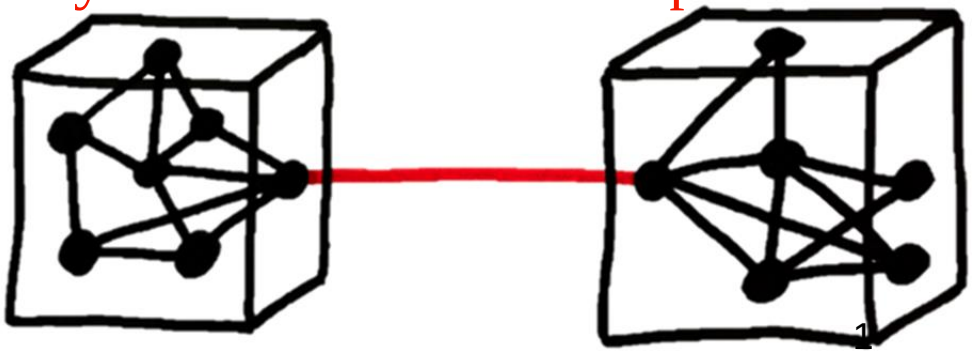
Chap7 (Schach) Cohesion and Coupling

- *Cohesion* - degree of interaction *within* a module
- *Coupling* - degree of interaction *between* modules
  - Want strong relationships between components *within* modules:
    - Aids in the localization of faults
    - Clearer insight on how parts of the system could be reused
  - Want minimal relationships *between* modules:
    - Modules will be relatively independent
    - Modifications to one subsystem will have little impact on the other modules



But Wait…. What's a module?

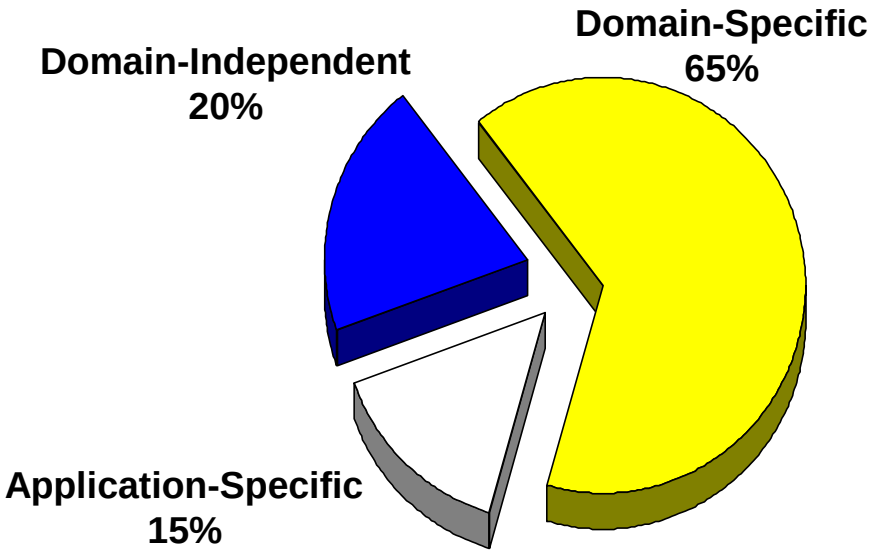
- *1974: "a set of one or more contiguous program statements having a name by which other parts of the system can invoke it, and preferably having its own distinct set of variable names."* Sounds very generic but is actually too restrictive.
- *1979: "a lexically contiguous sequence of program statements, bounded by boundary elements, having an aggregate identifier."* Our definition for this course.
- But wait, sir… What's that *mean*?
  - Classical/Procedural Paradigm:
    - a function or procedure
  - Object Oriented Paradigm:
    - a class
    - a method/function within an class

Cohesion/coupling **impacts** Software Reuse

- *Software Reuse*: *Using* components from one product in the developing a different product
  Goal: Spend less on software production, but (hopefully) get increased quality.

- What (exactly) is reused?
  - Application system reuse
  - Sub-system reuse
  - Class reuse
  - Functional (low-level) reuse

- Typically, software breaks down into three areas that impact reuse:



Cohesion: *Why* are these things together?

- *Ideal:* A module implements a single logical function or entity and all parts of the module contribute to this implementation.

  - Measure of the strength of the relationships between functionality within a given module

  - Why do we care about a module's cohesion?

Seven Levels of Cohesion

7.	Informational cohesion	(Good)
6.	Functional cohesion	
5.	Communicational cohesion	
4.	Procedural cohesion	
3.	Temporal cohesion	
2.	Logical cohesion	
1.	Coincidental cohesion	(Bad)

- **Wanted:** High (strong) cohesion so that the module will have a high *potential* for reuse.

(1) Coincidental Cohesion

- Arise from rules like: "Every module will consist of between 35 and 50 statements"
- Lines of code not really related, just bundled together Example:

```
short printNextLine(String inStr, short x, short y)
{   System.out.println(inStr);
    resetScreen();
    return x+y;
 }
```

  - What is printNextLine() intended to do?

- Why is Coincidental Cohesion so bad?
  - Difficult to maintain, not reusable
  - Easy to fix: Break into separate modules, each performing more cohesive tasks

(2) Logical Cohesion

A module contains related actions, *caller selects* which one to use

- Example 1:

```
someOperation (op code, dummy 1, dummy 2, dummy 3);
   // dummy 1, dummy 2, and dummy 3 are dummy
   // variables, not used if op code is equal to 7
```

- Example 2: One Module performs all input and output
- Example 3: OS/2
  - A version of OS/2 had a logically cohesive module with 13 different actions. Interface contained 21 arguments used to determine action selection.

- Why is logical cohesion so bad?
  - The interface is difficult to understand
  - Code for more than one action may be intertwined
  - Difficult to reuse

(3) Temporal Cohesion

- A series of actions related *only* by time (not sequence)
  - Example: **`init()`** performs several functions that are *only* related because they need to be done before other processing.

```
void init() {
  openAccountDB();
  openTransactionDB();
  resetTransactionCount();
  println("Update in progress");
  …
}
```

- Why is temporal Cohesion so bad?
  - Actions only weakly related to each other; they are more strongly related to the "other" modules.
  - Difficult to freely alter the "other" modules without also affecting a temporally cohesive module.

(4) Procedural Cohesion

- Performs a series of operations related by the *sequence* of steps to be followed.
- In other words, the order matters, and changing the order would mean that the module would no longer function correctly.
- Example:

```
void readPartNumberAndUpdateRepairRecordOnFile() {
…
}
```

- Why is Procedural Cohesion so bad?
  - Actions are still only weakly connected, so module is not so reusable
  - Better: Break into separate modules

(5) Communicational Cohesion

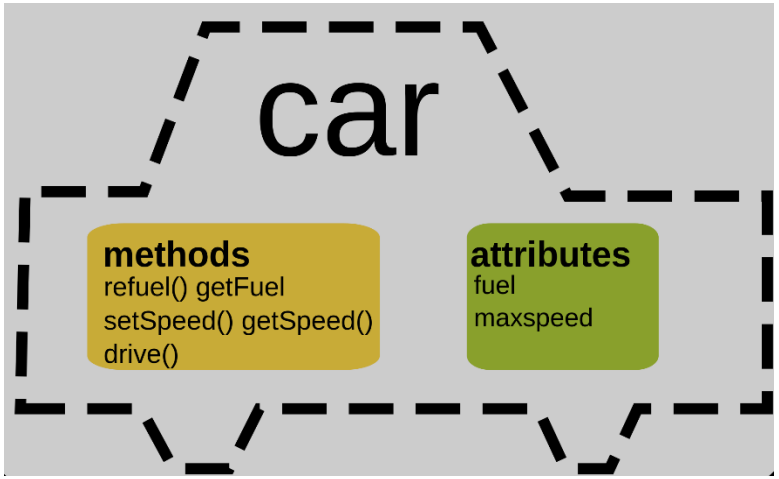
- Elements of a module perform a series of actions, and all operate on the *same input* data

  - Example 1
    - update record in database *and* write it to audit trail
  - Example 2
    - write error message to screen, then to error log file

- Why is Communicational Cohesion so bad?
  - Main drawback is lack of reusability.
  - Can't reuse the module unless all of its actions are needed in the new system.

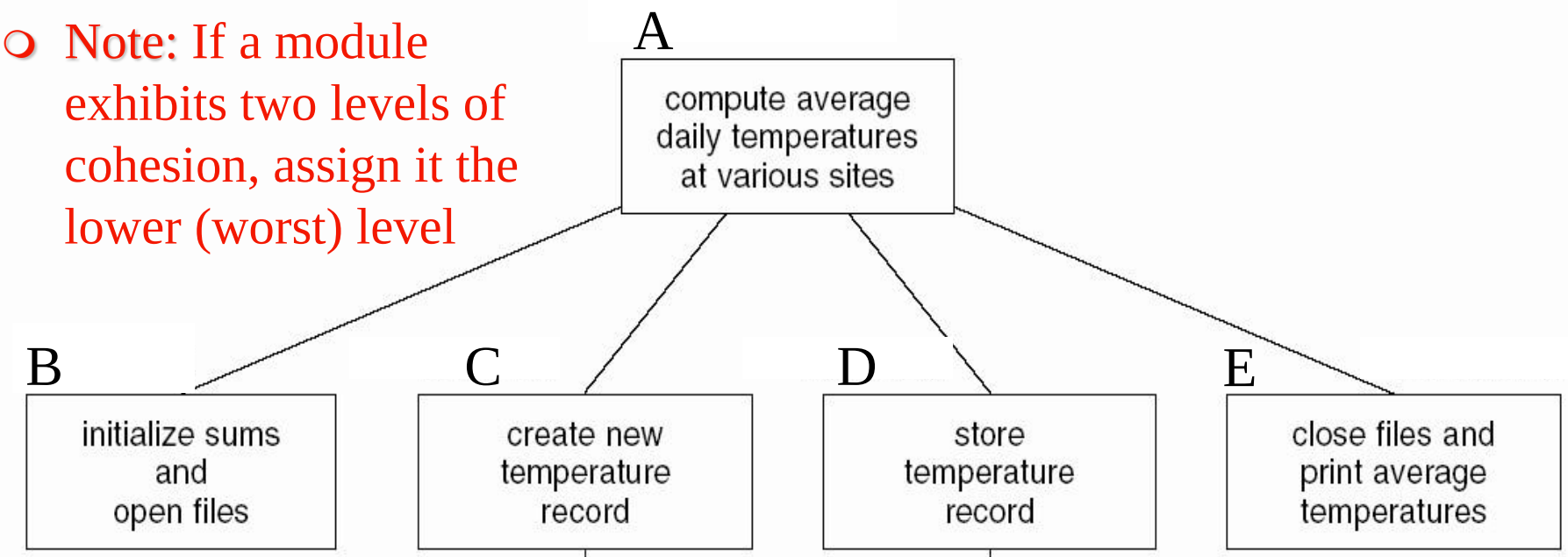
Good forms of cohesion

- **(6) Functional:** Module performs exactly ***one (and only one)*** operation or achieves a single goal.
  - Great for isolating faults, but not very practical.
  - Overkill for OOP (writing classes with only one method)
- **(7) Informational:** Performs a number of operations, each with its own entry point, with independent code for each operation, all performed on the same data structure.
  - Examples:
    - a *well designed* OO class
    - an implementation of an abstract data type



ICE: Determine Cohesiveness based on Description

- Note: If a module exhibits two levels of cohesion, assign it the lower (worst) level



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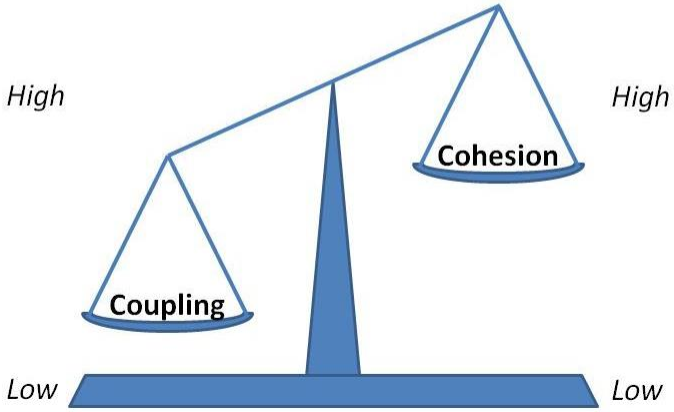
ICE: Does good cohesion come from just using OO?

- High degree of cohesion *is* a feature of *properly designed* object-oriented systems.
  - OO design, if done right, does lead naturally to components that are cohesive.
  - **Question:** How should we design OO classes in order to increase their cohesiveness?

Relationship between Coupling and Cohesion

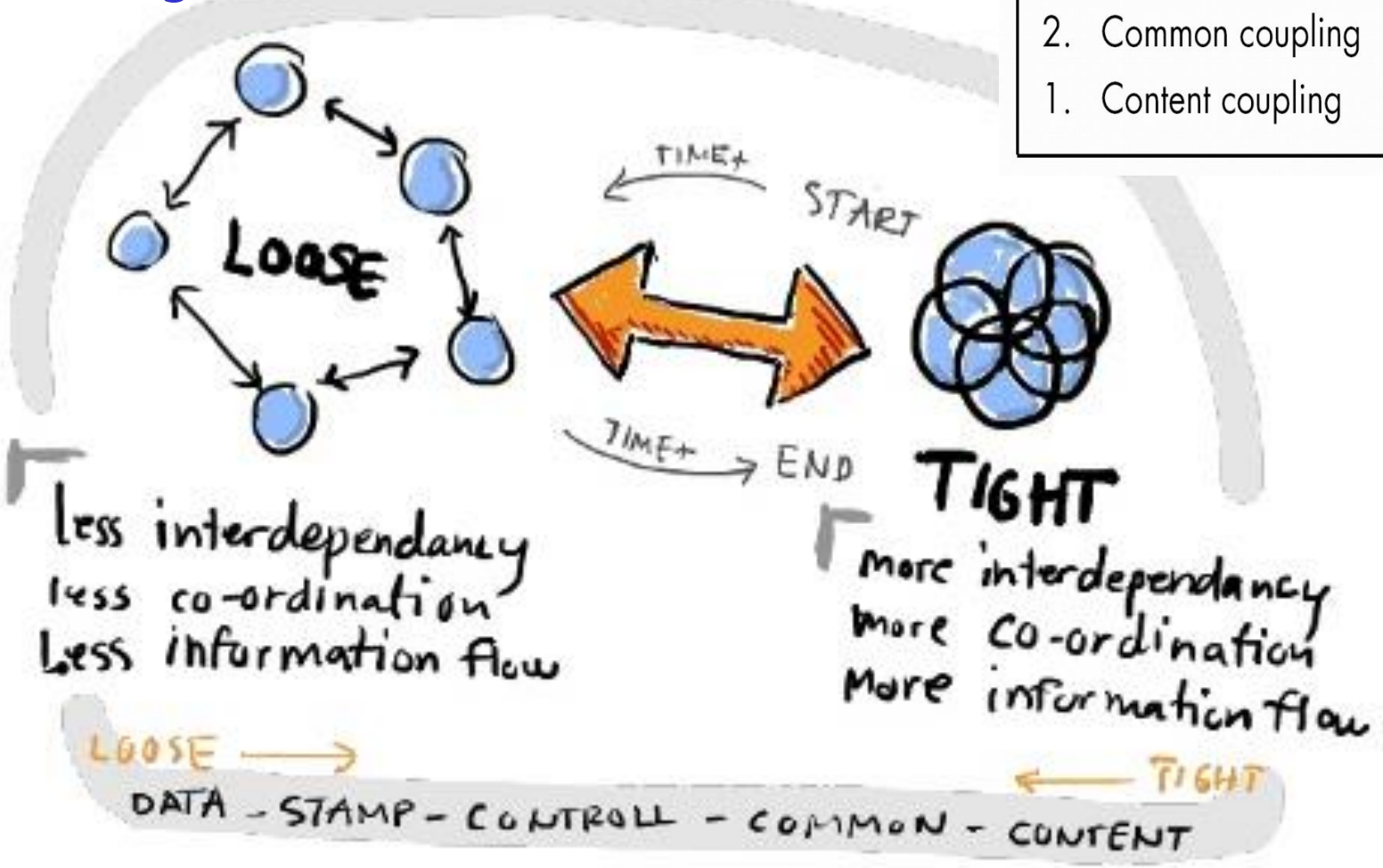


Five levels of Coupling

Couplings: Interactions *between* modules

- ***Loose* -> good for maint/reuse**
- ***Tight* -> bad for maint/reuse**

5.	Data coupling	(Good)
4.	Stamp coupling	
3.	Control coupling	
2.	Common coupling	
1.	Content coupling	(Bad)

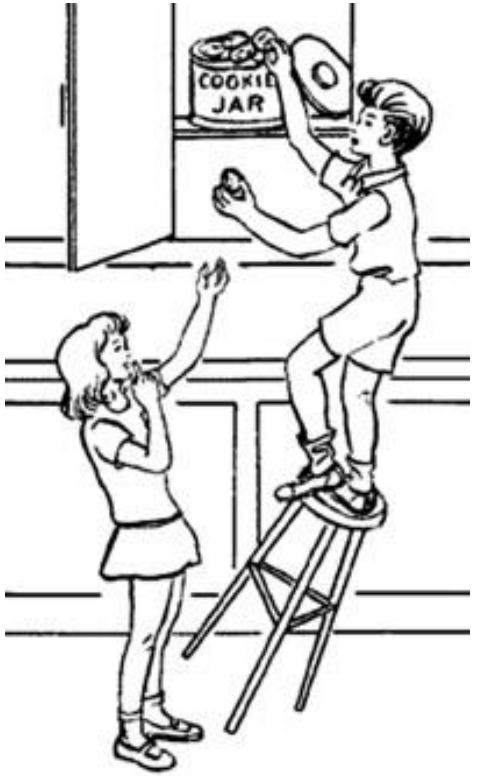


Content Coupling

- ***(1) Content** coupling* - one module directly references the contents of the other.

```
public class Multiplier {
  public static int multiplier = 1;
  public static int multiplierOf(int x) {
        return (x* multiplier); }}

public class MultiplierUser {
  int user() {
    Multiplier.multiplier=3;
    return Multiplier.multiplierOf(2));}}
```



- Class `MultiplierUser` *modifies* the value of `multiplier` directly so they are *content-coupled*
- Other examples?

(2) Common coupling

- Modules directly access same data. Make use of shared variables and read/write to the shared variables.
  - `sumOfTran()` sums shared arrays and thus is common-coupled with any other modules referring to these arrays.

```
void sumOfTran() {
  DB[0]=0; CR[0]=0;
  for (short i=1; i<= numAcct; i++){
    DB[0] += DB[i]; CR[0] += CR[i];
  }
  return;
}
```

Other examples: global variables.

- Results in code with poor readability, generally a hack to circumvent scoping/visibility issues

(3) Control Coupling

- ***Control** coupling* - One module tells another module what to do via the info it passes to the calling module.

```
short mySwitch(char opCode, short x, short y){
  switch (opCode){
    case '+' : return (x+y);
    case '-' : return (x-y);
    case '*' : return (x*y);
    case '/' : return (x/y);
    default: return 0;}
}
```

- mySwitch()'s caller passes a control flag and is control coupled with mySwitch().
- Why is this so bad?

The two modules are *not* independent

- Caller must be aware of mySwitch's internal structure.
- if mySwitch is altered during maintenance, Caller must be made aware of the changes.

(4) Stamp Coupling

- Data structure argument, but callee only ever operates on just part of that data structure. Example,

```
short sumOfFirstTwo(short number[]) {
  switch (number.len) {
    case 0: return 0;
    case 1: return number[0];
    default: return (number[0]+number[1]);
  }}
```

- sumOfFirstTwo() operates only on first two elements of array parameter and is thus stamp-coupled with the caller.

  - Passing entire array when only one or two cells are (at most) needed
  - Would rather *not* have module able to access entire array if it is only supposed to need a single cell of array

(5) Data Coupling

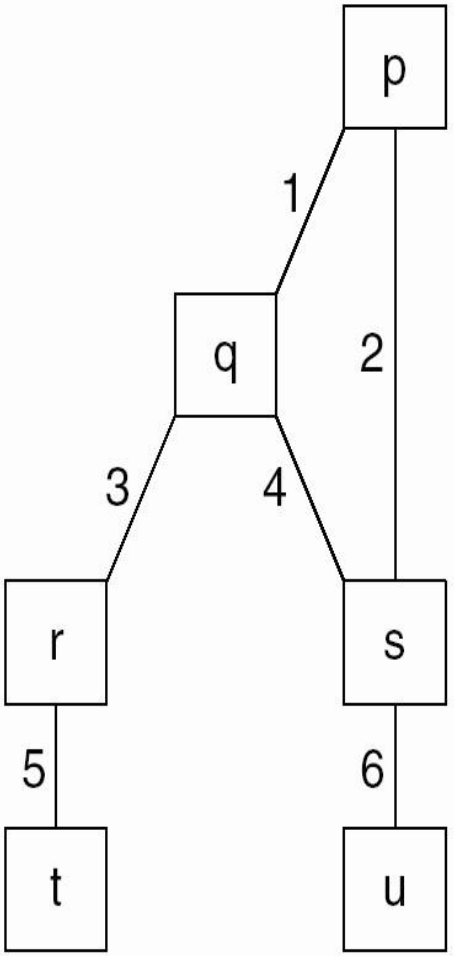
- Arguments are either
  - a simple argument (integer), or
  - a data structure in which **all** elements are used by the callee
- Also: a class accessing *it's own* data members.

```
short sumOfArray(short number[]){
  short result = 0;
  for (i=0; i< number.len; i++)
    result += number[i];
  return result;
}
```

- `sumOfArray()` accesses every element parameter, so is data coupled with caller

- With data coupling, changing module is less likely to cause fault in calling module, results in easier maintenance.
- Should strive for Data Coupling in OO software development

ICE: Determine Couplings given Interface descriptions



Example: 1. When p calls q's interface, p passes one argument, an aircraft type, and q passes back a "status flag".

p, t, and u access the same database in update mode

Number	In	Out
1	aircraft type	status flag
2	list of aircraft parts	—
3	function code	—
4	list of aircraft parts	—
5	part number	part manufacturer
6	part number	part name

5. Data coupling (Good)
4. Stamp coupling
3. Control coupling
2. Common coupling
1. Content coupling (Bad)

Conditions for software development with reuse

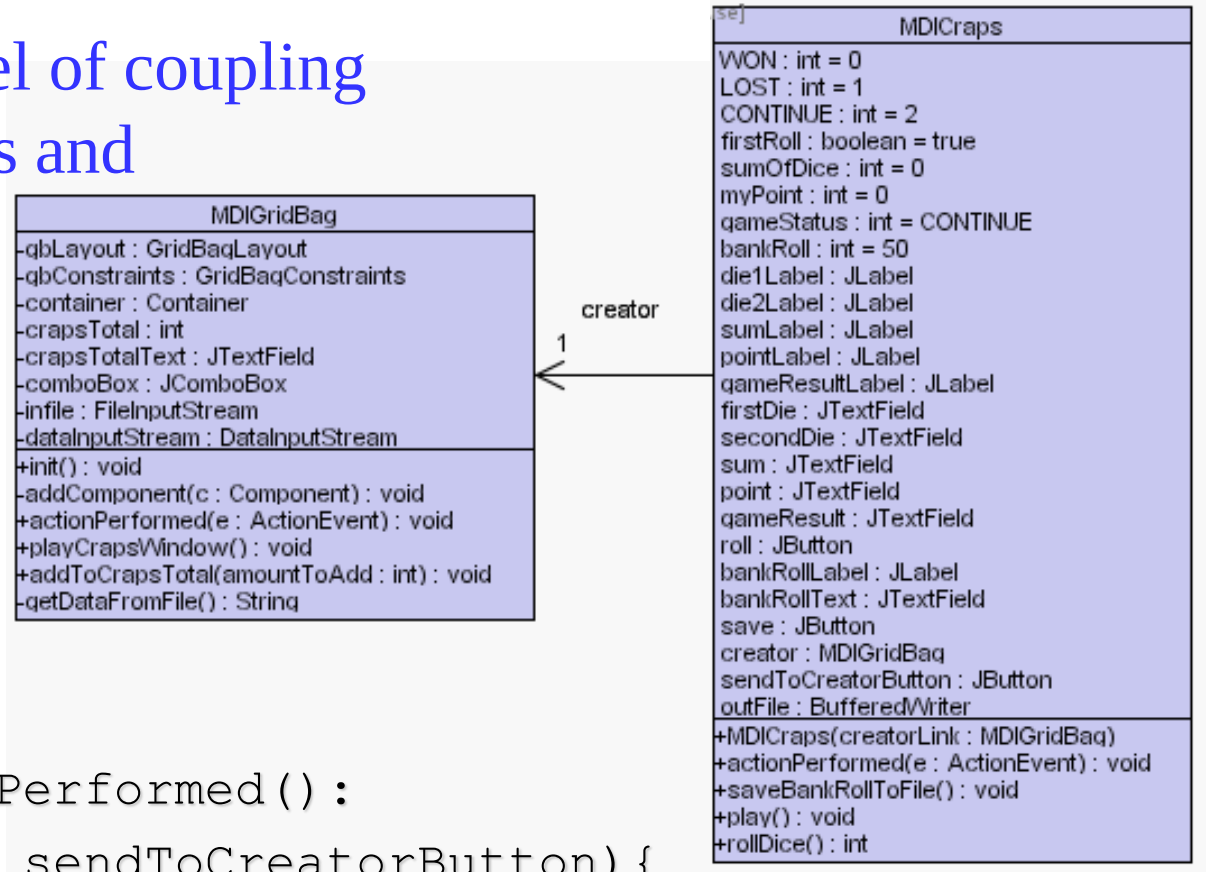
- Must be possible to find appropriate reusable components.
  - Re-user must have confidence that the components will behave as specified and be reliable.
  - Component documentation to help re-user understand and adapt them

- Possible adverse affects of inheritance on reuse?
  - With inheritance, code not collected together in one place
  - Reuse of improper inheritance can lead to extra, unwanted functionality.
  - OOP has a lot going for it, but inheritance has not proven to be a silver-bullet answer to re-usability.

Consider our Craps Software

- **ICE:** Evaluate level of coupling between MDICraps and MDIGridBag

5.	Data coupling	(Good)
4.	Stamp coupling	
3.	Control coupling	
2.	Common coupling	
1.	Content coupling	(Bad)




```
//In MDICraps actionPerformed():
  if(e.getSource()== sendToCreatorButton){
     creator.AddToCrapsTotal(bankRoll);
     bankRoll = 0;
     bankRollText.setText
        (Integer.toString(bankRoll));}}
```

What if:

```
creator.crapsTotal+=bankRoll;
```