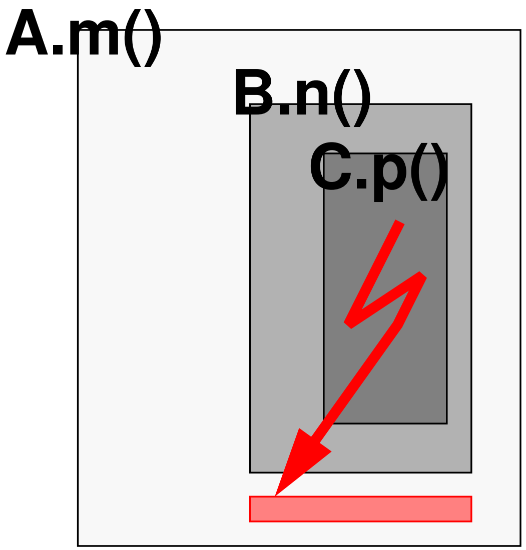
23 Error Handling

- Exit program (`System.exit()`)
  - usually a bad idea
- Output an error message
  - does not help to recover from the error
- Special error return
  - Constructors do not have a return value
  - What if method uses the full range of the return type?
- Call a user defined error handler
  - awkward
  - What must this method do?
- Exceptions!

23.1 What is Exception Handling?

- Transfer control from error origin to error handler



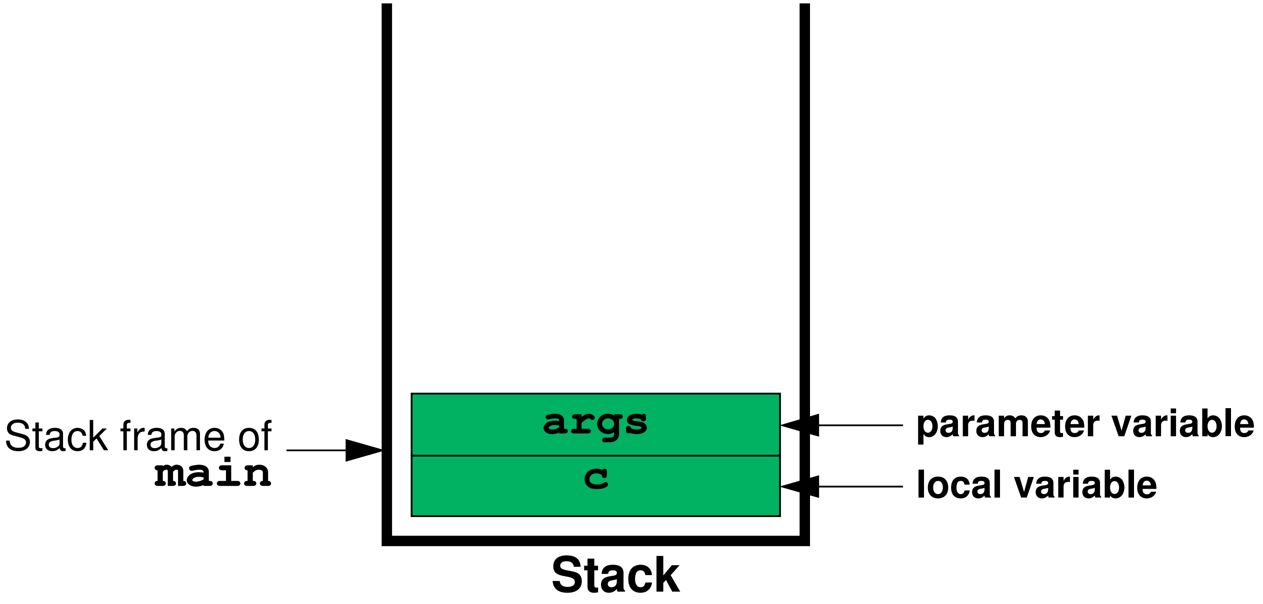
- Responsibilities:
  - Code author can detect the error but doesn't know how to handle it.
  - Code user can handle the error but cannot detect it.

23.1 What happens when a method is called?

```
class Customer {
  void createAccount(Bank bank) {
    Account account = new Account();
    bank.newAccount(account, 5);
  }
}
```

```
class Bank {
  void newAccount(Account a, int i) {
          int counter = 0;
      ...
  }
}
```

```
class Main {
  public static void main(String args[]) {
          Customer c = new Customer();
          c.createAccount(new Bank());
  }
}
```



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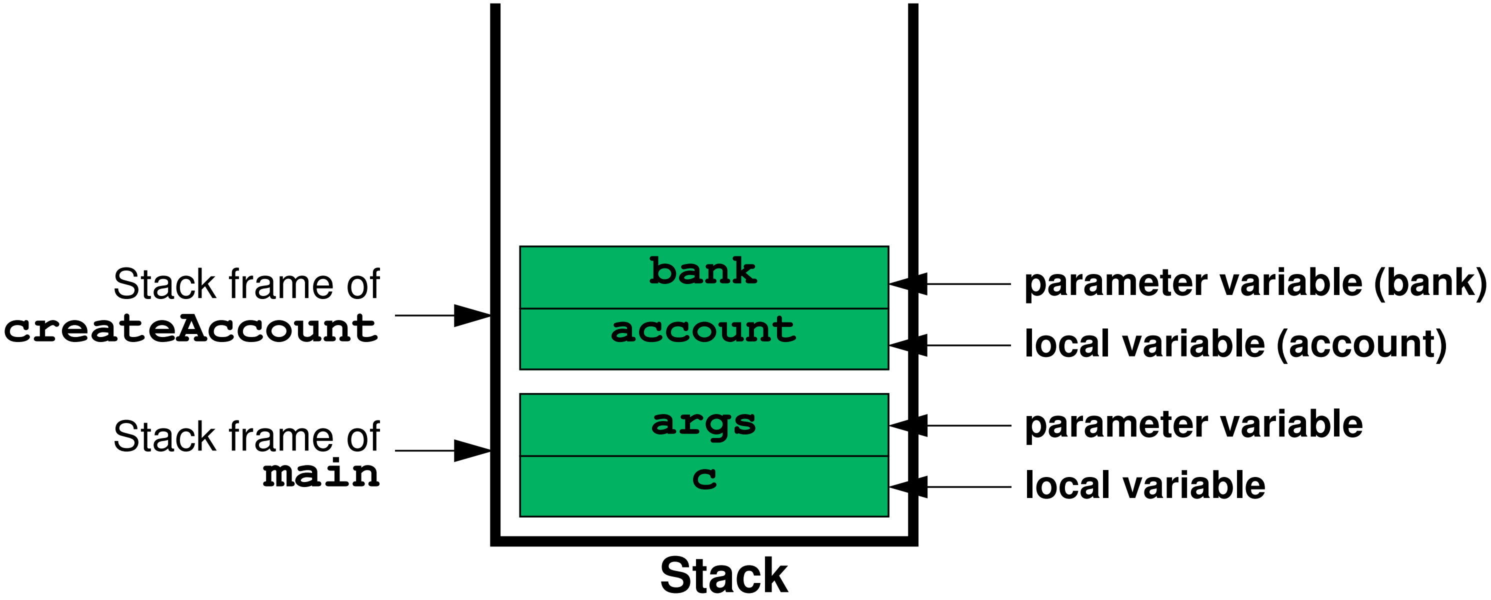

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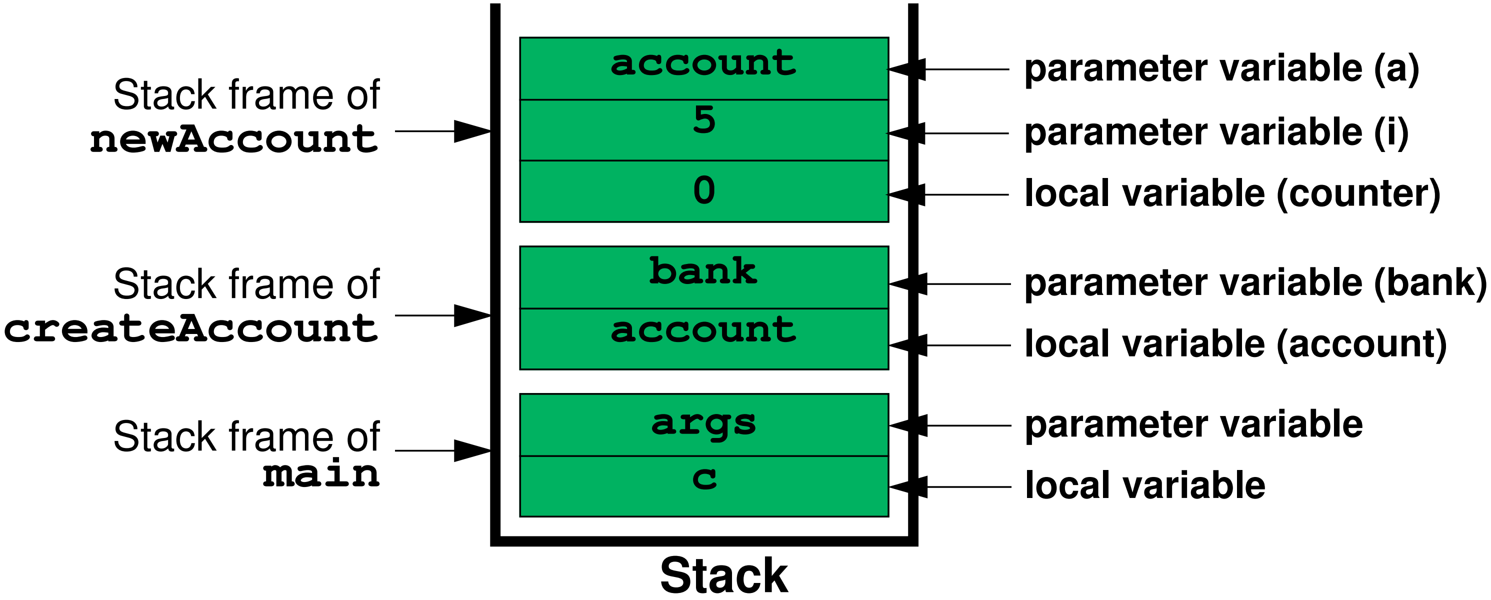

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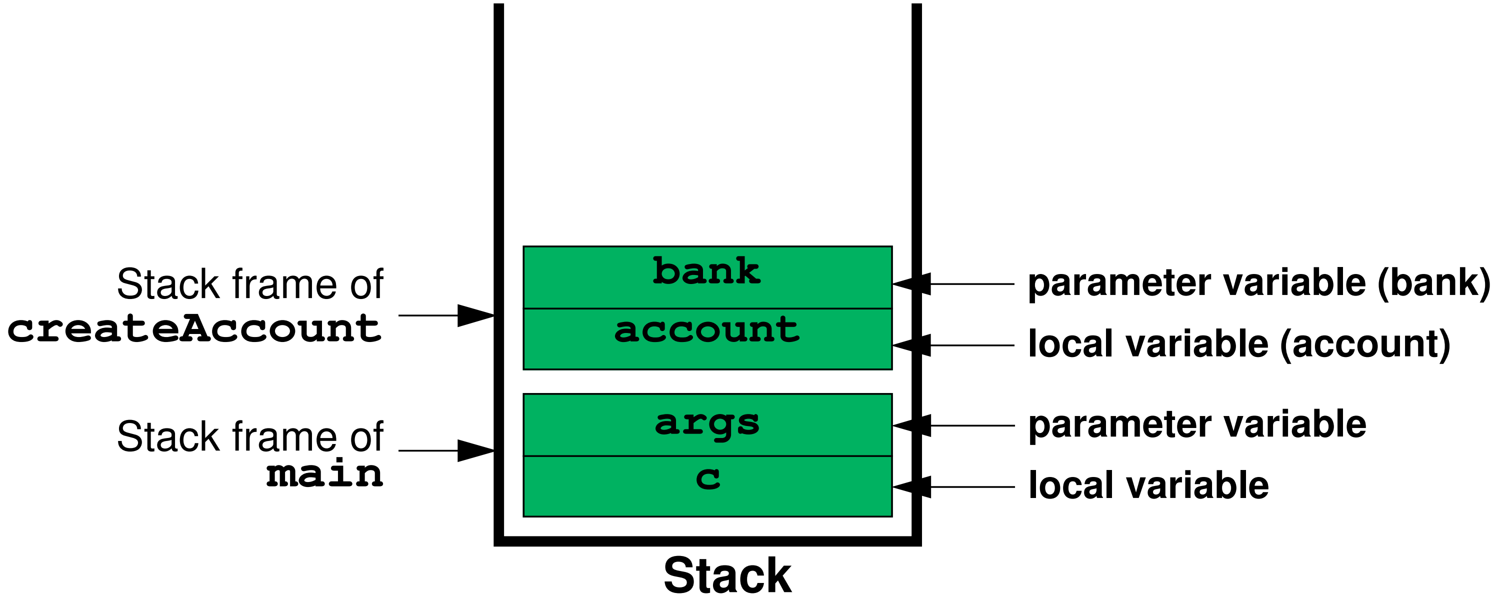

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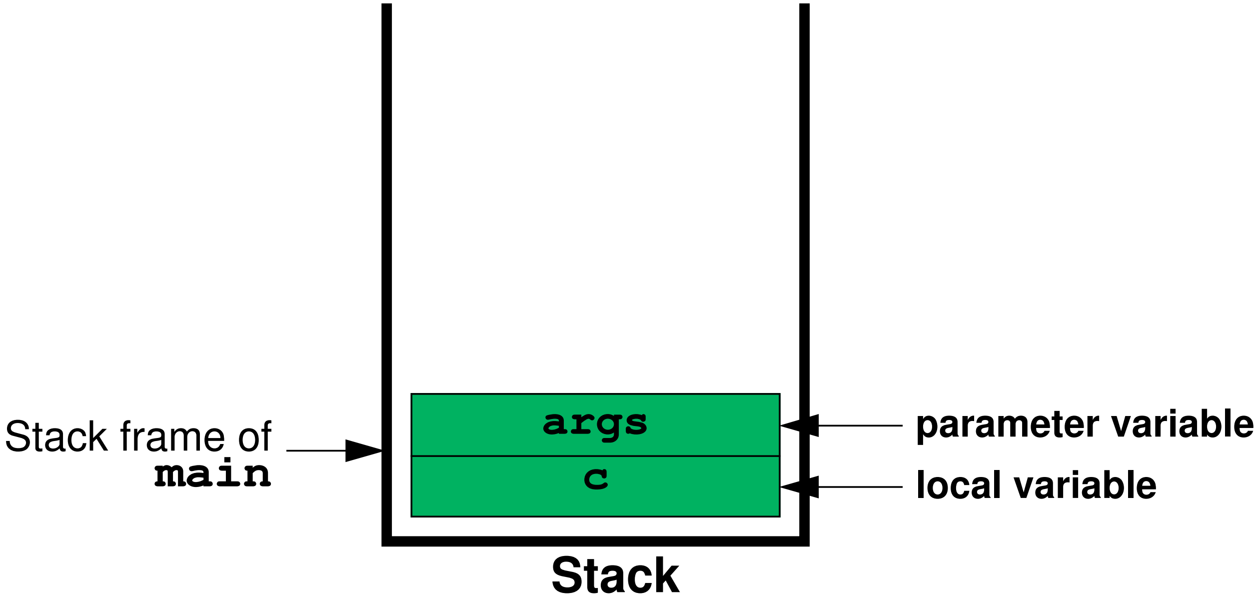

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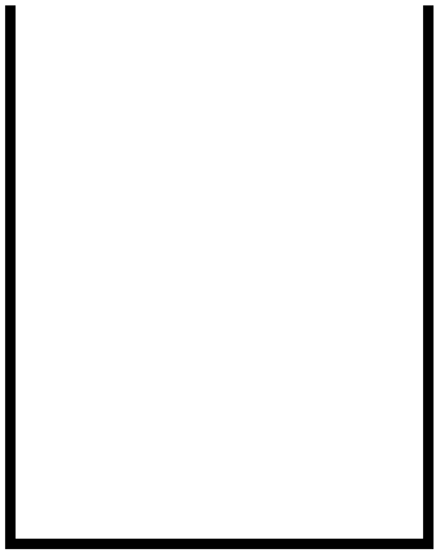


Stack

23.2 Try, Throw, and Catch

```
try {
    ...
    if (...) throw new MyException();
    ...
} catch(MyException e) {
    // exception handler
    ...
}
```

- use throw to thow an exception
- catch block must immediately follow try block
- there can be more than one catch block
  - catch blocks are matched in program order
- a method may not catch all exceptions
  - uncatched exceptions are automatically thrown up the stack

23.3 Finally

- the finally block is executed if the try block was entered
  - can be used to clean up in case of (un-)catched exceptions

```
try {
    ...
} catch(...) {
    // error handling
    ...
} finally {
    // release resources
    ...
}
```

- a `finally` block can also be used without `catch`

```
try {
    ...
    if (...) return;
    ...
} finally { ... }
```

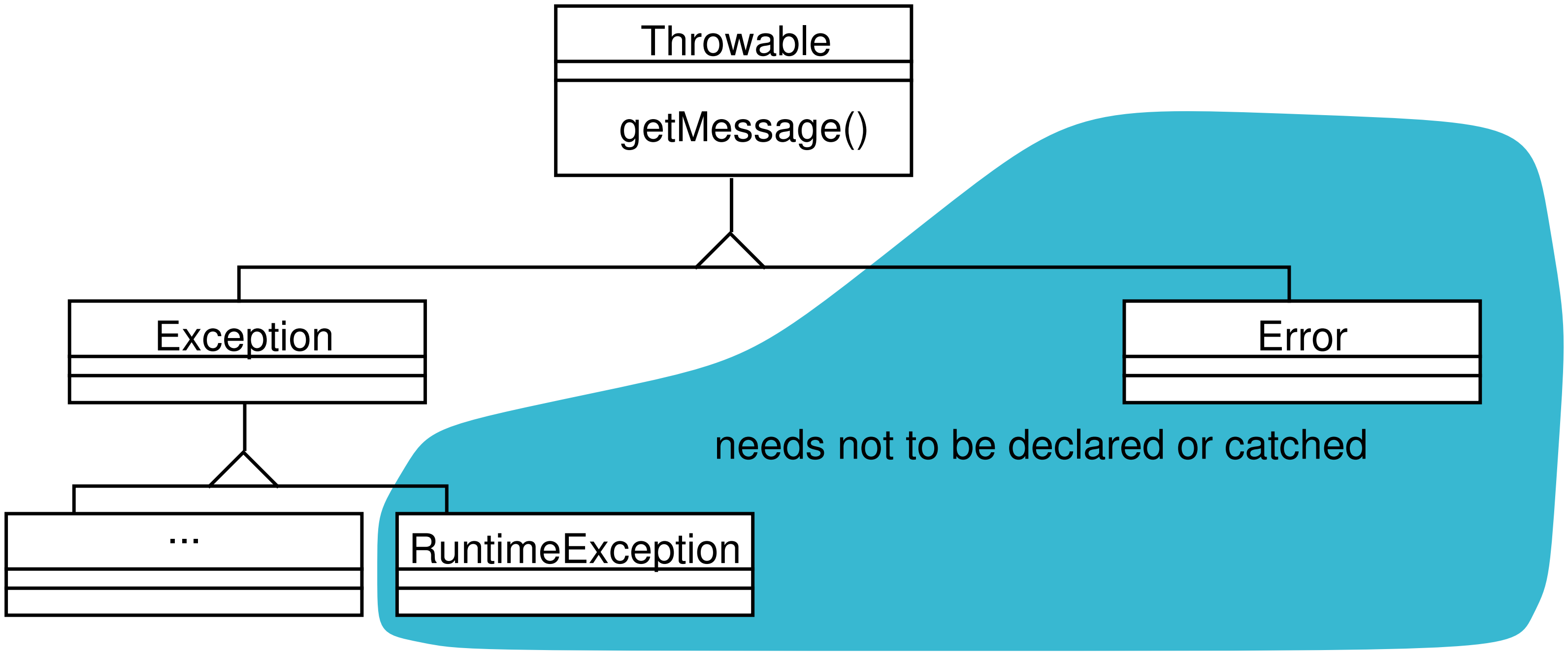
23.4 throws

- Exceptions must be declared in method header

```
class Test {
    void m() throws MyException {
        ...
        if (...) throw new MyException();
        ...
    }
}
```

23.5 Error Classes

- All exceptions are derived from **`Throwable`**
- Exceptions that can be expected nearly everywhere:
  - ◆ **`Error`**: Linker errors, errors in the format of class files, out of memory, ...
  - ◆ **`RuntimeException`**: array index, null pointer, illegal cast, arithmetic, ...
- Application-program exceptions are derived from **`java.lang.Exception`**



23.6 Exceptions and Inheritance: Catching

- Catching exception subclasses with multiple catch blocks
- Notice: Superclasses match all subclasses, catch superclasses at last

```
class MathException {}
class ZeroDivideException extends MathException {}
class InvalidArgException extends MathException {}
try {
    ...
} catch(ZeroDivideException e) {
    ...
} catch(InvalidArgException e) {
    ...
} catch(MathException e) {
    ...
}
```

23.6 Example

```
class TestException extends Exception {
  public TestException(String s) {super(s);}
}


public class Test {

  public void hello() throws TestException {
    if (...) throw new TestException("...an error description...");
  }

  public void testIt() {
    try {
      hello();
      ...
    }
    catch (TestException t) {
      System.out.println("Exception raised:" + t.getMessage());
    }
    finally {
      // clean up
    }
  }
}
```

23.7 Exceptions and Inheritance: Throwing

- Can overriding method throw other exceptions than the original method?
- Principle:
  - ◆ Subclasses can be used wherever a superclass is expected.
  - ◆ Subclasses are "better" than superclasses.
- This means:
  - ◆ Subclass must not throw more exceptions than superclass.
  - ◆ Subclass may throw subclasses of the superclass-thrown exceptions.
  - ◆ Subclass must not throw superclasses of the exceptions.

23.8 Example

```
class E1 extends Exception {}
class E2 extends Exception {}
class E3 extends E2 {}
class A {
    void m() throws E2 {}
}
class B extends A {
    void m() throws ??? {}
}
```

- ??? =

23.8 Example

```
class E1 extends Exception {}
class E2 extends Exception {}
class E3 extends E2 {}
class A {
    void m() throws E2 {}
}
class B extends A {
    void m() throws ??? {}
}
```

- ??? =

Wrong:	Correct:
`E1`	`E2`
`Exception`	`E3`
`...`	`none`

23.9 Summary

- Throwing an exception: `throw new MyException("...");`
- Block that may throw exceptions: `try { ... }`
- Handling exceptions:

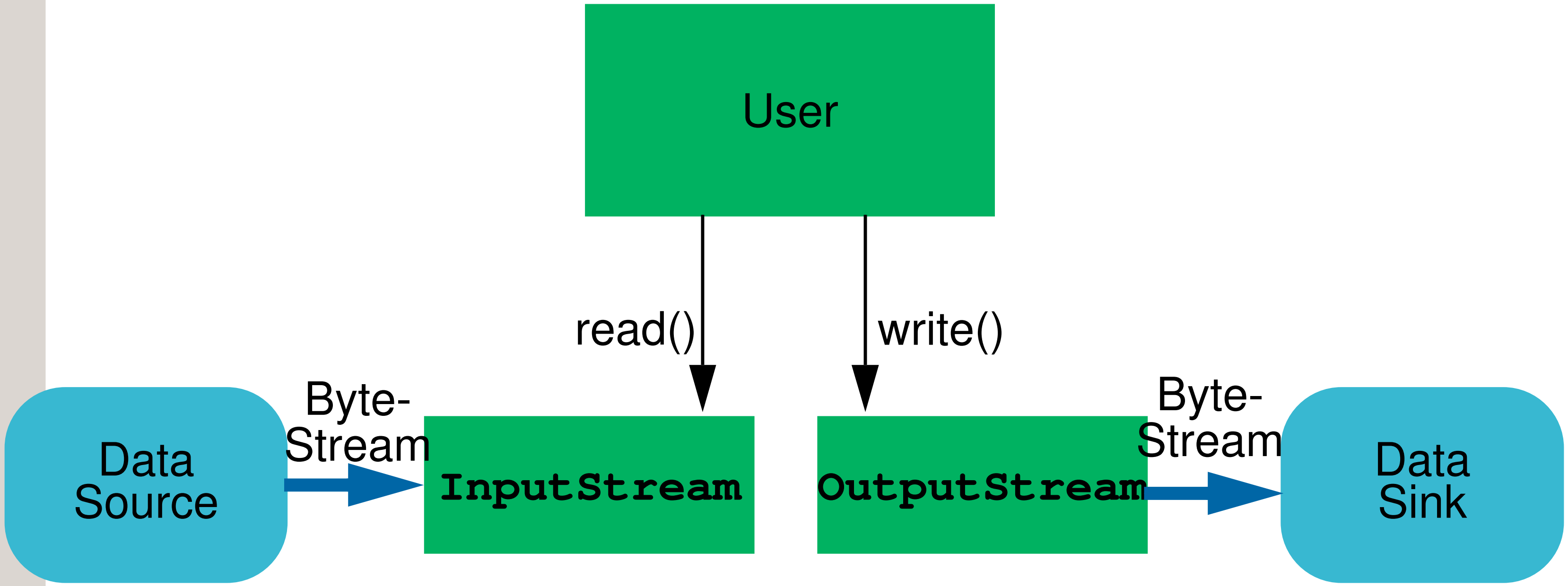
```
try {
... throw new MyException("..."); ...
} catch(MyException e) { ... }
```

- Additionally: `finally` block
- Exceptions must be subclasses of `Throwable`.
- Application exceptions should be subclasses of `Exception`.
- Exceptions must be declared in the method header with `throws`

24 The Java IO System

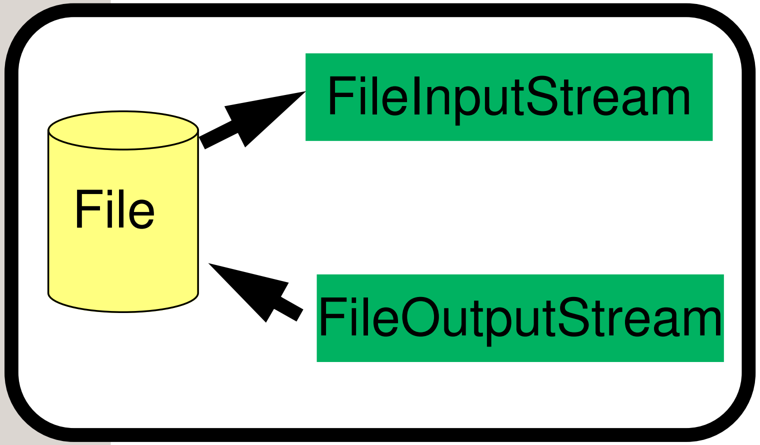
- Basic concept: streams
  - ◆ Byte streams (InputStream/OutputStream)
  - ◆ Charater streams (Reader/Writer)

24.1 Byte Streams



24.2 Stream Specializations

- Where do the data come from / go to?



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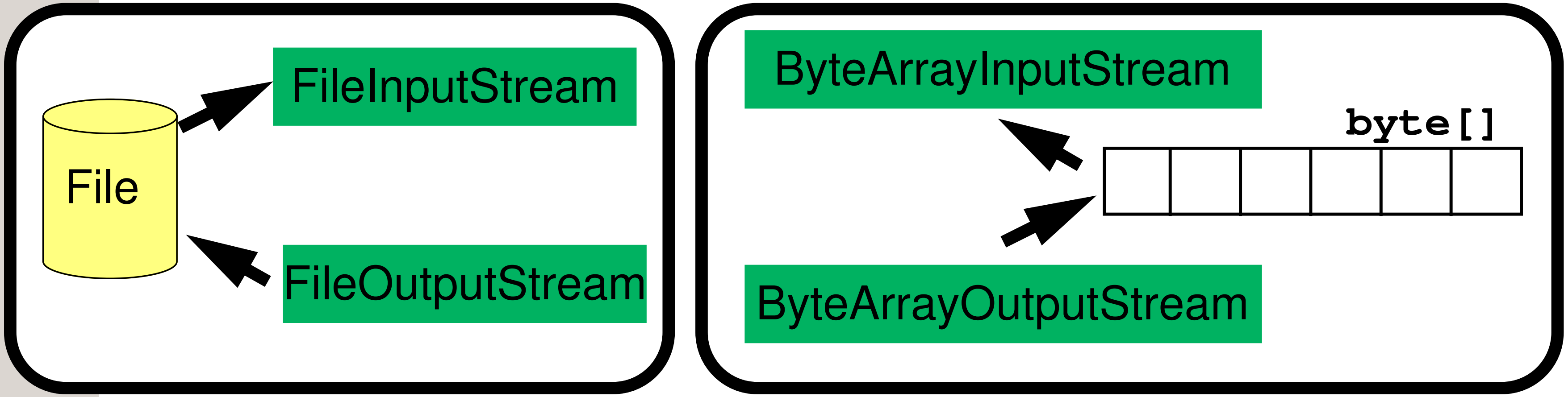

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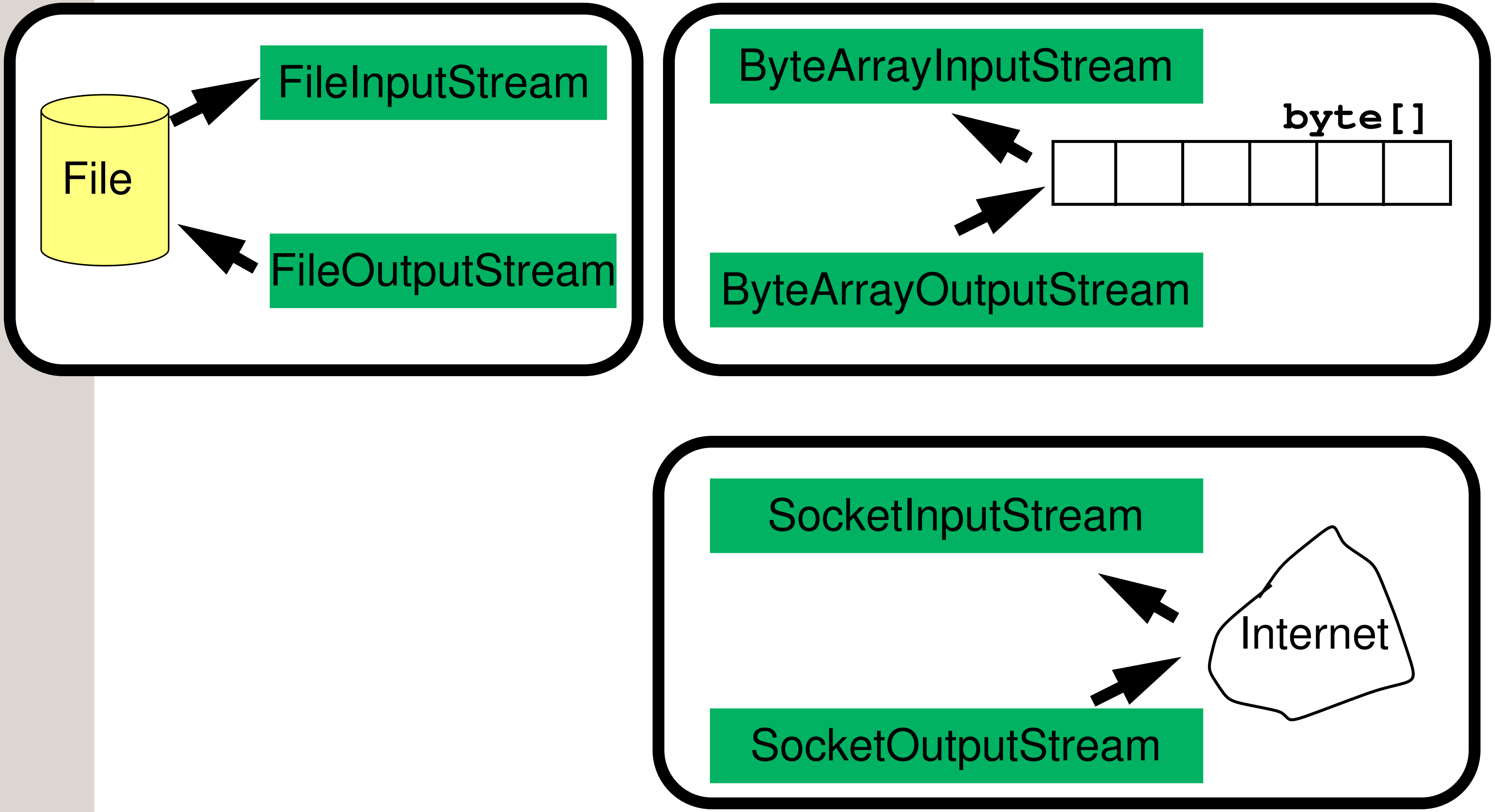

Stream Specializations

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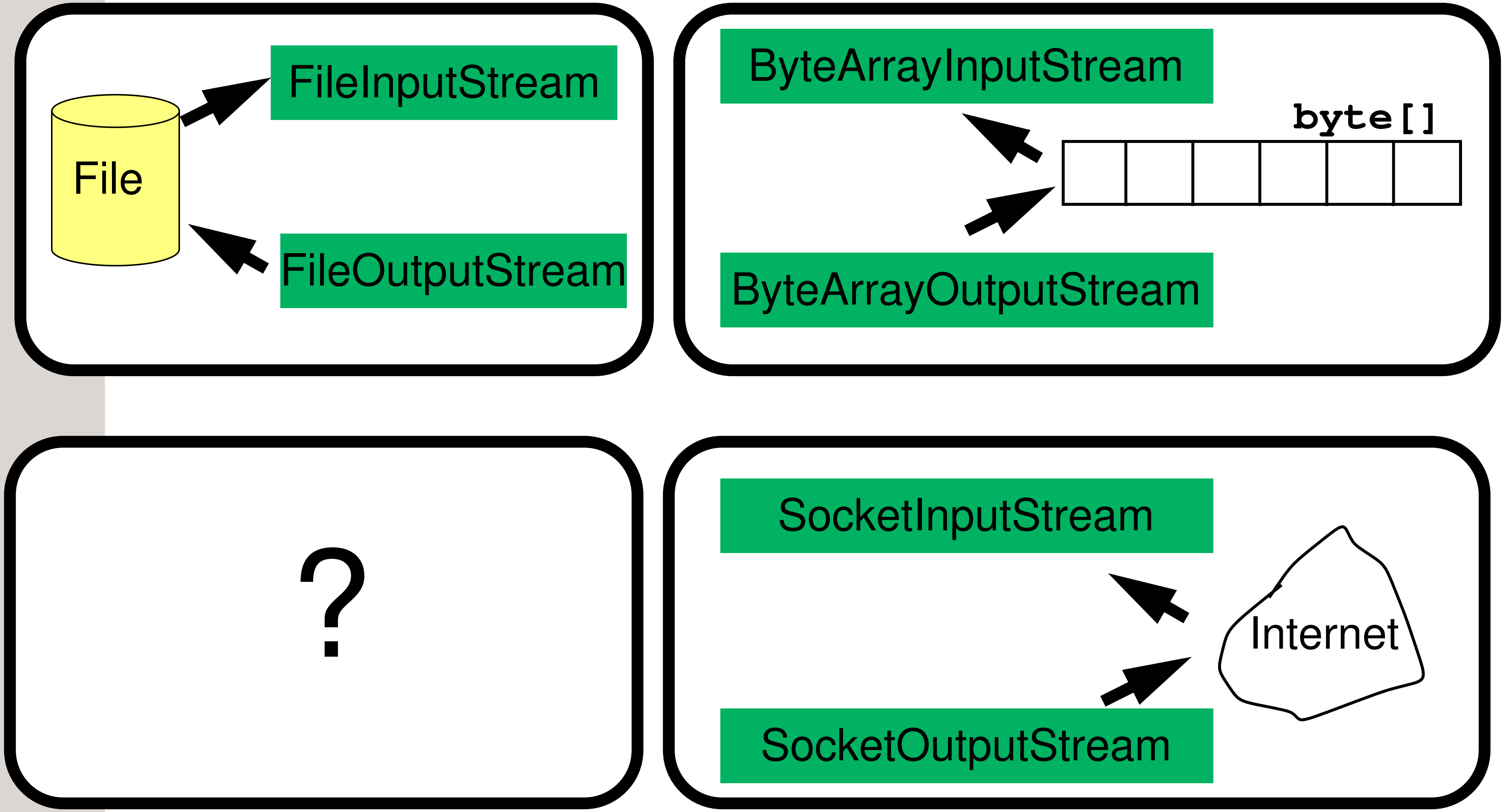
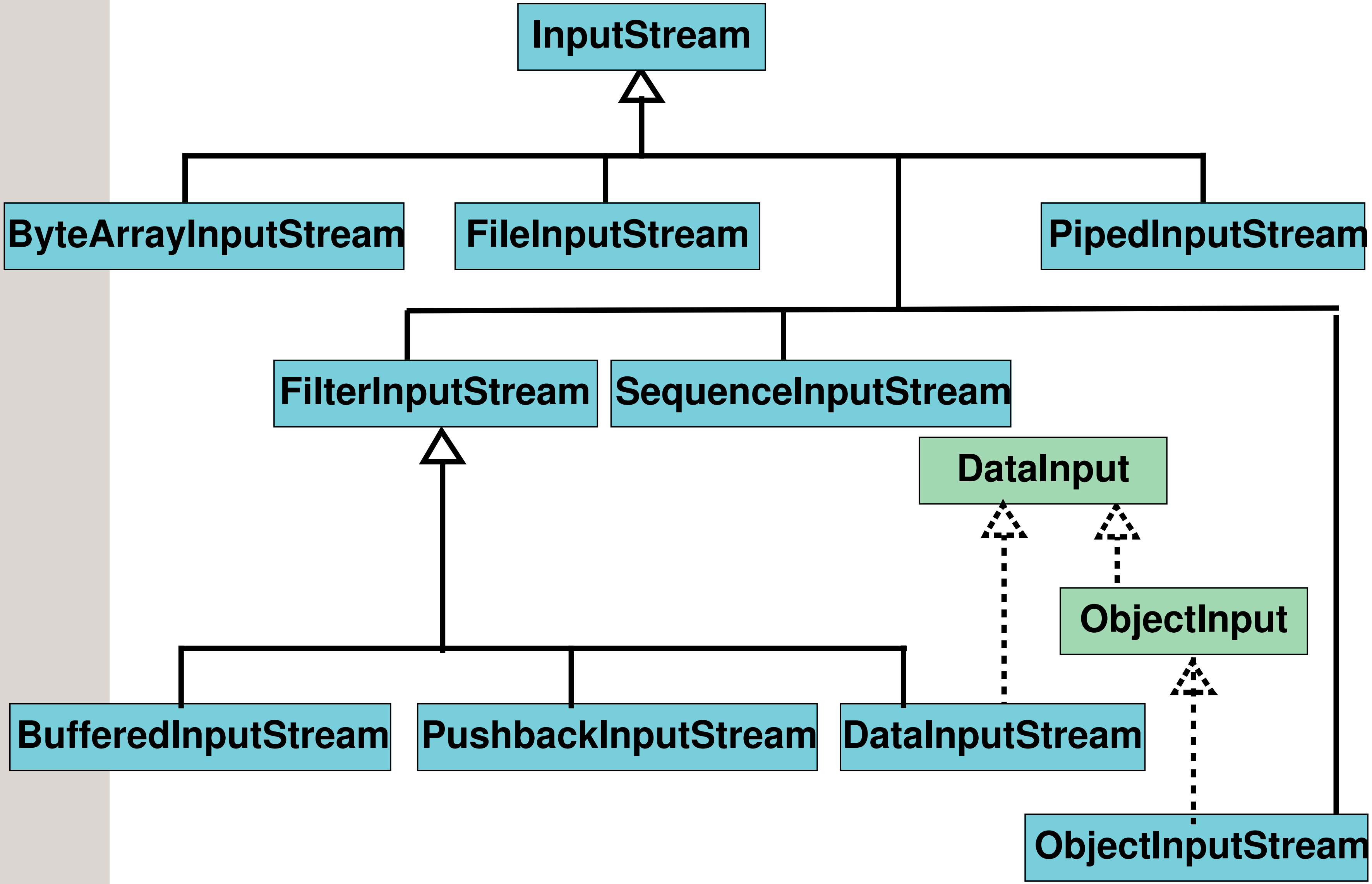


24.3 Input Streams Class Diagram



24.4 FileInputStream, FileOutputStream

- Read from a file

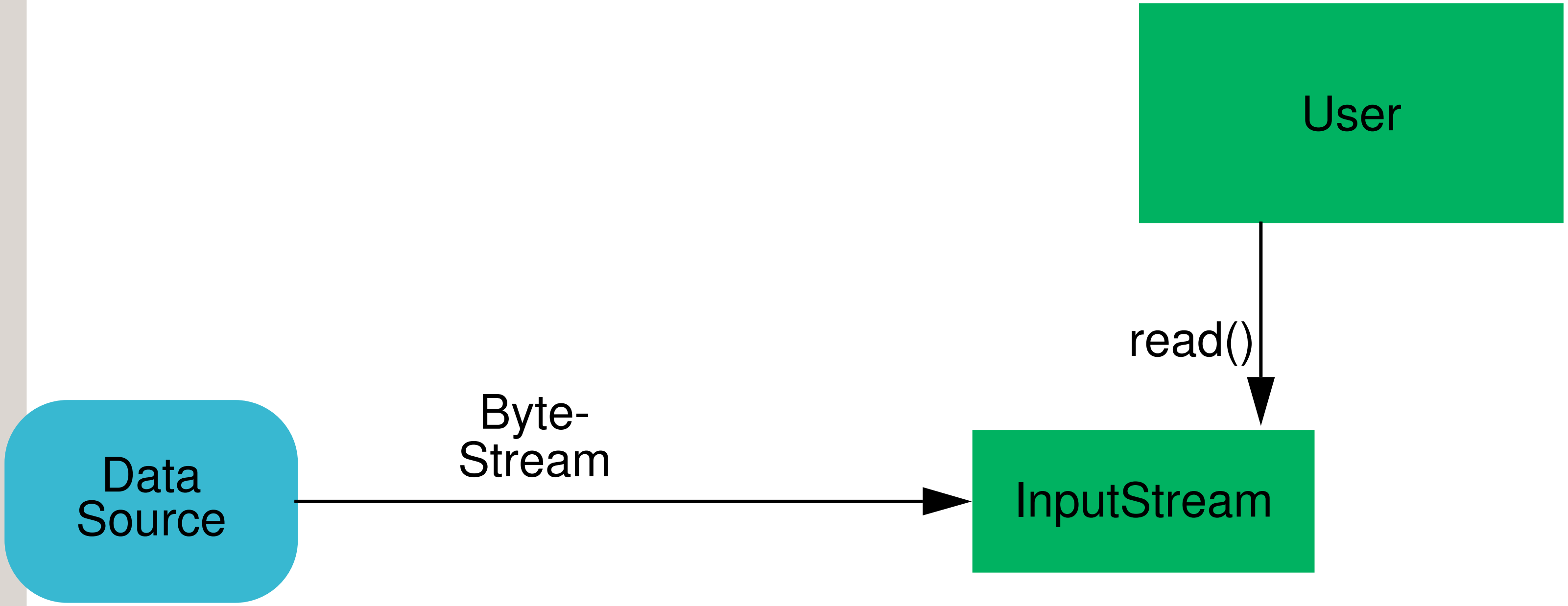
```
import java.io.*;

public class Test {
  public static void main (String argv[]) throws IOException {
    FileInputStream f = new FileInputStream ("/tmp/test");
    byte buf[] = new byte[4];
    f.read(buf);
  }
}
```

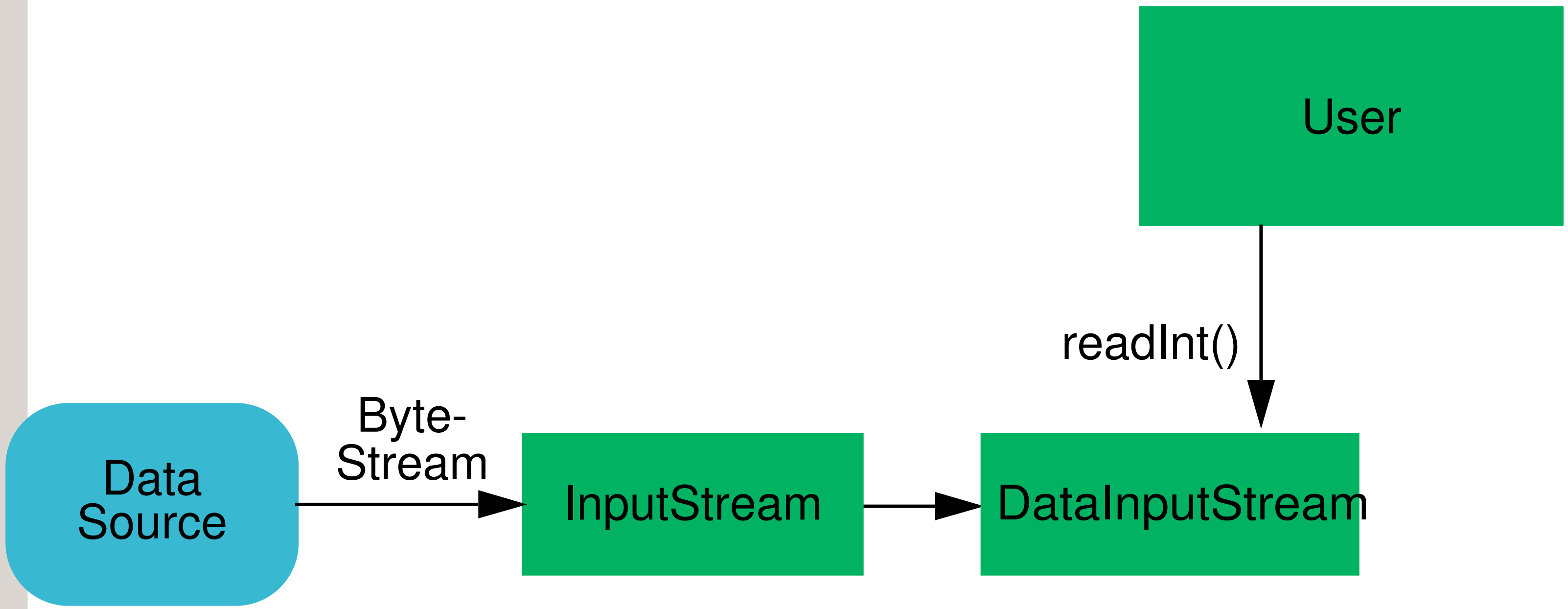
24.5 Combining Streams

- Create comfortable streams from simple streams
- The comfortable stream wraps the simple stream
- ➜ Decorator Design-Pattern

24.6 Combining Streams



24.7 Combining Streams



24.8 DataInputStream

- `InputStream` rather uncomfortable
- `DataInputStream` used to read *binary representation* of data (int, float,...)
- can be created from every `InputStream`

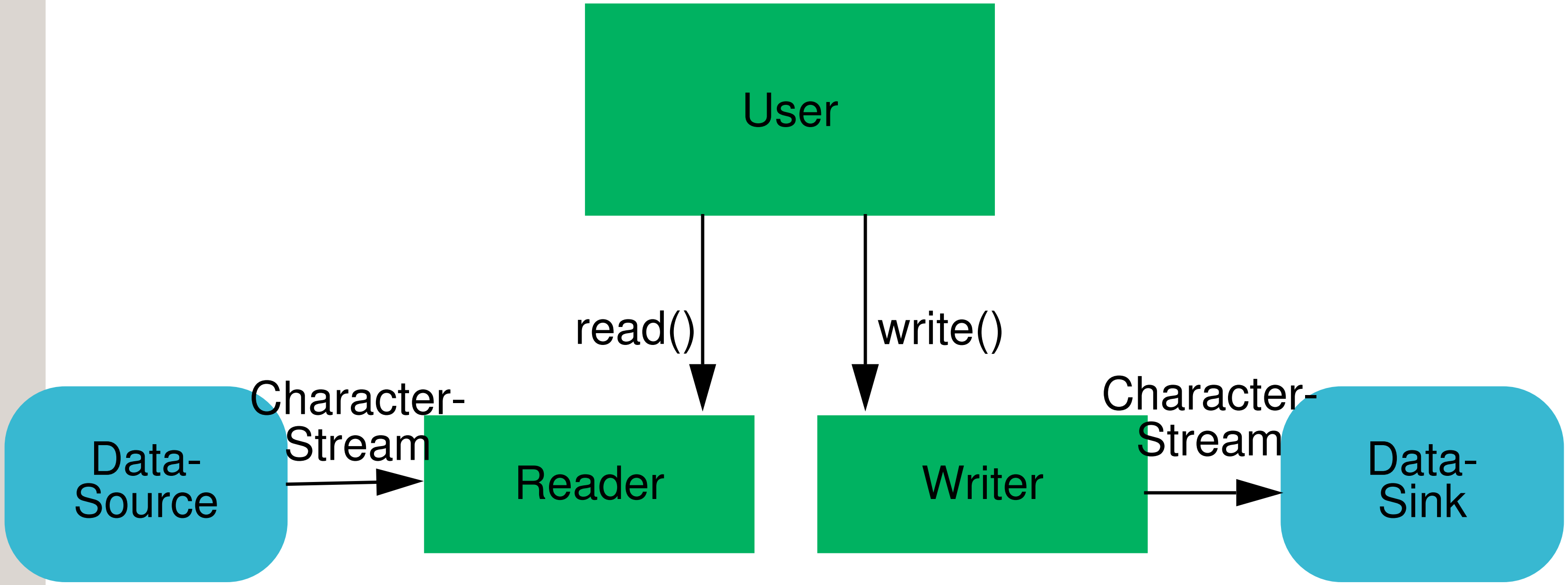
```
InputStream in = new FileInputStream ("/tmp/test");
DataInputStream dataIn = new DataInputStream(in);
float f = dataIn.readFloat();
```

- `readLine()` can be used to read whole lines

```
for(;;) {
    String s = dataIn.readLine();
    System.out.println(s);
}
```

24.9 Reader/Writer

- Character streams for input/output (**`Reader, Writer`**)



- Character streams contain Unicode characters (16 bit)

24.10 Reader

- important methods:

  `int read()`
  Read one character and return it as **`int`**.

  `int read(char buf[])`
  Read characters into buffer. Return number of read characters or -1 in case of error.

  `int read(char buf[], int offset, int len)`
  Read **`len`** characters in buffer **`buf`** starting at **`offset`**.

  `long skip(long n)`
  Skip **`n`** characters.

  `void close()`
  Closes the stream.

24.10.1 FileReader

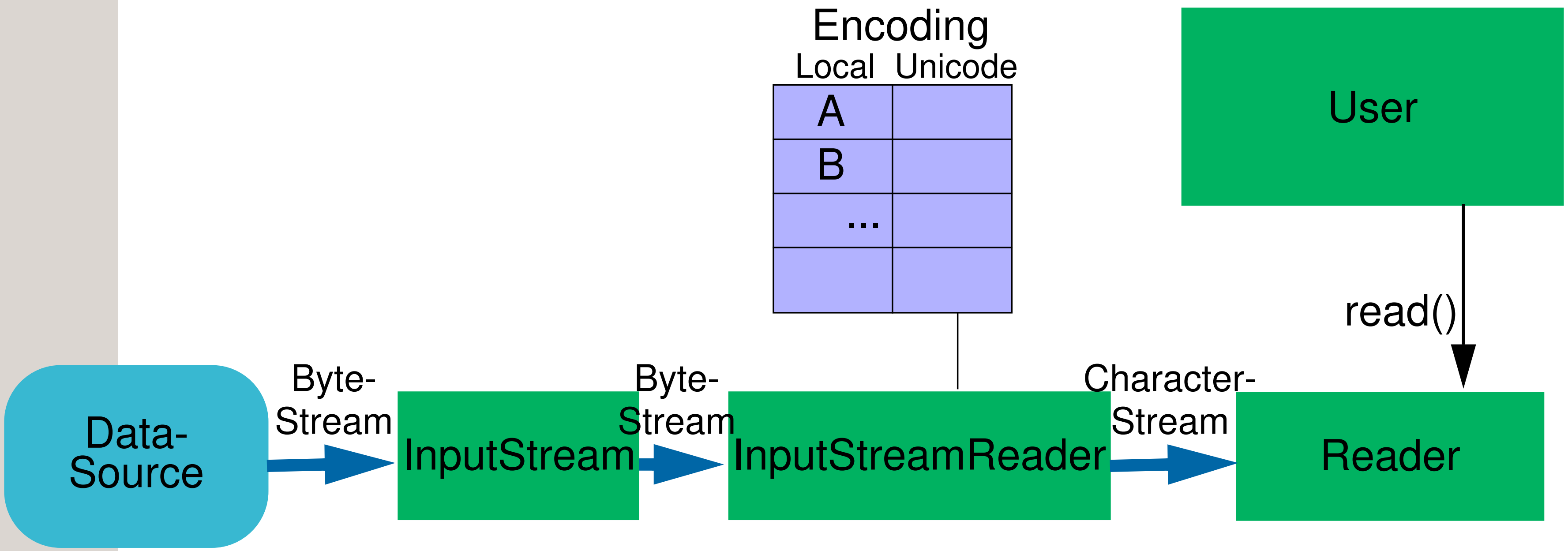
- Used to read from file
- Constructors:

```
FileReader(String fileName)
FileReader(File file)
FileReader(FileDescriptor fd)
```

- No additional methods (only inherited fom **`InputStreamReader`**)
- What is an **`InputStreamReader`**?

24.11 Byte Streams and Character Streams

- Convert byte streams to character streams using an *encoding*

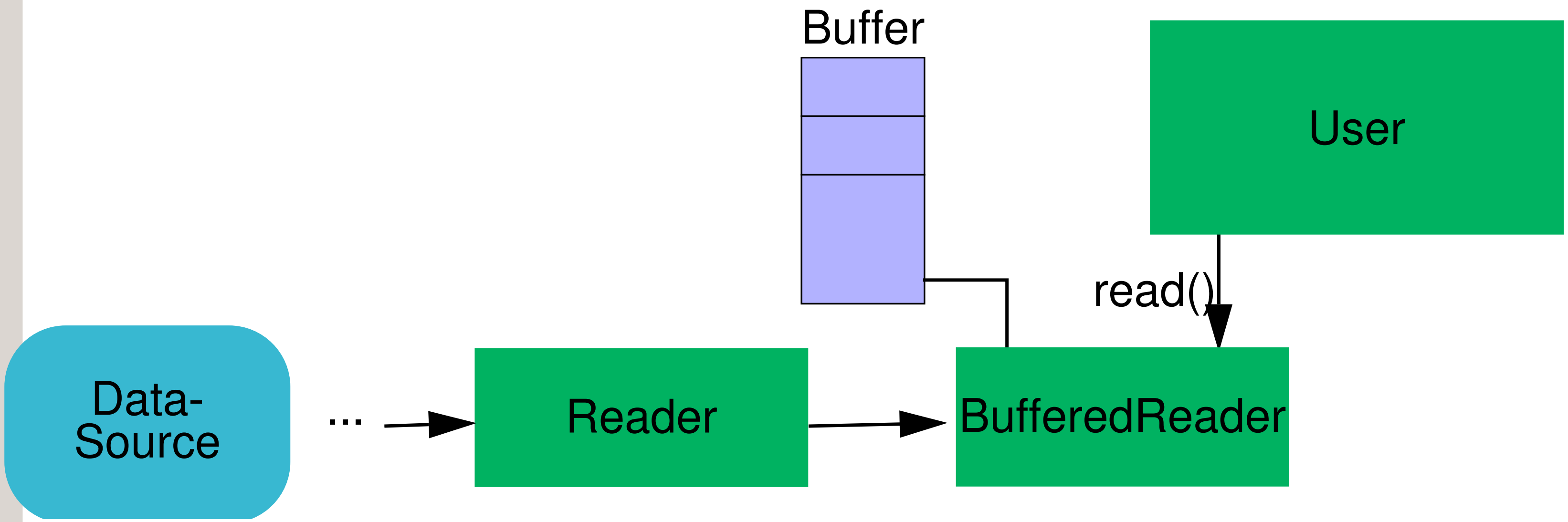


- some encodings: "Basic Latin", "Greek", "Arabic", "Gurmukhi"

24.12 Buffered IO

- Reading/writing single characters can be expensive.
- Converting encodings can be expensive.
- Use **`BufferedReader`**, **`BufferedWriter`** if possible.
- **`BufferedReader`** can be created from every other Reader.
- Important method of **`BufferedWriter`**:

  `void flush():` Empties the buffer - writes buffer to unbuffered writer.



24.13 Buffered IO

- **`BufferedReader`** can read whole lines: **`String readLine()`**

```
BufferedReader in = new BufferedReader(new FileReader("test.txt"));
String line = in.readLine();

BufferedReader in = new BufferedReader(new InputStreamReader(System.in));
String line = in.readLine();
```

24.14 PrintWriter

- Can be created from every **OutputStream** or **Writer**
- **println(String s)**: write string and end-of-line character(s)
- Example: Read file and print it to standard output

```
import java.io.*;

public class CopyStream {
    public static void main(String a[]) throws Exception {
        BufferedReader in = new BufferedReader(
                                new FileReader("test.txt"));
        PrintWriter out = new PrintWriter(System.out);
        for(String line; (line = in.readLine())!=null;) {
            out.println(line);
        }
        out.close();
    }
}
```

24.15 FileWriter

- used to write characters to a file
- invoke **`close()`** after you finished writing!