Exceptions and Assertions

Objectives

- After you have read and studied this chapter, you should be able to
  - Improve the reliability of code by incorporating exception-handling and assertion mechanisms.
  - Write methods that propagate exceptions.
  - Implement the try-catch blocks for catching and handling exceptions.
  - Write programmer-defined exception classes.
  - Distinguish the checked and unchecked, or runtime, exceptions.

Definition

- An *exception* represents an error condition that can occur during the normal course of program execution.

- When an exception occurs, or is *thrown*, the normal sequence of flow is terminated. The exception-handling routine is then executed; we say the thrown exception is *caught*.

Not Catching Exceptions

```
String inputStr;
int    age;

inputStr = JOptionPane.showInputDialog(null, "Age:");
age      = Integer.parseInt(inputStr);
```

Error message for invalid input

```
java.lang.NumberFormatException: ten
        at java.lang.Integer.parseInt(Integer.java:405)
        at java.lang.Integer.parseInt(Integer.java:454)
        at Ch8Sample1.main(Ch8Sample1.java:20)
```

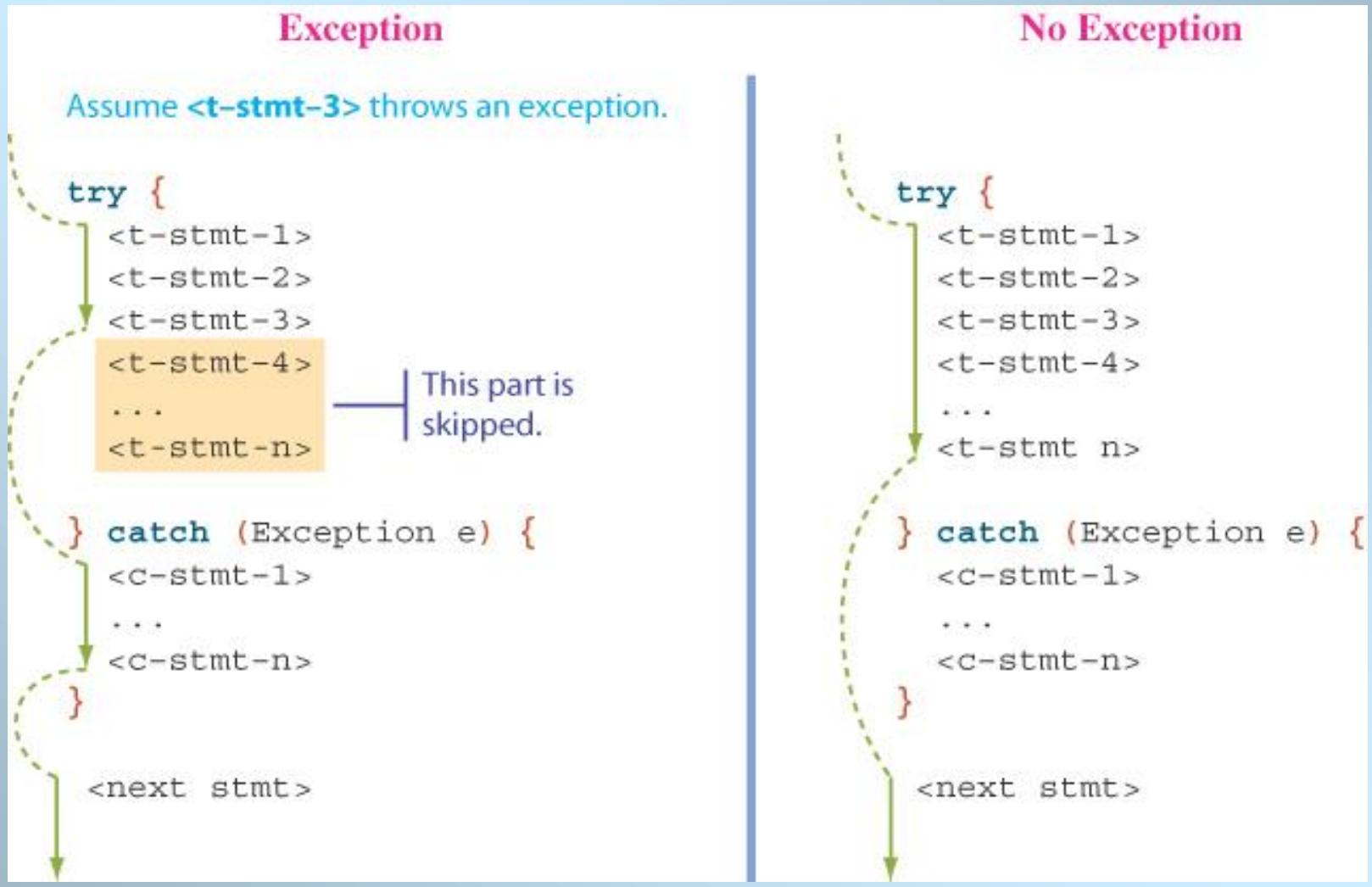
Catching an Exception

```
inputStr = JOptionPane.showInputDialog(null, "Age:");

try {

    age = Integer.parseInt(inputStr);

} catch (NumberFormatException e){

    JOptionPane.showMessageDialog(null, "'" + inputStr
        +  "' is invalid\n"
        +  "Please enter digits only");
}
```

try

catch

try-catch Control Flow



Getting Information

- There are two methods we can call to get information about the thrown exception:
  - **getMessage**
  - **printStackTrace**

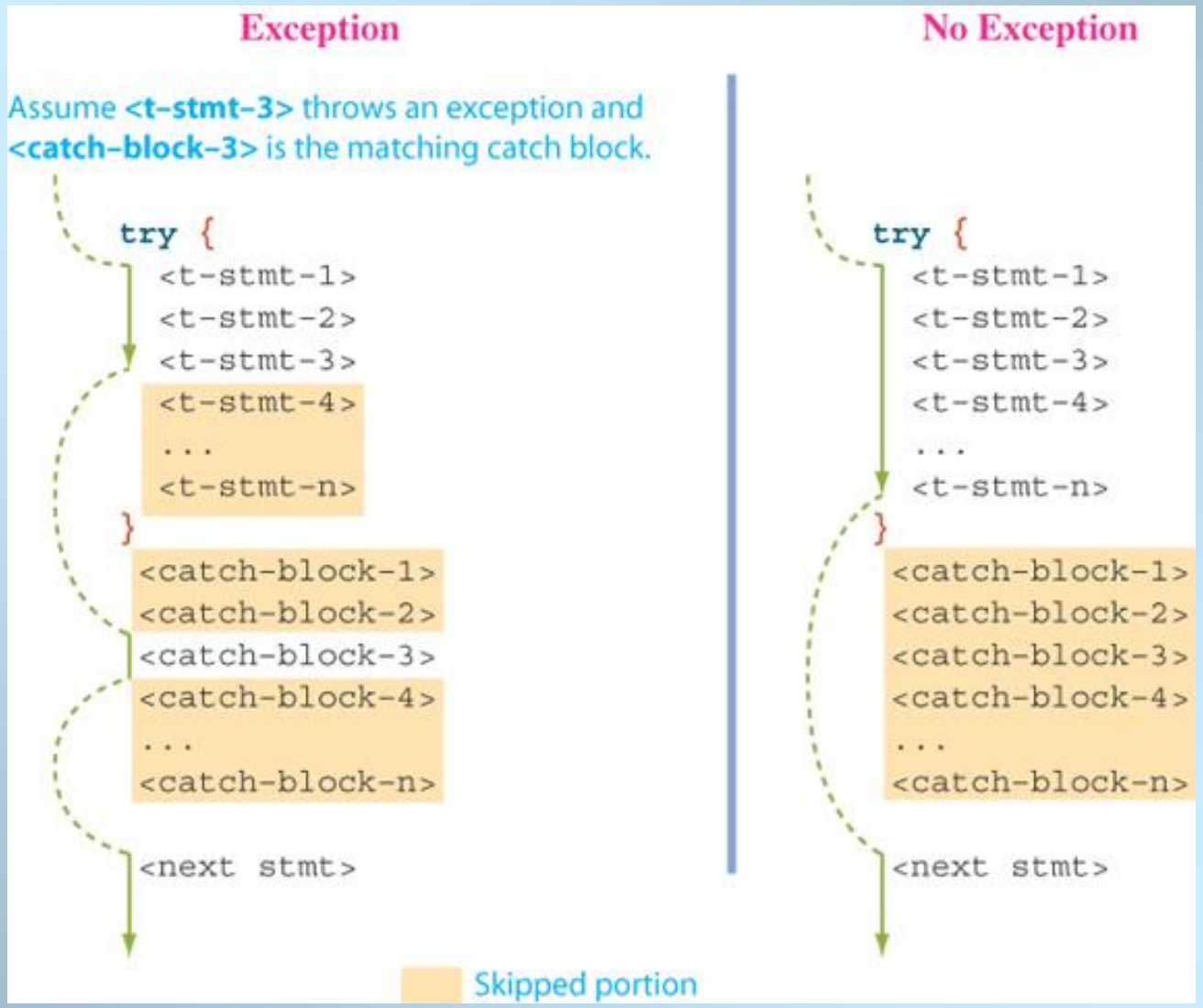
```
try {
    . . .
} catch (NumberFormatException e){

    System.out.println(e.getMessage());
    System.out.println(e.printStackTrace());
}
```

Multiple catch Blocks

- A single try-catch statement can include multiple catch blocks, one for each type of exception.

```
try {
    . . .
    age = Integer.parseInt(inputStr);
    . . .
    val = cal.get(id); //cal is a GregorianCalendar
    . . .
} catch (NumberFormatException e){
    . . .
} catch (ArrayIndexOutOfBoundsException e){
    . . .
}
```

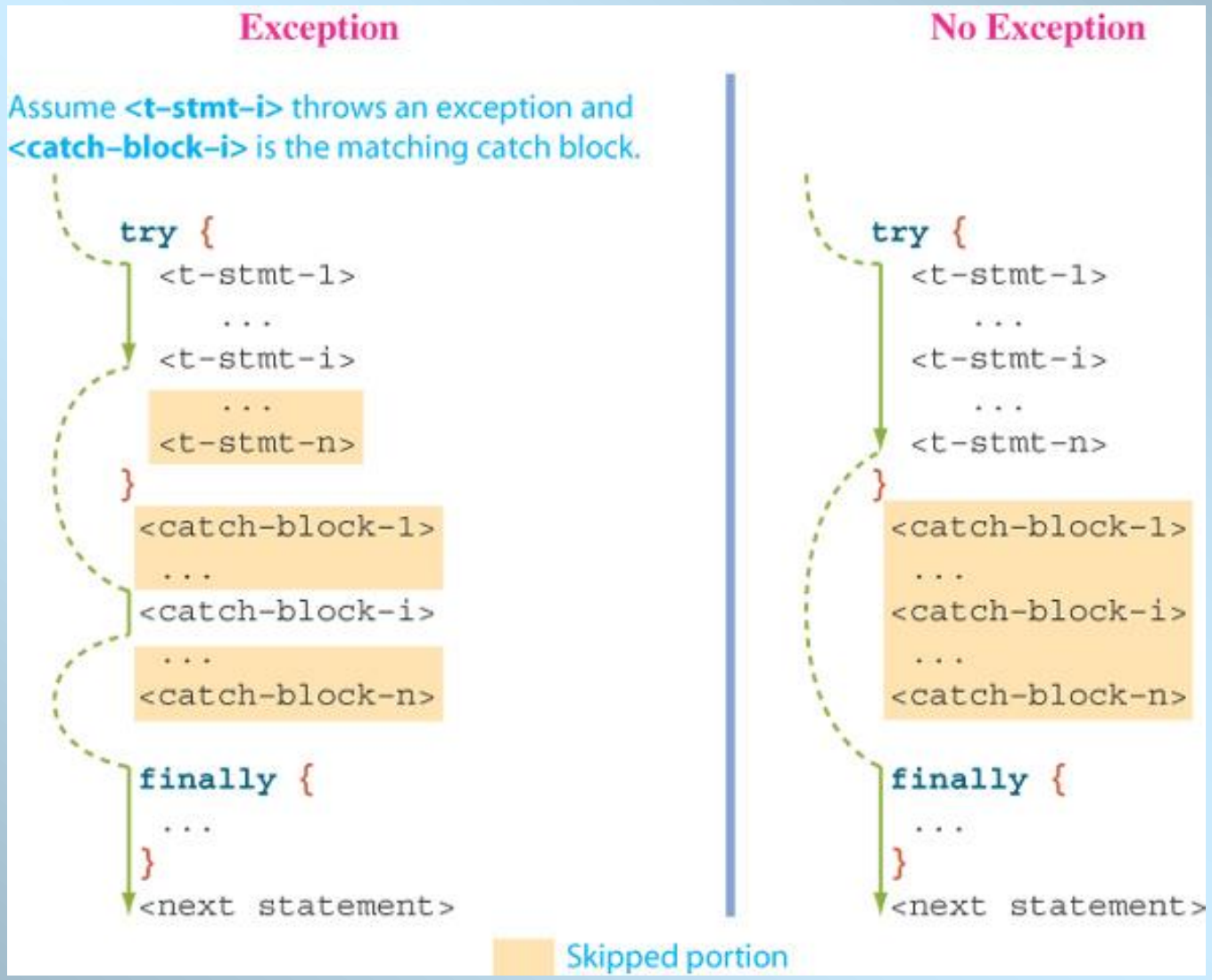
Multiple catch Control Flow



The finally Block

- There are situations where we need to take certain actions regardless of whether an exception is thrown or not.
- We place statements that must be executed regardless of exceptions in the finally block.

try-catch-finally Control Flow



Propagating Exceptions

- Instead of catching a thrown exception by using the try-catch statement, we can propagate the thrown exception back to the caller of our method.
- The method header includes the reserved word throws.

```
public int getAge( ) throws NumberFormatException {
    . . .
    int age = Integer.parseInt(inputStr);
    . . .
    return age;
}
```

Throwing Exceptions

- We can write a method that throws an exception directly, i.e., this method is the origin of the exception.
- Use the throw reserved to create a new instance of the Exception or its subclasses.
- The method header includes the reserved word throws.

```
public void doWork(int num) throws Exception {
    . . .
    if (num != val) throw new Exception("Invalid val");
    . . .
}
```

Exception Thrower

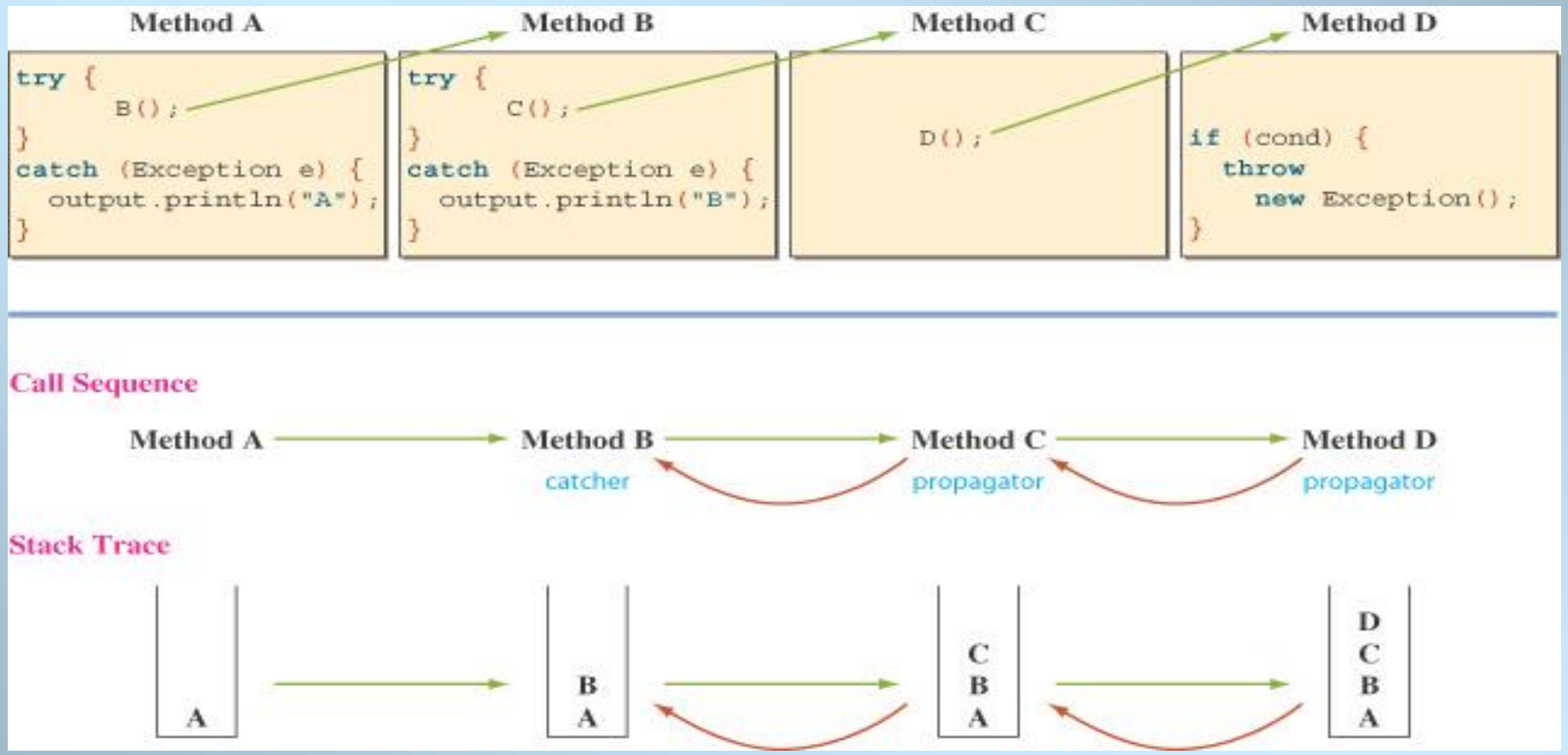
- When a method may throw an exception, either directly or indirectly, we call the method an *exception thrower*.

- Every exception thrower must be one of two types:
  - catcher.
  - propagator.

Types of Exception Throwers

- An *exception catcher* is an exception thrower that includes a matching **catch** block for the thrown exception.
- An *exception propagator* does not contain a matching **catch** block.
- A method may be a catcher of one exception and a propagator of another.

Sample Call Sequence

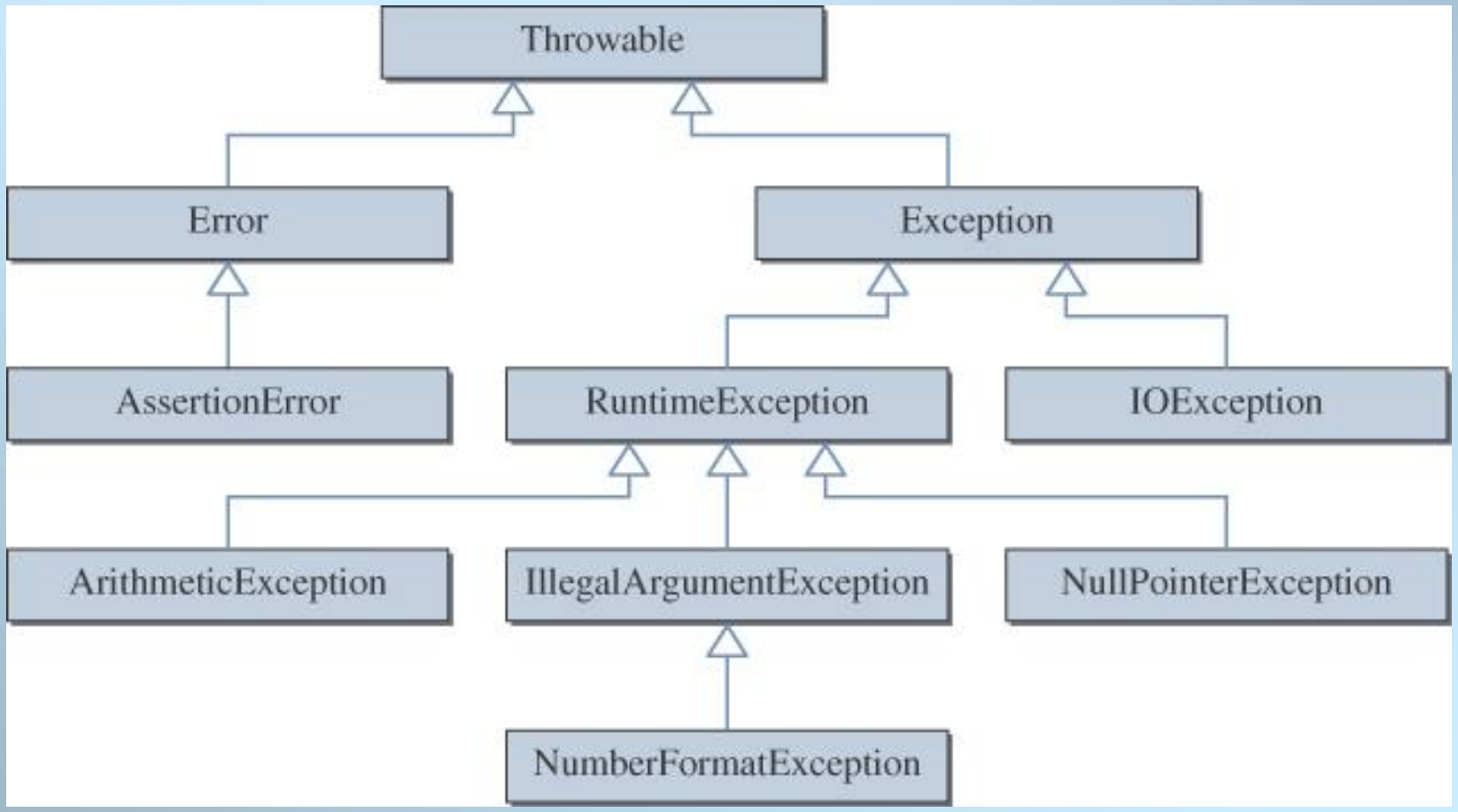


Exception Types

- All types of thrown errors are instances of the **Throwable** class or its subclasses.
- Serious errors are represented by instances of the **Error** class or its subclasses.
- Exceptional cases that common applications should handle are represented by instances of the **Exception** class or its subclasses.

Throwable Hierarchy

- There are over 60 classes in the hierarchy.



Checked vs. Runtime

- There are two types of exceptions:
  - Checked.
  - Unchecked.
- A *checked exception* is an exception that is checked at compile time.
- All other exceptions are *unchecked*, or *runtime, exceptions*. As the name suggests, they are detected only at runtime.
  - E.g. trying to divide a number by zero – ArithmeticException; trying to convert a string with letters to an integer - NumberFormatException

Different Handling Rules

- When calling a method that can throw checked exceptions
  - use the **try-catch** statement and place the call in the **try** block, or
  - modify the method header to include the appropriate **throws** clause.

- When calling a method that can throw runtime exceptions, it is optional to use the try-catch statement or modify the method header to include a throws clause.

Handling Checked Exceptions

Caller A (Catcher)

```
void callerA( ) {
 try {
   doWork( );
 } catch (Exception e) {
 ...
}
```

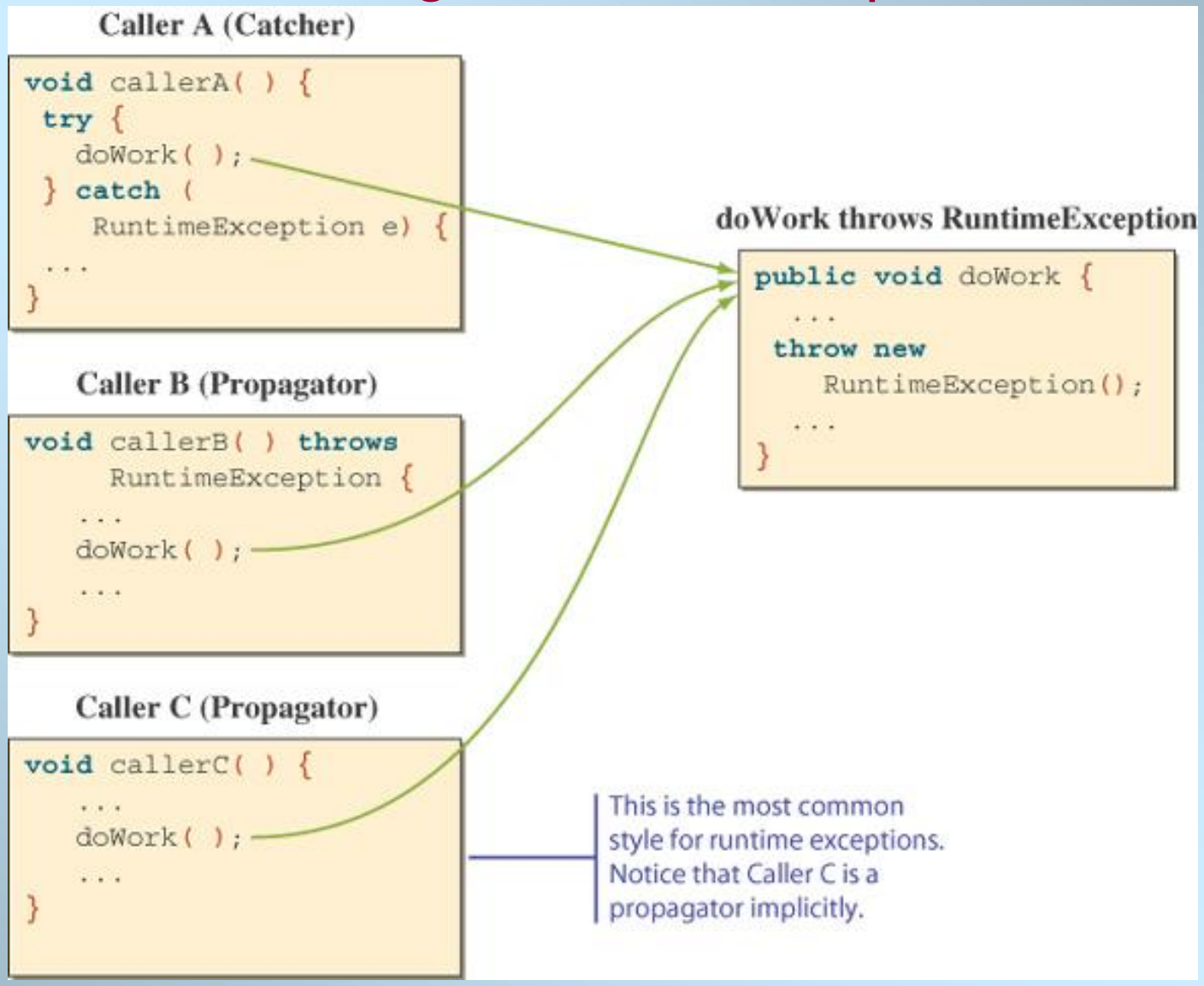
Caller B (Propagator)

```
void callerB( )
      throws Exception {
   ...
   doWork( );
   ...
}
```

doWork throws Exception

```
public void doWork ()
 throws Exception {
  ...
 throw new Exception();
  ...
}
```

Handling Runtime Exceptions



Programmer-Defined Exceptions

- Using the standard exception classes, we can use the getMessage method to retrieve the error message.
- By defining our own exception class, we can pack more useful information
  - for example, we may define a OutOfStock exception class and include information such as how many items to order
- AgeInputException is defined as a subclass of Exception and includes public methods to access three pieces of information it carries: lower and upper bounds of valid age input and the (invalid) value entered by the user.

Assertions

- The syntax for the **assert** statement is

```
assert <boolean expression>;
```

  where `<boolean expression>` represents the condition that must be true if the code is working correctly.

- If the expression results in **false**, an **AssertionError** (a subclass of **Error**) is thrown.

Sample Use #1

```
public double deposit(double amount) {
    double oldBalance = balance;
    balance += amount;
    assert balance > oldBalance;
}

public double withdraw(double amount) {
    double oldBalance = balance;
    balance -= amount;
    assert balance < oldBalance;
}
```

Second Form

- The assert statement may also take the form:

```
assert <boolean expression>: <expression>;
```

where `<expression>` represents the value passed as an argument to the constructor of the **AssertionError** class. The value serves as the detailed message of a thrown exception.

Sample Use #2

```
public double deposit(double amount) {

   double oldBalance = balance;

   balance += amount;

   assert balance > oldBalance :
      "Serious Error - balance did not " +
      " increase after deposit";
}
```

Compiling Programs with Assertions

- Before Java 2 SDK 1.4, the word **assert** is a valid nonreserved identifier. In version 1.4 and after, the word **assert** is treated as a regular identifier to ensure compatibility.

- To enable the assertion mechanism, compile the source file using

```
javac –source 1.4 <source file>
```

Running Programs with Assertions

- To run the program with assertions enabled, use

```
java -ea <main class>
```

- If the `-ea` option is not provided, the program is executed without checking assertions.

Different Uses of Assertions

- *Precondition assertions* check for a condition that must be true before executing a method.
- *Postcondition assertions* check conditions that must be true after a method is executed.
- A *control-flow invariant* is a third type of assertion that is used to assert the control must flow to particular cases.

END