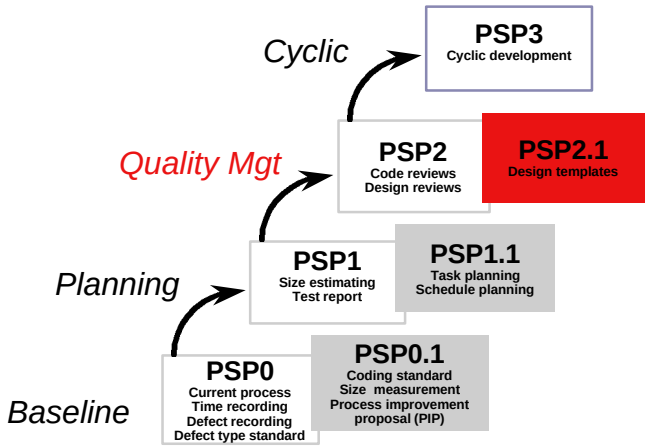
Software Design

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*

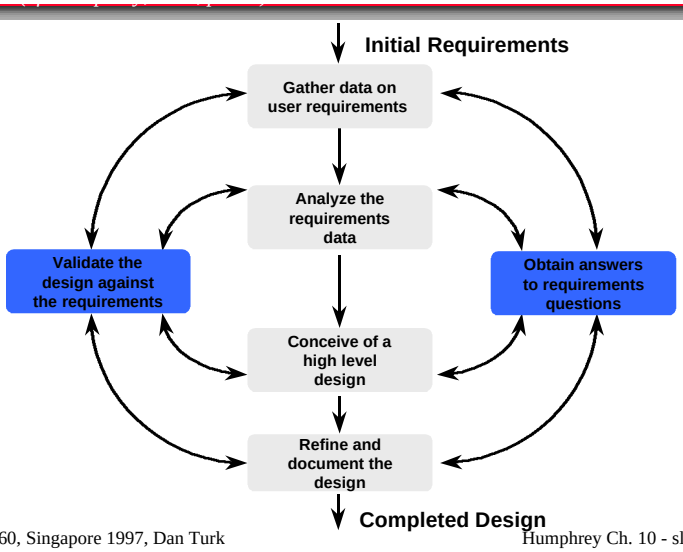
The Design Process

(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.*

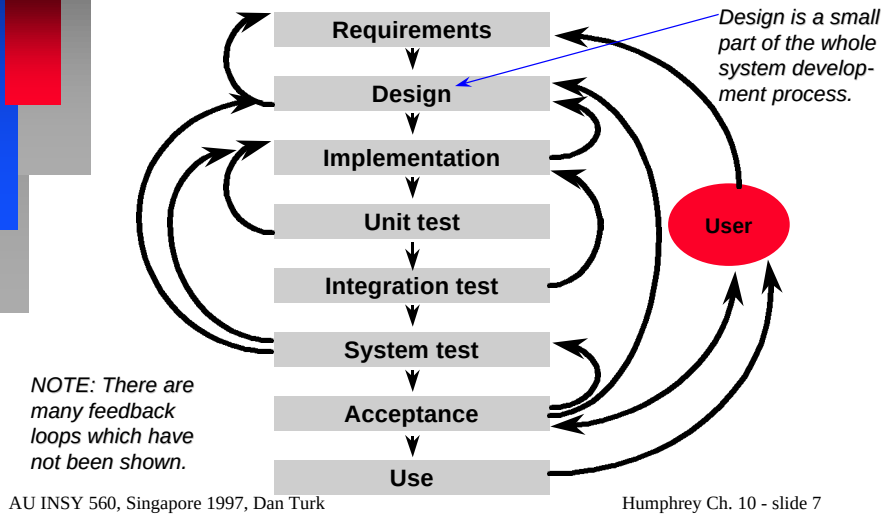
The Design Framework

(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.*

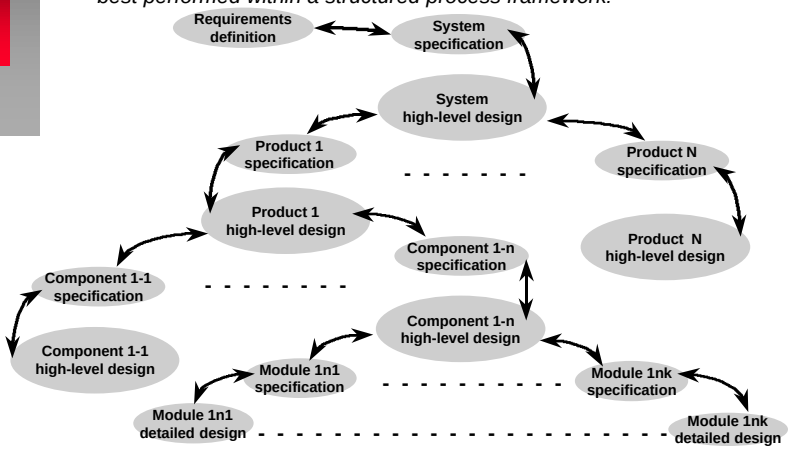
Design Levels *(cf. Humphrey, 1995, p. 317)*

- *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 problem and/or need in user terms. It does not propose a solution.*
- *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 concise and precise statements of exactly what the program is to do and how to do it".*
- *A design specification describes solutions to the problem in both user and technical 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)*

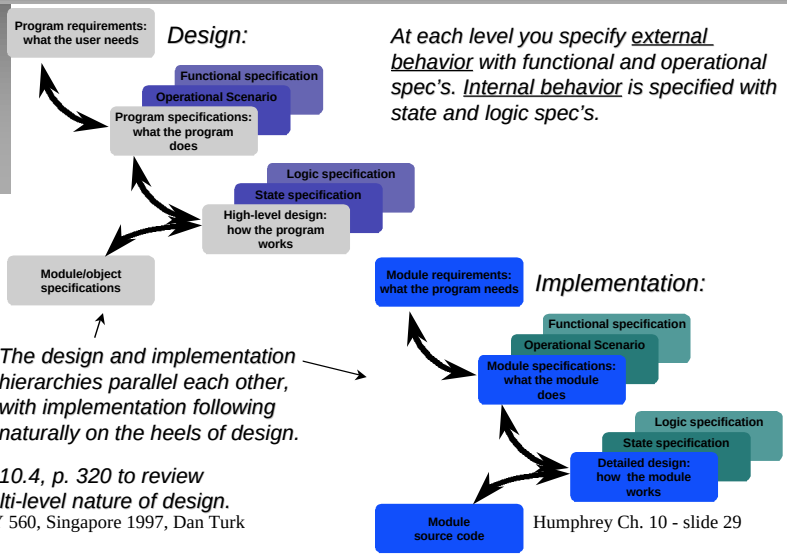
- *The logic specification describes the internal processing logic of each method. It provides:*
  - *Pseudocode describing the method's internal processing logic*
  - *The object's language-specific internal attributes and actual definition and calling / return protocol*
  - *#defines, #includes, ...*
- *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)



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.*