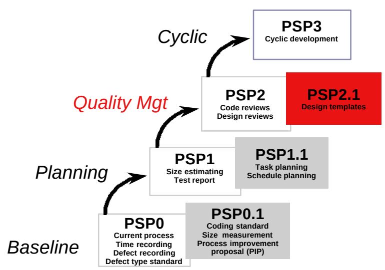
Software Design

Outline

- Review of PSP Levels
- Overview
- The Design Process
- Design Quality
- Structuring the Design Process
- Design Notation
- Templates for use in Design
- Design Guidelines

Review of PSP Levels *(Humphrey, 1995, p. 11)*



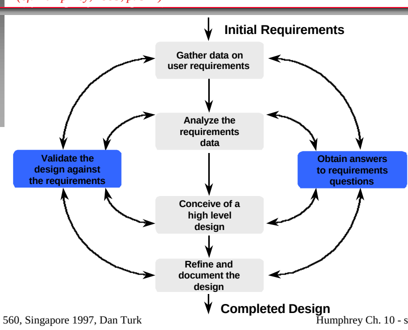
Overview *(cf. Humphrey, 1995, p. 309-310)*

- Good SW design transforms (ill-defined) requirements into an implementable product design specification.
  - Ill-defined requirements?
  - Requirements are generally less-than-perfectly defined. Thus we say they are ill-defined. Ideally we would have well-defined requirements.
- Two aspects of design quality:
  - Content
  - Representation
- Even a good design will probably be poorly implemented if its representation is bad
- The PSP addresses design from a defects-prevention perspective
- Design defects are more difficult to reduce than are coding defects

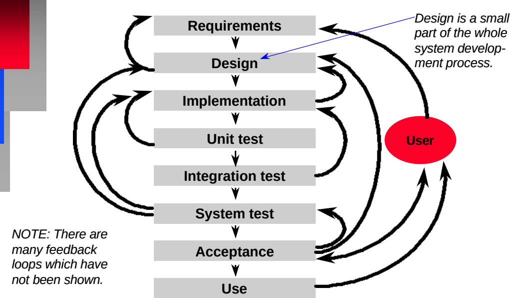
The Design Process
(cf. Humphrey, 1995, p. 309-310)

- Design is creative and cannot be reduced to a routine,
- However, it need not be totally unstructured.
- Design involves many parallel, cooperating activities in which discovery, invention, and intuition are frequently required.

The Design Framework
(cf. Humphrey, 1995, p. 311)



The (Simplified) Systems Development Framework
(cf. Humphrey, 1995, p. 312)



Design is a Learning Process
(cf. Humphrey, 1995, p. 310-314)

- *Design starts out with no one really understanding the requirements, design, or the implementation.*
- *The Requirements Uncertainty Principle: Users don't really (begin to) understand their requirements until they first see and use the system.*
- *Thus designers must create workable solutions to ill-defined problems.*
- *While there is no procedural way to accomplish this, a rigorous and explicit design process can help.*
- *There are several especially good paragraphs in this section describing these processes and difficulties.*

Conceptual Design (cf. Humphrey, 1995, p. 3132)

- *Types of problems and solutions:*
  - *Sometimes complex problems have complex solutions.*
  - *However, sometimes there are simple solutions.*
  - *On the other hand, sometimes simple problems have complex solutions.*
  - *And finally, sometimes the problem is in the great volume of detail.*
- *A general iterative design process is helpful:*
  - *Focus on high-level issues until you know enough to create a conceptual design*
  - *Complete & document the conceptual design*
  - *Document and make the development plan*
  - *Test the conceptual design by "walking around it" from every conceivable angle, thinking about user-issues, scenarios, etc.*
  - *Focus on the details.*
- *Note how the SASY process differs from Humphrey's description of an iterative process.*

SASY Iterative Incremental Process

Activity	*Iteration 1*	*Iteration 2*	*Iteration 3*	*Iteration 4…*
Domain Analysis				
Application Analysis				
Application Design				
Component Development				
Integration / Testing				

Darker shading indicates more emphasis on activity during iteration.

Design Quality (cf. Humphrey, 1995, p. 314-317)

- *Quality designs contain sufficiently complete, accurate, and precise solutions.*
- *Design specifications include:*
  - *class & object definitions & relationships*
  - *required data*
  - *state transitions*
  - *system inputs / outputs*
- *Design documentation can greatly exceed source code in size*
- *The program source listing is the most precise design document, but it is usually hard to understand.*
- *Sometimes design decisions can be deferred - experienced developers can make them, so don't waste time designing them. However, make sure not to underspecify the design too much - this is costly and error-prone.*

Design Decisions are Based on Design Users' Needs
(cf. Humphrey, 1995, p. 315-316)

- *Types of design users:*
  - *implementers*
  - *design & code reviewers*
  - *documenters*
  - *test developers & testers*
  - *maintainers & enhancers*
- *Each design product should have an owner and author.*
  - *The owner is the only one who can make changes to the design.*
  - *Categories of owners:*
    - *System / Product Mgt*
    - *System Engineers*
    - *Software Designers*

Products Controlled by Design Product Owners *(cf. Humphrey, 1995, p. 315-316)*

- *System / Product Mgt*
  - *Issues log*
  - *Program's intended function & how it should be used*
  - *System-level user scenarios*
  - *System constraints*
- *System Engineers*
  - *File descriptions*
  - *System messages*
  - *Reasons why system design decisions were made*
  - *Special error check / conditions*
- *Software Designers*
  - *List of related objects*
  - *External variables, calls, references*
  - *Statement of program's logic*
  - *Picture of where the program fits into the system*

Change Control *(cf. Humphrey, 1995, p. 316)*

- *Because of the large size of the design of any reasonably large system, the number of changes will be large / frequent and change control is absolutely necessary.*
- *Make sure that you only specify the absolute minimum of information, and*
- *Document each piece of information in just one place (so that multiple occurrences do not become inconsistent).*
- *The PSP deals with design standards for individual developers.*

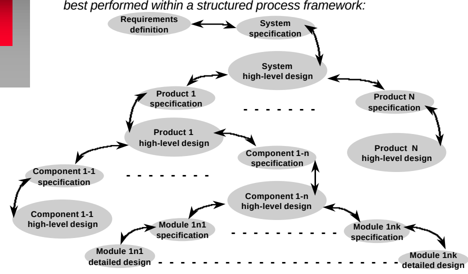
Design Levels *(cf. Humphrey, 1995, p. 317)*

- *Design proceeds at multiple levels of abstraction. (cf. Fig 10.3 Design Pyramid)*
- *Decisions should be documented at each level where they are made.*
- *If not, they will have to be reconstructed at each successively higher level.*
- *This reconstruction is an error-prone process.*
- *Attempting to work at multiple levels at one time causes difficulty and facilitates errors.*

Structuring the Design Process

(cf. Humphrey, 1995, p. 318-320)

- *Design is a dynamic, iterative-incremental, and creative process, yet it is best performed within a structured process framework:*



Requirements Definition

(cf. Humphrey, 1995, p. 318-319)

- *A requirements definition statement describes the <u>problem and/or need</u> in <u>user</u> terms. It does <u>not propose a solution</u>.*
- *It is rare that you can get a complete and accurate req's statement before you begin work because:*
  - *Few people have the specialized skills needed for req's specification*
  - *Req's change: over time and as you ask questions the users will think more deeply about their needs.*
  - *New solutions will cause needs, and thus req's, to change. This is a feedback loop…*
- *Thus, your focus is to work with users to help them generate as clear, precise, and specific a req's statement as they can at a given point in time.*

Design Specification

(cf. Humphrey, 1995, p. 319-322)

- *The goal of software design is "to produce <u>concise</u> and <u>precise</u> statements of exactly <u>what</u> the program is to do and <u>how</u> to do it".*
- *A design specification describes <u>solutions</u> to the problem in both <u>user</u> and <u>technical</u> terms. One or more potential solutions are proposed.*
- *Designs are specified at multiple levels:*
  - *High-Level*
  - *Detailed*
  - *Implementation*

Multiple Design Levels
(cf. Humphrey, 1995, p. 319-322)

- *High-Level*
  - *Conceptual / overall design.*
  - *Critical trade-off decisions are made here.*
  - *Balances development economics, application needs, and technology: what is feasible, desirable, and affordable. (And, we should add, what is politically / organizationally acceptable…)*
  - *Thus to make proper high-level designs you must have accurate development estimates. This will allow you to present in economic terms the costs of each request the user has for system features.*
- *Detailed*
  - *Reduces high-level design to implementable form: functions, objects, states, …*
- *Implementation*
  - *While implementation is not design, it implements detailed design, provides feedback (testing) on the quality of the design, and may in fact motivate changes in the design.*

Design Notation *(cf. Humphrey, 1995, p. 322-324)*

- *English (and any other natural language) is too redundant and imprecise to use as a design notation.*
- *The PSP provides a set of design templates & logic notation to facilitate documenting the various aspects of design.*
- *Design notation criteria:*
  - *Can precisely and completely represent the design.*
  - *Is understandable and usable by the people who must use the design.*
  - *Helps in efficiently producing a design.*
- *Design notation used for high-level design work should be implementation independent, but as lower and lower-level design is performed the notation should be come more and more implementation dependent, even to the point of using constructs from the implementation language.*

- *Question: What are some design notations with which you are familiar?*

Learning Design Notations
(cf. Humphrey, 1995, p. 323-324)

- *It takes time to learn design notations.*
- *Thus, at first your design work will be harder and will take longer.*
- *So, give yourself time to first learn a variety of notations.*
- *Then analyze the effectiveness of various techniques in contrast to not using these techniques.*
- *Keep techniques that help you address problem areas, and discard techniques that are not helpful.*

- *Summary: learn, experiment / measure, analyze, select.*
- *The design method should serve you, not you serve it.*
- *If the data you collect does not indicate that a technique is useful, find something that does!*

The PSP's Design Notation

- *cf. Appendix B*
- *cf. Tables 10.1 / 2, p. 325, 326*

- *Do Appendix B examples in-class.*

Design Templates *(cf. Humphrey, 1995, p. 324-327)*

- *The PSP focuses on OO design; however, non-OO designs can use the very same techniques:*
  - *Define ADT's, organize your designs around "logical" classes, the functions that implement them, state diagrams for these logical "objects", etc.*
- *The PSP provides templates that help lead to complete and precise designs, and minimize duplication of information. Information is stored in one place and is then simply referenced other places.*

Template Dimensions
(cf. Humphrey, 1995, p. 325-327)

- *The elements of a complete design can be organized as follows:*
  - *Internal-Static:*
    - *logical design*
    - *attributes, constraints*
  - *Internal-Dynamic*
    - *dynamic behavior*
    - *state diagram*
  - *External-Static*
    - *relationships to other objects*
    - *inheritance hierarchy*
    - *logical behavior*

- *NOTE: This model doesn't seem to map directly to the four templates as Humphrey suggests it should.*

Functional Specification Templates (cf. Humphrey, 1995, p. 327-333)

- *The functional specification describes several aspects of a system, including:*
  - *Class / object names & attributes*
  - *Inheritance hierarchy (parent classes)*
  - *Method names (declarations)*
  - *Method preconditions and actions*
- *These aspects describe each class conceptually (inheritance, pre-conditions & actions), and specify how the class will be used (method names and calling format).*
- *Thus we see that this template describes both internal requirements and external uses of each class / method, as well as both static and dynamic aspects.*
- *cf. Example template and notation on p. 327-330.*
- *cf. Appendix B1-5 on design notation*

State Specification Templates (cf. Humphrey, 1995, p. 333-337)

- *The state specification describes the internal dynamic behavior of an object. This includes:*
  - *The object's states*
  - *All allowed transitions between these states*
  - *All conditions that cause transitions.*
- *What we desire is a "proper" state machine. Proper state machines have the following properties:*
  - *States are complete & orthogonal.*
  - *State transitions are complete & orthogonal.*
  - *Can reach an exit state from every other state.*
- *cf. Example template and notation on p. 331-335. (State machine can be shown both graphically and functionally.)*
- *cf. Appendix B6 on "proper state machines"*
- *Do "LOC counter" state machine*

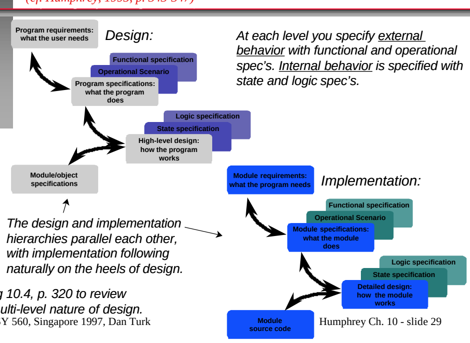
Logic Specification Templates (cf. Humphrey, 1995, p. 337-339)

- *The logic specification describes the internal processing logic of each method. It provides:*
  - *Pseudocode describing the method's internal processing logic*
  - *The object's language-specific internal attributes and actual definition and calling / return protocol*
  - *#defines, #includes, ...*
- *cf. Example template on p. 339.*
- *cf. CRC cards are conceptually a better way to do this. They can be used to combine the functional and logic templates all together.*

Operational Scenario Templates (cf. Humphrey, 1995, p. 340-343)

- *Operational scenarios are descriptions of how a user might expect to interact with the system. They describe things users will want to be able to do. They can also describe incorrect ways the system might be used.*
  - *Question: Who are "users" of objects…?*
  - *Answer: People, other objects, etc.*
- *cf. Example template on p. 341-343.*
- *cf. Ivar Jacobson's "Use Cases"*

Using Templates in Design
(cf. Humphrey, 1995, p. 343-347)



At each level you specify external behavior with functional and operational spec's. Internal behavior is specified with state and logic spec's.

cf. Fig 10.4, p. 320 to review the multi-level nature of design.

Design Guidelines (cf. Humphrey, 1995, p. 347-349)

- *Design Levels*
  - *Work up and down the design hierarchy, however:*
    - *When possible complete higher-level designs first.*
    - *Do not consider a higher-level design complete until all abstractions it uses are fully specified.*
    - *Do not consider program element designs complete until all the elements that call them are complete.*
    - *Document assumptions as you go.*
    - *Defer lower-level design decisions if they do not affect other parts of the system.*
- *Prototyping*
  - *Prototyping can help you resolve difficult issues so you can specify designs about which uncertainty remains until actual implementation is performed.*
- *Redesign*
  - *Use the design templates when you have to reverse engineer or redesign an already-existing product.*