

# Integration and Object Oriented Testing – Part 2



**Idaho State  
University**

Computer  
Science

**Isaac Griffith**

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Department of Computer Science  
Idaho State University

**ROAR**

# Outcomes

At the end of Today's Lecture you will be able to:

- Understand the basic idea of integration testing and what it is for
- Understand the concepts of mutation testing applied to integration testing
- Understand and use the 4 basic types of mutation operators
- Understand and use the 5 basic integration mutation operators
- Start to understand the ideas of integration mutation applied to java and other OO languages



# Inspiration

"Lots of methodologies have come and gone, paradigms have changed but the requirements are always the same; Make it good and make it fast." – Anonymous

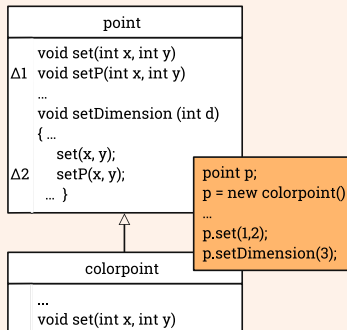


# Inheritance Operators

## 6. IOR – Overridden Method Rename

Renames the parent's versions of methods that are overridden in a subclass so that the overriding does not affect the parent's method

### Example



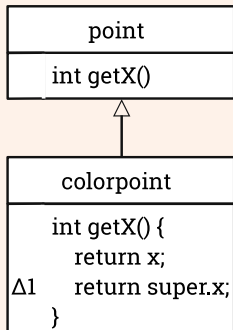


# Inheritance Operators

## 7. ISI – Super Keyword Insertion

Inserts the super keyword before overriding variables or methods (if the name is also defined in an ancestor class)

### Example

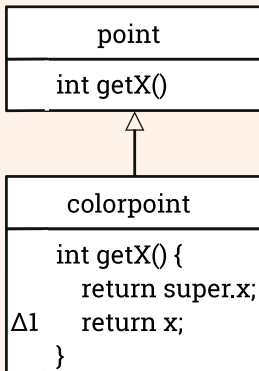


# Inheritance Operators

## 8. ISD – Super Keyword Deletion

Delete each occurrence of the super keyword

### Example

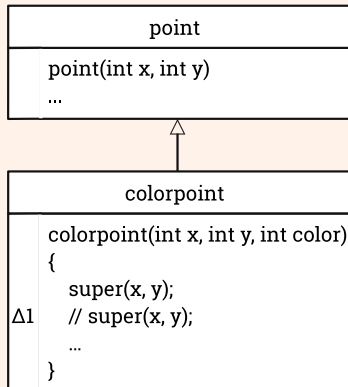


# Inheritance Operators

## IPC – Explicit Parent Constructor Deletion

Each call to a super constructor is deleted

### Example





# Class Mutation Operators for Java

## (1) Encapsulation

AMC

## (2) Inheritance

IHI, IHD, IOD, IOP, IOR, ISI, ISD, IPC

## (3) Polymorphism

PNC, PMD, PPD, PCI, PCD, PCC, PRV, OMR, OMD, OAC

## (4) Java-Specific

JTI, JTD, JSI, JSD, JID, JDC



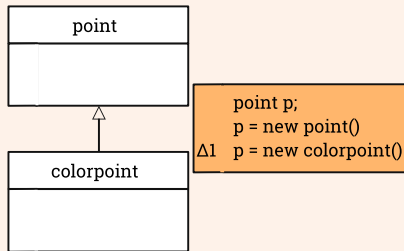


# Polymorphism Operators

## 10. PNC – new Method Call with Child Class Type

The actual type of a new object is changed in the new() statement

### Example



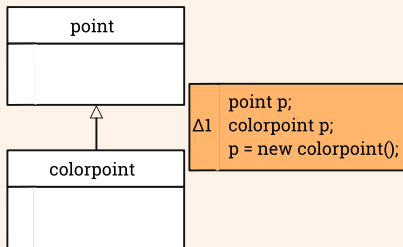


# Polymorphism Operators

## 11. PMD – Member Variable Declaration with Parent Class Type

The declared type of each new object is changed in the declaration

### Example

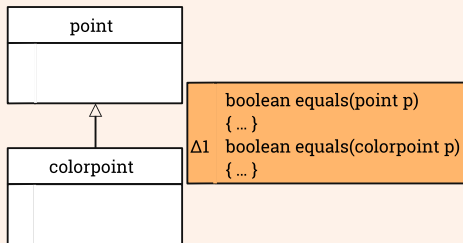


# Polymorphism Operators

## 12. PPD – Parameter Variable Declaration with Child Class Type

The declared type of each parameter object is changed in the declaration

### Example

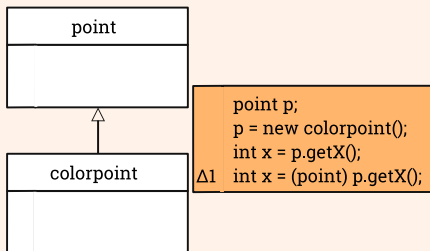


# Polymorphism Operators

## PCI – Type Cast Operator Insertion

The actual type of an object reference is changed to the parent or to the child of the original declared type

## Example

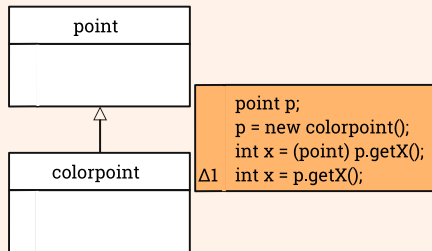


# Polymorphism Operators

## PCD – Type Cast Operator Deletion

Type casting operators are deleted

### Example

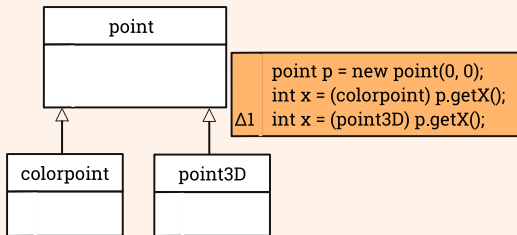


# Polymorphism Operators

## PPC – Cast Type Changed

Changes the type to which an object reference is being cast

## Example

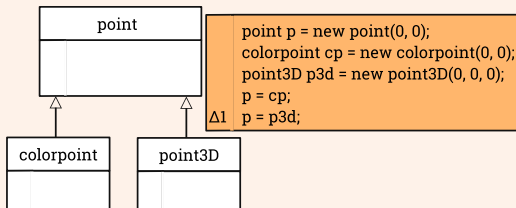


# Polymorphism Operators

## PRV – Reference Assignment with Other Compatible Type

The right side objects of assignment statements are changed to refer to objects of a compatible type

### Example

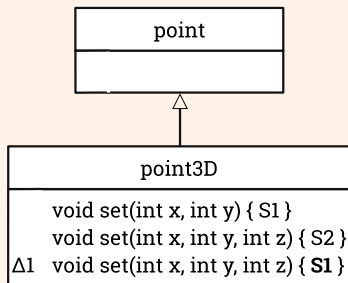


# Polymorphism Operators

## OMR – Overloading Method Contents Replacement

For each pair of methods that have the same name, the bodies are interchanged

### Example



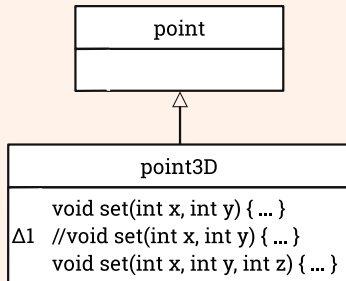


# Polymorphism Operators

## OMD – Overloading Method Deletion

Each overloaded method declaration is deleted, one at a time

### Example

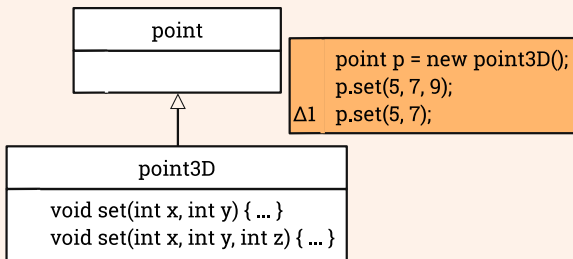


# Polymorphism Operators

## OAC – Arguments of Overloading Method Call Changed

The order of the arguments in method invocations is changed to the same as that of another overloading method, if one exists

### Example





# Class Mutation Operators for Java

## (1) Encapsulation

AMC

## (2) Inheritance

IHI, IHD, IOD, IOP, IOR, ISI, ISD, IPC

## (3) Polymorphism

PNC, PMD, PPD, PCI, PCD, PCC, PRV, OMR, OMD, OAC

## (4) Java-Specific

JTI, JTD, JSI, JSD, JID, JDC



# Java-Specific Operators

## JTI – this Keyword Insertion

The keyword `this` is inserted whenever possible

### Example

point	
	...
	void set(int x, int y)
	{
	x = x;
Δ1	this.x = x;
	y = y;
Δ2	this.y = y;
	}
	...

# Java-Specific Operators

## JTD – this Keyword Deletion

The keyword `this` is deleted whenever possible

### Example

point	
	...
	void set(int x, int y)
	{
	this.x = x;
$\Delta 1$	x = x;
	this.y = y;
$\Delta 2$	y = y;
	}
	...

# Java-Specific Operators

## JSI – Static Modifier Insertion

The static modifier is added to instance variables

### Example

point	
	public int x = 0;
Δ1	public static int x = 0;
	public int y = 0;
Δ2	public static int y = 0;

# Java-Specific Operators

## JSD – Static Modifier Deletion

Each instance of the static modifier is removed

### Example

	point
	public static int x = 0;
Δ1	public int x = 0;
	public static int y = 0;
Δ2	public int y = 0;

# Java-Specific Operators

## JID – Member Variable Initialization Deletion

Remove initialization of each member variable

### Example

point	
	int x = 5;
$\Delta$ 1	int x;
	...



# Java-Specific Operators

## JDC – Java-supported Default Constructor Deletion

Delete each declaration of default constructor (with no parameters)

### Example

point	
	point() {...}
$\Delta 1$	// point() {...}
	...



# Class Mutation Operators for Java

## (1) Encapsulation

AMC

## (2) Inheritance

IHI, IHD, IOD, IOP, IOR, ISI, ISD, IPC

## (3) Polymorphism

PNC, PMD, PPD, PCI, PCD, PCC, PRV, OMR, OMD, OAC

## (4) Java-Specific

JTI, JTD, JSI, JSD, JID, JDC



# Integration Mutation Summary

- Integration testing often looks at **couplings**
- We have not used **grammar testing** at the integration level
- Mutation testing modifies **callers** and **callees**
- **OO Mutation** focuses on inheritance, polymorphism, dynamic binding, information hiding and overloading
  - The access levels make it easy to make mistakes in OO software
- **muJava** is an educational & research tools for mutation of Java programs
  - <http://cs.gmu.edu/~offutt/mujava/>



**Are there any questions?**