

## Systems Engineering

### Chapter 4:

### Systems Design: Selected Topics

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## Outline

- § 1. Systems Architecture
- § 2. Forms and Reports
- § 2. Interfaces and Dialogs

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## §1. Systems Architecture

- ISO/IEC 42010: Systems and Software Engineering – Architecture Description
- The **architecture** of a system is the set of fundamental concepts or properties of the system in its environment, embodied in its elements, relationships, and the principles of its design and evolution

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## Systems Elements and Relationships

- Elements are pieces that constitute a system
  - module, component, partition, subsystem, ...
- Architecturally significant pieces of a system: clearly identifiable and self-meaningful
- Elements and relations between them define the structure of the system
  - Static structure: organization of design-time elements
  - Dynamic structure: organization of runtime elements

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## Static Structure

- Definition of internal design-time elements and their arrangement in the system
- Software elements: programs, object-oriented classes or packages, services, any self-contained code unit
- Data elements: classes, database entities, data files
- Hardware elements: computers or their constituent parts (disk, CPU), networking elements (cables, routers, hubs)
- Arrangement:
  - Hierarchy:  $A$  is built from  $B$  and  $C$
  - Dependency:  $A$  relies on services of  $B$
  - Data relationship: data item is linked to another one

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## Dynamic Structure

- Definition of runtime elements and their interactions
- Information flows:  $A$  sends messages to  $B$
- Tasks execution (parallel or sequential):  $A$  invokes a routine on  $B$
- Effect on data: data item  $A$  is created, updates many times, and finally destroyed

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## Fundamental System Properties

- Externally visible behavior: what a system does from the standpoint of an external observer
  - Defines the functional interactions between the system and its environment
  - Black box model
  - State model: internal state changes in response to external stimuli
- Quality properties: an externally visible, nonfunctional property
  - Performance, security, scalability

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## Principles of Design and Evolution

- Architectural principle: Fundamental approach or intent that guides the definition of architecture
- Architecture requires definition of a set of principles
- Principles expose underlying assumptions, making "implicit explicit"

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## §2. Forms and Reports

- Key elements of an information system
- Related to system inputs and outputs
- Identified during requirements analysis
  - Focus on which forms and reports need to be and their content
- Design: precise appearance and elaboration
- Integrally related to various system models
  - Every form or report is associated with data flow elements

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## Form

- A business document that contains some predefined data and often includes some areas where additional data are to be filled in
- In a stylized format, not usually in a simple row and column format
  - Product forms, employment applications, ...
- Traditionally: paper medium
- Video display: duplicate the layout of any printed form
- Internet: gathering and displaying info when consumers order products, request product information, query account status

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## Report

- A business document that contains only predefined data: passive doc used solely for reading/viewing
  - Invoices, sales summaries, charts of population by age
- Report: data about multiple unrelated records
- Form: data from one record or based on data of one record
- Design rules are similar

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## Design Process

- User-focused activity
- Prototyping
- Design solutions: (i) content and (ii) layout
- Fundamental questions for form or report A:
  1. Who will use A?
  2. What is the purpose of A?
  3. When A is needed and used?
  4. Where does A need to be delivered and used?
  5. How many people need to use A?
- Design solution: (iii) implementation

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## Specification

1. Narrative view
2. Sample design
3. Testing and usability assessment

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## Formatting Guidelines: General

- Meaningful titles
  - Clear description of content and use
  - Dates (revision, current, valid)
- Meaningful information
  - Display what is needed
  - Usable info without modification
- Balance the layout
  - Screen/page space, Spacing and margins
  - Labels on all data and entry fields
- Easy navigation
  - How to move forward/backward
  - Where you are, last page notification

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## Formatting Guidelines: Advanced

- Highlighting information
  - Error/warning
  - Attention to keywords, high-priority messages, changes
- Color use
  - Benefits only if the information is first provided in the most appropriate format
- Displaying text
  - Case and punctuation, hyphenation, abbreviations
  - Double spacing, justification
- Tables and lists
  - Meaningful labels
  - Formatting columns, rows, and content

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## Assessing Usability

Design should assist, not hinder, user performance

Basic three characteristics:

1. **Speed**: can you complete a task efficiently?
2. **Accuracy**: Does the output provide what you expect?
3. **Satisfaction**: Do you like using the input?

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## Measures of Usability

- Time to learn
  - How long it takes the average user to become proficient for using the system
- Speed of task completion
- Rate of errors
  - Less usability, more errors
- Retention over time
  - The extent to which users remember how to use inputs and outputs over time
- Subjective satisfaction

Observations, Interviews, Keystroke capturing, Questionnaires

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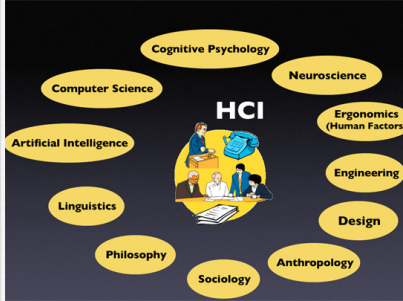
## §3. Interfaces and Dialogs

- Design problem:  
Defining the manner in which humans and computers exchange information
- **Interface design** focuses on how information is provided to and captured from users
- **Dialog design** focuses on the sequencing of interface displays

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## Human-Computer interface (HCI)



Different fields of HCI

<http://cs3240hci.wordpress.com/2011/09/04/post-1-human-computer-interaction-hci-%E2%80%9993-the-next-decade/>

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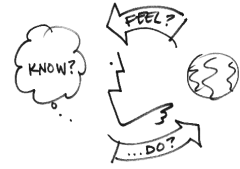
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## Methods of Interacting

HCI: an interaction style and some hardware for supporting the interaction

- Command language
- Menu: single-level, hierarchical, pop-up menu, drop-down menu
- Form
- Object-based: icons or symbols
- Natural language

INTERACTION DESIGN

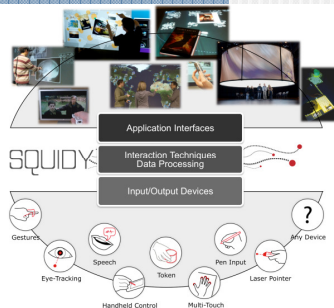


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## Hardware Options

- Keyboard
- Mouse
- Joystick
- Trackball
- Touch screen
- Light pen
- Graphics tablet
- Voice
- ...



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## Hardware Options: Example

- Schoolhouse Training System for distributed simulations
- Air Traffic Control
- Airspace trials with unmanned aircraft



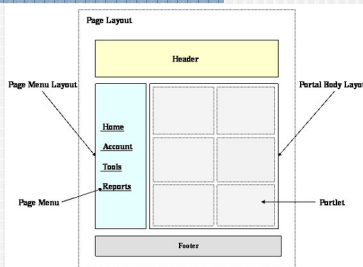
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## Interface Layouts

- Standard formats (similar to paper-based formats)
- Between-field navigation: left-to-right, top-to-bottom
- Grouping data fields into logical categories
- Data entry screen functional capabilities:
  - Cursor control
  - Editing
  - Exit
  - Help

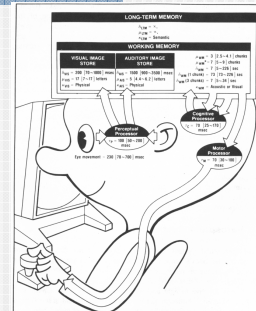


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## Human-Computer Dialogs: General Guidelines

- Consistency: uniform representation
- Shortcuts and Sequence: advanced users, intuitive steps
- Feedback: e.g., confirmation of every action
- Closure: beginning, middle, end
- Error handling: detection, reporting, suggestion
- Reversal: e.g., undo
- Control: make the user feel in control
- Ease: simple process



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