CSE-433: Software Engineering

Source:

S. Pfleeger, *Software Engineering Theory and Practice, Prentice Hall, 2001*

Modularity

- A concept closely tied to abstraction
- Modularity supports independence of modules
- Modules support abstraction in software
- Supports hierarchical structuring of programs
- Modularity enhances design clarity, eases implementation
- Reduces cost of testing, debugging and maintenance
- Cannot simply chop a program into modules to get modularly
- Need some criteria for decomposition

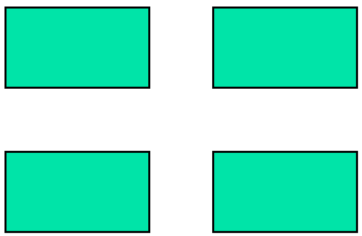
Desired Class/Object Interaction

- **Maximize internal interaction (cohesion)**
  - easier to understand
  - easier to test
- **Minimize external interaction (coupling)**
  - can be used independently
  - easier to test
  - easier to replace
  - easier to understand

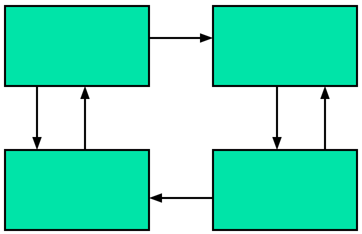
Characteristics of Good Design

- **Component independence**
  - High cohesion
  - Low coupling
- **Exception identification and handling**
- **Fault prevention and fault tolerance**

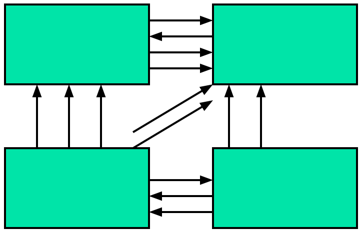
Coupling: Degree of dependence among components



No dependencies



Loosely coupled-some dependencies



Highly coupled-many dependencies

High coupling makes modifying parts of the system difficult, e.g., modifying a component affects all the components to which the component is connected.

Coupling

- **Coupling addresses the attribute of "<u>degree of</u> *<u>interdependence</u>*" between software units, modules or components.**

Content Coupling — **Accessing the internal data or procedural information**

Common Coupling

Control Coupling

Stamp Coupling

Levels of coupling where <u>Data coupling</u> is lowest

Lower the better

Data Coupling — **Passing only the necessary information**

No Coupling — **Ideal, but not practical**

Content Coupling

- **Definition:** A module directly references the content of another module
  - module ***p*** modifies a statement of module ***q***
  - *Module **p** refers to local data of module **q** (in terms of a numerical displacement)*
  - *Module **p** branches to a local label of module **q***

Common Coupling

- Using global variables (i.e., *global coupling*)
- All modules have read/write access to a global data block
- Modules exchange data using the global data block (instead of arguments)
- *Single module with write access where all other modules have read access is not common coupling*

Control Coupling

- Definition: Component passes control parameters to coupled components.
- May be either good or bad, depending on situation.
  - Bad when component must be aware of internal structure and logic of another module
  - Good if parameters allow factoring and reuse of functionality

Example

- Acceptable: Module p calls module q and q returns a flag that indicates an error (if any)
- Not Acceptable: Module p calls module q and q returns a flag back to p that says it must output the error "I goofed up"

Stamp Coupling

- Definition: Component passes a data structure to another component that does not have access to the entire structure.
- Requires second component to know how to manipulate the data structure (e.g., needs to know about implementation)
- May be necessary due to efficiency factors: this is a choice made by insightful designer, not lazy programmer.

Example

Customer Billing System

The print routine of the customer billing accepts a customer data structure as an argument, parses it, and prints the name, address, and billing information.

double printEmployee(Employee& e);

Better:

```
double printEmployee(
        String Name,
        String Address,
        float BillAmount);
```

Data Coupling

- Definition: Two components are data coupled if there are homogeneous data items.
- Every argument is simple argument or data structure in which all elements are used
- Good, if it can be achieved.
- Easy to write contracts for this and modify component independently.

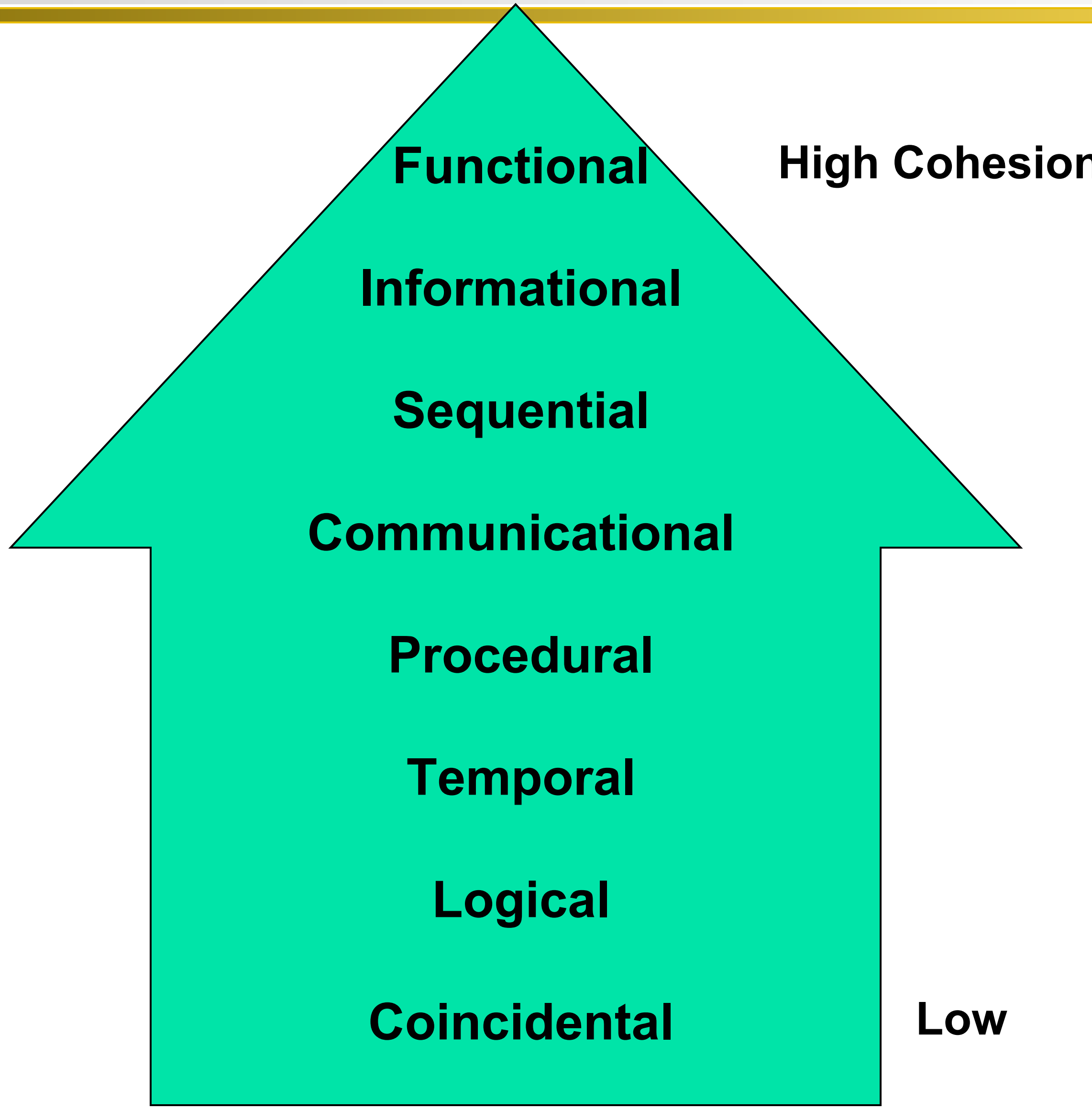
Key Idea in Object-Oriented Programming

- Object-oriented designs tend to have low coupling.

Cohesion

- Definition: The degree to which all elements of a component are directed towards a single task and all elements directed towards that task are contained in a single component.
- Cohesion of a unit, of a module, of an object, or a component addresses the attribute of “ degree of *relatedness*” within that unit, module, object, or component.
- Internal glue with which component is constructed
- All elements of a component are directed toward and essential for performing the same task
- High is good

Range of Cohesion



Coincidental Cohesion

- Definition: Parts of the component performs multiple, completely unrelated actions
- May be based on factors outside of the design:
  - skillset or interest of developers
  - avoidance of small modules
- No reusability
- Difficult corrective maintenance or enhancement
- Elements needed to achieve some functionality are scattered throughout the system.
- Accidental Worst form
- Example : *an "Utilities" class*

Logical Cohesion

- Definition: Elements of component are related logically and not functionally.
- Several logically related elements are in the same component and one of the elements is selected by the caller.
- May include both high and low-level actions in the same class
- May include unused parameters for certain uses
- Interface is difficult to understand
  - in order to do something you have to wade through a lot of unrelated possible actions
- Example: *grouping all mouse and keyboard input handling routines*

Temporal Cohesion

- Definition: Elements of a component are related by timing.
- Difficult to change because you may have to look at numerous components when a change in a data structure is made.
- Increases chances of regression fault
- Component unlikely to be reusable.
- Often happens in initialization or shutdown
- *Example: a function which is called after catching an exception which closes open files, creates an error log, and notifies the user*

Procedural Cohesion

- Definition: Elements of a component are related only to ensure a particular order of execution.
- Actions are still weakly connected and unlikely to be reusable
- Changes to the ordering of steps or purpose of steps requires changing the module abstraction
- *Example: a function which checks file permissions and then opens the file*

Communicational Cohesion

- Definition: Module performs a series of actions related by a sequence of steps to be followed by the product and all actions are performed on the same data
- Action based on the ordering of steps on all the same data
- Actions are related but still not completely separated
- Module cannot be reused

Sequential Cohesion

- Methods are together in a class because the output from one part is the input to another part like an assembly line
- The output of one component is the input to another.
- Occurs naturally in functional programming languages
- Good situation
- *Example: a function which reads data from a file and processes the data*

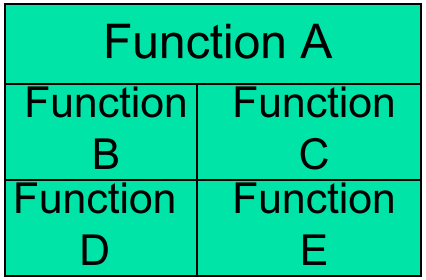
Informational Cohesion

- Definition: Module performs a number of actions, each with its own entry point, with independent code for each action, all performed on the same data.
- Different from logical cohesion
  - Each piece of code has single entry and single exit
  - In logical cohesion, actions of module intertwined
- ADT and object-oriented paradigm promote

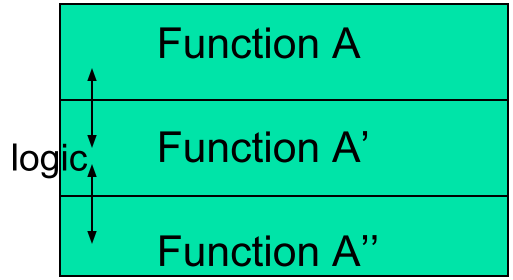
Functional Cohesion

- Definition: Every essential element to a single computation is contained in the component.
- Every element in the component is essential to the computation.
- Ideal situation.
- *Example: tokenizing a string of XML*

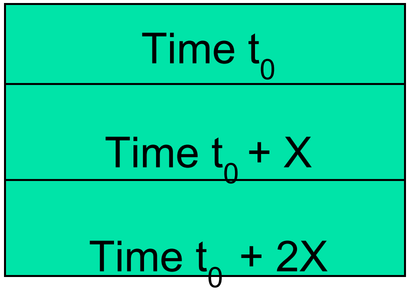
Examples of Cohesion-1



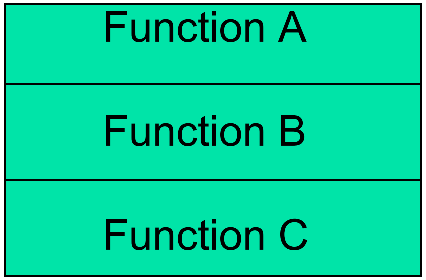
Coincidental
Parts unrelated



Logical
Similar functions

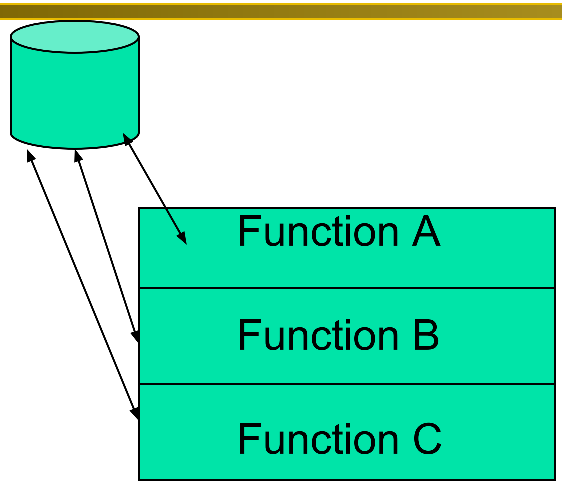


Temporal
Related by time

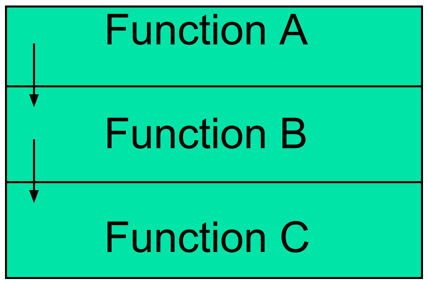


Procedural
Related by order of functions

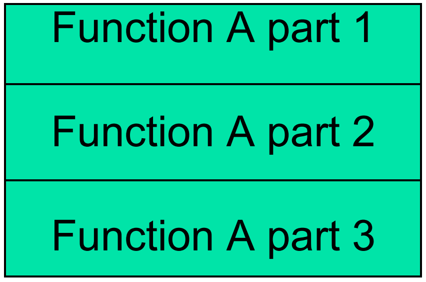
Examples of Cohesion-2



Communicational
Access same data



Sequential
Output of one is input to another



Functional
Sequential with complete, related functions

Thank You