# Introduction to Software Testing

## *(2nd edition)*

## Chapter 4

# Putting Testing First

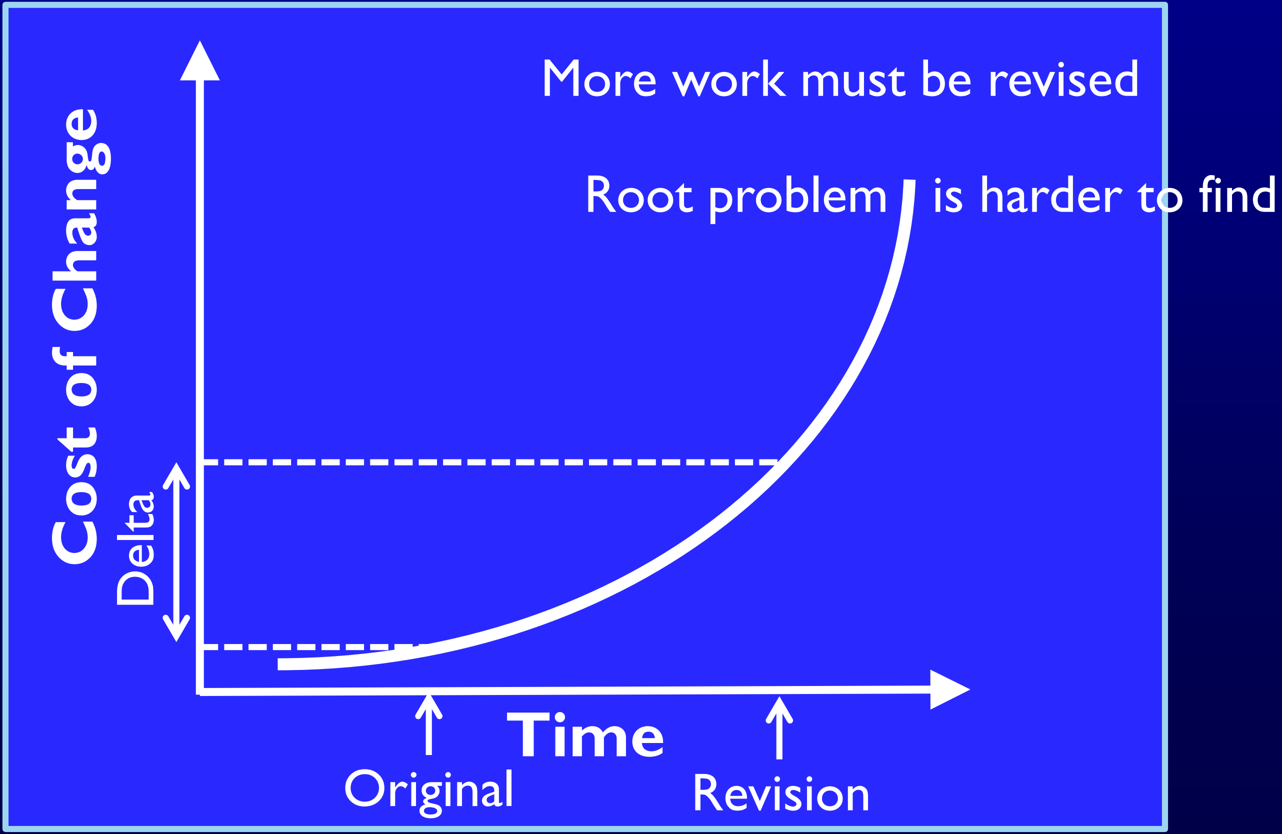
Paul Ammann & Jeff Offutt

http://www.cs.gmu.edu/~offutt/softwaretest/

*August 2014*

# The Increased Emphasis on Testing

- Philosophy of traditional software development methods
  - Upfront analysis
  - Extensive modeling
  - Reveal problems as early as possible



# Traditional Assumptions

1. Modeling and analysis can identify potential problems early in development

2. Savings implied by the cost-of-change curve justify the cost of modeling and analysis over the life of the project

- These are true if requirements are always complete and current
- But those annoying customers keep changing their minds!
  - Humans are naturally good at approximating
  - But pretty bad at perfecting
- These two assumptions have made software engineering frustrating and difficult for decades

Thus, agile methods …

# Why Be Agile ?

- Agile methods start by recognizing that neither assumption is valid for many current software projects
  - Software engineers are not good at developing requirements
  - We do not anticipate many changes
  - Many of the changes we do anticipate are not needed
- Requirements (and other "non-executable artifacts") tend to go out of date very quickly
  - We seldom take time to update them
  - Many current software projects change continuously
- Agile methods expect software to start small and evolve over time
  - Embraces software evolution instead of fighting it

# The Test Harness

- An agile principle states that traditional planning is not precise because:
  - Predicting system evolution is fundamentally hard
  - Hence expected savings from the cost-of-change curve do not materialize
- Instead, agile methods such as TDD defer many design and analysis decisions and focus instead on creating a running system that does "something" as early as possible
- At first glance, this may sound like a return to the dark days before traditional software engineering
- But no! In fact, there is a crucial difference
- So, what's different?
- Answer: The test harness

# A Limited View of Correctness

- In traditional methods, we try to define all correct behavior completely, at the beginning
  - – What is correctness?
  - – Does "correctness" mean anything in large engineering products?
  - – People are VERY BAD at completely defining correctness
- In agile methods, we redefine correctness to be relative to a specific set of tests
  - – If the software behaves correctly on the tests, it is "correct"
  - – Instead of defining all behaviors, we demonstrate some behaviors
  - – Mathematicians may be disappointed at the lack of completeness

But software engineers ain't mathematicians!

# Test Harnesses Verify Correctness

A *test harness* runs all automated tests efficiently and reports results to the developers

- Tests must be automated
  - Test automation is a prerequisite to test driven development
- Every test must include a test oracle that can evaluate whether that test executed correctly
- The tests replace the requirements
- Tests must be high quality and must run quickly
- We run tests every time we make a change to the software

# The Development Cycle in Agile Methods

- In agile methods, test cases are the de facto specification for the system
- This makes testing the central activity in development
- This is the reason that agile methods such as TDD order
  - writing tests first
  - implementing functionality second
  - and following good design principles third (i.e. refactoring)
- It is important to emphasize that good design still matters in TDD
  - It simply occupies a different, and later, niche in the development cycle

# Continuous Integration

- Agile methods work best when the current version of the software can be run against all tests at any time

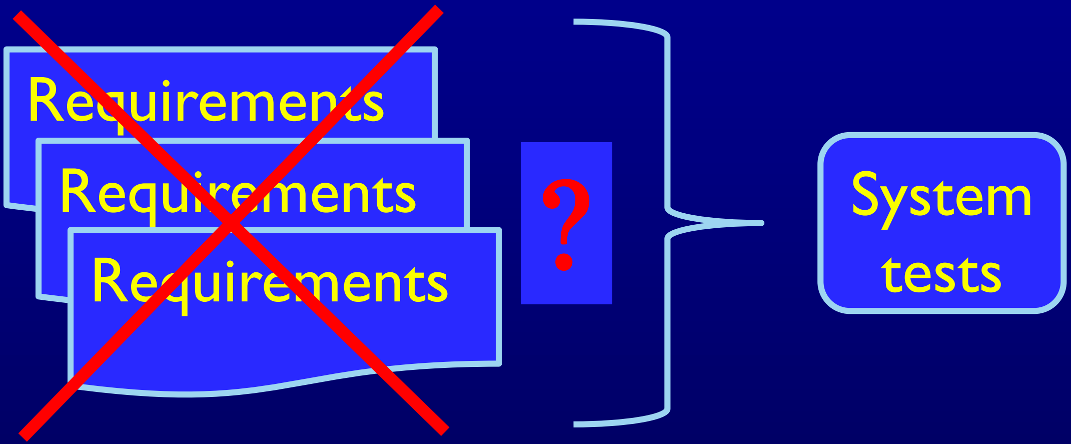
> A *continuous integration server* rebuilds the system and reverifies tests whenever *any* update is checked into the repository

- Mistakes are caught earlier
- Other developers are aware of changes early
- The rebuild and reverify must happen as soon as possible
  – Thus, tests need to execute quickly

> A *continuous integration server* doesn’t just run tests, it decides if a modified system is still correct

# System Tests in Agile Methods

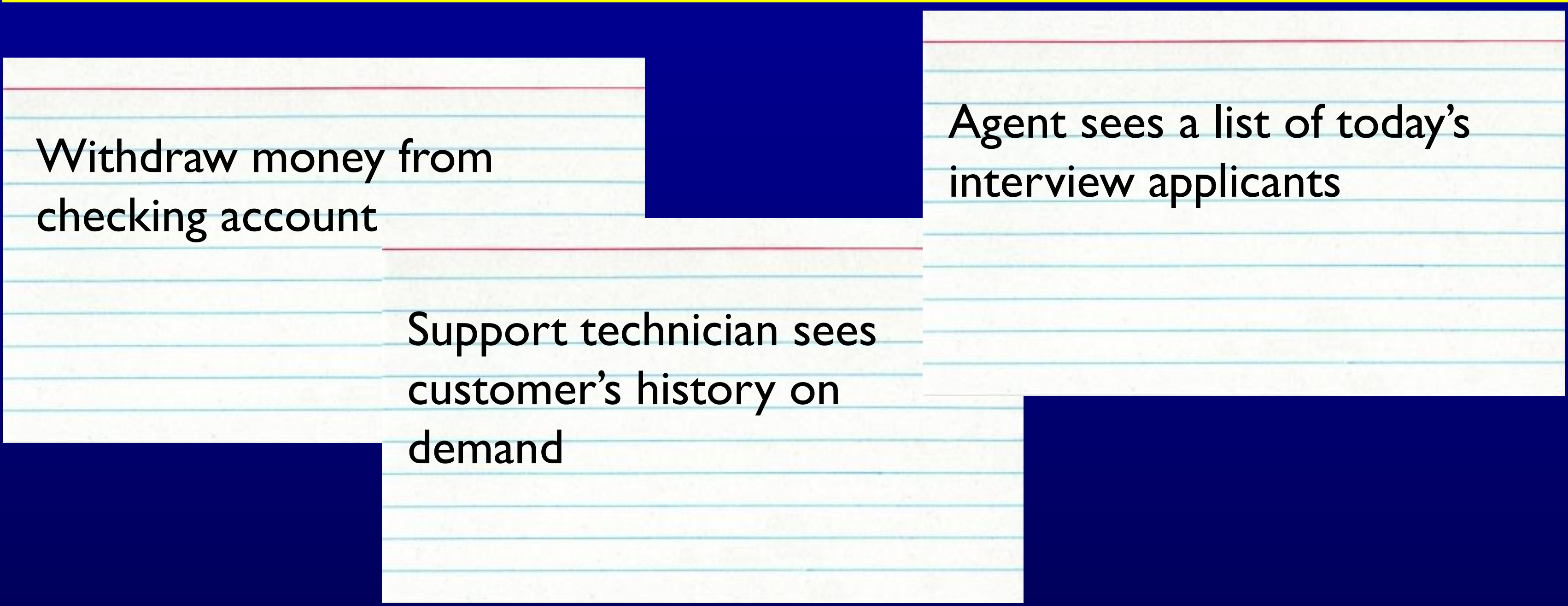
Traditional testers often design system tests from requirements (or design specifications)



But … what if there are no traditional requirements documents ?

# User Stories

A *user story* is a few sentences that captures what a user will do with the software



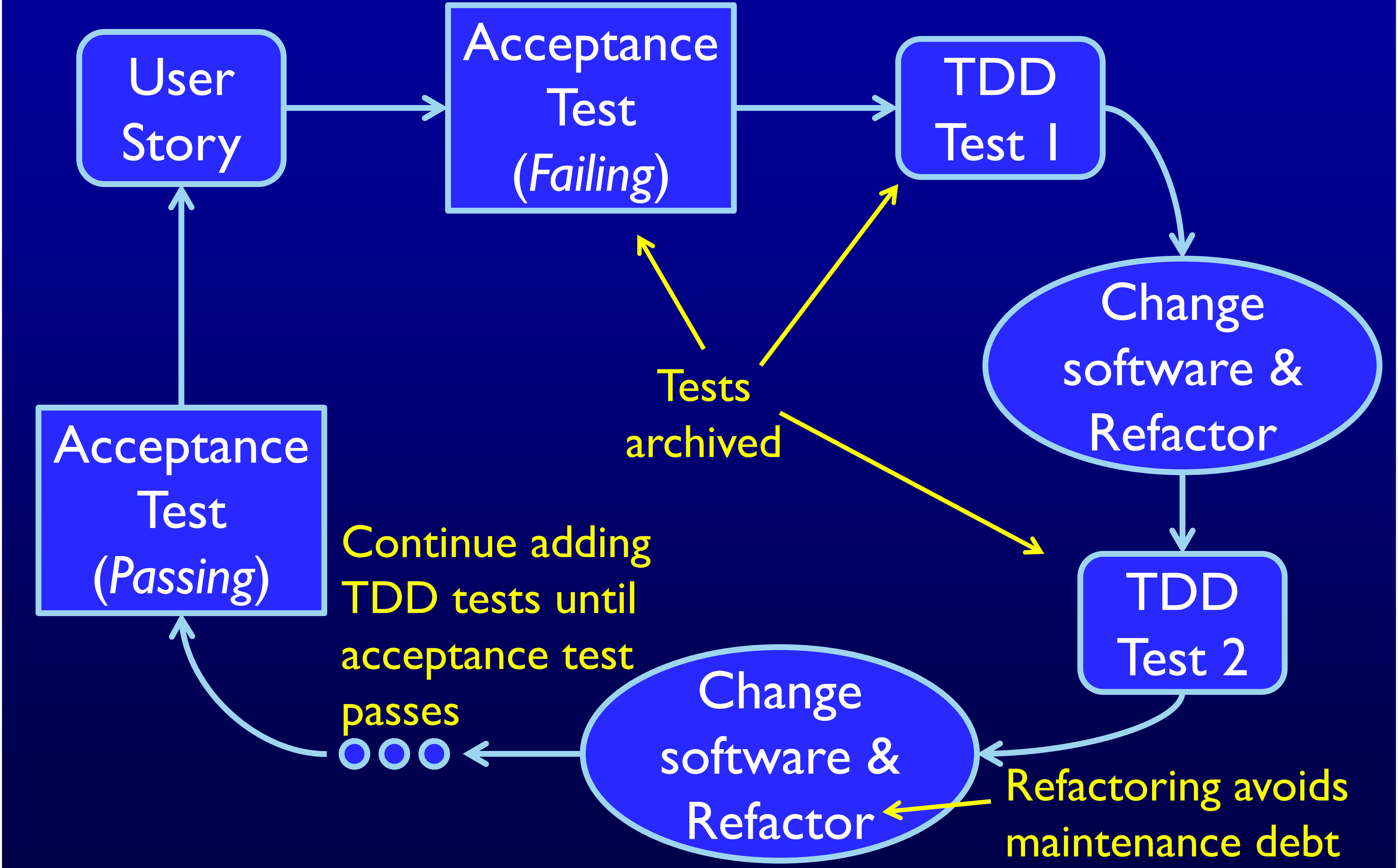
Withdraw money from checking account

Support technician sees customer's history on demand

Agent sees a list of today's interview applicants

- In the language of the end user
- Usually small in scale with few details
- Not archived

# Acceptance Tests in Agile Methods



User Story
Acceptance Test *(Failing)*
TDD Test 1
Change software & Refactor
TDD Test 2
Change software & Refactor
Acceptance Test *(Passing)*

Tests archived

Continue adding TDD tests until acceptance test passes

Refactoring avoids maintenance debt

# Adding Tests to Existing Systems

- Most of today's software is legacy
  - No legacy tests
  - Legacy requirements hopelessly outdated
  - Designs, if they were ever written down, lost
- Companies sometimes choose not to change software because of fear of the consequences of changes

How to apply TDD to legacy software with no tests?

- Create an entire new test set? — too expensive!
- Give up? — a mixed project is unmanageable

# Incremental TDD

- When a change is made, add TDD tests for just that change
  - Refactor
- As the project proceeds, the collection of TDD tests continues to grow
- Eventually the software will have strong TDD tests

# The Testing Shortfall

- Do TDD tests (acceptance or otherwise) test the software well?
  - Do the tests achieve good coverage on the code?
  - Do the tests find most of the faults?
  - If the software passes, should management feel confident the software is reliable?

**NO!**

# Why Not?

- Most agile tests focus on "*happy paths*"
  - What should happen under normal use
- They often miss things like
  - Confused-user paths
  - Creative-user paths
  - Malicious-user paths

The agile methods literature does not give much guidance

# What Should Testers Do?

Ummm … Excuse me, Professor …

What do I **DO**?

# Design Good Tests

## 1. Use a human-based approach

- Create additional user stories that describe non-happy paths
- How do you know when you're finished?
- Some people are very good at this, some are bad, and it's hard to teach

Part 2 of book …

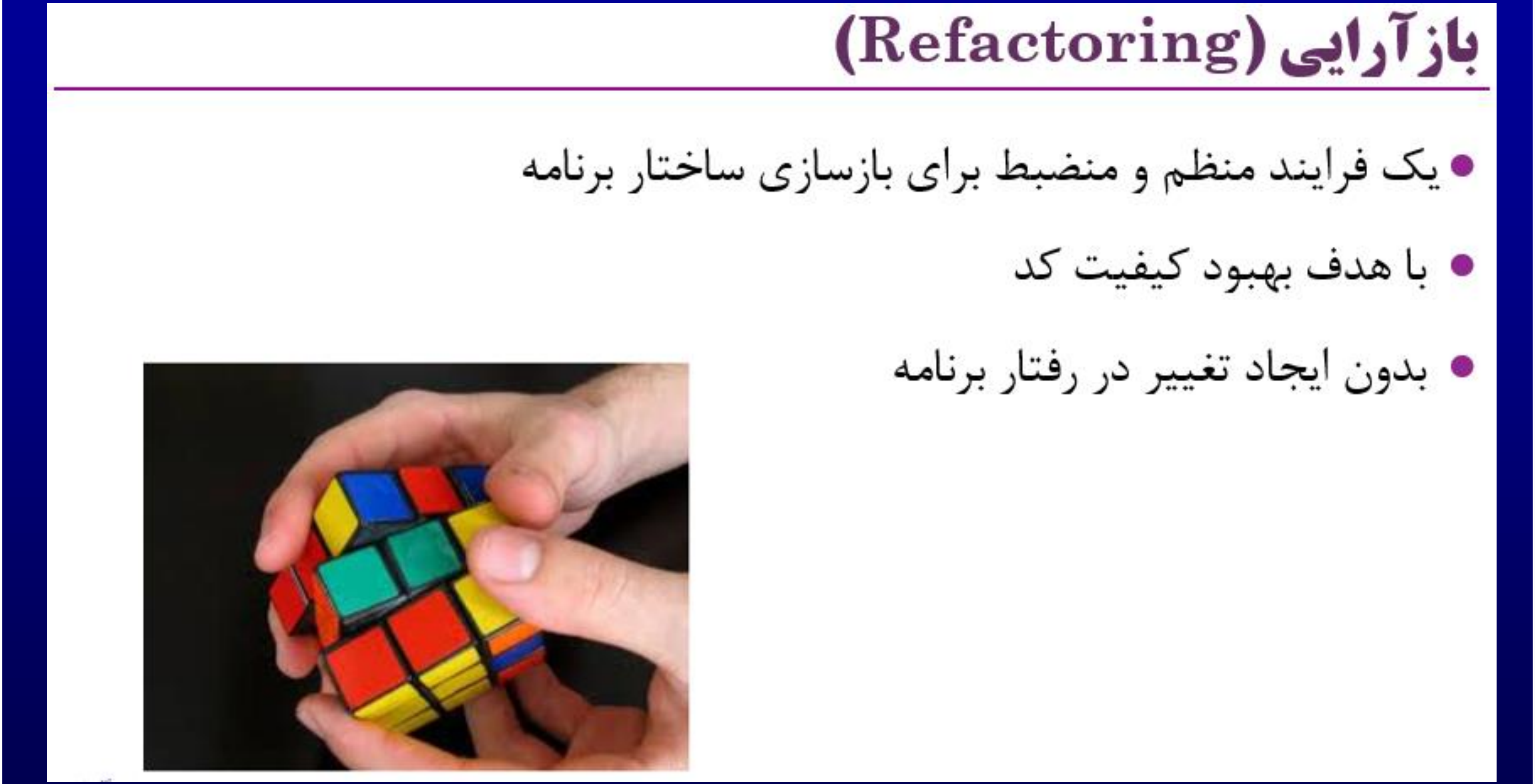
## 2. Use modeling and criteria

- Model the input domain to design tests
- Model software behavior with graphs, logic, or grammars
- A built-in sense of completion
- Much easier to teach—engineering
- Requires discrete math knowledge

# Summary

- More companies are putting testing first
- This can dramatically decrease cost and increase quality
- A different view of "*correctness*"
  - – Restricted but practical
- Embraces evolutionary design
- TDD is definitely not test automation
  - – Test automation is a prerequisite to TDD
- Agile tests aren't enough
  - – Applying coverage criteria can help testers design very high quality tests

# مطالب تکمیلی: باز آرایی



# بازآرایی (Refactoring)

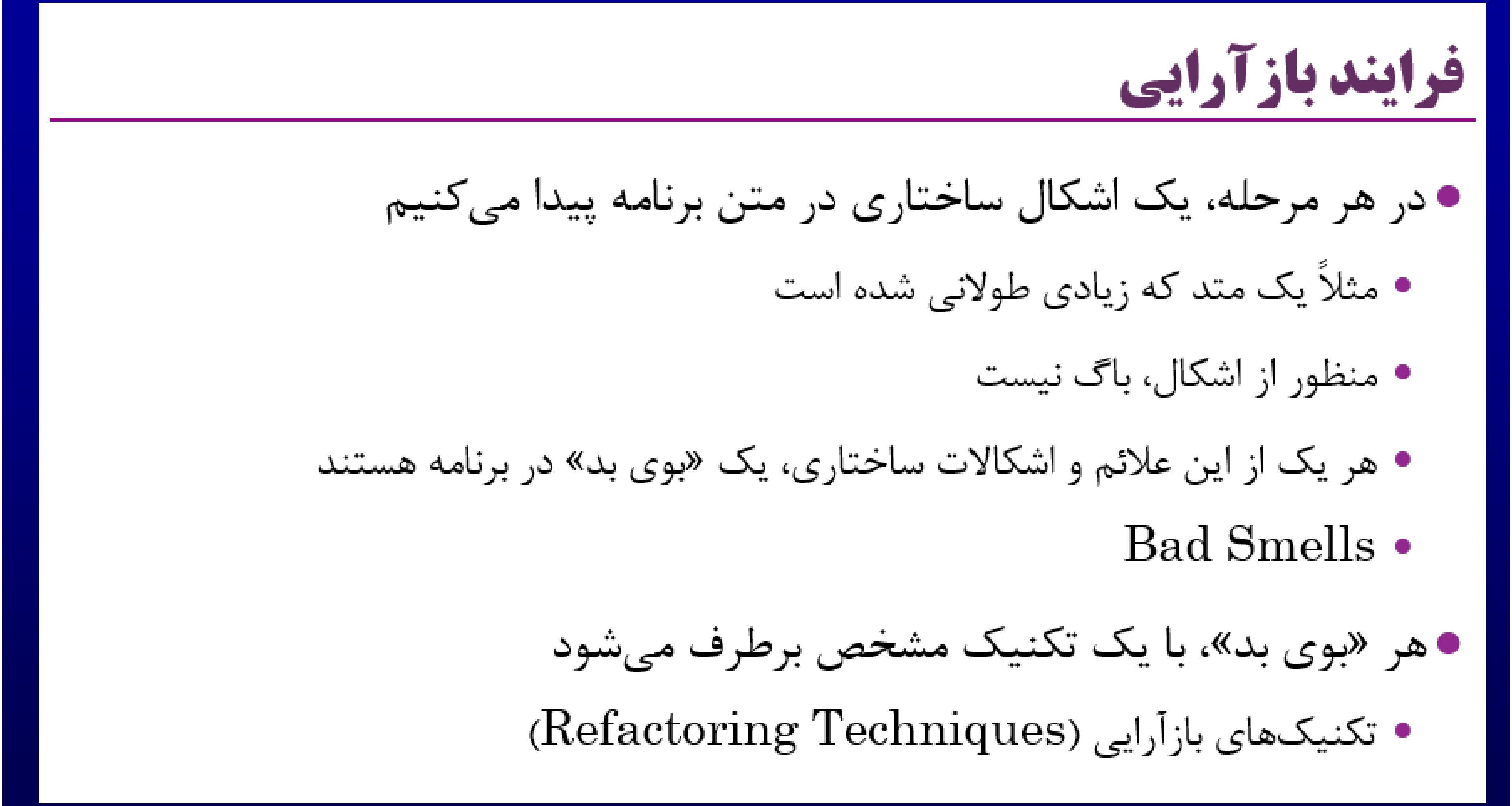
- یک فرایند منظم و منضبط برای بازسازی ساختار برنامه
- با هدف بهبود کیفیت کد
- بدون ایجاد تغییر در رفتار برنامه

# تعریف بازآرایی

- تغییری در ساختار داخلی نرم‌افزار،
- که باعث می‌شود راحت‌تر خوانده و فهمیده شود،
- و تغییر (نگهداری) آن کم هزینه‌تر و ساده‌تر شود،
- بدون این که تغییری در رفتار نرم‌افزار مشاهده شود.
- مهمترین فایده بازآرایی: افزایش **قابلیت نگهداری** نرم‌افزار

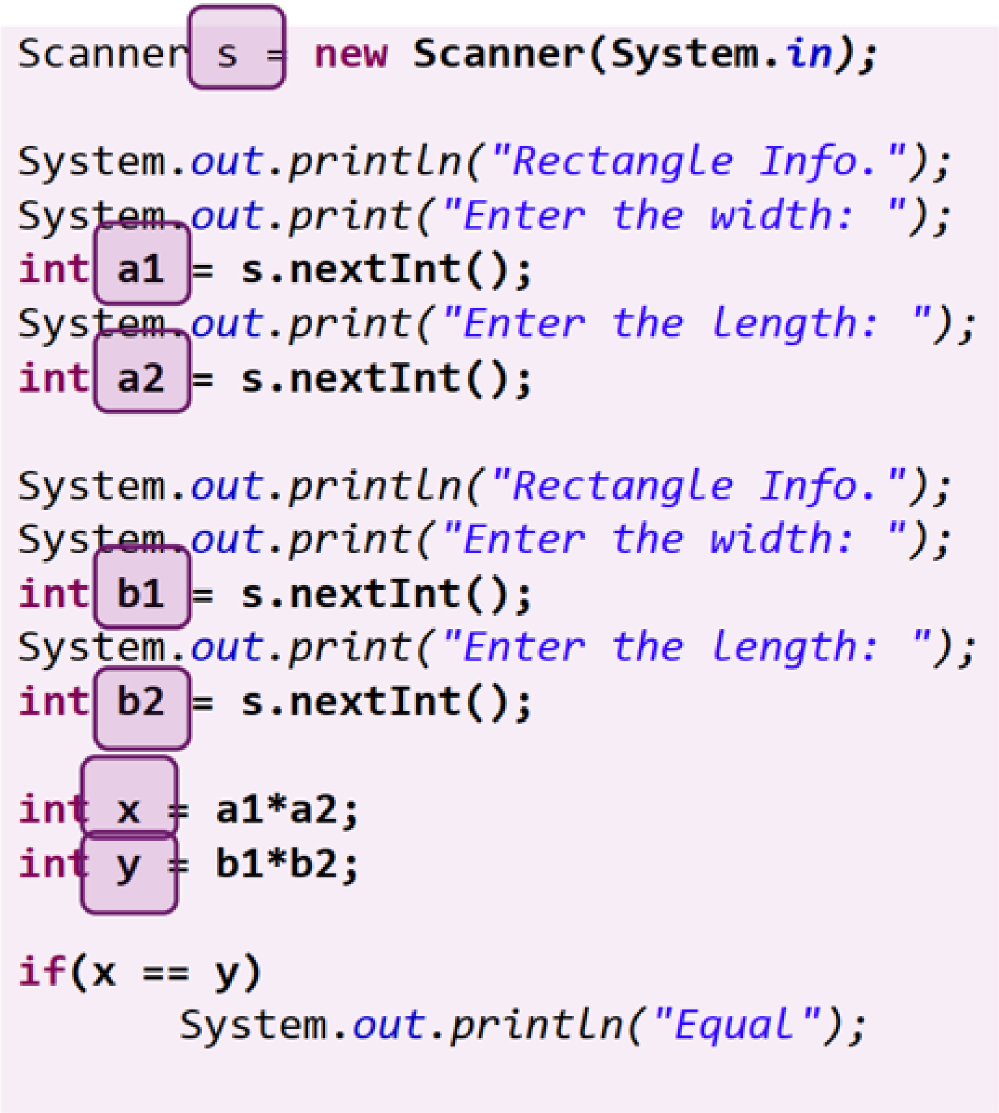
# بازآرایی چه می‌کند؟

- بهبود ساختار داخلی برنامه
- اجرای فرایندی منظم برای تمیز کردن کد
- بهبود طراحی برنامه بعد از نوشتن کد
  - بخصوص در فرایندهای چابک تولید نرم‌افزار
  - بهبود دائمی طراحی برنامه



# فرایند بازآرایی

- در هر مرحله، یک اشکال ساختاری در متن برنامه پیدا می‌کنیم
  - مثلاً یک متد که زیادی طولانی شده است
  - منظور از اشکال، باگ نیست
  - هر یک از این علائم و اشکالات ساختاری، یک «بوی بد» در برنامه هستند
  - Bad Smells
- هر «بوی بد»، با یک تکنیک مشخص برطرف می‌شود
  - تکنیک‌های بازآرایی (Refactoring Techniques)

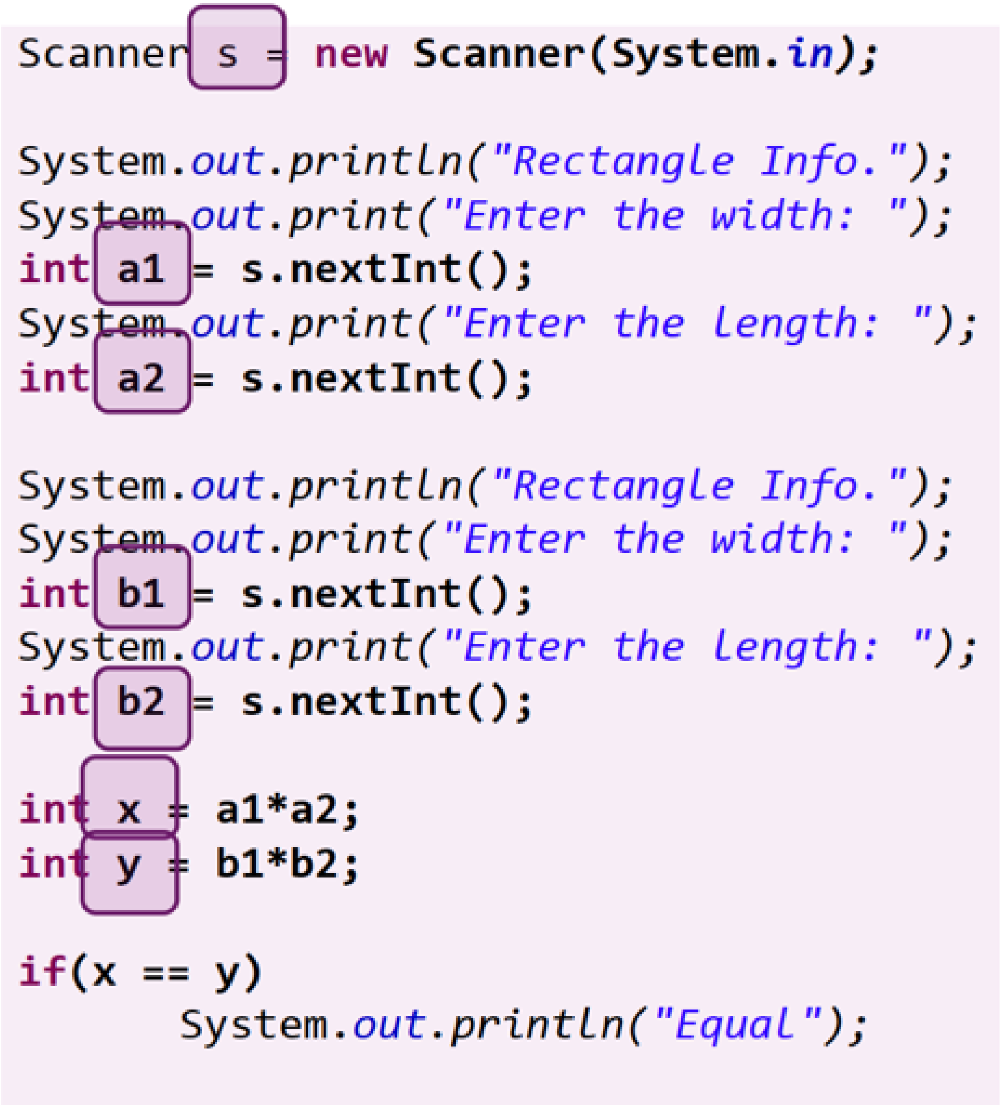


```
Scanner s = new Scanner(System.in);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int a1 = s.nextInt();
System.out.print("Enter the length: ");
int a2 = s.nextInt();

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int b1 = s.nextInt();
System.out.print("Enter the length: ");
int b2 = s.nextInt();

int x = a1*a2;
int y = b1*b2;

if(x == y)
        System.out.println("Equal");
```

# مثال

- این برنامه را ببینید
- چه اشکالاتی دارد؟
- چگونه ساختار آن را بهبود بخشیم؟

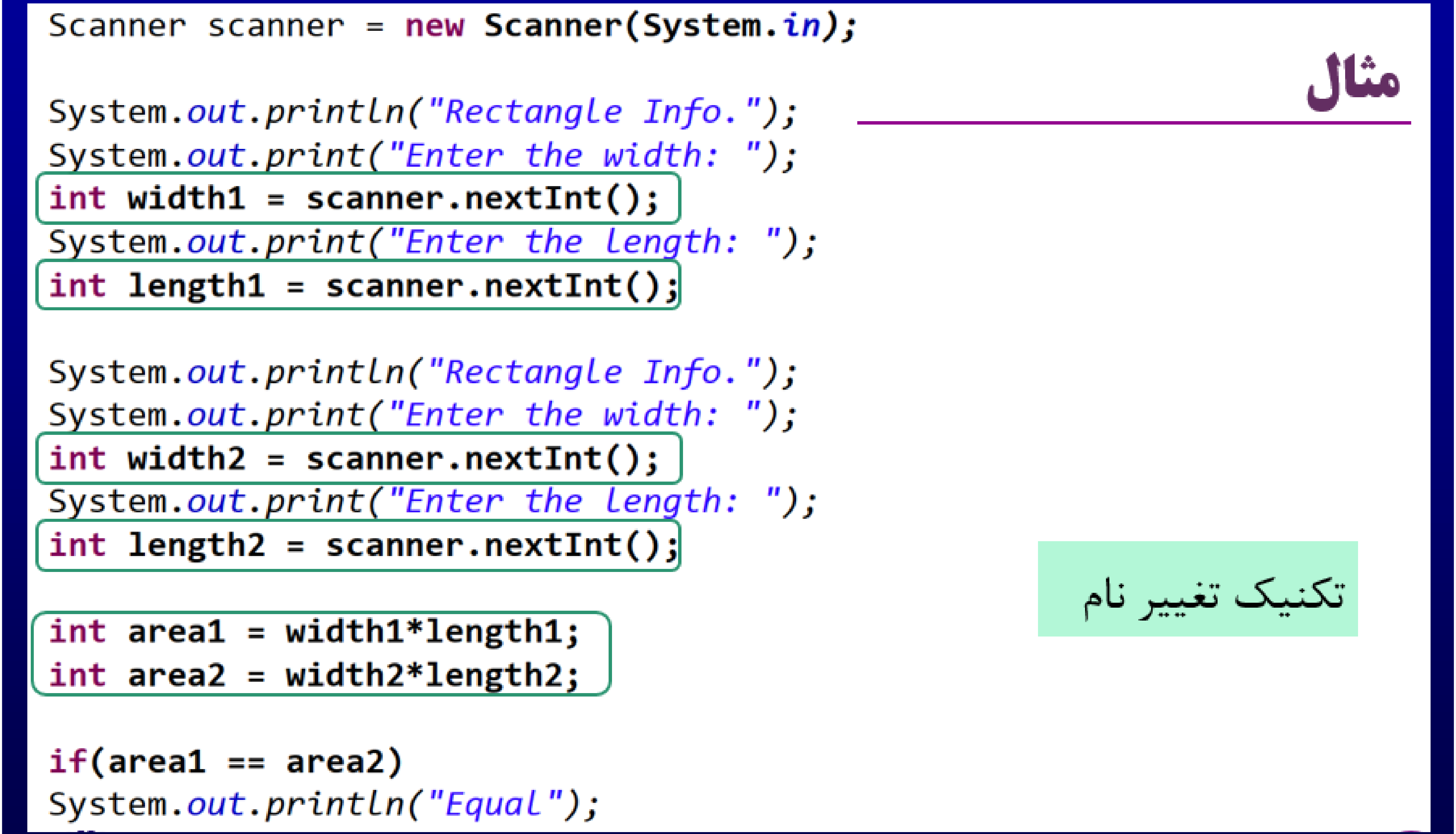
# مثال



```
Scanner s = new Scanner(System.in);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int a1 = s.nextInt();
System.out.print("Enter the Length: ");
int a2 = s.nextInt();

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int b1 = s.nextInt();
System.out.print("Enter the Length: ");
int b2 = s.nextInt();

int x = a1*a2;
int y = b1*b2;

if(x == y)
        System.out.println("Equal");
```

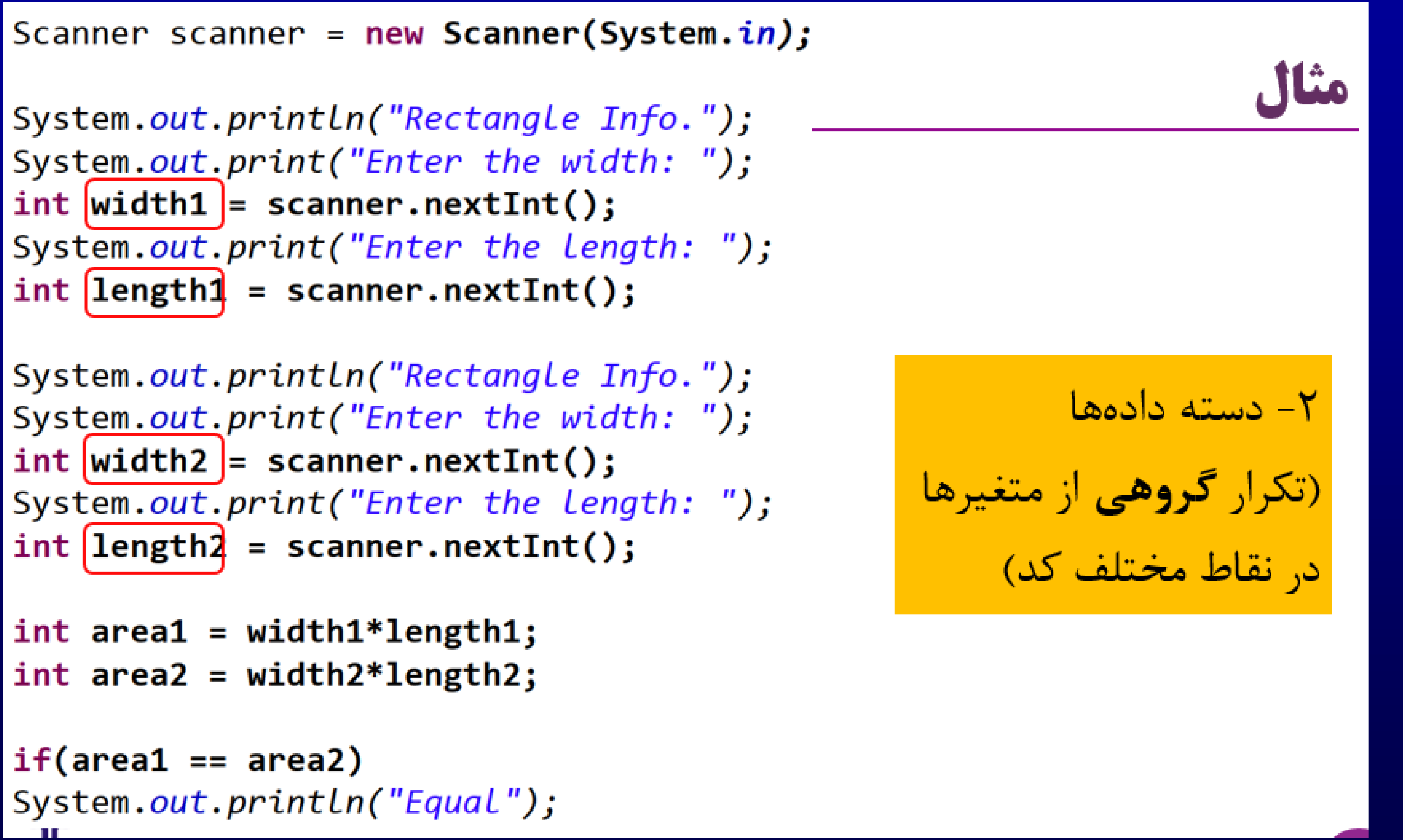
١ – اسامی نامناسب برای متغیرها

# مثال



```
Scanner scanner = new Scanner(System.in);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int width1 = scanner.nextInt();
System.out.print("Enter the length: ");
int length1 = scanner.nextInt();

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int width2 = scanner.nextInt();
System.out.print("Enter the length: ");
int length2 = scanner.nextInt();

int area1 = width1*length1;
int area2 = width2*length2;

if(area1 == area2)
System.out.println("Equal");
```

تکنیک تغییر نام



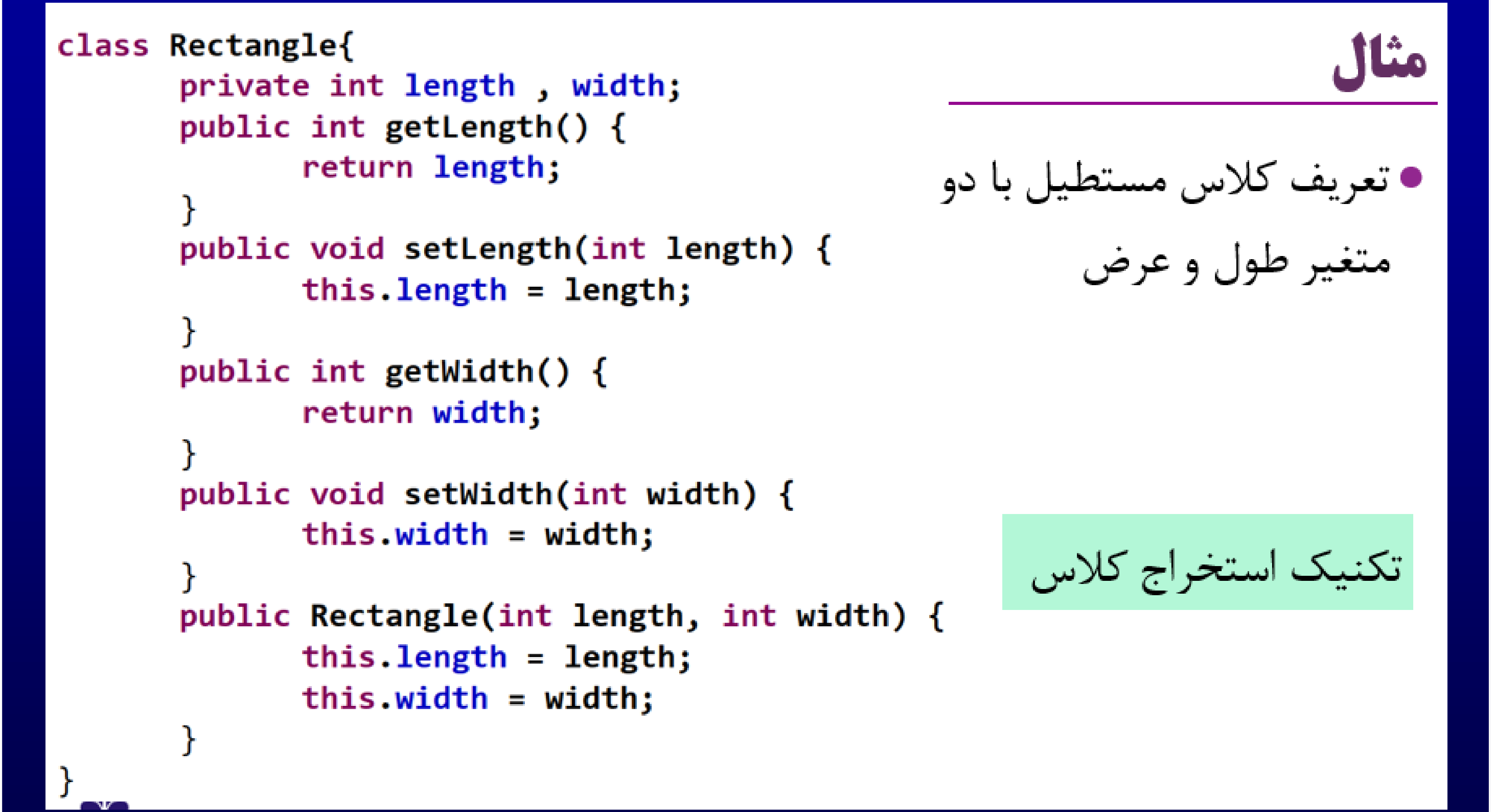
# مثال

```
Scanner scanner = new Scanner(System.in);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int width1 = scanner.nextInt();
System.out.print("Enter the length: ");
int length1 = scanner.nextInt();

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int width2 = scanner.nextInt();
System.out.print("Enter the length: ");
int length2 = scanner.nextInt();

int area1 = width1*length1;
int area2 = width2*length2;

if(area1 == area2)
System.out.println("Equal");
```

۲- دسته داده‌ها

(تکرار **گروهی** از متغیرها

در نقاط مختلف کد)

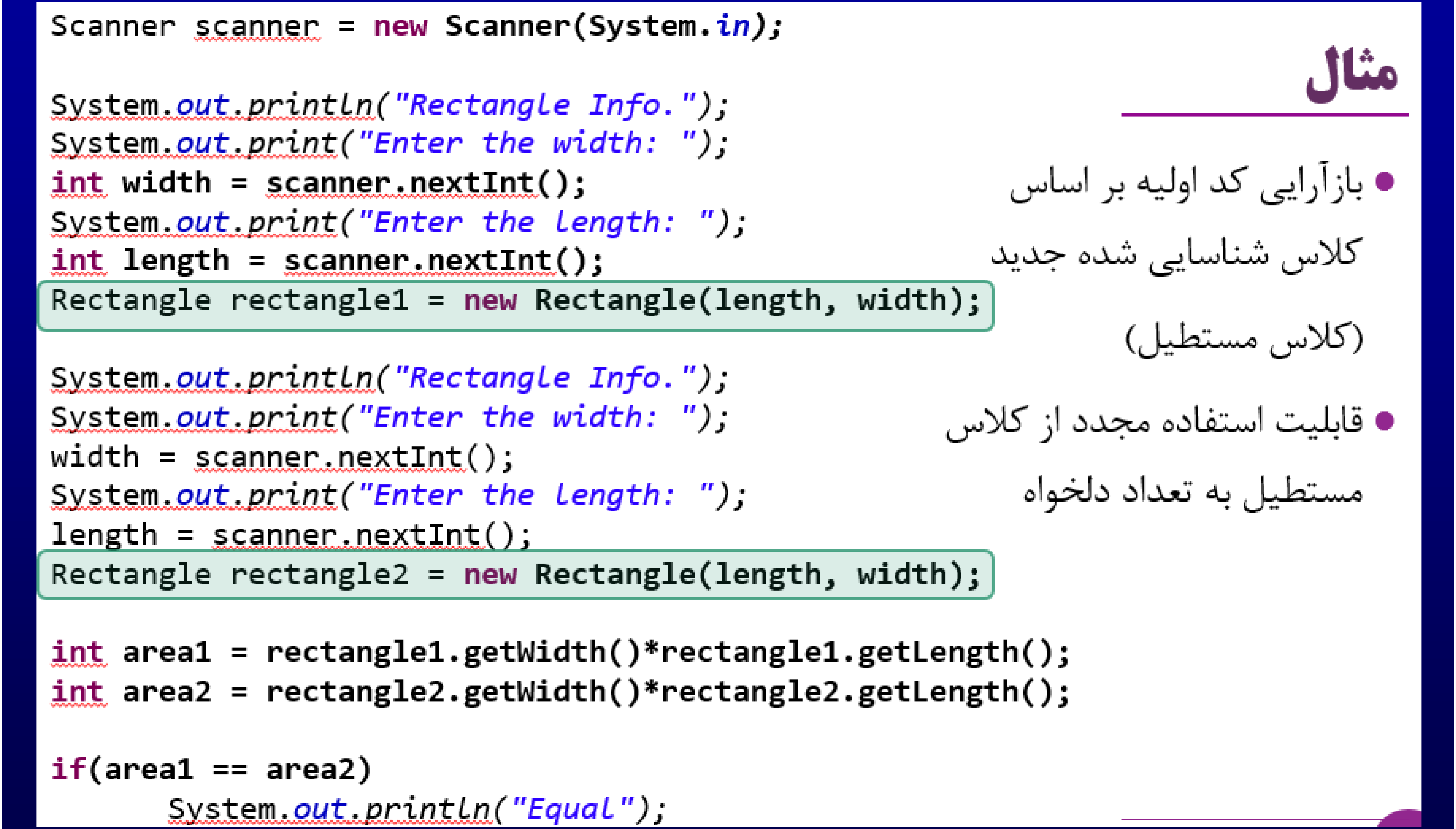


## مثال

- تعریف کلاس مستطیل با دو متغیر طول و عرض

```
class Rectangle{
      private int length , width;
      public int getLength() {
            return length;
      }
      public void setLength(int length) {
            this.length = length;
      }
      public int getWidth() {
            return width;
      }
      public void setWidth(int width) {
            this.width = width;
      }
      public Rectangle(int length, int width) {
            this.length = length;
            this.width = width;
      }
}
```

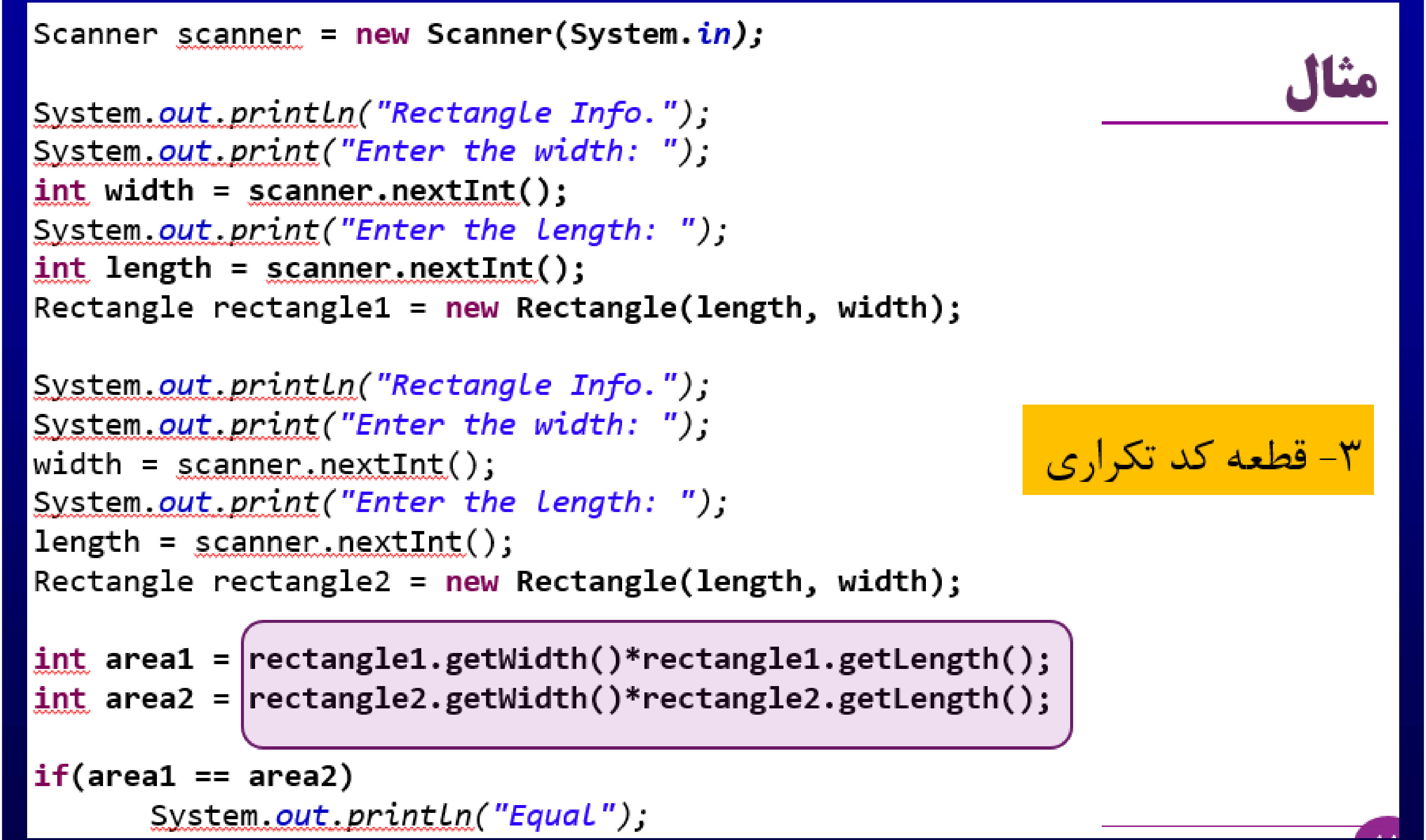
تکنیک استخراج کلاس



# مثال

- بازآرایی کد اولیه بر اساس کلاس شناسایی شده جدید (کلاس مستطیل)
- قابلیت استفاده مجدد از کلاس مستطیل به تعداد دلخواه

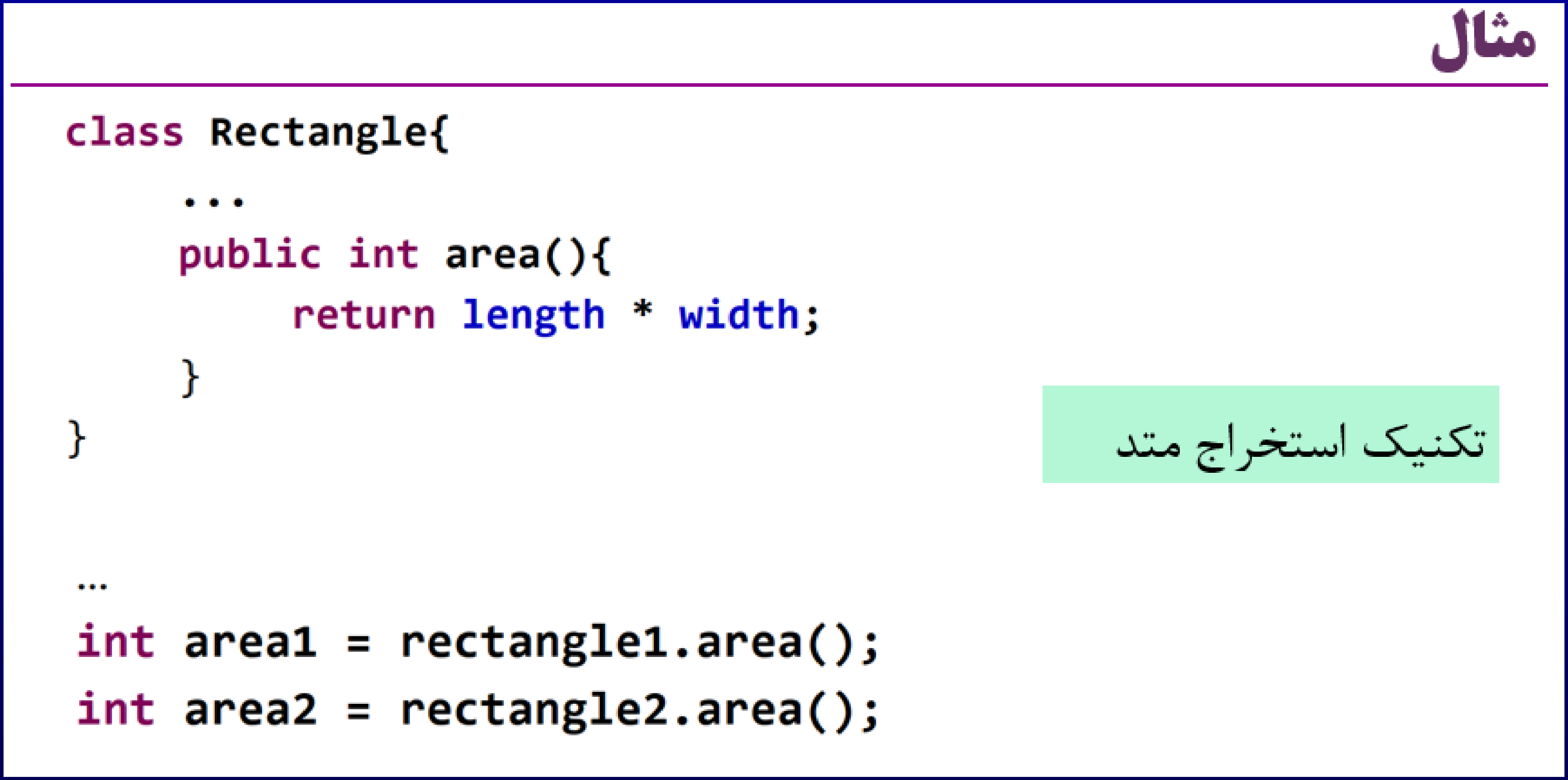
```java
Scanner scanner = new Scanner(System.in);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int width = scanner.nextInt();
System.out.print("Enter the length: ");
int length = scanner.nextInt();
Rectangle rectangle1 = new Rectangle(length, width);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
width = scanner.nextInt();
System.out.print("Enter the length: ");
length = scanner.nextInt();
Rectangle rectangle2 = new Rectangle(length, width);

int area1 = rectangle1.getWidth()*rectangle1.getLength();
int area2 = rectangle2.getWidth()*rectangle2.getLength();

if(area1 == area2)
      System.out.println("Equal");
```



## مثال

```
Scanner scanner = new Scanner(System.in);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int width = scanner.nextInt();
System.out.print("Enter the length: ");
int length = scanner.nextInt();
Rectangle rectangle1 = new Rectangle(length, width);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
width = scanner.nextInt();
System.out.print("Enter the length: ");
length = scanner.nextInt();
Rectangle rectangle2 = new Rectangle(length, width);

int area1 = rectangle1.getWidth()*rectangle1.getLength();
int area2 = rectangle2.getWidth()*rectangle2.getLength();

if(area1 == area2)
      System.out.println("Equal");
```

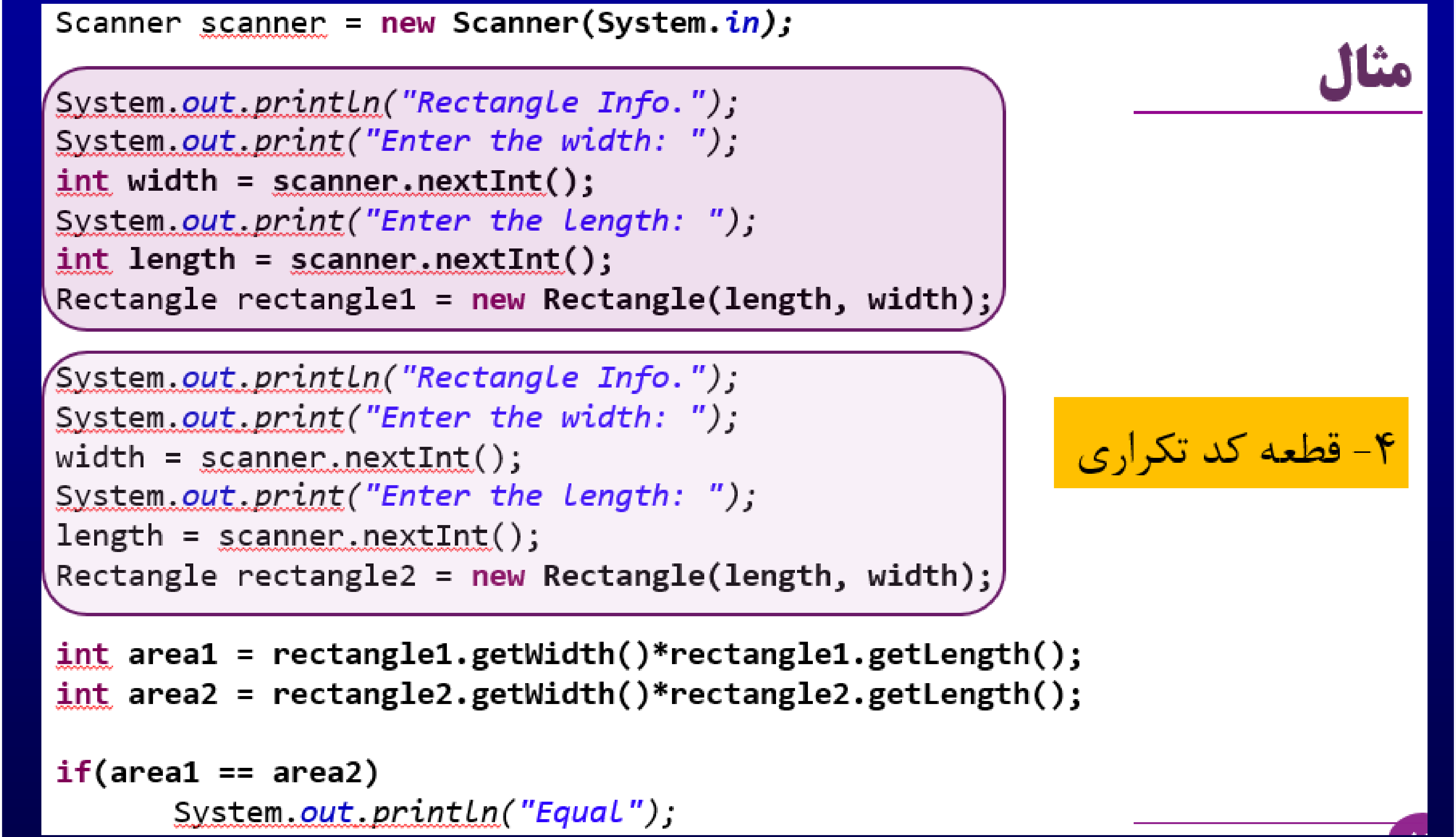
۳- قطعه کد تکراری



## مثال

```
class Rectangle{
    ...
    public int area(){
        return length * width;
    }
}


…
int area1 = rectangle1.area();
int area2 = rectangle2.area();
```

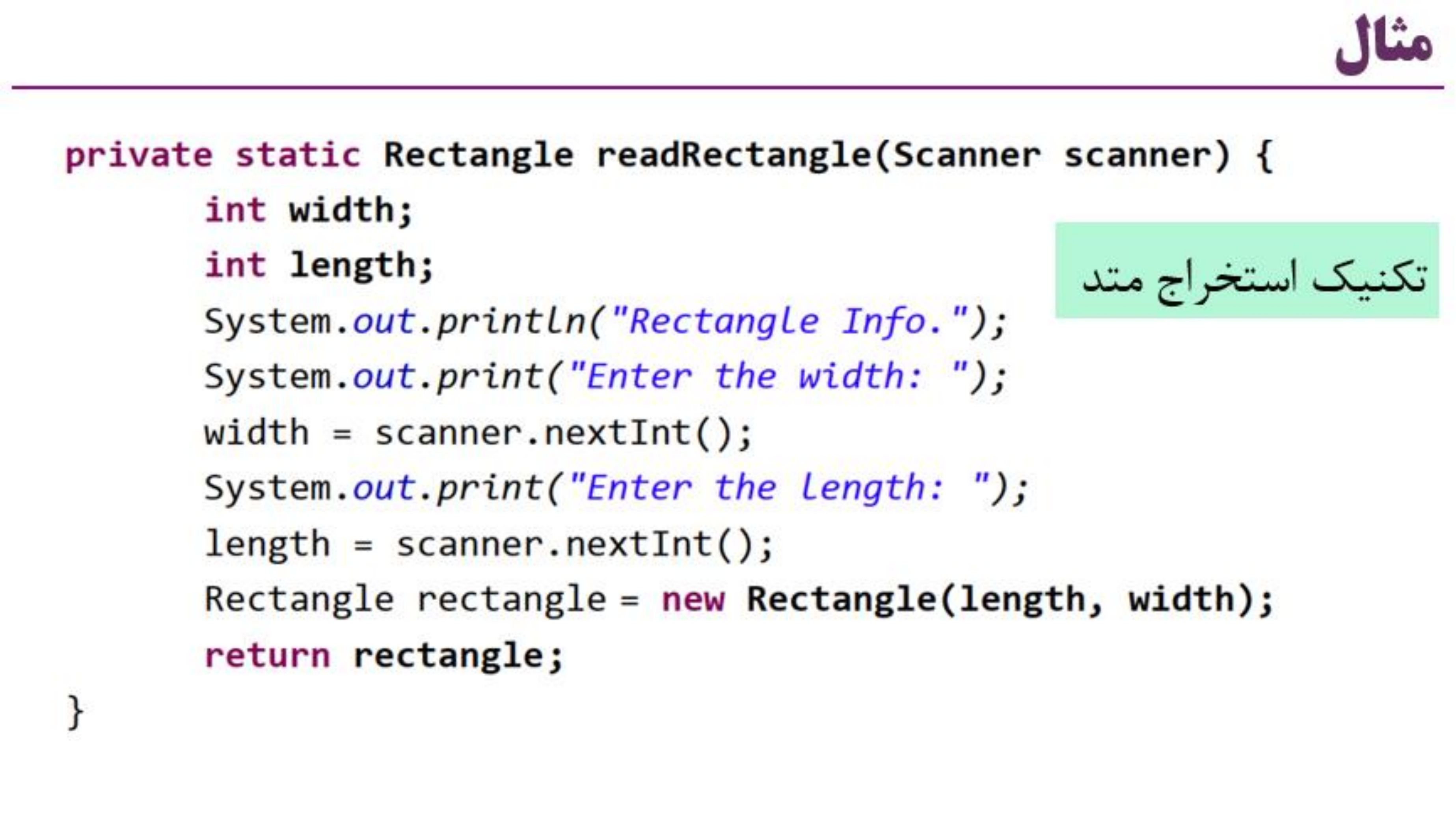
تکنیک استخراج متد



## مثال

```
Scanner scanner = new Scanner(System.in);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int width = scanner.nextInt();
System.out.print("Enter the length: ");
int length = scanner.nextInt();
Rectangle rectangle1 = new Rectangle(length, width);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
width = scanner.nextInt();
System.out.print("Enter the length: ");
length = scanner.nextInt();
Rectangle rectangle2 = new Rectangle(length, width);

int area1 = rectangle1.getWidth()*rectangle1.getLength();
int area2 = rectangle2.getWidth()*rectangle2.getLength();

if(area1 == area2)
      System.out.println("Equal");
```

۴- قطعه کد تکراری

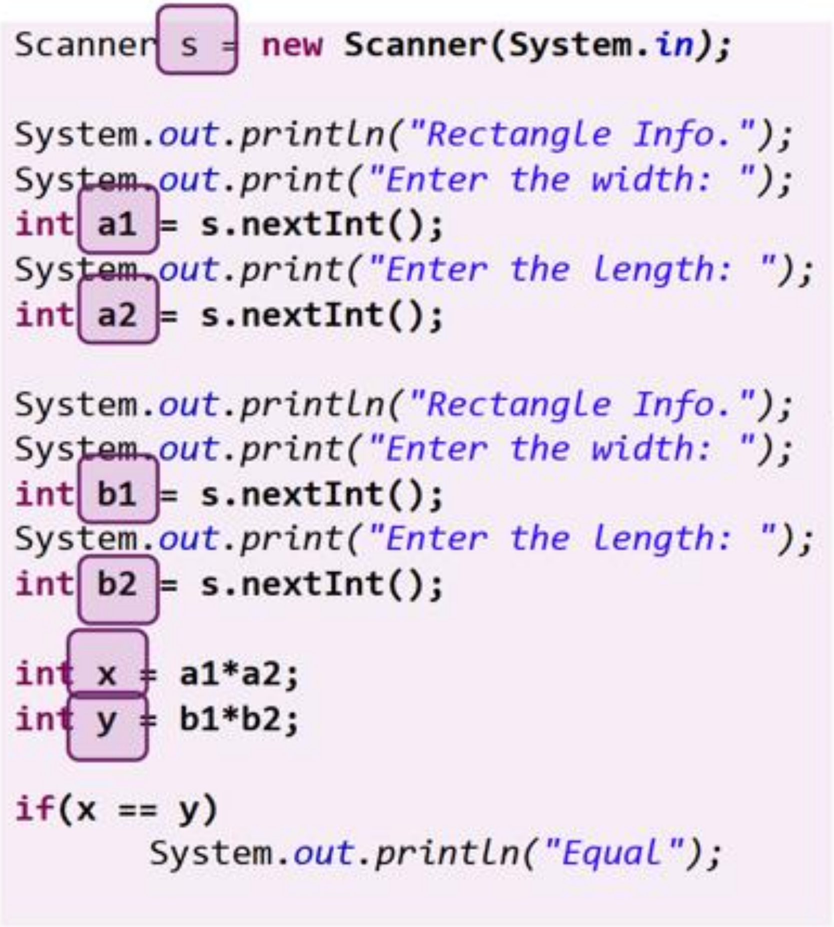


## مثال

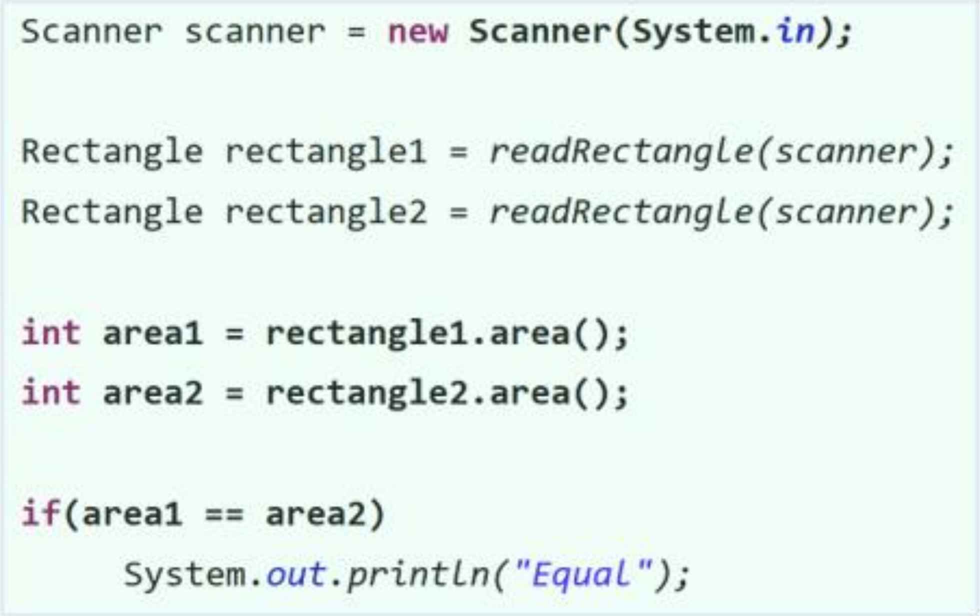
```
private static Rectangle readRectangle(Scanner scanner) {
        int width;
        int length;
        System.out.println("Rectangle Info.");
        System.out.print("Enter the width: ");
        width = scanner.nextInt();
        System.out.print("Enter the length: ");
        length = scanner.nextInt();
        Rectangle rectangle = new Rectangle(length, width);
        return rectangle;
}
```

تکنیک استخراج متد

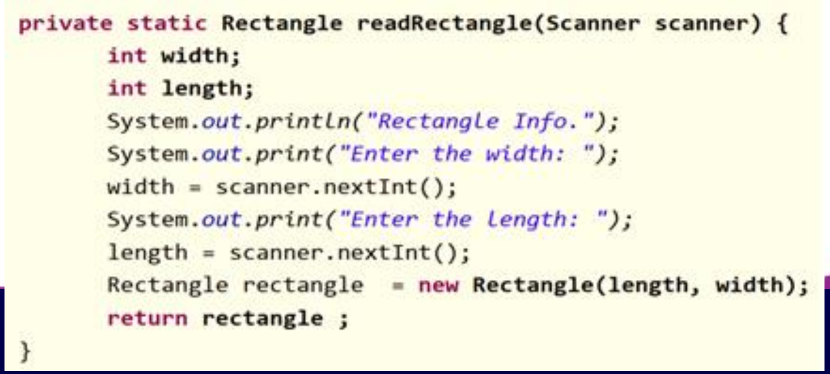
# مقایسه کد اولیه با کد باز آرایی شده



```
Scanner s = new Scanner(System.in);

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int a1 = s.nextInt();
System.out.print("Enter the length: ");
int a2 = s.nextInt();

System.out.println("Rectangle Info.");
System.out.print("Enter the width: ");
int b1 = s.nextInt();
System.out.print("Enter the length: ");
int b2 = s.nextInt();

int x = a1*a2;
int y = b1*b2;

if(x == y)
        System.out.println("Equal");
```



```
Scanner scanner = new Scanner(System.in);


Rectangle rectangle1 = readRectangle(scanner);
Rectangle rectangle2 = readRectangle(scanner);


int area1 = rectangle1.area();
int area2 = rectangle2.area();


if(area1 == area2)
     System.out.println("Equal");
```



```
private static Rectangle readRectangle(Scanner scanner) {
        int width;
        int length;
        System.out.println("Rectangle Info.");
        System.out.print("Enter the width: ");
        width = scanner.nextInt();
        System.out.print("Enter the length: ");
        length = scanner.nextInt();
        Rectangle rectangle  = new Rectangle(length, width);
        return rectangle ;
}
```