# Cohesion and Coupling

CS 4311

Frank Tsui, Orland Karam, and Barbara Bernal, *Essential of Software Engineering*, 3rd edition, Jones & Bartett Learning. Section 8.3.

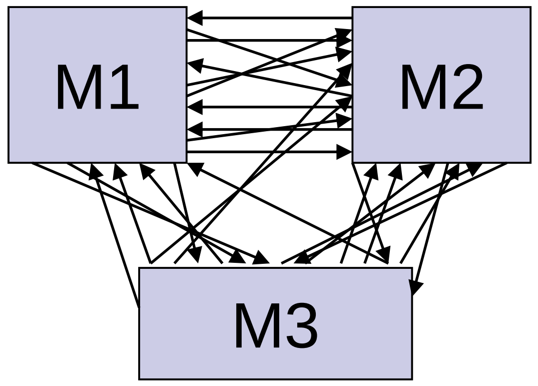
Hans van Vliet, *Software Engineering, Principles and Practice*, 3rd edition, John Wiley & Sons, 2008. (Section 12.1)

## Outline

- Cohesion
- Coupling

# Characteristics of Good Design

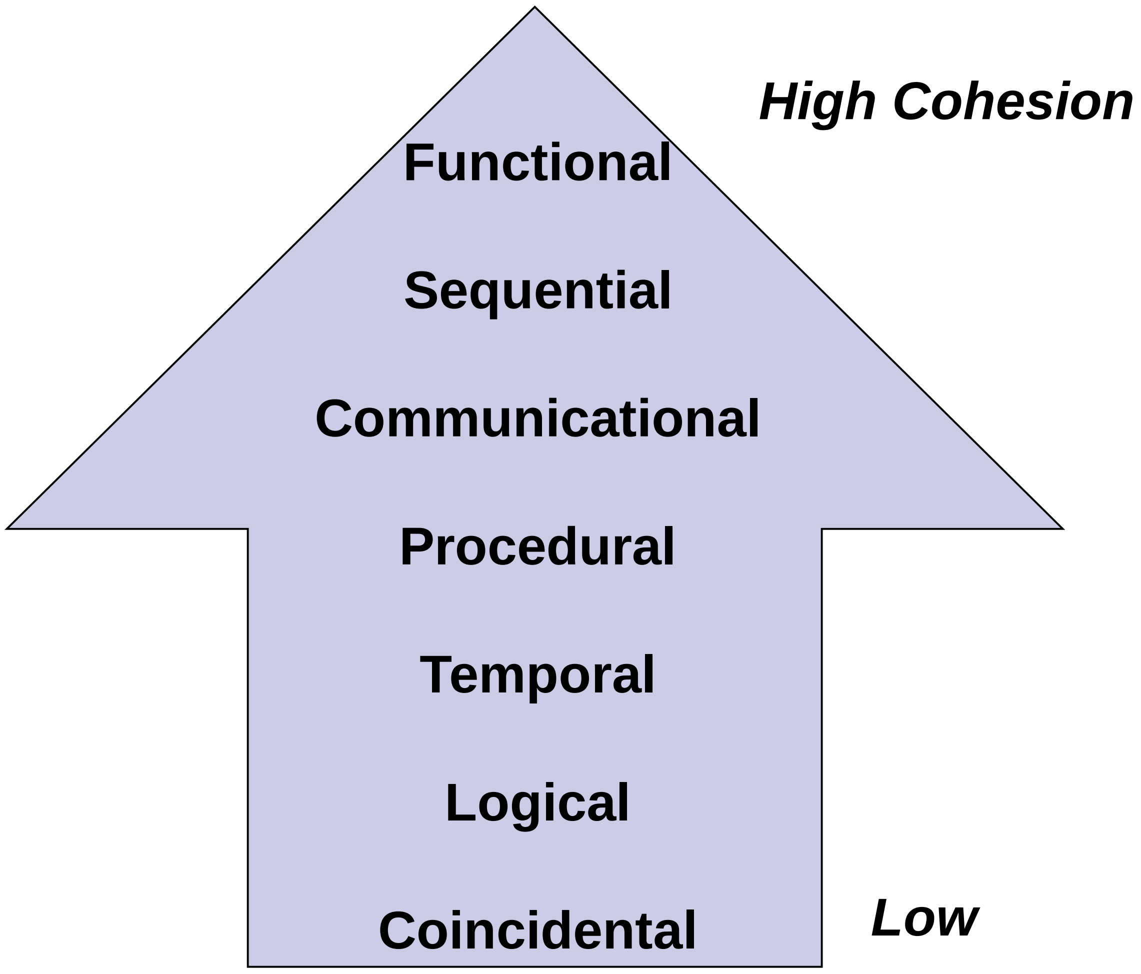
- Component independence
  - High cohesion
  - Low coupling
- Exception identification and handling
- Fault prevention and fault tolerance
- Design for change



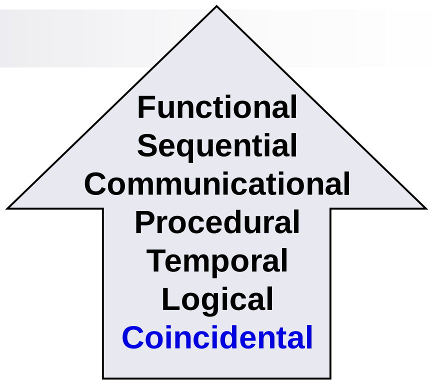
## Cohesion

- Definition
  - The degree to which all elements of a component are directed towards a single task.
  - The degree to which all elements directed towards a task are contained in a single component.
  - The degree to which all responsibilities of a single class are related.
- Internal glue with which component is constructed
- All elements of component are directed toward and essential for performing the same task.

## Type of Cohesion



## Coincidental Cohesion

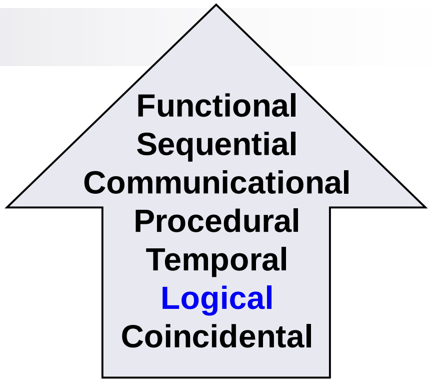


- Def: Parts of the component are unrelated (unrelated functions, processes, or data)
- Parts of the component are only related by their location in source code.
- Elements needed to achieve some functionality are scattered throughout the system.
- Accidental
- Worst form

# Example

1. Print next line
2. Reverse string of characters in second argument
3. Add 7 to 5th argument
4. Convert 4th argument to float

## Logical Cohesion



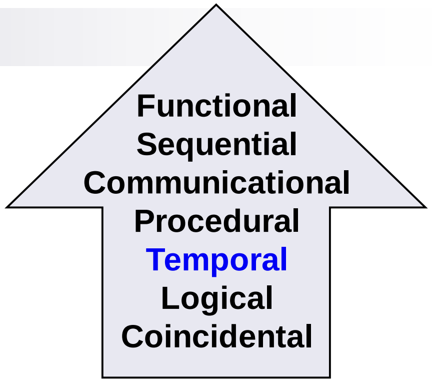
- Def: Elements of component are related logically and not functionally.
- Several logically related elements are in the same component and one of the elements is selected by the client component.

## Example

- A component reads inputs from tape, disk, and network.
- All the code for these functions are in the same component.
- Operations are related, but the functions are significantly different.

Improvement?

## Temporal Cohesion



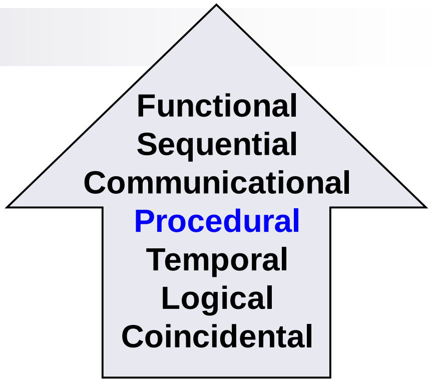
- Def: Elements are related by timing involved
- Elements are grouped by when they are processed.
- Example: An exception handler that
  - Closes all open files
  - Creates an error log
  - Notifies user
  - Lots of different activities occur, all at same time

## Example

- A system initialization routine: this routine contains all of the code for initializing all of the parts of the system. Lots of different activities occur, all at init time.

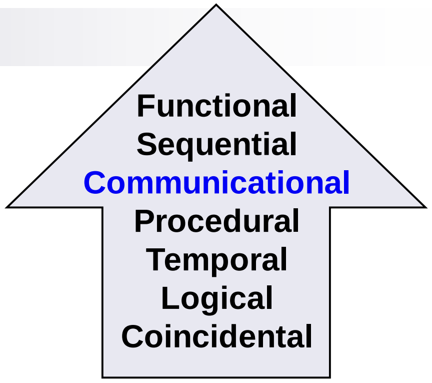
  Improvement?

# Procedural Cohesion



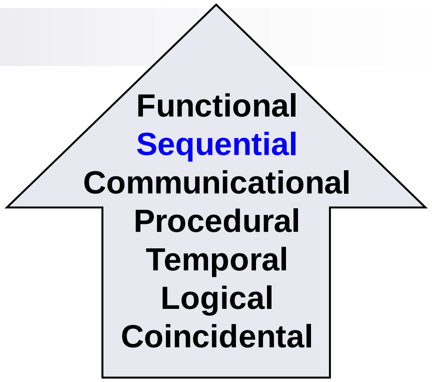
- Def: Elements of a component are related only to ensure a particular order of execution.
- Actions are still weakly connected and unlikely to be reusable.
- Example:
  - ...
  - Write output record
  - Read new input record
  - Pad input with spaces
  - Return new record
  - ...

# Communicational Cohesion



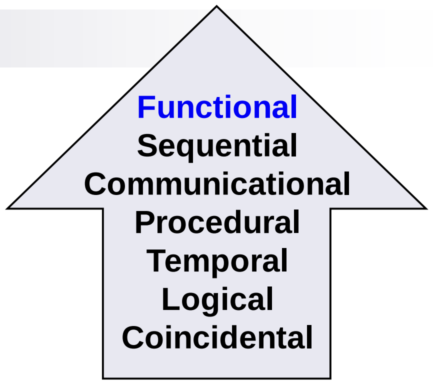
- Def: Functions performed on the same data or to produce the same data.
- Examples:
  - Update record in data base and send it to the printer
    - Update a record on a database
    - Print the record
  - Fetch unrelated data at the same time.
    - To minimize disk access

# Sequential Cohesion



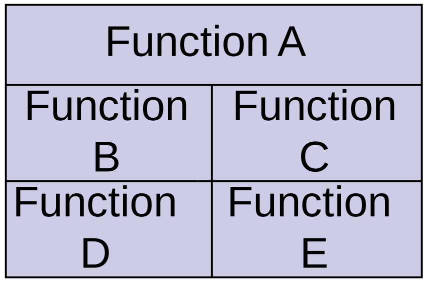
- Def: The output of one part is the input to another.
- *Data flows* between parts (different from procedural cohesion)
- Occurs naturally in functional programming languages
- Good situation

# Functional Cohesion

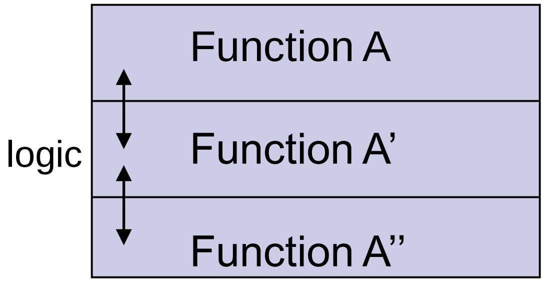


- Def: Every essential element to a single computation is contained in the component.
- Every element in the component is essential to the computation.
- Ideal situation
- What is a functionally cohesive component?
  - One that not only performs the task for which it was designed but
  - it performs only that function and nothing else.

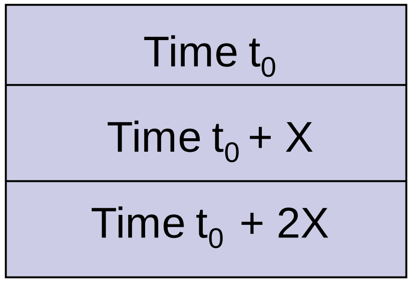
# Examples of Cohesion



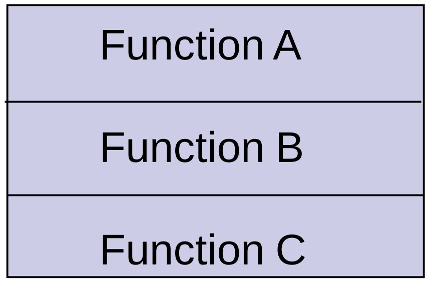
*Coincidental*
Parts unrelated



*Logical*
Similar functions

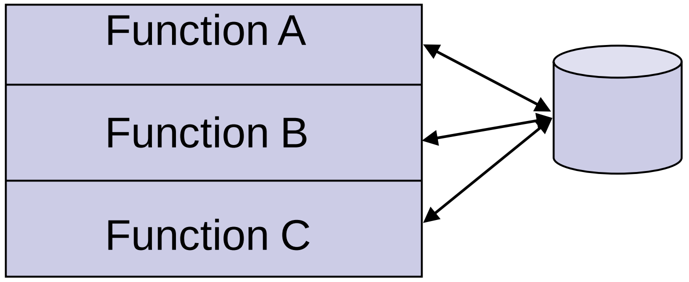


*Temporal*
Related by time

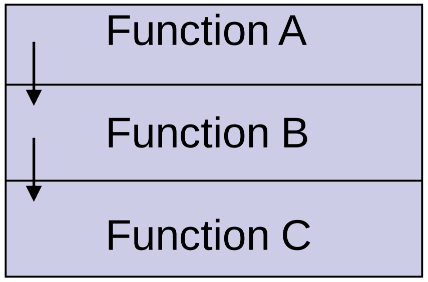


*Procedural*
Related by order of functions

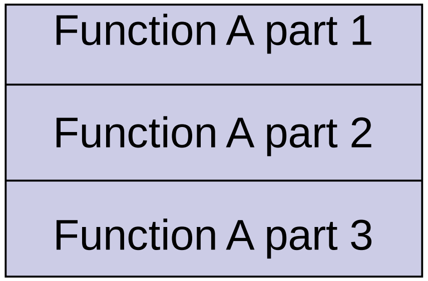
# Examples of Cohesion (Cont.)



*Communicational*
Access same data



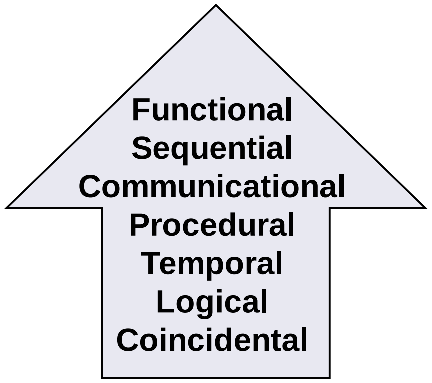
*Sequential*
Output of one is input to another



*Functional*
Sequential with complete, related functions

## Exercise: Cohesion for Each Module?

- Compute average daily temperatures at various sites
- Initialize sums and open files
- Create new temperature record
- Store temperature record
- Close files and print average temperatures
- Read in site, time, and temperature
- Store record for specific site
- Edit site, time, or temperature field

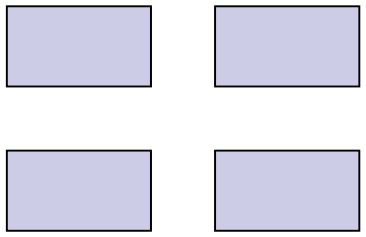


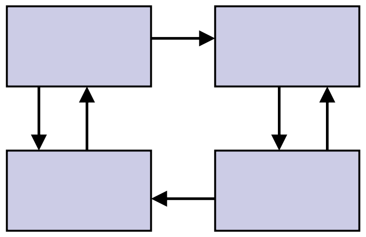
## Outline

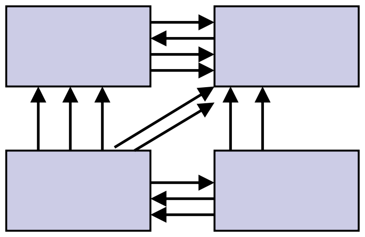
- ✓ Cohesion
- Coupling

# Coupling

- The degree of dependence such as the amount of interactions among components


No dependencies


Loosely coupled
some dependencies


Highly coupled
many dependencies

## Coupling

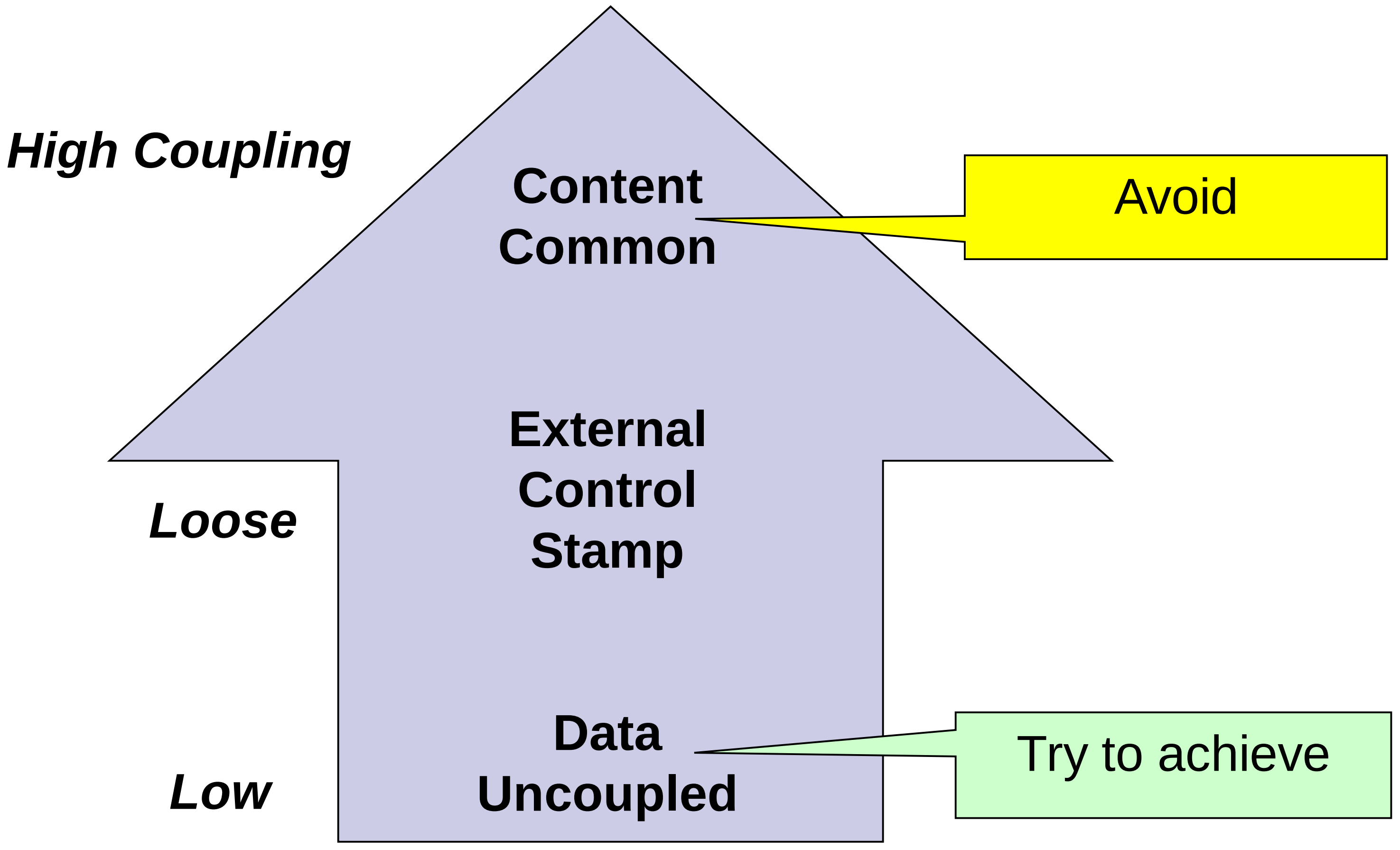
- The degree of dependence such as the amount of interactions among components
- How can you tell if two components are coupled?

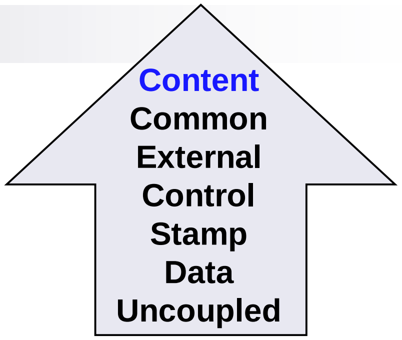
- (In pairs, 2 minutes)

## Indications of Coupling

- ?

# Type of Coupling





## Content Coupling

- Def: One component modifies another.
- Example:
  - Component directly modifies another’s data
  - Component modifies another’s code, e.g., jumps (goto) into the middle of a routine
- Question
  - Language features allowing this?

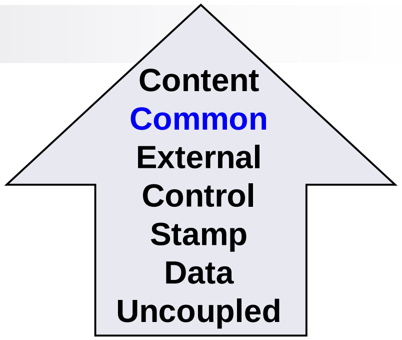
## Example

Part of a program handles lookup for customer.

When customer not found, component adds customer by directly modifying the contents of the data structure containing customer data.

Improvement?

# Common Coupling



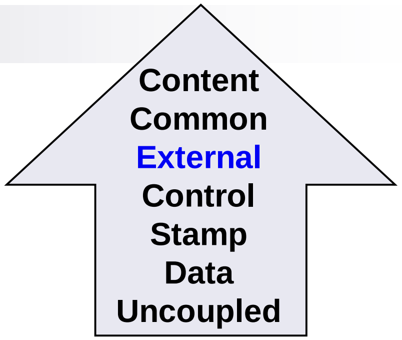
- Def: More than one component share data such as global data structures
- Usually a poor design choice because
  - Lack of clear responsibility for the data
  - Reduces readability
  - Difficult to determine all the components that affect a data element (reduces maintainability)
  - Difficult to reuse components
  - Reduces ability to control data accesses

## Example

Process control component maintains current data about state of operation. Gets data from multiple sources. Supplies data to multiple sinks. Each source process writes directly to global data store. Each sink process reads directly from global data store.

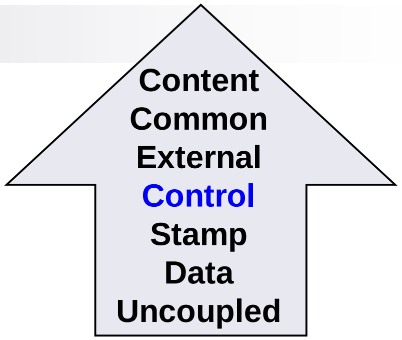
Improvement?

# External Coupling



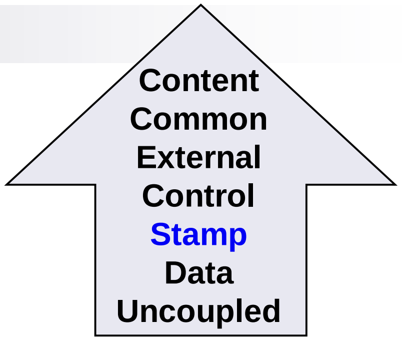
- Def: Two components share something externally imposed, e.g.,
  - External file
  - Device interface
  - Protocol
  - Data format
- Improvement?

# Control Coupling



- Def: Component passes control parameters to coupled components.
- May be either good or bad, depending on situation.
  - Bad if parameters indicate completely different behavior
  - Good if parameters allow factoring and reuse of functionality
- Good example: sort that takes a comparison function as an argument.
  - The sort function is clearly defined: return a list in sorted order, where sorted is determined by a parameter.

# Stamp Coupling



- Def: 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).
- The second has access to more information that it needs.
- May be necessary due to efficiency factors: this is a choice made by insightful designer, not lazy programmer.

## Example

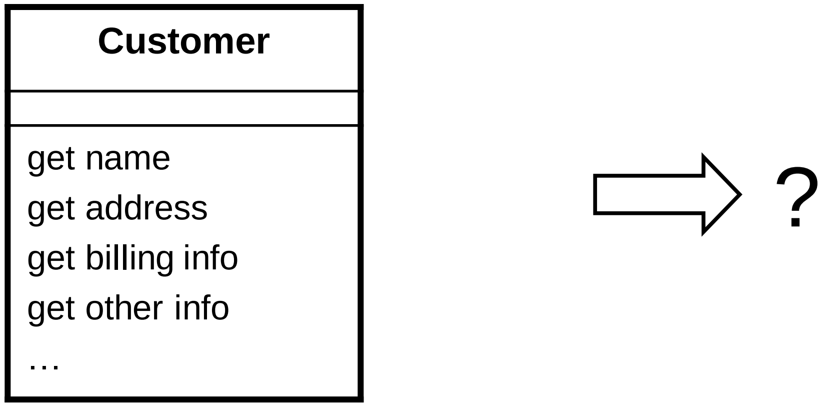
Customer Billing System

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

Improvement?

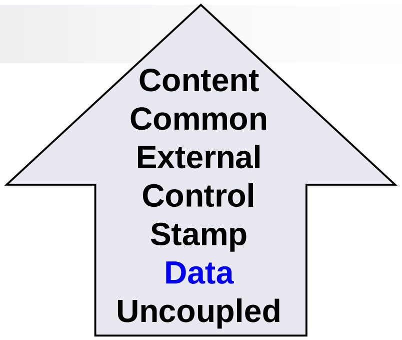
## Improvement --- OO Solution

- Use an interface to limit access from clients



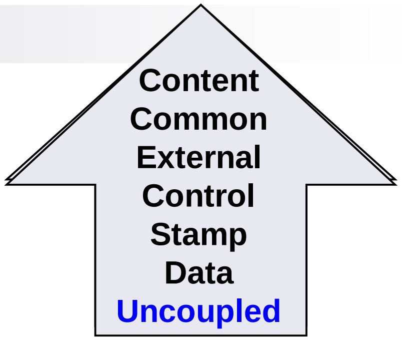
void print (Customer c) { … }

# Data Coupling



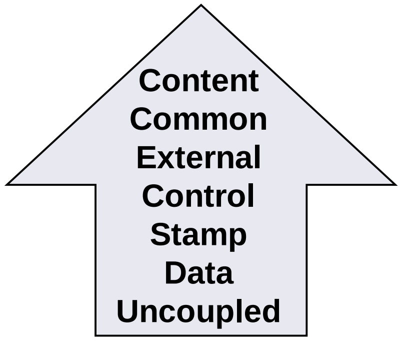
- Def: Component passes data (not data structures) to another component.
- Every argument is simple argument or data structure in which all elements are used
- Good, if it can be achieved.
- Example: Customer billing system
  - The print routine takes the customer name, address, and billing information as arguments.

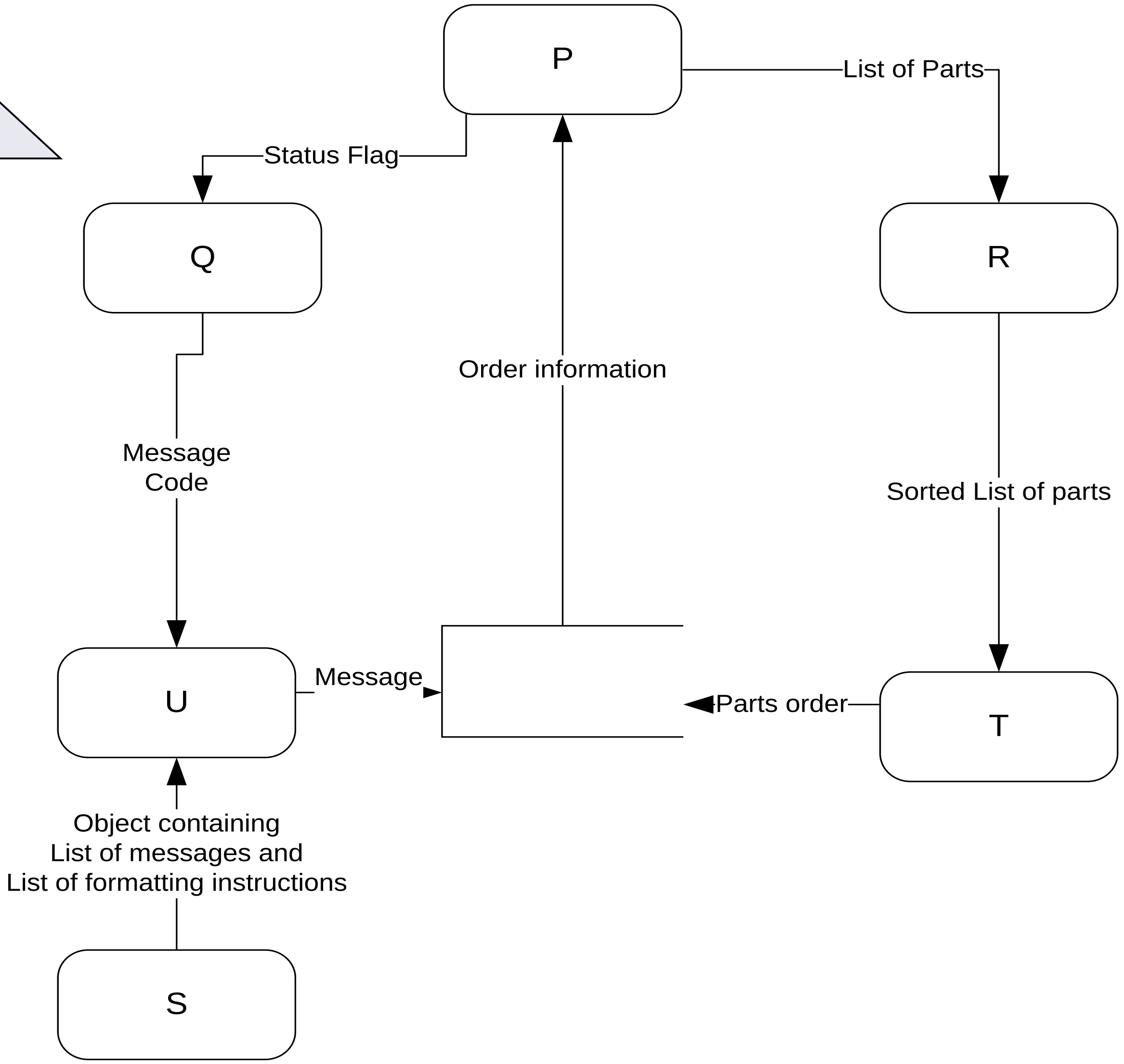
## Uncoupled



- Completely uncoupled components are not systems.
- Systems are made of interacting components.

# Exercise: Define Coupling between Pairs of Modules





## Coupling between Pairs of Modules

| | Q | R | S | T | U |
|---|---|---|---|---|---|
| P | | | | | |
| Q | | | | | |
| R | | | | | |
| S | | | | | |
| T | | | | | |

## Consequences of Coupling

- Why does coupling matter? What are the costs and benefits of coupling?
- (pairs, 3 minutes)

## Consequences of Coupling

- High coupling
  - Components are difficult to understand in isolation
  - Changes in component ripple to others
  - Components are difficult to reuse
    - Need to include all coupled components
    - Difficult to understand
- Low coupling
  - May incur performance cost
  - Generally faster to build systems with low coupling

## In Class

Groups of 2 or 3:

- P1: What is the effect of cohesion on maintenance?
- P2: What is the effect of coupling on maintenance?