➢Software

➢Design

Software Design

- More creative than analysis
- Problem solving activity

WHAT IS DESIGN

'HOW' → Software design document (SDD)

Software Design

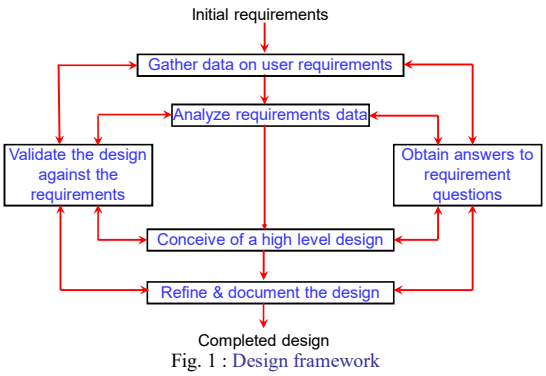
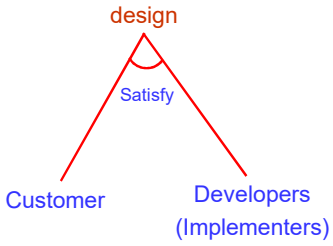


Fig. 1 : Design framework

Software Design



Software Design

Conceptual Design and Technical Design

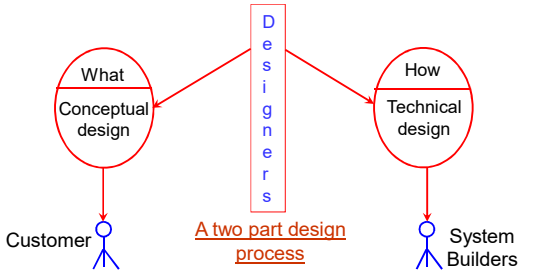


Fig. 2 : A two part design process

Software Design

Conceptual design answers :

- ✓ Where will the data come from ?
- ✓ What will happen to data in the system?
- ✓ How will the system look to users?
- ✓ What choices will be offered to users?
- ✓ What is the timings of events?
- ✓ How will the reports & screens look like?

Software Design

Technical design describes :

- Hardware configuration
- Software needs
- Communication interfaces
- I/O of the system
- Software architecture
- Network architecture
- Any other thing that translates the requirements in to a solution to the customer's problem.

Software Design

The design needs to be

- Correct & complete
- Understandable
- At the right level
- Maintainable

Software Design

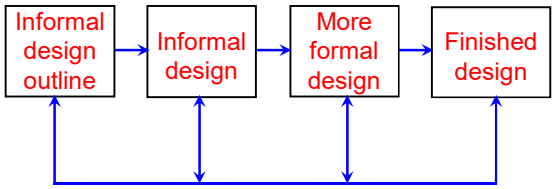


Fig. 3 : The transformation of an informal design to a detailed design.

Software Design

MODULARITY

There are many definitions of the term module. Range is from :

i. Fortran subroutine
ii. Ada package
iii. Procedures & functions of PASCAL & C
iv. C++ / Java classes
v. Java packages
vi. Work assignment for an individual programmer

Software Design

All these definitions are correct. A modular system consist of well defined manageable units with well defined interfaces among the units.

Software Design

Properties :

i. Well defined subsystem
ii. Well defined purpose
iii. Can be separately compiled and stored in a library.
iv. Module can use other modules
v. Module should be easier to use than to build
vi. Simpler from outside than from the inside.

Software Design

Modularity is the single attribute of software that allows a program to be intellectually manageable.

It enhances design clarity, which in turn eases implementation, debugging, testing, documenting, and maintenance of software product.

Software Design

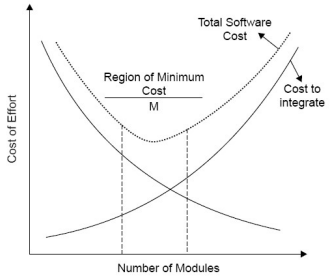
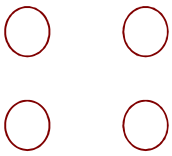


Fig. 4 : Modularity and software cost

Software Design

Module Coupling

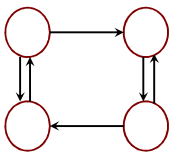
Coupling is the measure of the degree of interdependence between modules.



(Uncoupled : no dependencies)

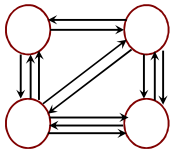
(a)

Software Design



Loosely coupled: some dependencies

(B)



Highly coupled: many dependencies

(C)

Fig. 5 : Module coupling

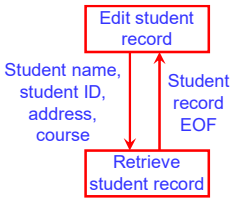
Software Design

This can be achieved as:

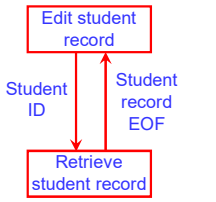
- Controlling the number of parameters passed amongst modules.
- Avoid passing undesired data to calling module.
- Maintain parent / child relationship between calling & called modules.
- Pass data, not the control information.

Software Design

Consider the example of editing a student record in a 'student information system'.



Poor design: Tight Coupling



Good design: Loose Coupling

Fig. 6 : Example of coupling

Software Design

Data coupling	Best
Stamp coupling	↑
Control coupling	
External coupling	
Common coupling	
Content coupling	Worst

Fig. 7 : The types of module coupling

Given two procedures A & B, we can identify number of ways in which they can be coupled.

Software Design

Data coupling

The dependency between module A and B is said to be data coupled if their dependency is based on the fact they communicate by only passing of data. Other than communicating through data, the two modules are independent.

Stamp coupling

Stamp coupling occurs between module A and B when complete data structure is passed from one module to another.

Software Design

Control coupling

Module A and B are said to be control coupled if they communicate by passing of control information. This is usually accomplished by means of flags that are set by one module and reacted upon by the dependent module.

Common coupling

With common coupling, module A and module B have shared data. Global data areas are commonly found in programming languages. Making a change to the common data means tracing back to all the modules which access that data to evaluate the effect of changes.

Software Design

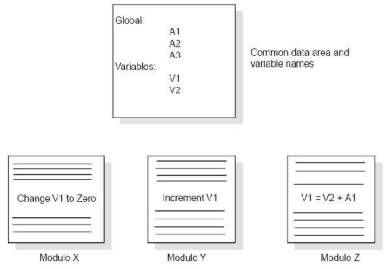


Fig. 8 : Example of common coupling

Software Design

Content coupling

Content coupling occurs when module A changes data of module B or when control is passed from one module to the middle of another. In Fig. 9, module B branches into D, even though D is supposed to be under the control of C.

Software Design

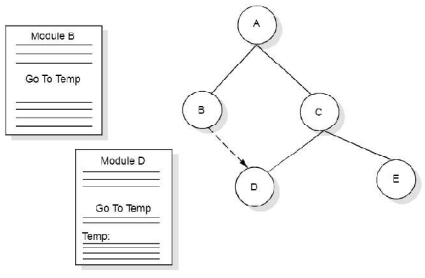


Fig. 9 : Example of content coupling

Software Design

Module Cohesion

Cohesion is a measure of the degree to which the elements of a module are functionally related.

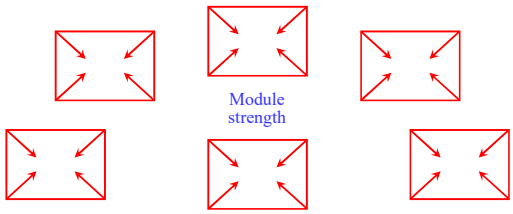


Fig. 10 : Cohesion=Strength of relations within modules

Software Design

Types of cohesion

- Functional cohesion
- Sequential cohesion
- Procedural cohesion
- Temporal cohesion
- Logical cohesion
- Coincident cohesion

Software Design

Functional Cohesion	Best (high)
Sequential Cohesion	↑
Communicational Cohesion	
Procedural Cohesion	
Temporal Cohesion	
Logical Cohesion	
Coincidental Cohesion	Worst (low)

Fig. 11 : Types of module cohesion

Software Design

Functional Cohesion

- A and B are part of a single functional task. This is very good reason for them to be contained in the same procedure.

Sequential Cohesion

- Module A outputs some data which forms the input to B. This is the reason for them to be contained in the same procedure.

Software Design

Procedural Cohesion

- Procedural Cohesion occurs in modules whose instructions although accomplish different tasks yet have been combined because there is a specific order in which the tasks are to be completed.

Temporal Cohesion

- Module exhibits temporal cohesion when it contains tasks that are related by the fact that all tasks must be executed in the same time-span.

Software Design

Logical Cohesion

- Logical cohesion occurs in modules that contain instructions that appear to be related because they fall into the same logical class of functions.

Coincidental Cohesion

- Coincidental cohesion exists in modules that contain instructions that have little or no relationship to one another.

Software Design

Relationship between Cohesion & Coupling

If the software is not properly modularized, a host of seemingly trivial enhancement or changes will result into death of the project. Therefore, a software engineer must design the modules with goal of high cohesion and low coupling.

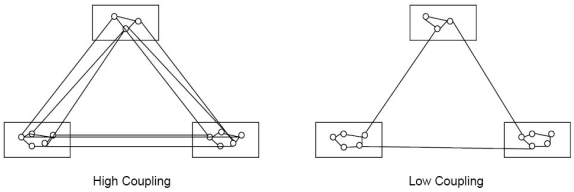


Fig. 12 : View of cohesion and coupling

Software Design

STRATEGY OF DESIGN

A good system design strategy is to organize the program modules in such a way that are easy to develop and latter to, change. Structured design techniques help developers to deal with the size and complexity of programs. Analysts create instructions for the developers about how code should be written and how pieces of code should fit together to form a program. It is important for two reasons:

- First, even pre-existing code, if any, needs to be understood, organized and pieced together.
- Second, it is still common for the project team to have to write some code and produce original programs that support the application logic of the system.

Software Design

Bottom-Up Design

These modules are collected together in the form of a “library”.

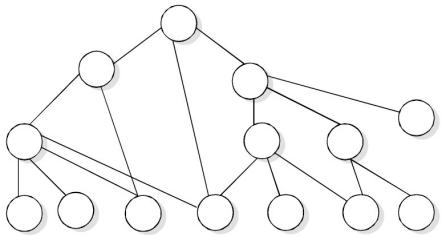


Fig. 13 : Bottom-up tree structure

Software Design

Top-Down Design

A top down design approach starts by identifying the major modules of the system, decomposing them into their lower level modules and iterating until the desired level of detail is achieved. This is stepwise refinement; starting from an abstract design, in each step the design is refined to a more concrete level, until we reach a level where no more refinement is needed and the design can be implemented directly.

Software Design

Hybrid Design

For top-down approach to be effective, some bottom-up approach is essential for the following reasons:

- To permit common sub modules.
- Near the bottom of the hierarchy, where the intuition is simpler, and the need for bottom-up testing is greater, because there are more number of modules at low levels than high levels.
- In the use of pre-written library modules, in particular, reuse of modules.

Software Design

FUNCTION ORIENTED DESIGN

Function Oriented design is an approach to software design where the design is decomposed into a set of interacting units where each unit has a clearly defined function. Thus, system is designed from a functional viewpoint.

Software Design

Consider the example of scheme interpreter. Top-level function may look like:

```
While (not finished)
{
    Read an expression from the terminal;
    Evaluate the expression;
    Print the value;
}
```

We thus get a fairly natural division of our interpreter into a "read" module, an "evaluate" module and a "print" module. Now we consider the "print" module and is given below:

```
Print (expression exp)
{
    Switch (exp → type)
    Case integer: /*print an integer*/
    Case real:    /*print a real*/
    Case list:    /*print a list*/
    :::
}
```


Software Design

We continue the refinement of each module until we reach the statement level of our programming language. At that point, we can describe the structure of our program as a tree of refinement as in design top-down structure as shown in fig. 14.

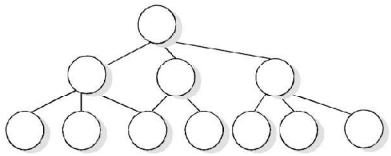


Fig. 14 : Top-down structure

Software Design

If a program is created top-down, the modules become very specialized. As one can easily see in top down design structure, each module is used by at most one other module, its parent. For a module, however, we must require that several other modules as in design reusable structure as shown in fig. 15.

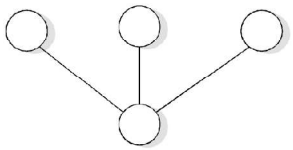


Fig. 15 : Design reusable structure

Software Design

Design Notations

Design notations are largely meant to be used during the process of design and are used to represent design or design decisions. For a function oriented design, the design can be represented graphically or mathematically by the following:

- Data flow diagrams
- Data Dictionaries
- Structure Charts
- Pseudocode

Software Design

Structure Chart

It partition a system into block boxes. A black box means that functionality is known to the user without the knowledge of internal design.

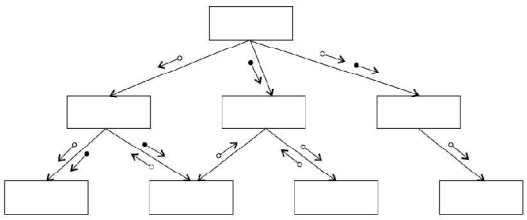


Fig. 16 : Hierarchical format of a structure chart

Software Design

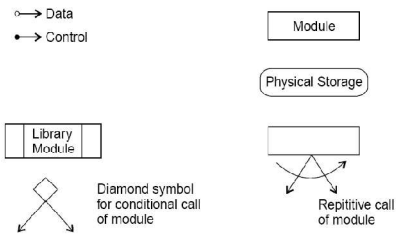


Fig. 17 : Structure chart notations

Software Design

A structure chart for "update file" is given in fig. 18.

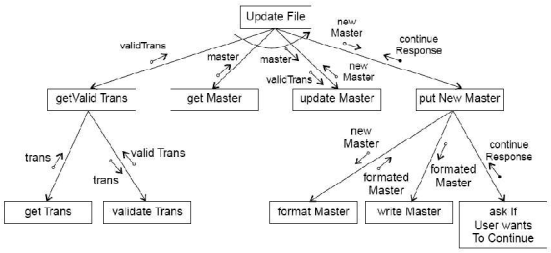


Fig. 18 : Update file

Software Design

A transaction centered structure describes a system that processes a number of different types of transactions. It is illustrated in Fig.19.

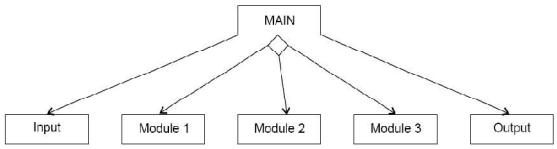


Fig. 19 : Transaction-centered structure

Software Design

In the above figure the MAIN module controls the system operation its functions is to:

- invoke the INPUT module to read a transaction;
- determine the kind of transaction and select one of a number of transaction modules to process that transaction, and
- output the results of the processing by calling OUTPUT module.

Software Design

Pseudocode

Pseudocode notation can be used in both the preliminary and detailed design phases.

Using pseudocode, the designer describes system characteristics using short, concise, English language phrases that are structured by key words such as It-Then-Else, While-Do, and End.

Software Design

Functional Procedure Layers

- Function are built in layers, Additional notation is used to specify details.
- Level 0
  - Function or procedure name
  - Relationship to other system components (e.g., part of which system, called by which routines, etc.)
  - Brief description of the function purpose.
  - Author, date

Software Design

- Level 1
  - Function Parameters (problem variables, types, purpose, etc.)
  - Global variables (problem variable, type, purpose, sharing information)
  - Routines called by the function
  - Side effects
  - Input/Output Assertions

Software Design

- Level 2
  - Local data structures (variable etc.)
  - Timing constraints
  - Exception handling (conditions, responses, events)
  - Any other limitations
- Level 3
  - Body (structured chart, English pseudo code, decision tables, flow charts, etc.)

Software Design

IEEE Recommended practice for software design descriptions (IEEE STD 1016-1998)

- Scope

An SDD is a representation of a software system that is used as a medium for communicating software design information.

- References

i. IEEE std 830-1998, IEEE recommended practice for software requirements specifications.

ii. IEEE std 610.12-1990, IEEE glossary of software engineering terminology.

Software Design

- Definitions

i. **Design entity.** An element (Component) of a design that is structurally and functionally distinct from other elements and that is separately named and referenced.

ii. **Design View.** A subset of design entity attribute information that is specifically suited to the needs of a software project activity.

iii. **Entity attributes.** A named property or characteristics of a design entity. It provides a statement of fact about the entity.

iv. **Software design description (SDD).** A representation of a software system created to facilitate analysis, planning, implementation and decision making.

Software Design

- Purpose of an SDD

The SDD shows how the software system will be structured to satisfy the requirements identified in the SRS. It is basically the translation of requirements into a description of the software structure, software components, interfaces, and data necessary for the implementation phase. Hence, SDD becomes the blue print for the implementation activity.

- Design Description Information Content
  - Introduction
  - Design entities
  - Design entity attributes

Software Design

The attributes and associated information items are defined in the following subsections:

a) Identification
b) Type
c) Purpose
d) Function
e) Subordinates
f) Dependencies
g) Interface
h) Resources
i) Processing
j) Data

Software Design

- Design Description Organization

Each design description writer may have a different view of what are considered the essential aspects of a software design. The organization of SDD is given in table 1. This is one of the possible ways to organize and format the SDD.

A recommended organization of the SDD into separate design views to facilitate information access and assimilation is given in table 2.

Software Design

1. Introduction
   - 1.1 Purpose
   - 1.2 Scope
   - 1.3 Definitions and acronyms
2. References
3. Decomposition description
   - 3.1 Module decomposition
     - 3.1.1 Module 1 description
     - 3.1.2 Module 2 description
   - 3.2 Concurrent Process decompostion
     - 3.2.1 Process 1 description
     - 3.2.2 Process 2 description
   - 3.3 Data decomposition
     - 3.3.1 Data entity 1 description
     - 3.3.2 Data entity 2 description

Cont...

Software Design

4. Dependency description
   - 4.1 Intermodule dependencies
   - 4.2 Interprocess dependencies
   - 4.3 Data dependencies
5. Interface description
   - 5.1 Module Interface
     - 5.1.1 Module 1 description
     - 5.1.2 Module 2 description
   - 5.2 Process interface
     - 5.2.1 Process 1 description
     - 5.2.2 Process 2 description
6. Detailed design
   - 6.1 Module detailed design
     - 6.1.1 Module 1 detail
     - 6.1.2 Module 2 detail
   - 6.2 Data detailed design
     - 6.2.1 Data entry 1 detail
     - 6.2.2 Data entry 2 detail

Table 1: Organization of SDD

Software Design

Design View	Scope	Entity attribute	Example representation
Decomposition description	Partition of the system into design entities	Identification, type purpose, function, subordinate	Hierarchical decomposition diagram, natural language
Dependency description	Description of relationships among entities of system resources	Identification, type, purpose, dependencies, resources	Structure chart, data flow diagrams, transaction diagrams
Interface description	List of everything a designer, developer, tester needs to know to use design entities that make up the system	Identification, function, interfaces	Interface files, parameter tables
Detail description	Description of the internal design details of an entity	Identification, processing, data	Flow charts, PDL etc.

Table 2: Design views