So Far …

Part 1: OOAD Intro

Part 2: Inception

Part 3: Elaboration—Iteration 1

- Iteration 1—Basics
- Domain Models
- System Sequence Diagrams
- Operation Contracts
- Requirements to Design—Iteratively
- Logical Architecture and UML Package Diagrams
- On to Object Design
- UML Interaction Diagrams (Self Study)
- UML Class Diagrams (Self Study)
- GRASP: Designing Objects with Responsibilities
- Object Design Examples with GRASP
- Designing for Visibility
- Mapping Designs to Code
- **Test-Driven Development and Refactoring**

Part: 4 Elaboration Iteration 2—More Patterns

- GRASP: More Objects with Responsibilities
- Applying GoF Design Patterns

Test-Driven Development and Refactoring

Abdulkareem Alali

Ack Dale Haverstock

Based on Larman's Applying UML and Patterns Book, 3d

Logic is the art of going wrong with confidence.

—Joseph Wood Krutch

Intro

Extreme Programming (XP) **promotes**

- Writing the **tests** first
- Continuous code **refactoring**

Why?

- **Improve its quality**
- **Less duplication**
- **Increased clarity**

Modern tools **support** practices, OO developers **swear** by their value

Unit Testing First

Testing individual components, individual classes

In OO unit testing TDD-style (Test Driven Dev.), test code is written before the class to be tested

1. Imagining a production code,
2. Write a little test code,
3. Then write a little production code,
4. Make it pass the test,
5. … then 1 & write some more test code, etc.

Unit Testing First, Why?

1. Unit tests get written—

Human nature, if left as an afterthought, writing unit test is avoided

2. Programmer Satisfaction—

- Test-last, or Just-this-one-time-I'll-skip-writing-the-test development
  Traditional style,
    - developer writes production code, debugs, then add unit tests,
    - it doesn't feel satisfying, you may even **hate** it!

- Human psychology. Test is written first, Pass Test, Can you?, I challenge you or myself?
    - Code is cut to pass the tests, feel of accomplishment—meeting a goal!

Unit Testing First, Why?

3. Clarification of detailed interface and behavior—

Writing tests, you imagine code exists, details of public view of methods

- Name, return value, parameters, and behavior

That improves/clarifies the detailed design;

designing your code before writing it

4. Provable, repeatable, automated verification—

Having hundreds or thousands of unit tests provides verification of correctness, runs automatically, it's easy

Unit Testing First, Why?

5. Confidence in change—

Unit test suite provides immediate feedback if the change caused an error

You write your own tests for your own code—

Who is better than the authors to write unit tests of their own code?

Unit Testing First, Why? Read today!

Ben Rees · 3rd+
Tech Lead at Kerv Digital
5d ·

✓ Following

Why should you write tests first? What's in it for YOU?

As a long time Test-Driven Design advocate, I can cite many productivity, quality, flow, speed, etc, etc, reasons. But those are delivery concerns, right? Boring. Why should an individual engineer care?

To start with, because it makes the development process FUN. You get a little endorphine hit every 10 minutes as you turn something broken into something fixed. Nice! Who doesn't like getting a boost several times an hour?

It also keeps your test suite TRUSTWORTHY. You know that the tests are doing a useful job, not just virtue signalling. When you run them, you know they are validating what you wanted the code to do, because they weren't written with any bias.

Lastly, your code will be easy to update. You will have built loosely coupled code, because you will have written it to be EXPLICITLY TESTABLE. Highly coupled code is hard to test; conversely, testable code has low coupling. Future you thanks you for your foresight.

So TDD doesn't just make your code BETTER, it makes it FUN TO WRITE. What's not to like?

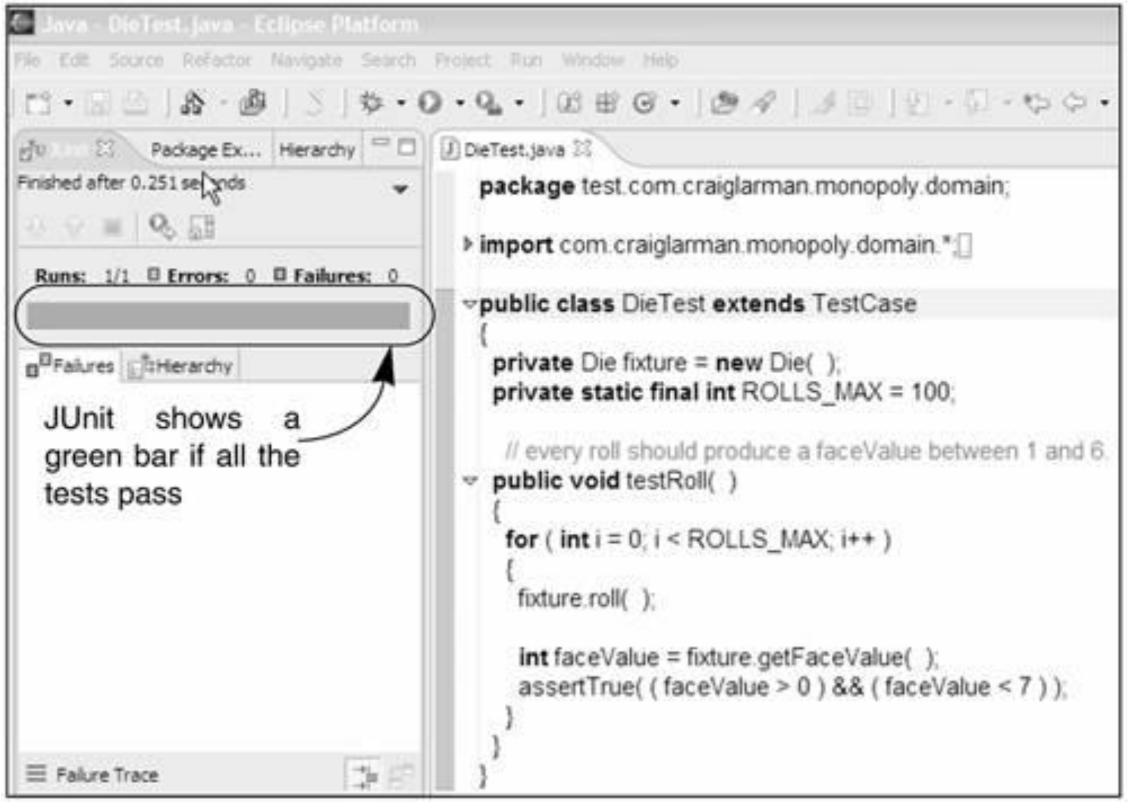
Frameworks

Most popular unit testing framework is the xUnit family (for many languages)

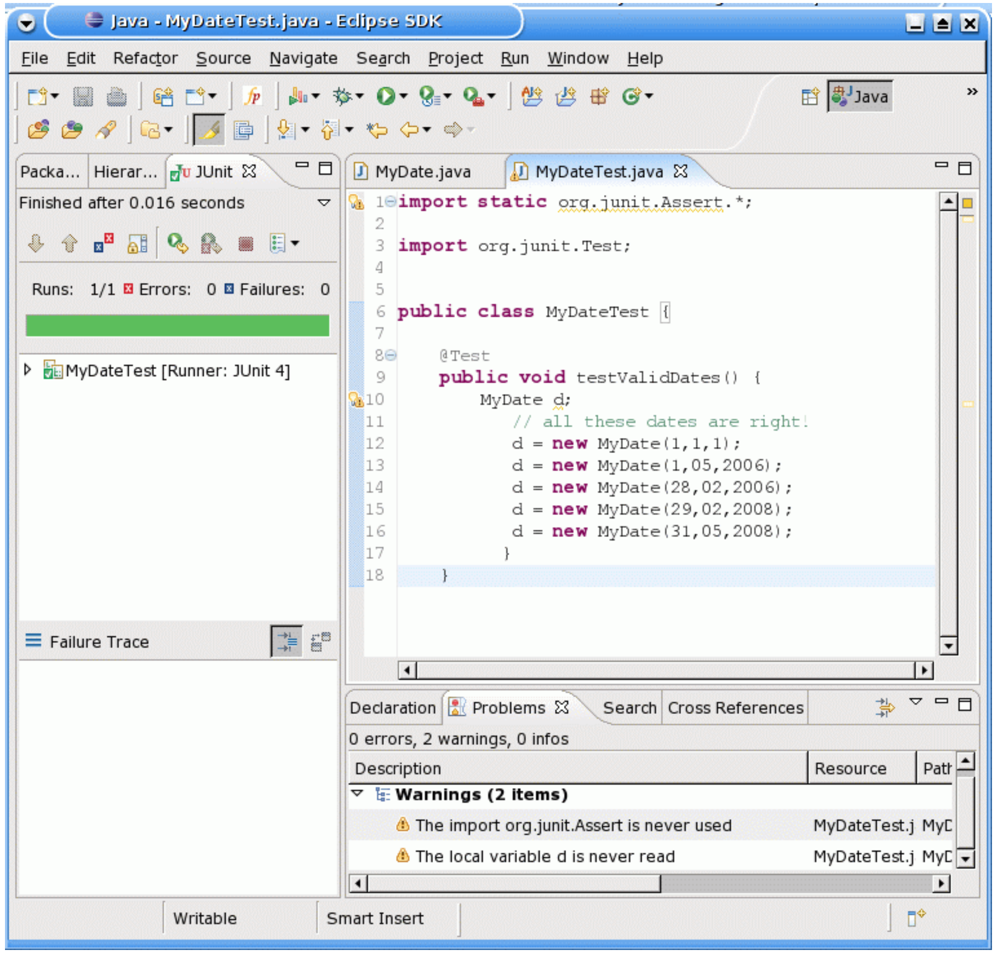
JUnit for Java, NUnit for .NET, etc. xUnits are integrated into IDEs (e.g. Eclipse, MS Visual Studio)

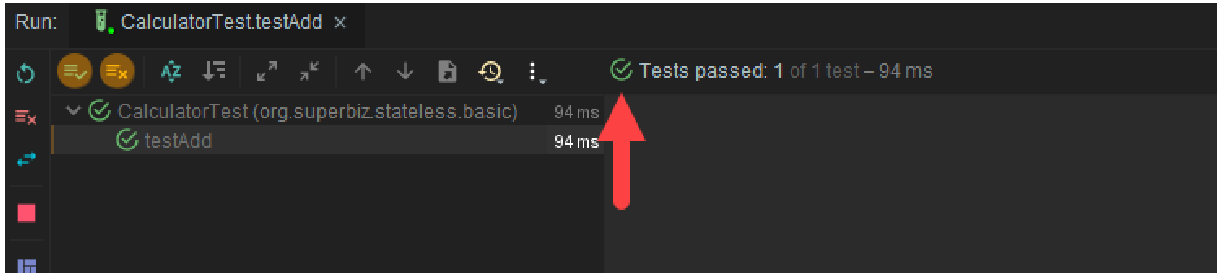
Keep the bar green to keep the code clean

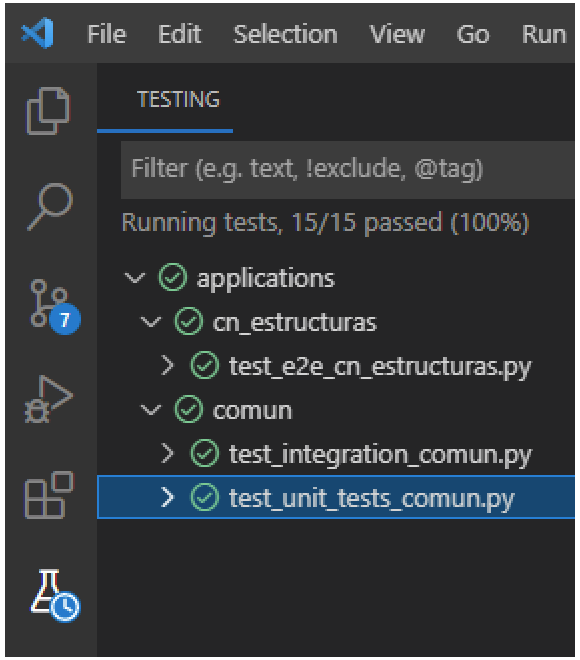
TDD and JUnit in Eclipse



TDD and JUnit in a popular IDEs, Eclipse, intellij, vscode







TDD –POS

Before programming **Sale** class, write unit testing method in a **SaleTest** class that does the following:

1. Create a **Sale**—the thing to be tested (also known as the fixture)

2. Add some line items for the public ***makeLineItem*** method to test

3. Ask for the total, and verify that it is the expected value, using the ***assertTrue*** method

TDD How – POS

Do not write all the unit tests for **Sale** first; rather,

- Write only one test method,
- Implement the solution in class **Sale** to make it pass,
- and then repeat

To use xUnit, create test class that extends xUnit **TestCase** class

Write unit testing methods (perhaps several) **for each public method** of the **Sale** class

TDD How –POS

Exceptions include trivial (and usually auto-generated) get and set methods

To test method ***MakeLineItem***, it is an idiom to name the testing method ***testMakeLineItem***

1. Write ***testMakeLineItem*** test method,
2. then ***Sale.makeLineItem*** method to pass test

SaleTest

```
public class SaleTest extends TestCase
{
    // ...

   // test the Sale.makeLineItem method
  public void testMakeLineItem()
  {
      // STEP 1: CREATE THE FIXTURE

      // -this is the object to test
      // -it is an idiom to name it 'fixture'
      // -it is often defined as an instance field rather than
      // a local variable
    Sale fixture = new Sale();

       //  set up supporting objects for the test
    Money total = new Money( 7.5 );
    Money price = new Money( 2.5 );
    ItemID id = new ItemID( 1 );
    ProductDescription desc =
             new ProductDescription( id, price, "product 1" );
```

SaleTest

```
    // STEP 2: EXECUTE THE METHOD TO TEST

    // NOTE: We write this code **imagining** there
    // is a makeLineItem method. This act of imagination
    // as we write the test tends to improve or clarify
    // our understanding of the detailed interface to
    // to the object. Thus TDD has the side-benefit of
    // clarifying the detailed object design.



    // test makeLineItem
  sale.makeLineItem( desc, 1 );
  sale.makeLineItem( desc, 2 );



     // STEP 3: EVALUATE THE RESULTS

     // there could be many assertTrue statements
     // for a complex evaluation

     // verify the total is 7.5
   assertTrue( sale.getTotal().equals( total ));
 }

}
```

Refactoring

Is a structured, disciplined method to rewrite or **restructure** existing code without changing its external behavior

Via applying **small transformation** steps combined with **re-executing tests** each step,

With the goal to improve the design, structure, and implementation of the software while preserving its functionality

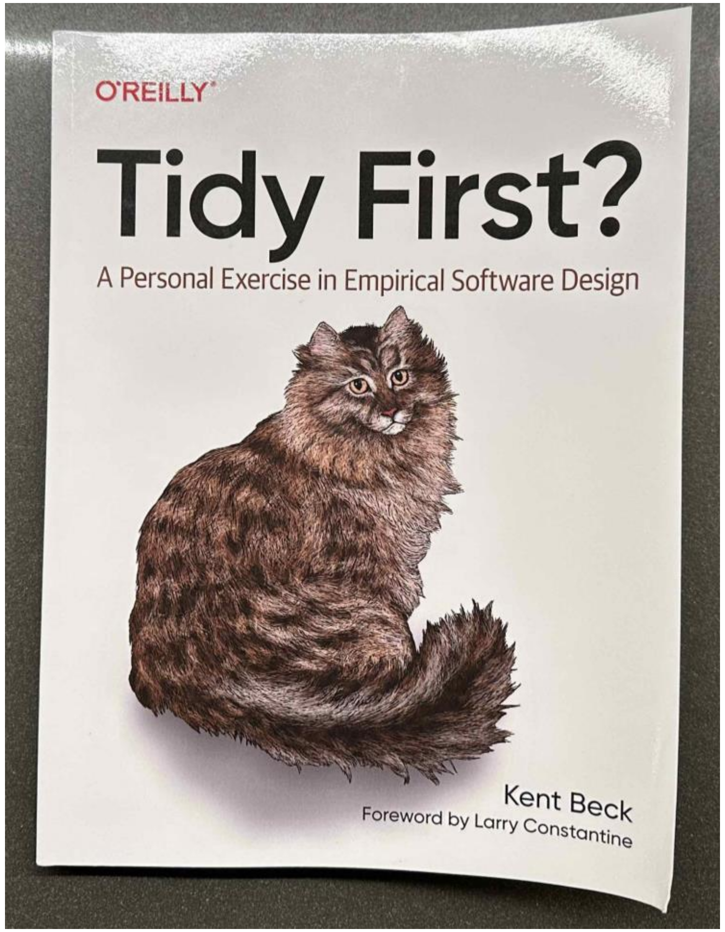
An XP practice, part of iterative methods, including UP

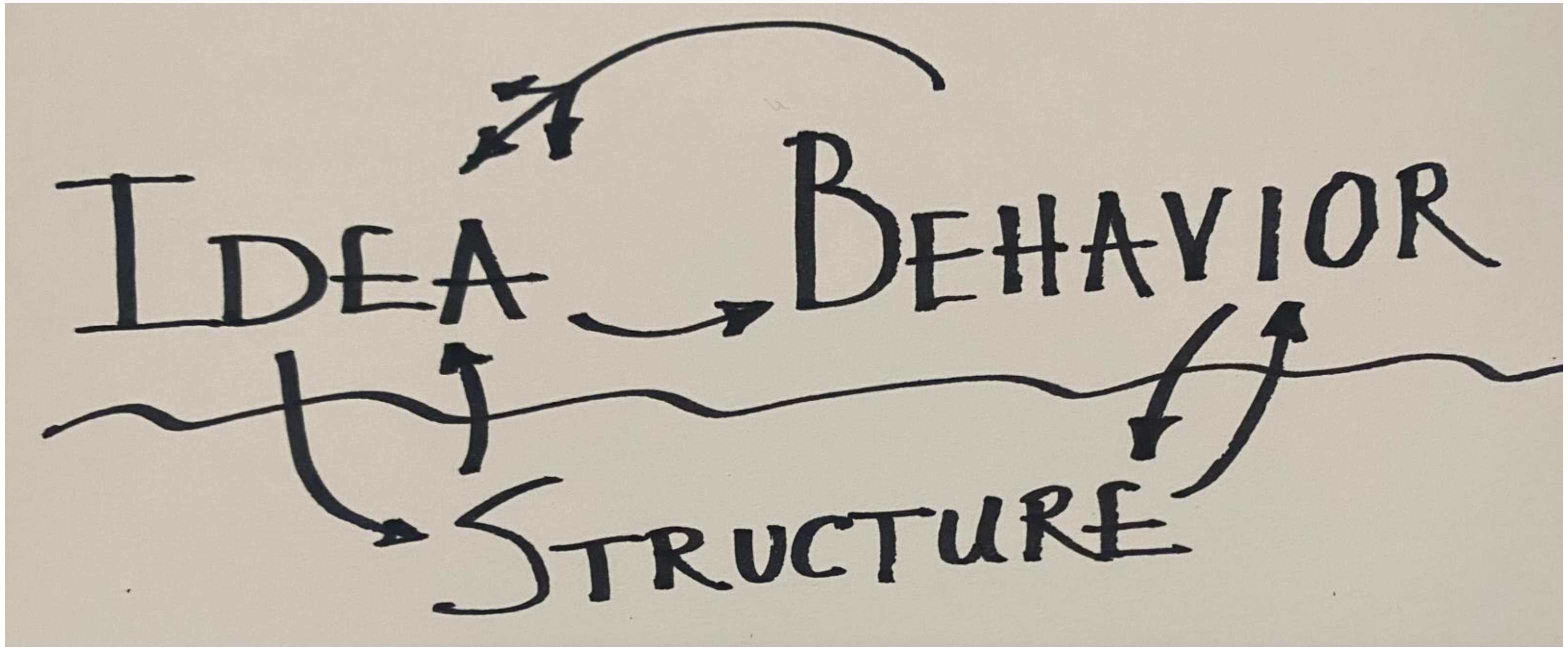
Refactoring, Why?

- More efficient by addressing dependencies and complexities
- More maintainable or reusable by increasing efficiency and readability
- Cleaner so it is easier to read and understand
- Easier for software developers to find and fix bugs or vulnerabilities

Summary, easier and resistant to change!!

Refactoring, README





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Refactoring and TDD

Refactoring is applying small behavior preserving transformations (each called a 'refactoring'), one at a time

After each transformation, the unit tests are re-executed to prove that the refactoring did not cause a failure

Relationship between refactoring and TDD—
Unit tests support refactoring

Refactoring, Why?

Each refactoring is small

A series of transformations—each followed by executing the unit tests again and again

Produces a major restructuring of code and design (for the better), while ensuring behavior remains the same

Refactoring, Why?

- More efficient by addressing dependencies and complexities
- More maintainable or reusable by increasing efficiency and readability
- Cleaner so it is easier to read and understand
- Easier for software developers to find and fix bugs or vulnerabilities

Summary, easier and resistant to change!!

Code Smells

Code that's been well-refactored is short, tight, clear, and without duplication—A work of a master programmer. Code that doesn't have these qualities smells bad or has code smells, poor design

Signs of Code Smell

- Duplicated code
- Big method
- Class with many instance variables
- Class with lots of code, non cohesive
- Strikingly similar subclasses
- Little or no use of interfaces in the design
- High coupling between many objects

Refactoring Activities

- Remove duplicate code
- Improve clarity
- Make long methods shorter
- Remove the use of hard-coded literal constants

Refactorings Have Names, too!

Refactoring	**Description**
Extract Method	Transform a long method into a shorter one by factoring out a portion into a private helper method
Extract Constant	Replace a literal constant with a constant variable
Introduce Explaining Variable	Put the result of the expression, or parts of the expression, in a temporary variable with a name that explains the purpose
Replace Constructor Call with Factory Method	Replace using the new operator and constructor call with invoking a helper method that creates the object (hiding details)

Extract Method Refactoring Example

Player.*takeTurn* has an initial section of code that rolls the dice and calculates the total in a loop

Make the ***takeTurn*** method shorter, clearer, and better supporting High Cohesion by extracting that code into a private helper method called ***rollDice***

Extract Method Refactoring —Before Refactoring

```
public class Player
{
   private Piece  piece;
   private Board  board;
   private Die[]  dice;
   // ...

public void takeTurn()
{
       // roll dice
   int rollTotal = 0;
   for (int i = 0; i < dice.length; i++)
   {
      dice[i].roll();
      rollTotal += dice[i].getFaceValue();
   }

   Square newLoc = board.getSquare(piece.getLocation(), rollTotal);
   piece.setLocation(newLoc);

}

} // end of class
```

Extract Method Refactoring —After Refactoring

```
public class Player
{
   private Piece  piece;
   private Board  board;
   private Die[]  dice;
   // ...

public void takeTurn()
{
       // the refactored helper method
   int rollTotal = rollDice();

   Square newLoc = board.getSquare(piece.getLocation(), rollTotal);
   piece.setLocation(newLoc);
}

private int rollDice()
{
   int rollTotal = 0;
   for (int i = 0; i < dice.length; i++)
   {
      dice[i].roll();
      rollTotal += dice[i].getFaceValue();
   }
   return rollTotal;
}

} // end of class
```

Introduce Explaining Variable —Before Refactoring

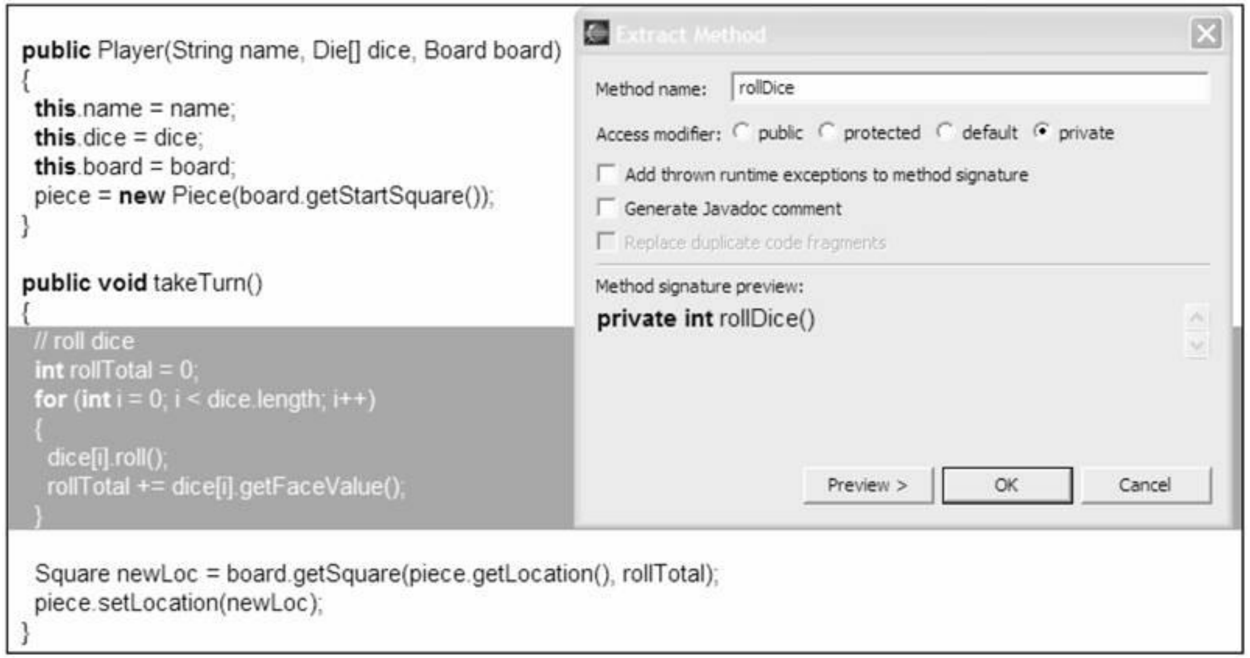
```
   // good method name, but the logic of the body is not clear
boolean isLeapYear( int year )
{
   return( ( ( year % 400 ) == 0 ) ||
         ( ( ( year % 4 ) == 0 ) && ( ( year % 100 ) != 0 ) ) );
}
```

Introduce Explaining Variable —After Refactoring

Clarifies, simplifies, and reduces the need for comments

```
   // that's better!
boolean isLeapYear( int year )
{
   boolean isFourthYear = ( ( year % 4 ) == 0 );
   boolean isHundrethYear = ( ( year % 100 ) == 0);
   boolean is4HundrethYear = ( ( year % 400 ) == 0);
   return (
      is4HundrethYear
      || ( isFourthYear && ! isHundrethYear ) );
}
```

IDE Support for Refactoring —Before Refactoring



IDE Support for Refactoring —After Refactoring

```
public void takeTurn()
{
  int rollTotal = rollDice();

  Square newLoc = board.getSquare(piece.getLocation(), rollTotal);
  piece.setLocation(newLoc);
}

private int rollDice()
{
  // roll dice
  int rollTotal = 0;
  for (int i = 0; i < dice.length; i++)
  {
    dice[i].roll();
    rollTotal += dice[i].getFaceValue();
  }
  return rollTotal;
}
```

AI CAN

You can prompt engineer your code into a better state by following patterns learned by an LLM

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Part: 4 Elaboration Iteration 2—More Patterns

- **GRASP: More Objects with Responsibilities**
- Applying GoF Design Patterns
- S.O.L.I.D

Part: 4 Elaboration Iteration 2—More Patterns

GRASP: More Objects with Responsibilities

Abdulkareem Alali

Ack Dale Haverstock

Based on Larman's Applying UML and Patterns Book, 3d

Luck is the residue of design.

—Branch Rickey

There Are Nine GRASP Patterns

1. Creator
2. Information Expert
3. Low Coupling
4. Controller
5. High Cohesion
6. Indirection
7. Pure Fabrication
8. Polymorphism
9. Protected Variations

Polymorphism

Polymorphism

- Alternatives based on type (Types with similar functionalities and different behavior)
  - If **If-then-else** or **case** statement **conditional** logic used,
  - A new variation arises,
  - Requires modification of logic often in many places,
  - Hard to extend a program

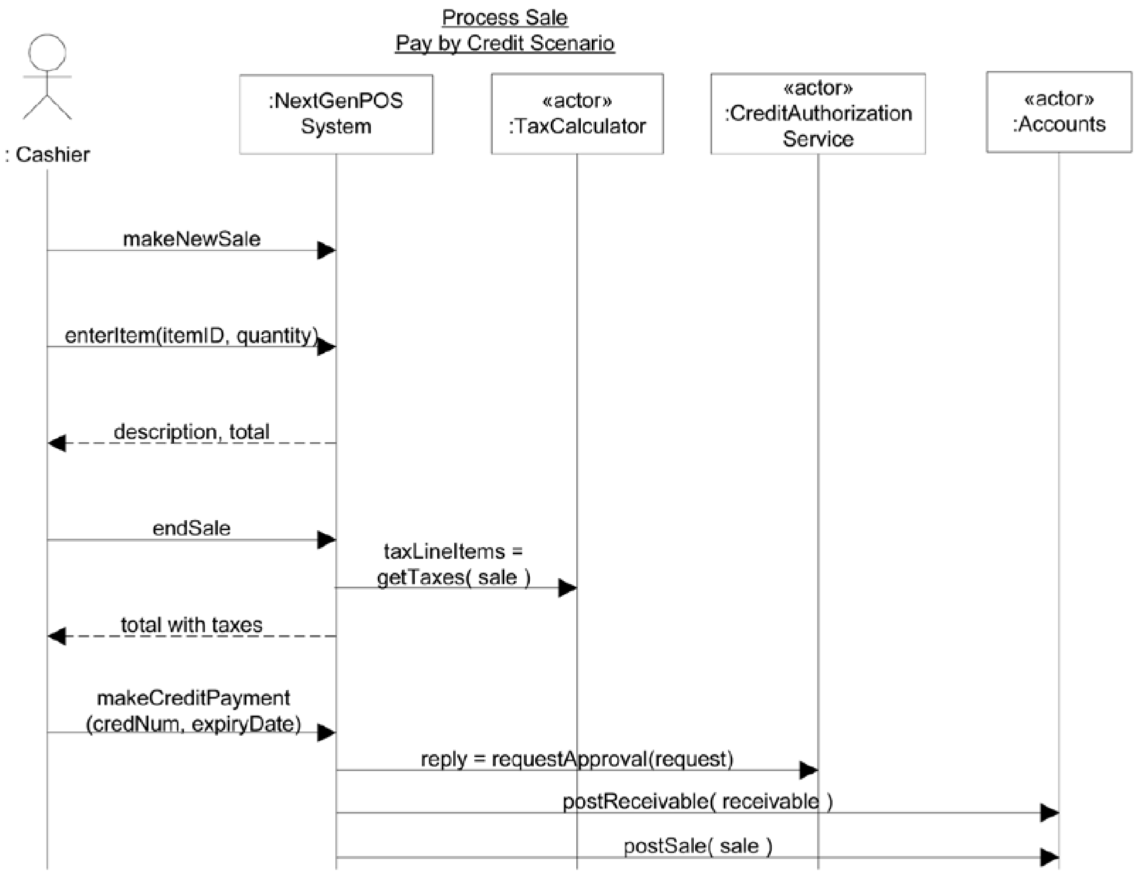
- **Pluggable** software components
  - e.g. Viewing components in client-server relationships,
    how can you replace one server component with another, without affecting the client?

Polymorphism

When related alternatives or
behaviors vary by type (class), with similar functionality

Assign responsibility for the behavior
—using polymorphic operations—
to the types for which the behavior varies

POS
—SSD for Process Sale … Updated
—External Systems



POS
—Support 3d-Party Tax Calculators?

Multiple external third-party tax calculators

e.g. Tax-Master, Good-As-Gold, TaxPro, etc.

System needs to integrate with different APIs

Behavior of calculator **varies** by **type** of calculator

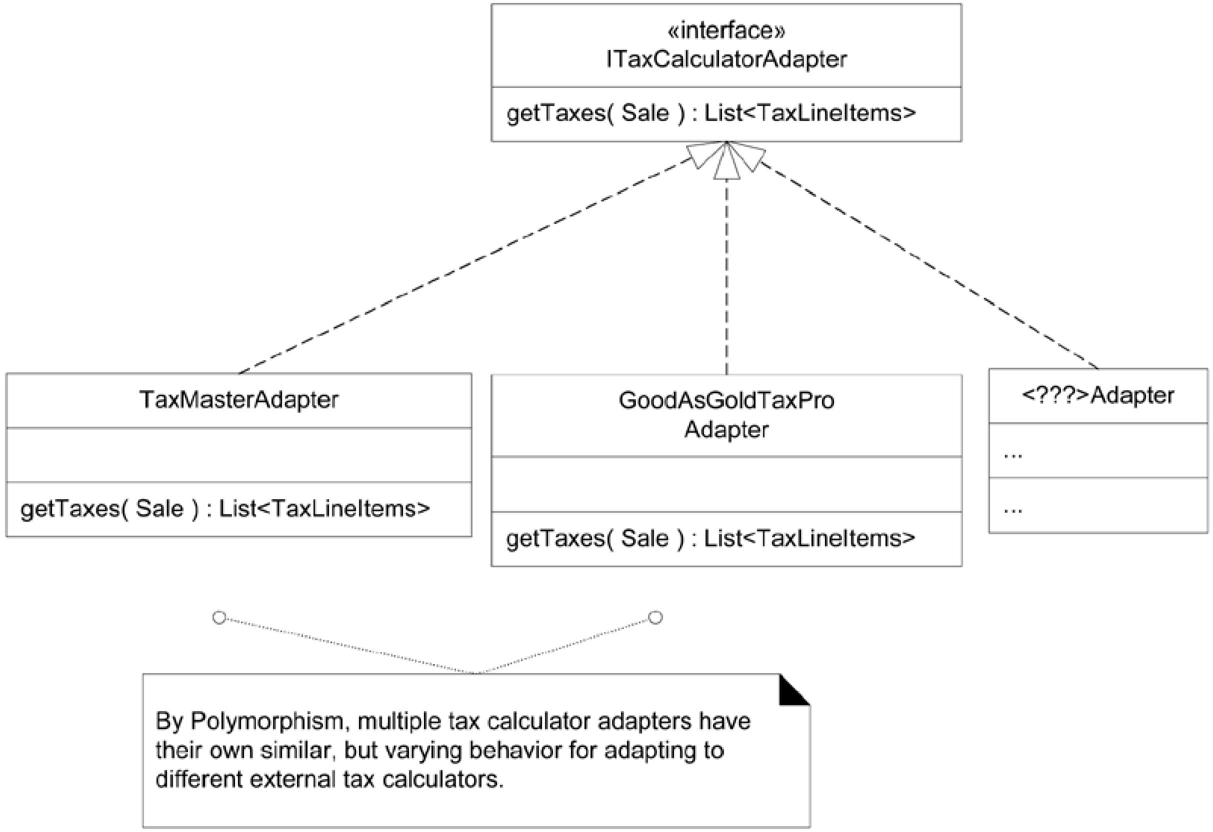
POS
—Support 3d-Party Tax Calculators?

*What **objects** should be responsible for handling these varying external tax calculator interfaces?*

- By **Polymorphism**, assign responsibility to different calculator (or calculator **Adapter** from **GoF**)

- Implement a polymorphic ***getTaxes*** operation

POS
—3d-Party Tax Calculators



POS
—3d-Party Tax Calculators

Calculator adapter objects are not external calculators but local software objects

that represent external calculators (**Adapters**)

Sending a message to the local object,

Calls external calculator in its native API

POS
—3d-Party Tax Calculators

Each ***getTaxes*** method takes the **Sale** object as a parameter, so that the calculator can analyze the sale

Implementation of each ***getTaxes*** method will be different:

- e.g. **TaxMasterAdapter** will adapt request to the API of Tax-Master, etc

Monopoly
How to Design for Different Square Actions?

Player lands on Go square, receive $200,

Land on the Income Tax square, gets a 10% detection of cash, etc.

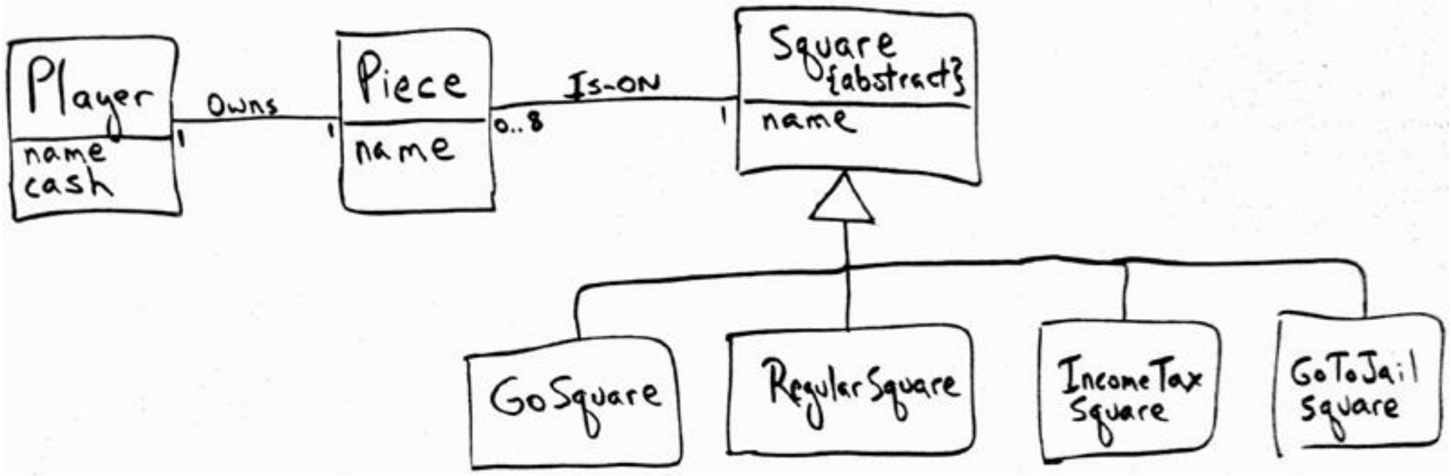
A **different rule for different types** of squares

Do not test for the type of an object and use conditional logic to perform varying alternatives based on type

Monopoly
—Design for Different Square Actions?

```
// Bad Design
SWITCH ON square.type
   CASE GoSquare:
      player receives $200
   CASE IncomeTaxSquare:
      player pays tax
   CASE GoToJailSquare:
      player locked in jail
   ...
```

Monopoly
—Design for Different Square Actions?



Monopoly
—Design for Different Square Actions

Create a **polymorphic operation** for each type for which the behavior varies

What is the operation that varies?

It's what happens when a player lands on a square

Polymorphic operation is ***landedOn***

Non default behavior in the superclass,

{abstract} declaration of the polymorphic operation in superclass

Monopoly
—Design for Different Square Actions

*What object should send the **landedOn** message to the square that a player lands on?*

Player knows its location square (Low Coupling + Expert)

Player is a good to send message, **Player** visible to **Square**

Naturally, this message should be sent at the end of the ***takeTurn*** method

Class Player

```
public class Player
{
  private String name;
  private Piece  piece;
  private Board  board;
  private Die[]  dice;

  public Player(String name, Die[] dice, Board board)
  {
    this.name = name;
    this.dice = dice;
    this.board = board;
    piece = new Piece(board.getStartSquare());
  }

  public void takeTurn()
  {
          // roll dice
    int rollTotal = 0;
    for (int i = 0; i < dice.length; i++)
    {
      dice[i].roll();
      rollTotal += dice[i].getFaceValue();
    }

    Square newLoc = board.getSquare(piece.getLocation(), rollTotal);
    piece.setLocation(newLoc);

  }


  public Square getLocation()
  {
    return piece.getLocation();
  }

  public String getName()
  {
    return name;
  }

}
```

Class MonopolyGame

```
public class MonopolyGame
{
   private static final int ROUNDS_TOTAL  = 20;
   private static final int PLAYERS_TOTAL = 2;
   private List players = new ArrayList( PLAYERS_TOTAL );
   private Board   board   = new Board(  );
   private Die[]   dice    = { new Die(), new Die() };

   public MonopolyGame(  )
   {
      Player p;
      p = new Player( "Horse", dice, board );
      players.add( p );
      p = new Player( "Car", dice, board  );
      players.add( p );
   }

   public void playGame(  )
   {
      for ( int i = 0; i < ROUNDS_TOTAL; i++ )
      {
         playRound();
      }
   }

   public List getPlayers(  )
   {
      return players;
   }


   private void playRound(  )
   {
      for ( Iterator iter = players.iterator(  ); iter.hasNext(  ); )
      {
         Player player = (Player) iter.next();
         player.takeTurn();
      }
   }
}
```

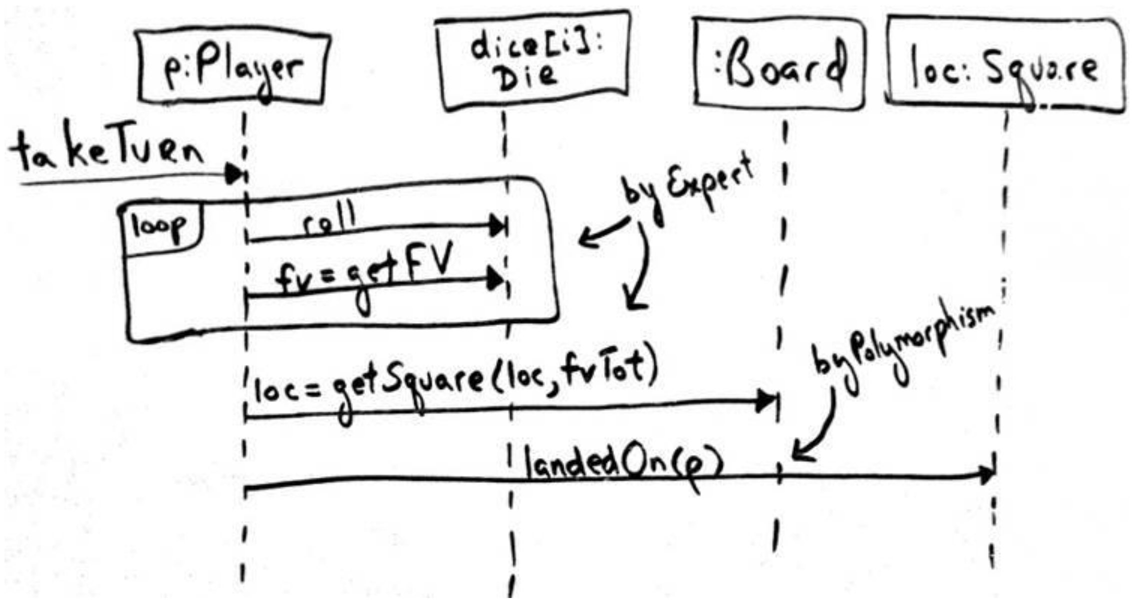
Monopoly
—Design for Different Square Actions
—Applying Polymorphism

Player object is labeled 'p' so that in the ***landedOn*** message we can refer to that object in the parameter list

Square object is labeled loc ('location')

and same label as return ***getSquare*** message; It is the same object

How to Design for Different Square Actions? Applying Polymorphism



Polymorphic In Terms of GRASP

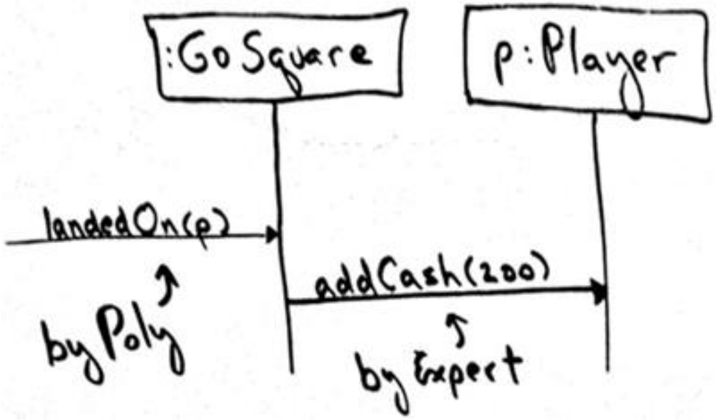
GoSquare—By **LRG**, **Player** knows its cash

By Expert, **Player** should be sent an ***addCash*** message

Square needs visibility to **Player** to send message

Player is passed as a parameter 'p' in the ***landedOn***

GoSquare Case



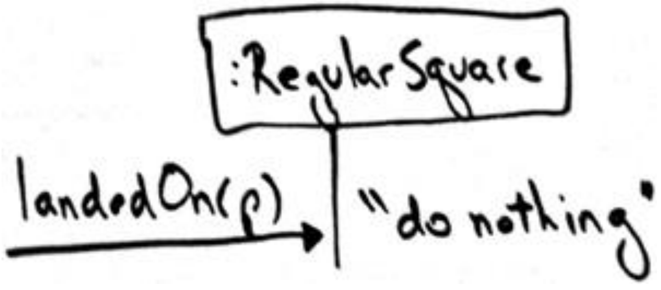
RegularSquare

RegularSquare—Nothing happens. Body of this method will be empty—sometimes called a NO-OP (no operation) method

Why send p (instance of **Player**) to **Square**, if NO-OP?

Note that to make the magic of polymorphism work, we need to use this approach to avoid special case logic

RegularSquare Case



IncomeTaxSquare

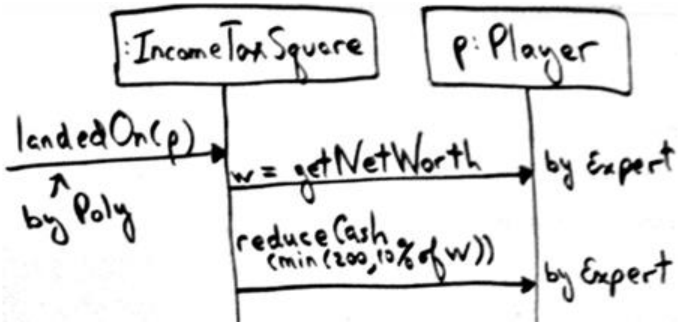
IncomeTaxSquare—Calculate 10% of the player's net worth

By LRG and by Expert, who should know this?

Player

Thus the **Square** asks for the **Player**'s worth, and then deducts the appropriate amount

IncomeTaxSquare Case



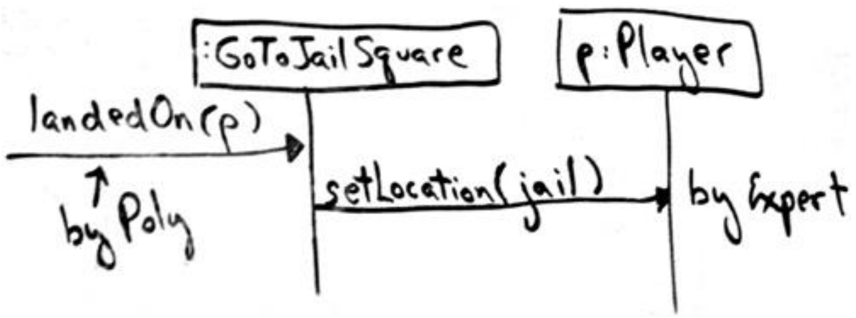
GoToJailSquare

GoToJailSquare—**Player**'s location must be changed

By Expert, it should receive a ***setLocation*** message

GoToJailSquare will be initialized with an attribute referencing the **JailSquare**, so that it can pass this square as a parameter to the **Player**

GoToJailSquare Case



Improving Coupling —OO Design refinement

Piece remembers square location but **Player** does not

Player must extract the location from the **Piece**

Send the ***getSquare*** message to the **Board**

Then re-assign the new location to the **Piece**

—Weak design point!

Player sends ***landedOn*** message to its **Square**, it becomes even weaker. Problems in coupling.

Improving Coupling

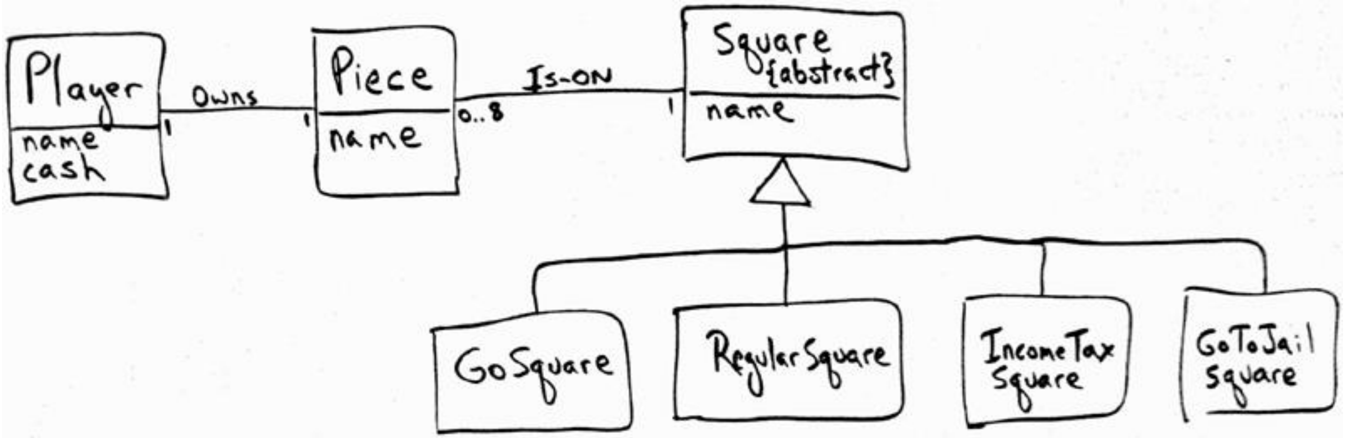
Player needs permanently to know its own **Square** location rather than **Piece**, since the **Player** keeps collaborating with its **Square**

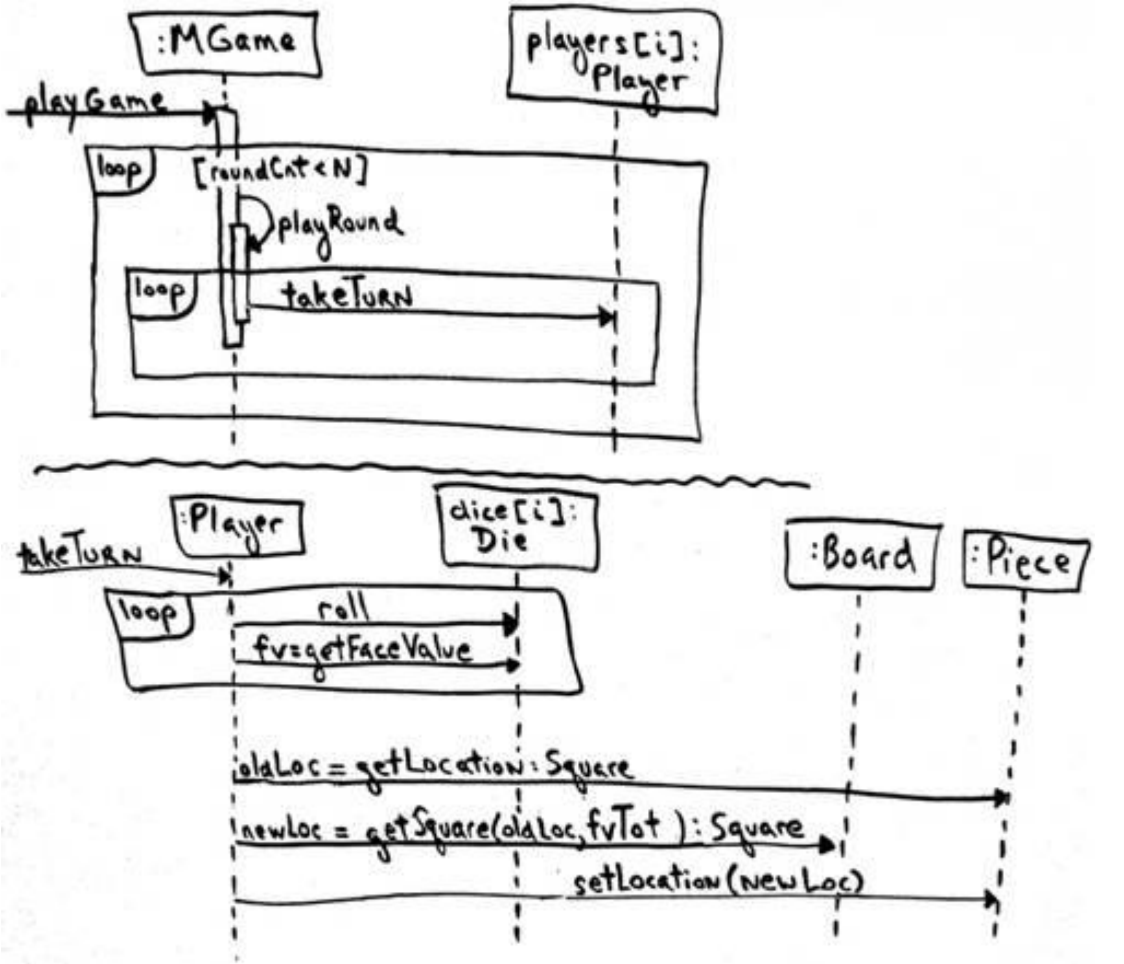
A **refactoring** opportunity to improve coupling

- Object **A** keeps needing the data in object **B** it implies:
  - Either Object **A** should **hold** that data
  - Object **B** should have the **responsibility** (by Expert) rather than object **A**

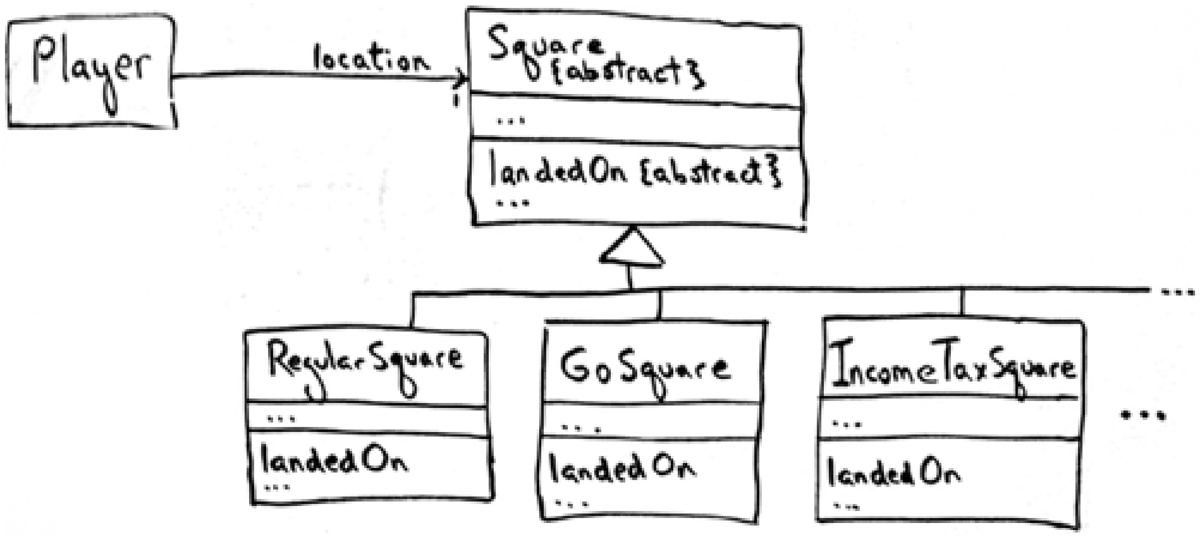
Player object can fulfill the role of the **Piece**

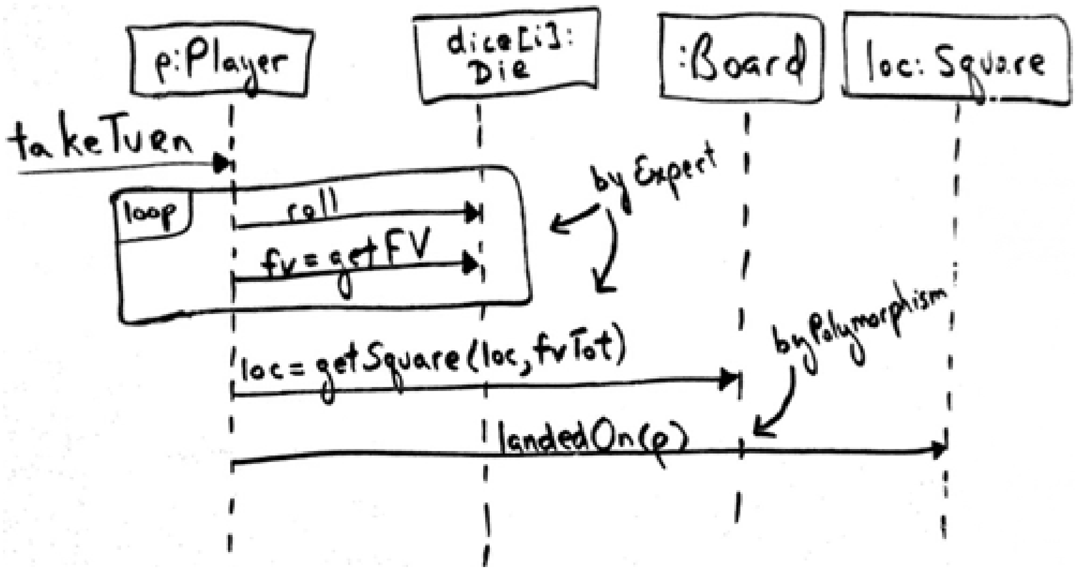
Improving Coupling —old *takeTurn*





Improving Coupling —new *takeTurn*





When to Design with Interfaces

Support **polymorphism** without being **committed** to a particular class hierarchy

Abstract Superclass **AC** used without an interface, any new polymorphic solution must be a subclass of **AC**, limiting in single-inheritance languages such as Java and C#

For a class hierarchy with an abstract superclass **C1**, consider making an interface **I1** that corresponds to the public method signatures of **C1**, and then declare **C1** to implement the **I1** interface

A Flexible Evolution Point For Unknown Future Cases

Interfaces, Benefits?

- Extensions required for new variations are easy to add

- **Pluggable**, New implementations can be introduced without affecting clients

Pure Fabrication

Pure Fabrication –Problem?

OOD **characterized** by software classes representations of concepts in the real-world problem domain to lower the representational gap (**LRG**)

Many situations, assigning responsibilities to domain layer software classes leads to problems in terms of

- poor cohesion or
- coupling, or
- low reuse potential

Pure Fabrication —Solution?

Artificial or **convenience** class that does not represent a problem domain concept

—Something made up, to support high cohesion, low coupling, and reuse

Design of the fabrication is very clean, or pure
—**Pure Fabrication**

POS
–Saving a Sale Object in a DB
–Problem?

Save **Sale** instances in a relational database, By Information Expert, **Sale** class saves itself, **Sale** has data to save (e.g. **Active Record** .)

Implications:

- Large number of supporting DB operations (CRUD), **Sale** becomes incohesive
- **Sale** coupled to relational DB interface, not close but far (a database interface)
- Saving objects in a relational database is a very general task, poor reuse or
- Lots of duplication in other classes that do the same thing

POS
–Saving a Sale Object in a DB
–Solution?

Leads low cohesion, high coupling, and low reuse potential

—exactly the kind of desperate situation that calls for making something up

PersistentStorage is a Pure Fabrication

e.g. **Table Data Gateway** .

Save Sale via PersistentStorage

PersistentStorage is not a domain concept, but something made up or fabricated for the convenience of the software developer

Solves:

- **Sale** remains well-designed, with high cohesion and low coupling, stable
- **PersistentStorage** is cohesive, sole purpose of storing or inserting objects in a persistent storage medium
- **PersistentStorage** is **generic** and **reusable** object.

Save Sale via PersistentStorage

Eliminated bad design based on Expert, with poor cohesion and coupling,

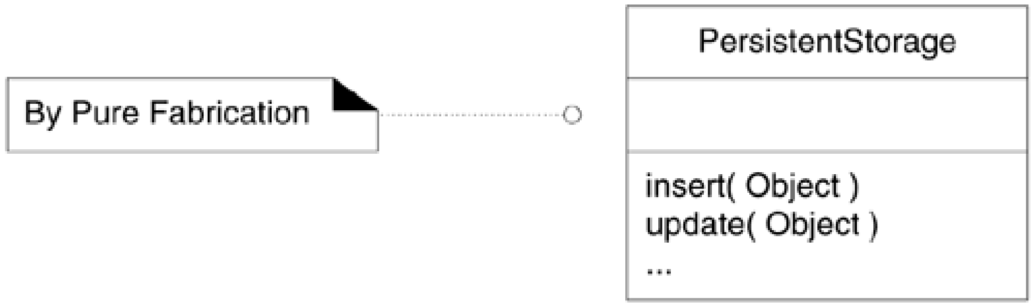
with a good design in which there is greater potential for reuse

GRASP patterns, responsibilities placed but shifted from **Sale** (by **Expert**) to a **Pure Fabrication**

Save Sale via PersistentStorage

ORM like solution,

Object-Relational Mapping e.g. Hibernate Tools .



Monopoly
–Class Player
–Handling Dice After Refactoring

```
public void takeTurn()
{
        // the refactored helper method
   int rollTotal = rollDice();
```

```
public void takeTurn()
{
        // the refactored helper method
   int rollTotal = rollDice();

   Square newLoc = board.getSquare(piece.getLocation(), rollTotal);
   piece.setLocation(newLoc);
}

private int rollDice()
{
   int rollTotal = 0;
   for (int i = 0; i < dice.length; i++)
   {
      dice[i].roll();
      rollTotal += dice[i].getFaceValue();
   }
   return rollTotal;
}
```

Monopoly –Handling Dice –Problem?

Player ***rolls*** all the dice and sums the total

Dice are very general objects, usable in many games

Summing service is not generalized for use in other games

It is not possible to simply ask for the current dice total without rolling the dice again

Monopoly —Handling Dice —Solution?

Pure Fabrication—make something up to conveniently provide related services

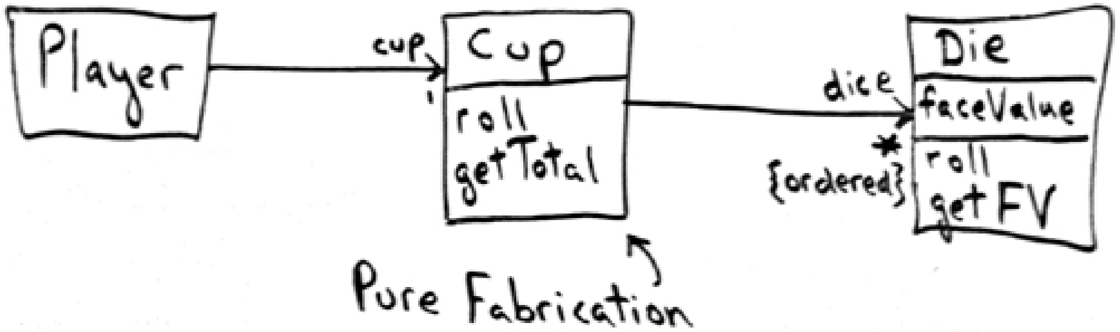
No **Cup** for dice in Monopoly, many games do use a dice cup

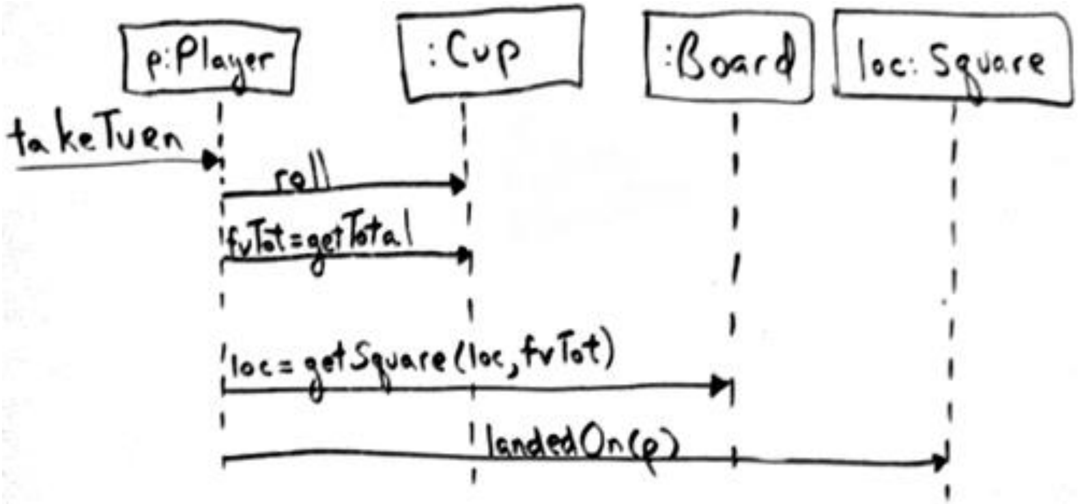
Cup hold all the dice, ***roll*** them onto a table, and know their total

Cup holds a collection of many **Die** objects.

When one sends a ***roll*** message to a **Cup**, it sends a ***roll*** message to all its dice

Monopoly –Handling Dice –Solution





Design of Objects –Two Groups

1. **Representational Decomposition**

2. **Behavioral Decomposition**

Design of Objects —Two Groups

1. **Sale** is by representational decomposition; software class represents a domain concept (**LRG**)

2. Grouping behaviors or by algorithm, without much concern for (**LRG**) class with a real-world domain concept name, behavioral decomposition

e.g. **PersistentStorage**, **ProcessSaleHandler**

Design of Objects —Two Groups

In a Word document software, “algorithm” that is a **TableOfContentsGenerator**

- Generates table of contents (helper/convenience class) with no concern using domain vocabulary of books and documents

To contrast, a software class named **TableOfContents** is inspired by representational decomposition

Design of Objects —Two Groups

1. Some software classes are inspired by representations of the domain

2. Some are simply made up designed to group together some common behavior

Pure Fabrication is usually based on related functionality,
function-centric or behavioral object

Examples of Pure Fabrications (behavioral design patters):
Adapter, **Strategy**, **Command**, etc.

Overusing Pure Fabrication

Functions just become objects

Needs To Be Balanced With The Ability To Design With Representational Decomposition

Overusing Pure Fabrication

Too many behavior objects with responsibilities not co-located with the information,

fulfillment which can adversely affect coupling

Symptom: Most of the **data** inside the objects is being passed to other objects to **process**

Indirection

Indirection

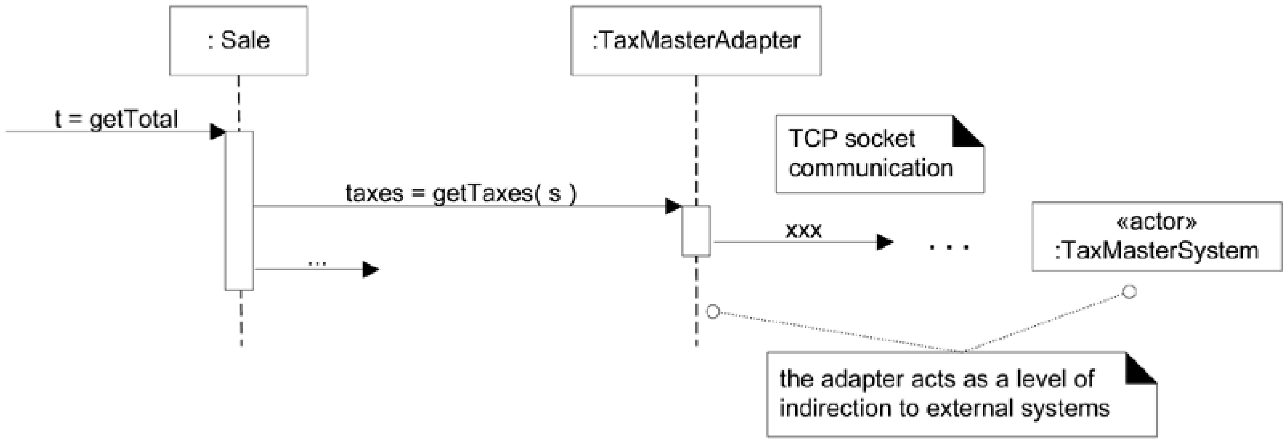
Problem:

Where to assign a responsibility, to avoid **direct coupling** between two (or more) things?

Solution:

Assign the responsibility to an **intermediate object** to mediate between other components or services so that they are **not directly coupled**

Indirection
—e.g. TaxCalculatorAdapter



Indirection —e.g. TaxCalculatorAdapter

These objects act as intermediaries to the external tax calculators

Via polymorphism, they provide a **consistent** interface to the inner objects and hide the **variations** in the external APIs

By adding a level of indirection and adding polymorphism, the adapter

Objects protect the inner design against **variations** in the external interfaces

Indirection —e.g. PersistentStorage

Pure Fabrication example of decoupling the **Sale** from the relational database services

Through a **PersistentStorage** class which is also an example of assigning responsibilities to support Indirection

PersistentStorage acts as a intermediary between the **Sale** and the DB

Protected Variations

Protected Variations

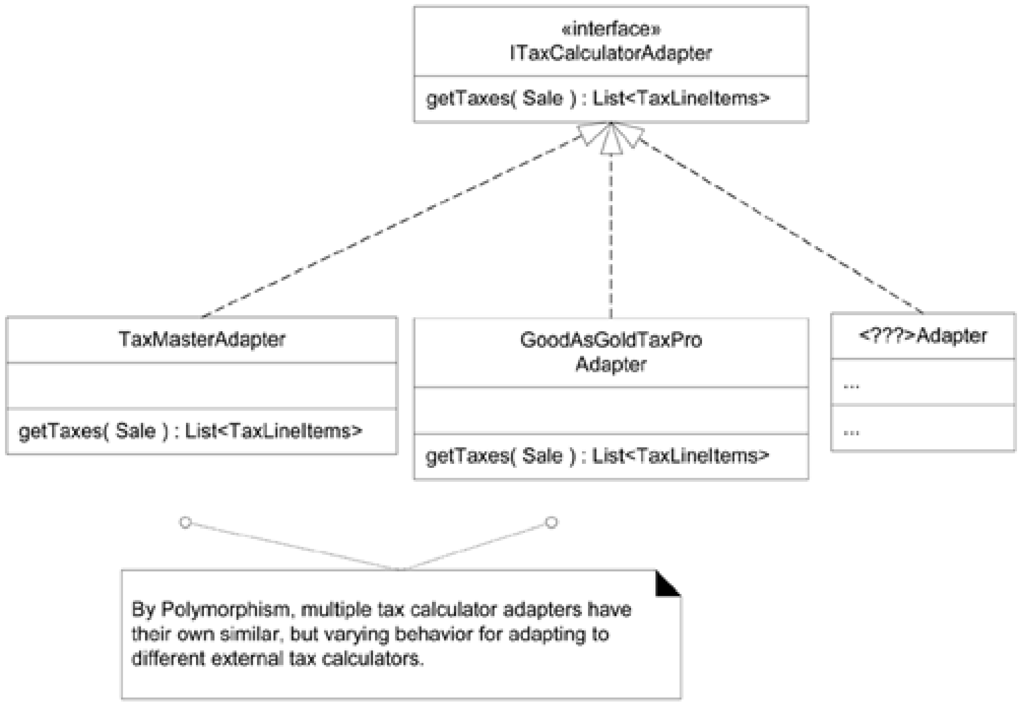
Problem

How to design objects, subsystems, and systems so that the **variations or instability** in these elements does not have an undesirable impact on other elements?

Solution

1. Identify points of **predicted variation** or **instability**;
2. Assign responsibilities to create a **stable interface** around them

External Tax Calculator



External Tax Calculator

Point of instability or variation is **the different interfaces** or **APIs** of external tax calculators

The POS system needs to be able to integrate with many existing tax calculator systems

And also with future third-party calculators not yet in existence

External Tax Calculator

By adding a level of **indirection**,

An interface, and using polymorphism with various **ITaxCalculatorAdapter** implementations,

protection within the system from variations in external APIs is achieved

Internal objects collaborate with a stable interface;

Various adapter implementations hide the variations to the external systems

Mechanisms Motivated by Protected Variations

PV is a root principle motivating most of the mechanisms and patterns in programming and design to:

Provide flexibility and Protection from variations

Variations in data,

behavior,

hardware,

software components,

operating systems, and more ...

Protected Variations, Motivation

Maturation of a developer or architect can be seen in their growing knowledge of ever-wider mechanisms to achieve PV

- To pick the appropriate PV battles worth fighting
- Their ability to choose a suitable PV solution

We learned about

data encapsulation,

interfaces,

and polymorphism—

all core mechanisms to achieve **PV** plus others …