with other events
  - E.g. only look at the video from the moment when a "new mail arrived" notification is issued till the user enters the email client
- Analysis of raw material is very time consuming!
  - 3h to 20h for 1h recording
  - Automatically annotate video recordings (time stamps)

Using further Sensors for Observation

- To ease the analysis it is helpful to automatically detect interactions of interest, e.g.
  - When did the person leave the room?
  - When did the person get something out of the shelf?
  - When did the person meet another person?
  - Where did the person go?
- Such information can be obtained using sensor systems, e.g.
  - RFID-Tags and readers
  - Activity sensors
  - Location tracking systems
- Depending on the requirements a technology should be selected. Currently most of these technologies are very new or still research prototypes

Scenario for combined analysis

- Camera
- Sensors (e.g. motion, touch, rfid, …)
- Logfile of the interactive devices (e.g. key-logger, application logger)

- Log all the data (video, sensors, key input) with time stamps

- Use sensor information to find the video scenes that are of interest, e.g.
  - Get me all video scenes that show what the user is doing before she/he switches to application X
  - Show me all sequence where users have to input a password

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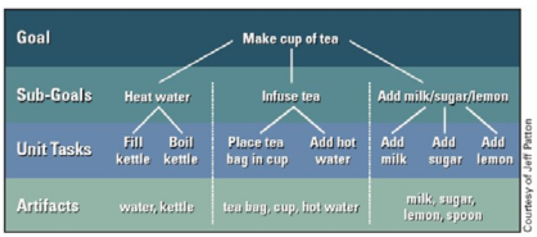
Task Analysis - Motivation

- Basically it is about all the actions performed by the user to accomplish a task
  - Its is about what we can observe
  - It is not really about the mental model
- Example – setting up a video projector:
  - unpacking the projector and placing it on the table
  - connecting the power cable to the projector and the socket
  - connecting a data cable between projector and computer
  - switching on the projector
  - waiting for the projector to be ready
  - switching the computer to dual screen mode
- Some issues
  - There is no single way to do that…
  - Granularity and details
  - Order of action

Task Analysis - Example



see: William Hudson. HCI and the web: A tale of two tutorials: a cognitive approach to interactive system design and interaction design meets agility. interactions Volume 12, Number 1 (2005), Pages 49-51

Task Analysis – High level Questions

- How do users know their goal is attainable?
- How do users know what to do?
- How will users know they have done the right thing?
- How will users know they have attained their goal?

William Hudson. HCI and the web: A tale of two tutorials: a cognitive approach to interactive system design and interaction design meets agility. interactions Volume 12, Number 1 (2005), Pages 49-51

Wharton, C., Rieman, J., Lewis, C., & Polson, P. (1994). The cognitive walkthrough method: A practitioner's guide. In J. Nielsen & R. L. Mack (eds.). Usability inspection methods. New York, NY: John Wiley.

What can we examine in Task Analysis?

- Input to the computer (keyboard, mouse, etc.)
- Physical actions, e.g. head movement, turning on the chair to reach for a document, lifting the mouse
- Perceptual actions, e.g. recognizing things that appear on the screen, finding a tool again
- Cognitive actions
- Mental actions and decision making
- Memory recall

Task analysis Set of basic questions

- Who is going to use the system? .
- What tasks do they now perform?
- What tasks are desired?
- How often are the tasks carried out?
- What time constraints on the tasks?
- What knowledge is required to do the task?
- How are the tasks learned?
- Where are the tasks performed (environment)?
- What other information and tools are required to do the task?
- What's the relationship between user & data?
- What is the procedure in case of errors and failures?
- Multi-user system: How do users communicated (CSCW Matrix)?

Task Analysis – Basics

- Analyze what the user has (or users have) to do in order to get a job done
  - What (physical) actions are done?
  - What cognitive processes are required?
- The task analysis is usually in the context of an existing system or for a established procedure
- The information flow is discovered
  - What information is used?
  - What information is created?
  - Also you ask with regard to the information: how, where, when, by whom, …
- Usually the information flow is essential when creating or changing a system
- The analysis is most often hierarchical
  - Task → sub task → sub sub task …

Task Analysis – Goals

- Find the tasks and actions that must be supported by a system
- Rank tasks and actions according to the requirement
- Identify the critical information flow in the system
- Understand how a task is composed of sub tasks
  - The relationship between tasks and sub tasks
  - The rational of task composition
  - The order of sub tasks (e.g. has the order significance or not)
- Specify which functions need to be include in the system/user interface that allow to do the overall task efficiently and with minimal effort for the user
- The description of tasks can be used to benchmark the system (it must at least support those tasks)

Task Analysis – How To?

- Task decomposition is at the center of the method
  - Identify high level tasks
  - Break them down into the subtasks and operations
- Task flows and alternatives
  - Identify for elementary subtasks their order (task flow)
  - Identify alternative subtasks
  - Understand and document decision processes (how are alternative subtasks chosen?)
- Present the result of the task analysis as chart
  - Charts may have different levels (overview and detailed subtasks)
  - Show sequences, alternatives, ordering in the diagram
- Questions that help in decomposition of tasks
  - How is the task done?
  - Why is the user doing this task?

See also: http://www.usabilitynet.org/tools/taskanalysis.htm

Task Analysis – Steps

- Starting the analysis
  - Specify the main task
  - Break down into 4 - 8 subtasks. The subtasks should be described as objectives - Should cover the whole main task
  - Draw subtasks as a layer. Make a plan how subtasks are connected.
- Progressing the analysis
  - Decide on the level of detail (detailed: keystroke-level - higher: general tasks)
  - Decide for each task if the analysis should be continued
  - Number boxes according levels
- Finalize the analysis
  - Check decompositions - all alternatives covered
  - Show the decomposition to an expert (evaluation - assessment)

From http://www.uwasa.fi/~mj/hci/hci7.html

Hierarchical Task Analysis

- Identify the goals the user wants to achieve
- Relate the goals to tasks (and potentially planning) done by the user
- Task decomposition
  - Ordering
  - Alternative plans
- How to limit the tasks to consider?
  - Defining a threshold based on probability of the task and cost in case of failure
  - If (failure_cost(task) * probability(task)) < threshold do not further consider this task
- For a detailed discussion on Task Analysis (hierarchical task analysis, knowledge based analysis, entity-relationship based technique, see Dix et. al – chapter 7)

Alternatives

- Task decomposition
  - Top-down approach
  - Breaking tasks into sequences of actions
- Knowledge based analysis
  - Bottom-up approach
  - Grouping simple actions and objects into classes by similarity
- Entity Relationship based analysis
  - Bottom-up approach
  - Defining objects, actors, actions and their relationship

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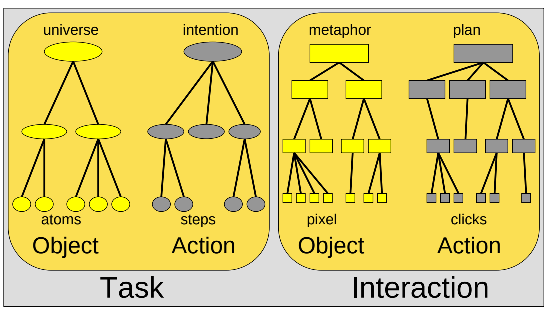
Object-Action Interface Model (OAI)

- Targeted at GUIs and applications in real world domains
- Steps
  1. Understanding the task, including
     - Universe of the real world, objects, atoms
     - Actions user can apply to objects, intention to steps
  2. Create a metamorphic representation of interface objects and actions
     - Object representation – metaphor to pixel
     - Actions – from plan level to specific clicks

Object-Action Interface Model (OAI)



From Shneiderman

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diary study

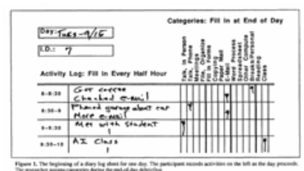
(usability glossary from www.usabilityfirst.com)

- A study that asks people to keep a diary, or journal, of their interactions with a computer system, any significant events or problems during their use of a system, or other aspects of their working life.
- A diary typically asks a user to record the date and time of an event, where they are, information about the event of significance, and ratings about how they feel, etc.
- An interesting alternative for making diary entries is to give users a tape recorder and a list of questions, so that users don't need to write things down as they encounter them.

Diary study - Discussion

- … your current homework includes a diary study
- What is a diary study good for?
- What are potential problems with this study type?
- How can technologies such as voice recorders, cameras, mobile phones help?

Image from: John Rieman. The diary study: a workplace-oriented research tool to guide laboratory efforts. Proceedings of the SIGCHI conference on Human factors in computing systems. pp 321-326. 1993.



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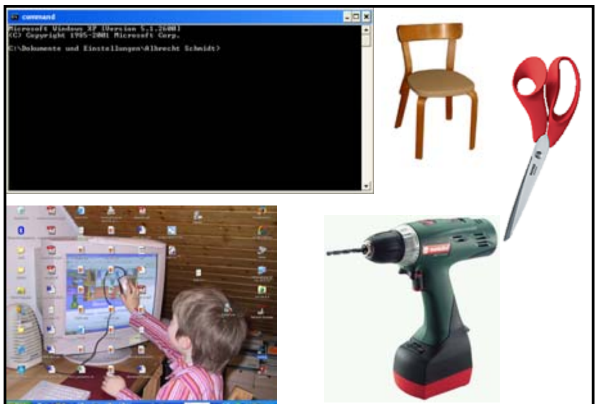
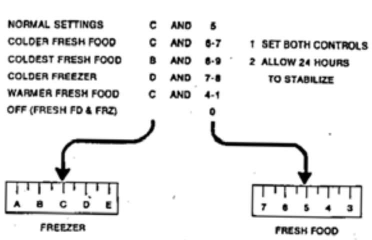
Background: The Psychology of Everyday Things (Norman 2002, Chapter 1)

- Not primarily aimed at computer science problems but with technologies (web, interactive media, embedded computers) moving into everyday life of most people it becomes highly relevant!
- Terms: Perceived and Real Affordances
  - Affordances determine the range of possible - usually physical - actions by a user on an system/object.
  - Perceived Affordances are the actions perceived by a user that appear to be possible.
  - Example: certain materials afford/support certain forms of vandalism (e.g. glass is smashed, wood is carved, graffiti appears on stone)
- This is also applicable to digital materials and designs.



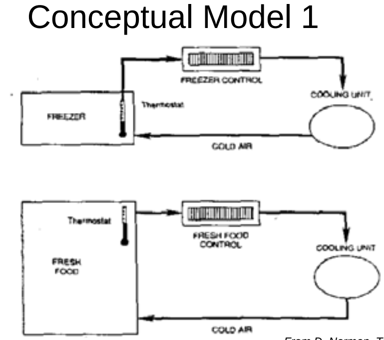
Explaining Conceptual Models Example –Refrigerator

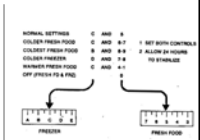


- 2 controls
- Freezer
- Fridge

From D. Norman, The Psychology of Everyday Things.

Example – Refrigerator Conceptual Model 1

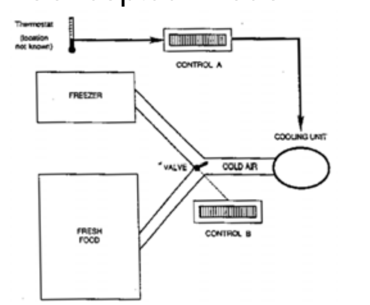


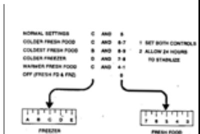


- Idea 1:
  2 cooling units
- One control each

From D. Norman, The Psychology of Everyday Things.

Example – Refrigerator Conceptual Model 2





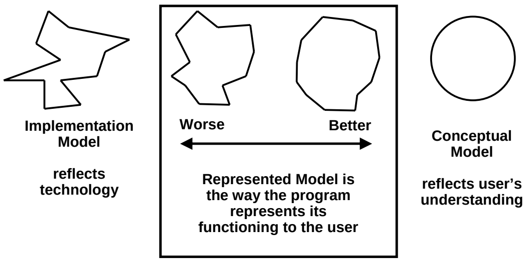
- Actual design – one cooling unit
- Controls have different functions

From D. Norman, The Psychology of Everyday Things.

Informal Exercise: Understand Conceptual Models

- Talk to "non-technical" people and try to understand their conceptual model for the following systems
  - Ordering a book from an online bookshop
  - Finding and reading information on the WWW on a particular topic using a search engine
  - Sending an email to someone who is traveling
- Hints to the conceptual model are often provided by
  - Observing what constraints on usage people apply (e.g. you have to do step x before step y)
  - How people explain errors (e.g. assuming the mental model does no include DNS – it is interesting to find out how people explain errors cause by failure of this component)

Implementation, Represented, Conceptual Model



From A. Cooper, About Face 2.0

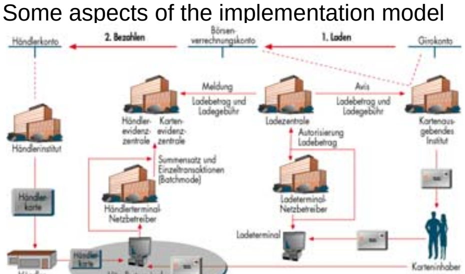
Example: 'Geldkarte' - Difference between the Conceptual Model and Implementation Model

- Store cash on the card
- Pay with the card

Conceptual Model – by the user

Example: 'Geldkarte' - Difference between the Implementation Model and Conceptual Model

Some aspects of the implementation model



From IX-Article: Chipgeld by Hans-Bernhard Beykirch, http://www.heise.de/ix/artikel/1998/12/148/

Models – Human and Computer

- Applications work on an Implementation Model
- They were designed after a Conceptual Model
- Users operate on their Mental Model
- The user interface translates between models

- Provocative Statement from A. Cooper
  "Computer literacy is nothing more than a euphemism for making the user stretch to understand an alien logic rather than having software-enabled products stretch to meet the user's way of thinking"

Implementation Model

- Model how a product is implemented
- Implementation details
  - data structures
  - control flow
  - functional components
- Constraints for the implementation, e.g.
  - remote data access vs. local data access
  - different ways to access records in a database depend on the existents of an index
- Terminology
  - terms/wording used reflect on technology
  - example – see error messages on various systems

Mental & Conceptual Model

- From the user's point of view
  - the explanation how something works
  - describing the basic properties and possible behaviour
  - the basis on which assumptions and predictions about the system and its behaviour are made
- Technically this is
  - in most cases a simplification of the underlying technology and
  - will most likely not reflect the correct mechanism or the actual implementation
- From the developers/designer point of view
  - how will the system appear to the user
  - how will the user understand the process
  - a conceptual description of the system at high level
- For the user the conceptual model is a psychological shorthand to understand how they can interact with a system

Conceptual Model
A Definition and its Significance

- A conceptual model is “the proposed system in terms of a set of integrated ideas and concepts about what it should do, behave and look like, that will be understandable by the users in the manner intended”
  (Preece, Rogers & Sharp, 2002, Interaction Design, Wiley, p 40)

- “The most important thing to design is the user’s conceptual model. Everything else should be subordinated to making that model clear, obvious and substantial. That is almost exactly the opposite of how most software is designed.”
  (David Liddle, 1996, Design of the conceptual model. In T. Winograd, (editor), Bringing Design to Software. Reading, MA: Addison-Wesley, p17)

Why is this a big issue new with digital products?

- For simple mechanical systems/processes the conceptual model and implementation model are very similar, e.g.
  - Hammer
  - Power drill

- For digital systems the implementation model is often very complex
  - Many components, often distributed
  - The service provided is a result of contributions from different parts
  - The digital components are not visible – even when you open the device

- Users still have a simple conceptual models to operate digital products
  - Based on what they see and their experience gained in use
  - By the control options they are given
  - By the behaviour and reactions they observe
  - By what they have learned about the system

How to get a Conceptual Model?
1st Analyse Problem Space

- Understand and analyse the problem space
  - Make problems of existing solution explicit (e.g. list of issue)
  - Why did you characterize them as problem? (because of intuition, reports, user studies, experiments?)
  - How does the envisioned concept solve the problem better? (is it faster, easier to use, easier to deploy, more fun?)
  - How would you see people using it with their current way of doing things?
  - How will it support people in their activities?
  - Will it really help them?
  - Would the envisioned solution introduce new problems? Which?
- Understanding the problem space leads to ideas about
  - What type of device/technology may be appropriate
  - What functionality is required under what conditions
  - What interaction metaphors can be used

How to get a Conceptual Model?
2nd Understand the User’s Goals

- What is the user (or are the users) trying to achieve
  - What is the final goal?
  - Are there intermediate goals?
  - Are there conflicting goals and trade-offs?
  - If multiple users - how are their goals related?
- Understand the tasks involved
  - What tasks and subtasks are carried out?
  - Why is the user doing these tasks?
  - How is this related to a potential solution?
  - Will the solution eliminate task and still reach the goals?
- Relate the user’s goals and tasks to the business model of the envisioned solution
  - Especially for service oriented digital products
  - Are there conflicts of interest between provider and consumer
    (e.g. quick answers and hence short connection time may conflict with a business model based on connection time, see WAP pages)

How to get a Conceptual Model?
3rd Make an Explicit Model

- Based on the analyses of the problem space and goals, identify
  - appropriate interface
  - Interaction methods and metaphors
  - Interaction paradigms
- Make the conceptual model explicit
  - Describe scenarios in detail and the use of the products
  - Storyboarding and videos
  - Sketching out ideas, design sketches
  - Put the solution into the wider context (e.g. an application on the mobile phone in the context of phone usage in general, what happens if a call comes in while you use the application?)
  - Create prototypes
    - low fidelity, e.g. paper prototypes, digital mock-ups (e.g. Flash examples, HTML-Forms with no Backend)
  - Documentation and training material

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Analyzing existing systems

- Observe usage manually → observation
- Monitor usage automatically
  - Use functions/mechanism included in products, e.g.
    - Log files for using web applications
  - Use additional software to monitor usage
    - Key logger
    - Proxy server
    - Screen capture tool
  - Extend the software that is used to track/analyze usage
  - Typical questions
    - What applications are used in the work process
    - How often is application X or function Y used
    - What files are accessed during the work process
- Tools, e.g.
  - analog - Web analysis software http://www.analog.cx
  - Filemon – logging files used http://www.sysinternals.com/Utilities/Filemon.html

Result of the analysis

- Definition of Requirements
- Clear description of
  - Goals of the user when operating the system
  - Tasks that need to be support
  - Context of use (technical, social)
  - Description of potential users
  - Side conditions
- Application / system concept
  - Description of the conceptual model
  - Concept design, sketches, video → design phase
  - Scenarios based on the contextual observation

User studies on existing systems

- Carry out user studies / controlled tests on the existing software
  - Provides understanding of the current system
  - Show opportunities for improvements
  - Base line to compare the new development
    - Ease of use
    - Speed for defined tasks
    - Frequency of errors
    - Effort for training
- Focus of the analysis depends on how the approach for the new development
  - Upgrading/improving the current system
  - Redesigning the system/software
  - Restructuring the work process and introduction of new software

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Chapter 4
Analyzing the Requirements and Understanding the Design Space

- 3.1 Factors that Influence the User Interface
- 3.2 Analyzing work processes and interaction
- 3.3 Conceptual Models – How the users see it
- 3.4 Analyzing existing systems
- **3.5 Describing the results of the Analysis**
- 3.6 Understanding the Solution Space
- 3.7 Design Space for Input/Output
- 3.8 Technology Overview