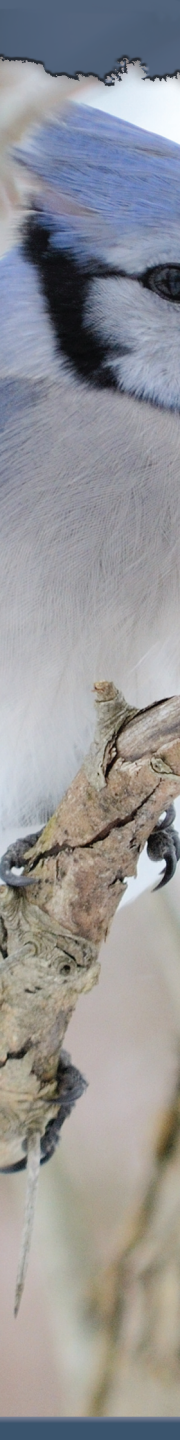
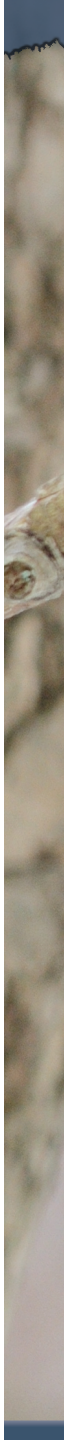
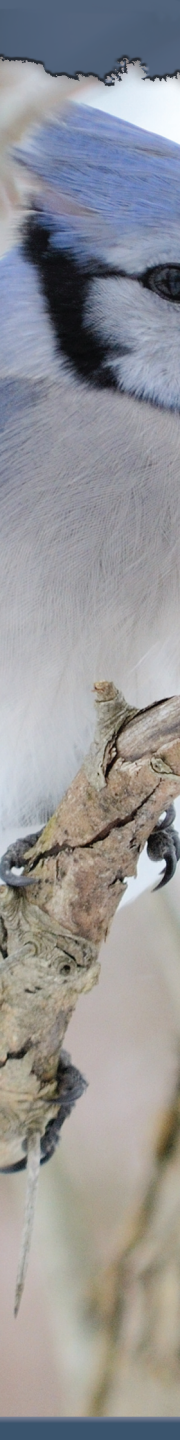


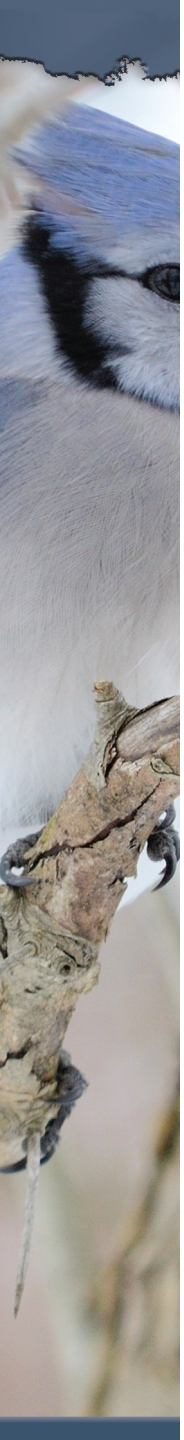
Handling errors





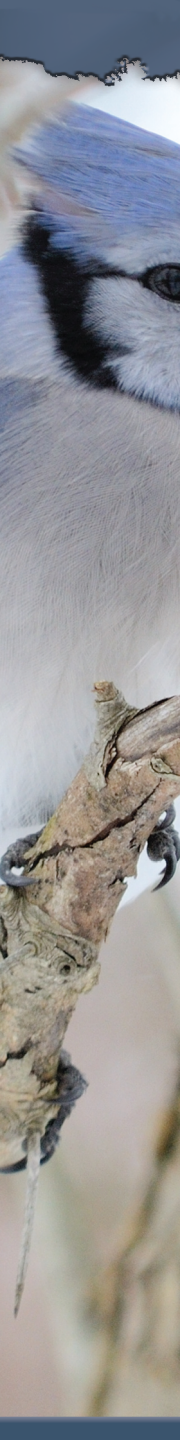
Main concepts to be covered

- Defensive programming.
  - Anticipating that things could go wrong.
- Exception handling and throwing.
- Error reporting.
- Simple file processing.



Typical error situations

- Incorrect implementation.
  - Does not meet the specification.
- Inappropriate object request.
  - E.g., invalid index.
- Inconsistent or inappropriate object state.
  - E.g. arising through class extension.



Not always programmer error

- Errors often arise from the environment:
  - Incorrect URL entered.
  - Network interruption.
- File processing is particular error-prone:
  - Missing files.
  - Lack of appropriate permissions.

Programmer error?

```
class Toto {
    private int i, k;

    void meth(int j) {
        …
        k = j / i;
        …
    }
}
```

Programmer error?

```
class Toto {
    private static final int J = 12;
    private int k;

    void meth(int i) {
        …
        k = J / i;
        …
    }
}
```

```
…
new Toto().meth(0);
…
```

Programmer error?

```
class Foo {
    void aMethod(Toto toto) {
        …
        toto.meth(6);
        …
    }
}
```

```
…
new Foo().aMethod(null);
…
```

Programmer error?

- Application working fine

- Application no longer working

Programmer error?

```
public class StockExchange {

    public void buy(int number) {
        …
        number always parsed as positive
        …
    }
}


…
new StockExchange().buy(-6);
…
```

Programmer error?

+0.15 +0.03 6.67 DOLLAR UNCHANGED. 8.65 EURO + NAN PENNY

SUNDAY, DECEMBER 2, UPDATED FÖR 22 MINUTER SEDAN

SvD NÄRINGSLIV

CAROLINA NEURATH

Carnegie could become mo banking

Neuraths Exchange blog | All Blogs

HOME NEWS LIVE EXCHANGE SECTORS INVESTING ANALYSIS ENGINE CAREER SvD.se AZ

Sweden World Digitally Lifestyle Quiz Find a Job SvD Quote

Monster Orders upholstered Exchange

Stockholm Stock Exchange was paralyzed on Wednesday morning of a purchase order of over 4.2 billion index futures. The value of words corresponding to 131 times Sweden's gross domestic product, and the stock market witnessed technical problems.

November 28, 2012 at 11:40, Updated: 29 november 2012 at 10:27

STOCK EXCHANGE Check out today's winners - and losers

Rekommendera 426

Tweet

+1 10

Apparently, the limitation to 31 bits as it stumbles ...

xngen

More reviews

MORE ON THE TOPIC

Check out today's winners - and

TOP NEWS SV

Clinton's goal: equality

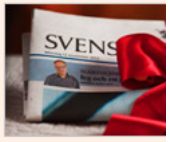
She will get the wo take advantage of t skills of a ...

Merkel opens f Greek write-do

Earlier harsh attitu softened.

"Divine" substa can become fue

Could thorium be t new energy source

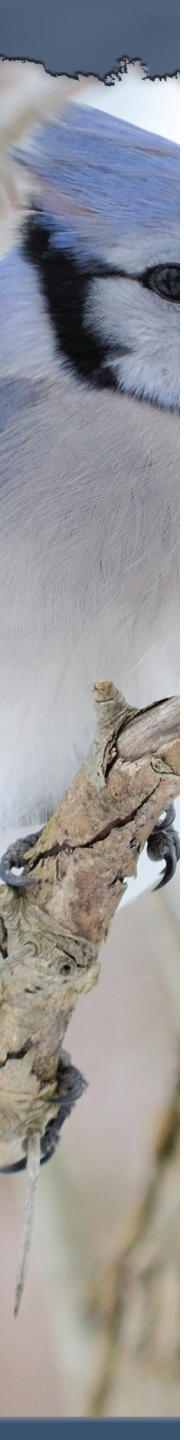


GÖR NLIV.S

LATEST NEW

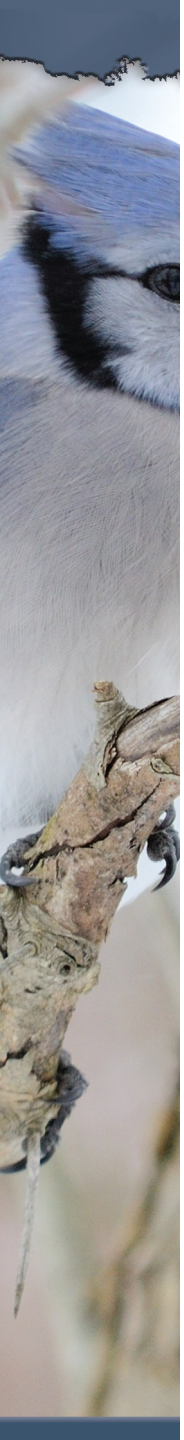
Enterprise

21:44 Merkel op down



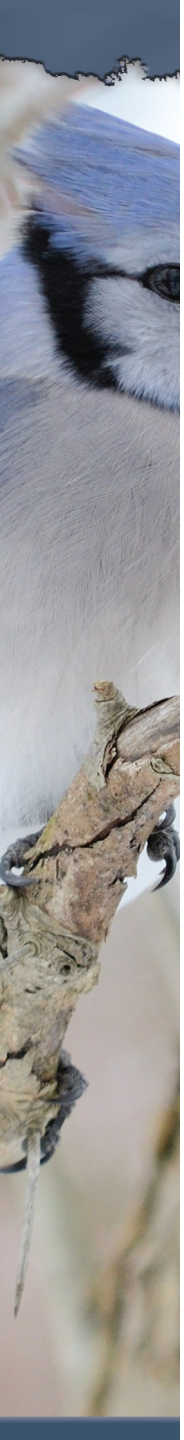
Exploring errors

- Explore error situations through the *address-book* projects.
- Two aspects:
  - Error reporting.
  - Error handling.



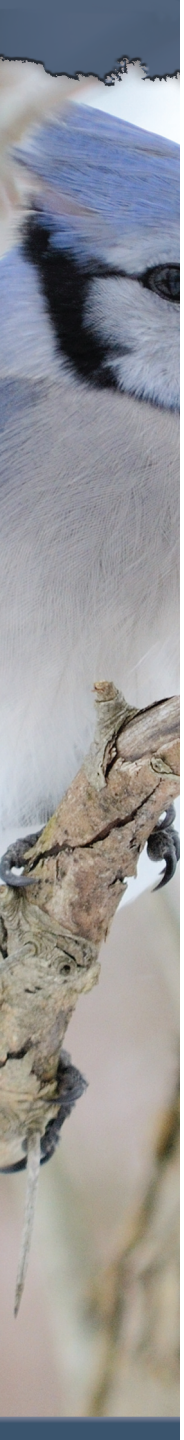
Defensive programming

- Client-developer interaction
  - Code seen only within declaring class - **`private`**
    - Code see only by developers – default (package-private)
    - Code meant to be extended by clients – **`protected`**
    - Code meant to be used by clients – **`public`**
- Constant-value code - **`final`**



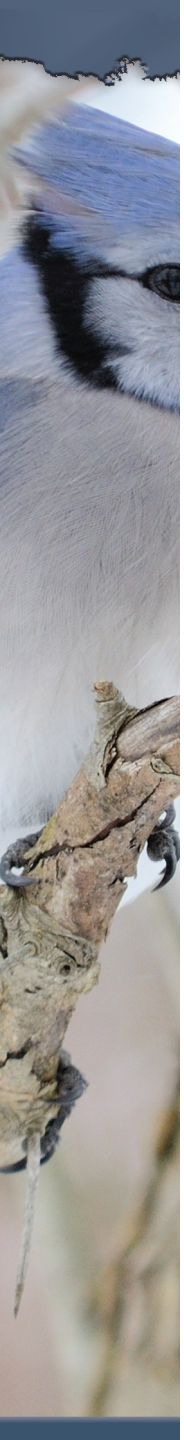
Defensive programming

- Client-server interaction.
  - Should a server assume that clients are well-behaved?
  - Or should it assume that clients are potentially hostile?
- Significant differences in implementation required.



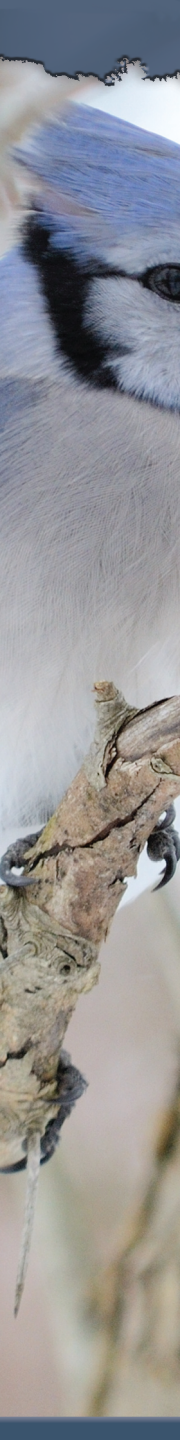
Issues to be addressed

- How much checking by a server on method calls?
- How to report errors?
- How can a client anticipate failure?
- How should a client deal with failure?



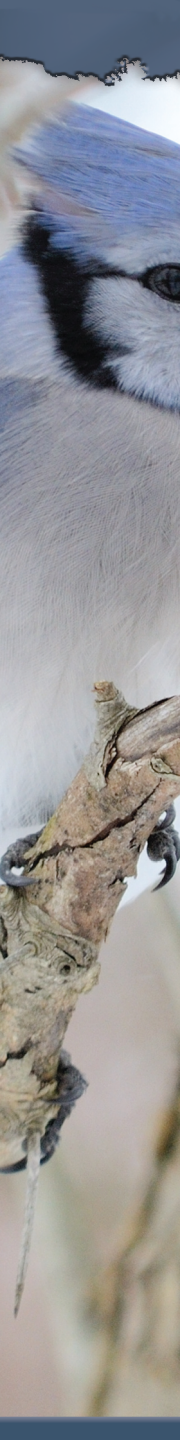
An example

- Create an **`AddressBook`** object.
- Try to remove an entry.
- A runtime error results.
  - Whose ‘fault’ is this?
- Anticipation and prevention are preferable to apportioning blame.



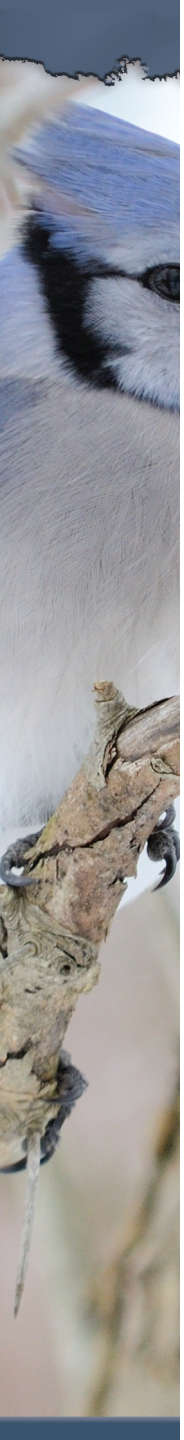
Argument values

- Arguments represent a major ‘vulnerability’ for a server object.
  - Constructor arguments initialize state.
  - Method arguments often contribute to behavior.
- Argument checking is one defensive measure.



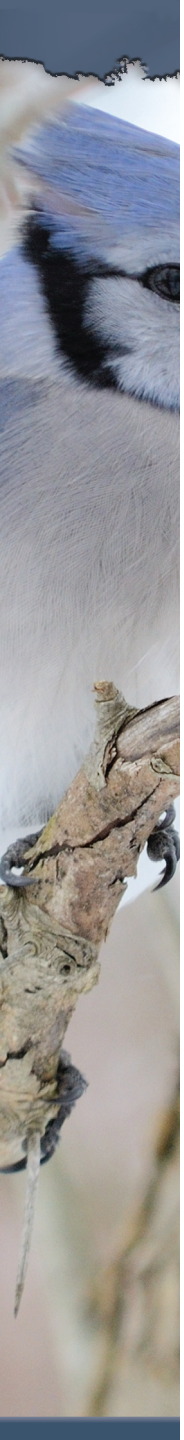
Checking the key

```
void removeDetails(String key) {
    if (keyInUse(key)) {
        ContactDetails details = book.get(key);
        book.remove(details.getName());
        book.remove(details.getPhone());
        numberOfEntries--;
    }
}
```



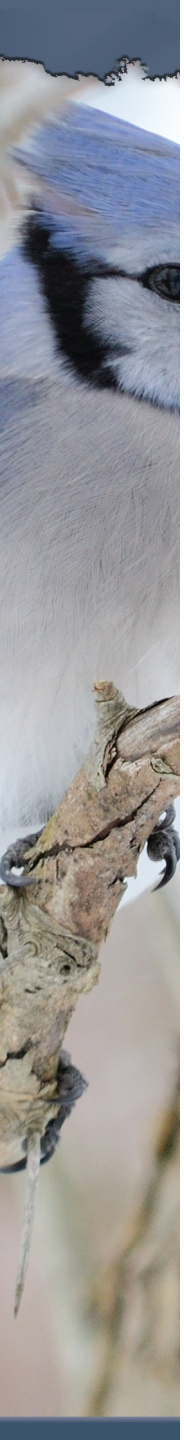
Server error reporting

- How to report illegal arguments?
  - To the user?
    - Is there a human user?
    - Can they solve the problem?
  - To the client object?
    - Return a diagnostic value.
    - *Throw an exception.*



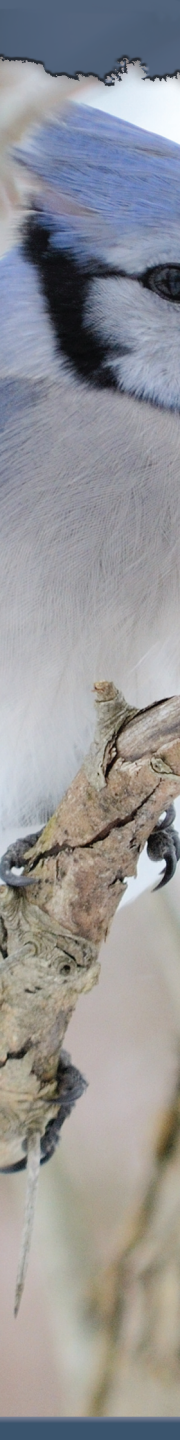
Returning a diagnostic

```
boolean removeDetails(String key) {
    if (keyInUse(key)) {
        ContactDetails details = book.get(key);
        book.remove(details.getName());
        book.remove(details.getPhone());
        numberOfEntries--;
        return true;
    } else {
        return false;
    }
}
```



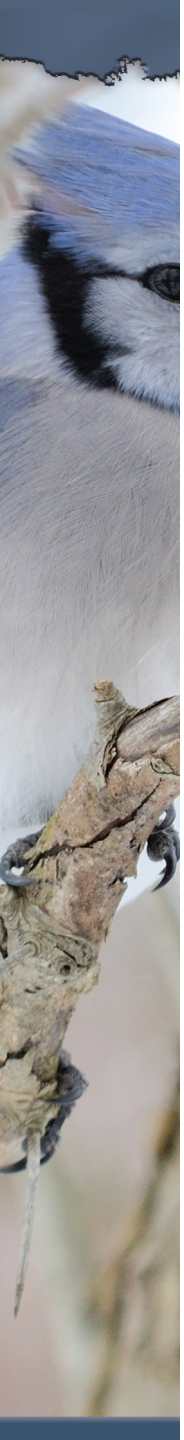
Client can check for success

```
if (contacts.removeDetails("…")) {
    // Entry successfully removed.
    // Continue as normal.
    …
} else {
    // The removal failed.
    // Attempt a recovery, if possible.
    …
}
```



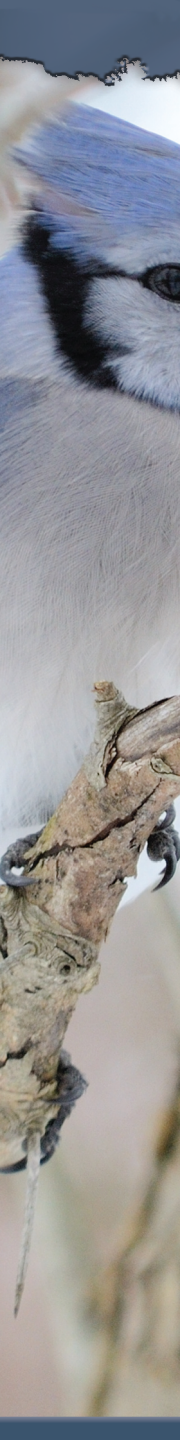
Potential client responses

- Test the return value.
  - Attempt recovery on error.
  - Avoid program failure.
- Ignore the return value.
  - Cannot be prevented.
  - Likely to lead to program failure.
- ‘Exceptions’ are preferable.



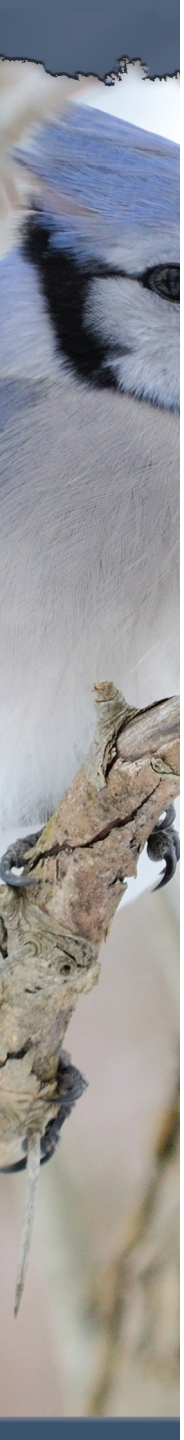
Exception-throwing principles

- A special language feature.
- No ‘special’ return value needed.
- Errors cannot be ignored in the client.
  - The normal flow-of-control is interrupted.
- Specific recovery actions are encouraged.



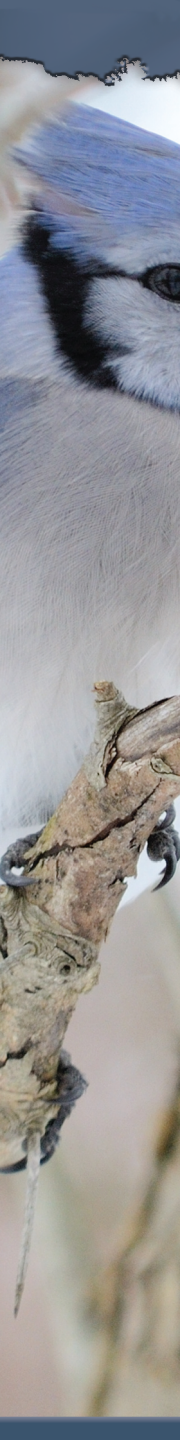
Throwing an exception

```
/**
 * Look up a name or phone number and return the
 * corresponding contact details.
 * @param key The name or number to be looked up.
 * @return The details corresponding to the key,
 *         or null if there are none matching.
 * @throws IllegalArgumentException if
 *         the key is invalid.
 */
ContactDetails getDetails(String key) {
    if (key == null) {
        throw new IllegalArgumentException(
                                "null key in getDetails");
    }
    return book.get(key);
}
```

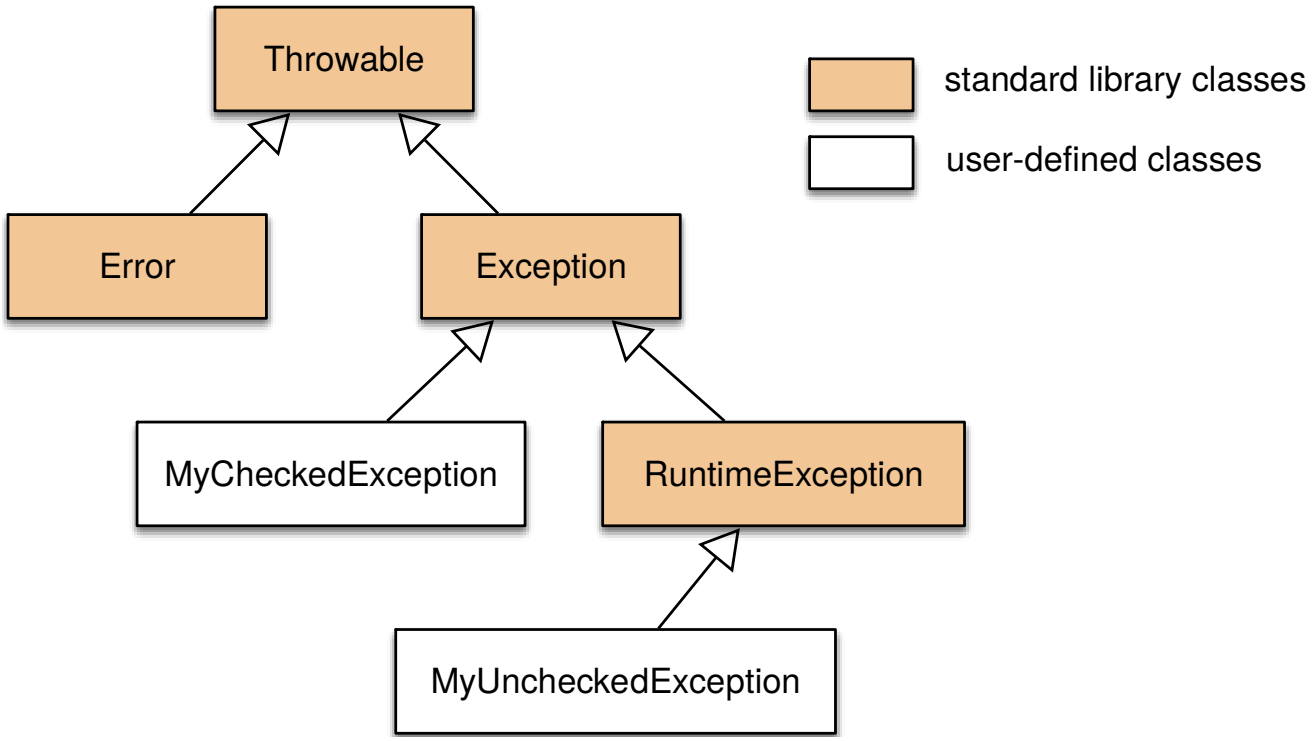


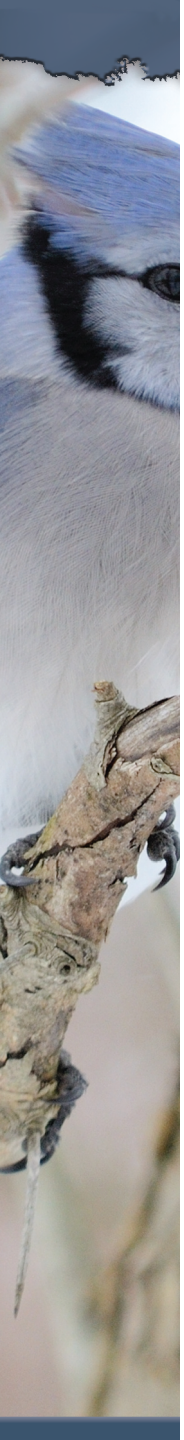
Throwing an exception

- An exception object is constructed:
  - `new ExceptionType("...")`
- The exception object is thrown:
  - `throw ...`
- Javadoc documentation:
  - `@throws ExceptionType reason`



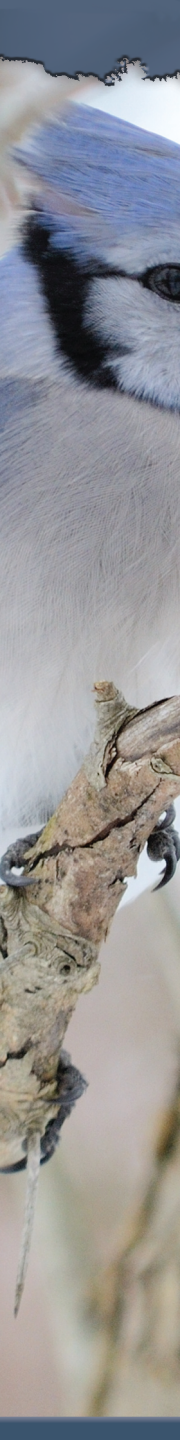
The exception class hierarchy





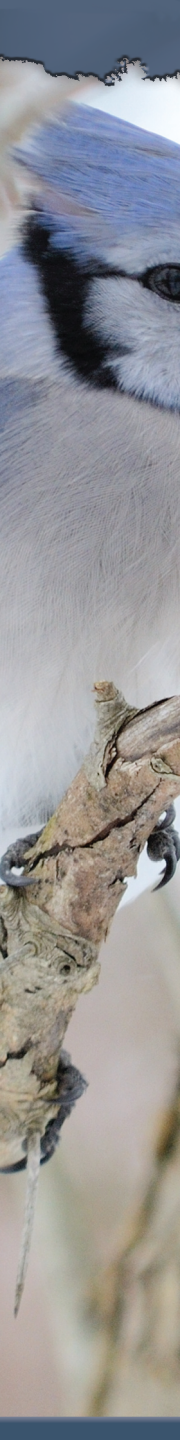
Exception categories

- Checked exceptions
  - Subclass of **`Exception`**
  - Use for anticipated failures.
  - Where recovery may be possible.
- Unchecked exceptions
  - Subclass of **`RuntimeException`**
  - Use for unanticipated failures.
  - Where recovery is unlikely.



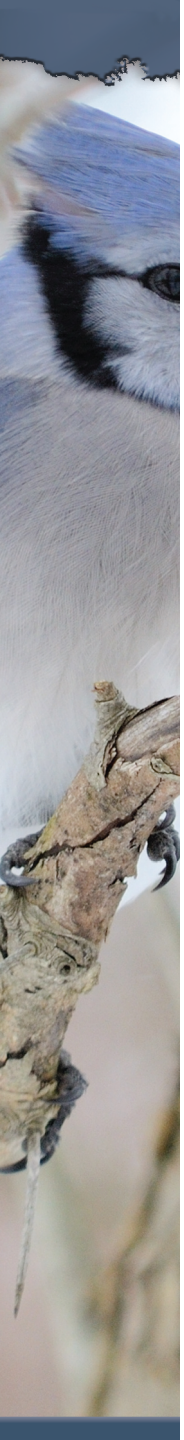
The effect of an exception

- The throwing method finishes prematurely.
- No return value is returned.
- Control does not return to the client's point of call.
  - So the client cannot carry on regardless.
- A client may 'catch' an exception.



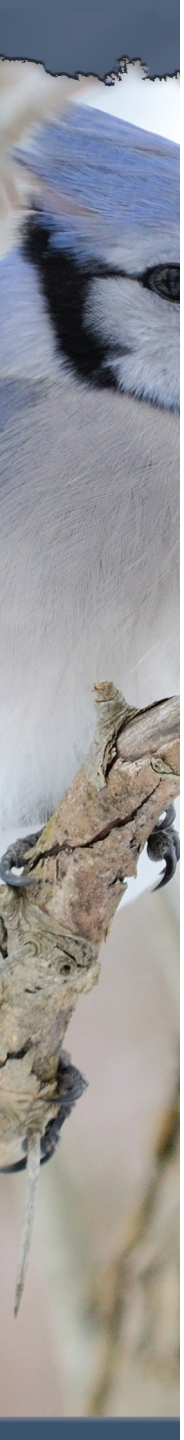
Unchecked exceptions

- Use of these is ‘unchecked’ by the compiler.
- Cause program termination if not caught.
  - This is the normal practice.
- **`IllegalArgumentException`** is a typical example.



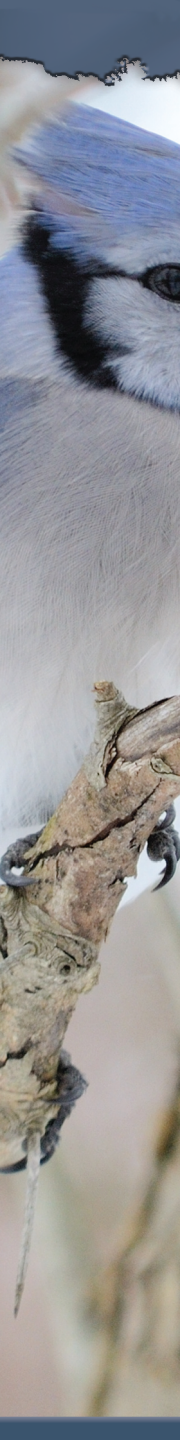
Argument checking

```
ContactDetails getDetails(String key) {
    if (key == null) {
        throw new IllegalArgumentException(
                            "null key in getDetails");
    }
    if (key.trim().length() == 0) {
        throw new IllegalArgumentException(
                        "Empty key passed to getDetails");
    }
    return book.get(key);
}
```



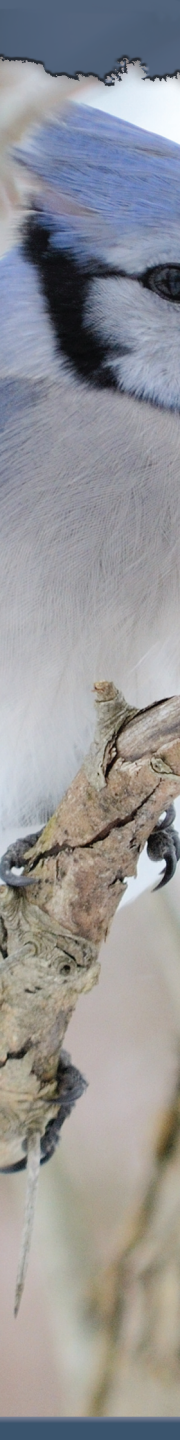
Preventing object creation

```
ContactDetails(String name, String phone, String address) {
    if (name == null) {
        name = "";
    }
    if (phone == null) {
        phone = "";
    }
    if (address == null) {
        address = "";
    }

    this.name = name.trim();
    this.phone = phone.trim();
    this.address = address.trim();

    if (this.name.length() == 0 && this.phone.length() == 0) {
        throw new IllegalStateException(
                "Either the name or phone must not be blank.");
    }
}
```



Exception handling

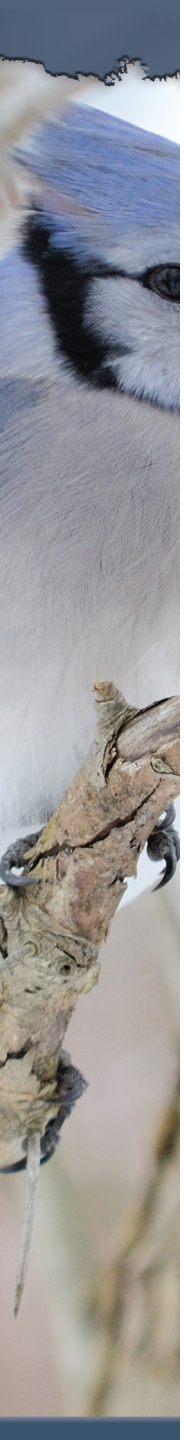
- Checked exceptions are meant to be caught and responded to.
- The compiler ensures that their use is tightly controlled.
  - In both server and client objects.
- Used properly, failures may be recoverable.



The throws clause

- Methods throwing a checked exception must include a throws clause:

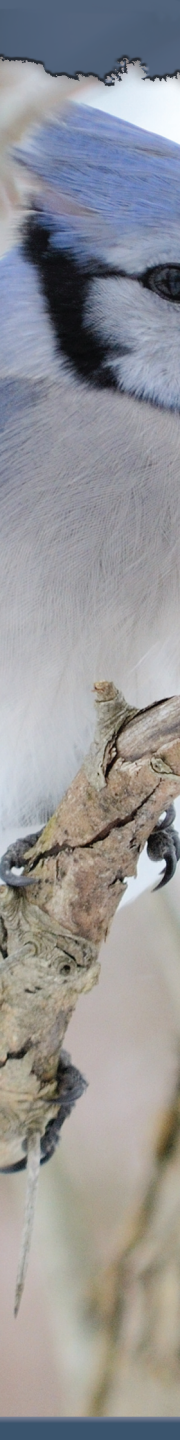
```
void saveToFile(String destinationFile)
    throws IOException
```



The try statement

- Clients catching an exception must protect the call with a try statement:

```
try {
    Protect one or more statements here.
} catch(Exception e) {
    Report and recover from the
    exception here.
}
```

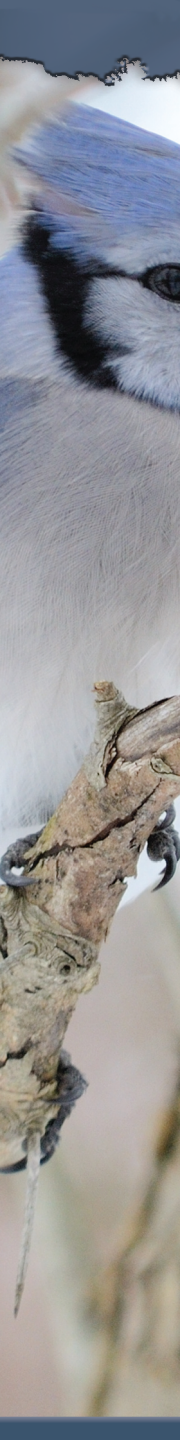


The try statement

1. Exception thrown from here

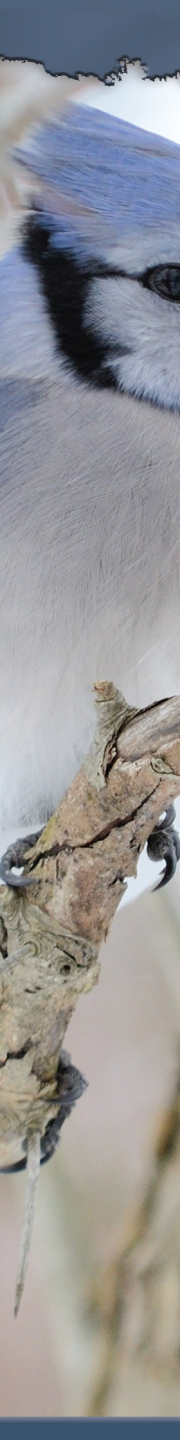
```
try {
    addressbook.saveToFile(filename);
    successful = true;
} catch(IOException e) {
    System.out.println("Unable to save to " + filename);
    successful = false;
}
```

2. Control transfers to here



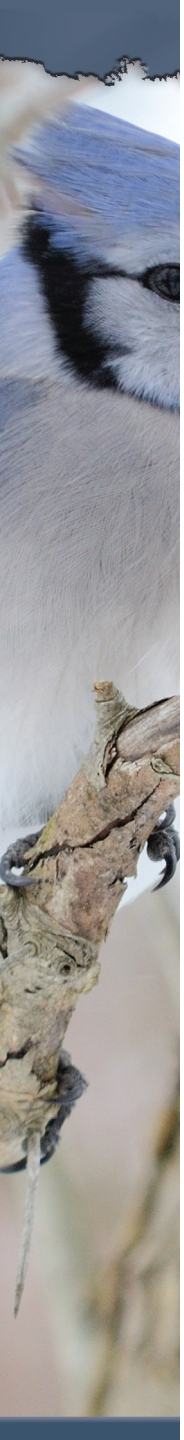
Catching multiple exceptions

```
try {
    ...
    ref.process();
    ...
} catch(EOFException e) {
    // Take action on an end-of-file exception.
    ...
} catch(FileNotFoundException e) {
    // Take action on a file-not-found exception.
    ...
}
```



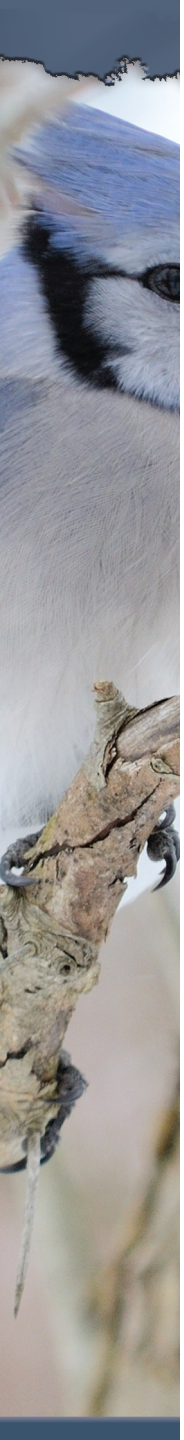
Multi-catch

```
try {
    ...
    ref.process();
    ...
} catch(EOFException | FileNotFoundException e) {
    // Take action appropriate to both types
    // of exception.
    ...
}
```



The finally clause

```
try {
    Protect one or more statements here.
} catch(Exception e) {
    Report and recover from the exception here.
} finally {
    Perform any actions here common to whether or
    not an exception is thrown.
}
```



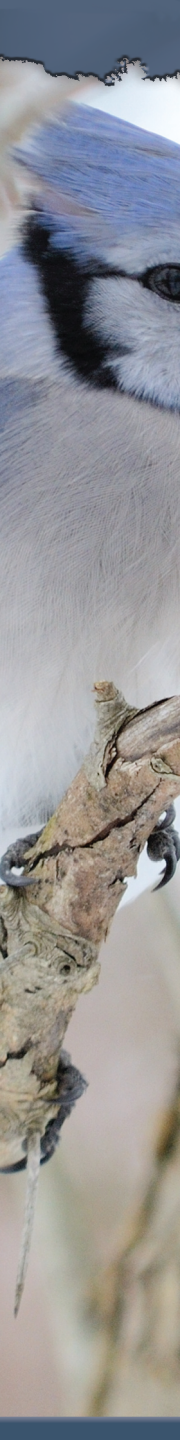
The finally clause

- A finally clause is executed even if a return statement is executed in the try or catch clauses.
- A uncaught or *propagated* exception still exits via the finally clause.

Defining new exceptions

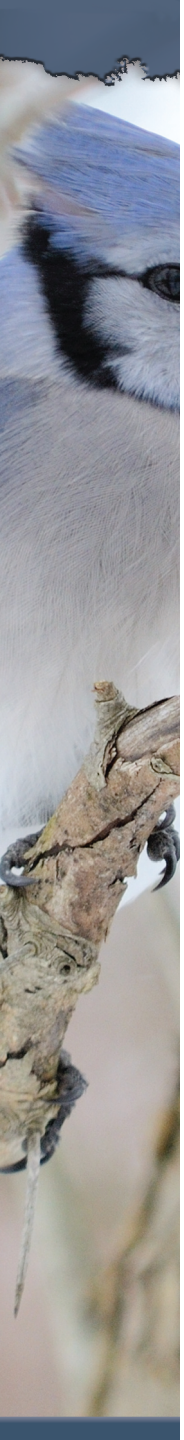
- Extend **`RuntimeException`** for an unchecked or **`Exception`** for a checked exception.
- Define new types to give better diagnostic information.
  - Include reporting and/or recovery information.

```
public class NoMatchingDetailsException extends Exception {
    private String key;

    public NoMatchingDetailsException(String key) {
        this.key = key;
    }

    public String getKey() {
        return key;
    }

    public String toString() {
        return "No details matching '" + key +
               "' were found.";
    }
}
```



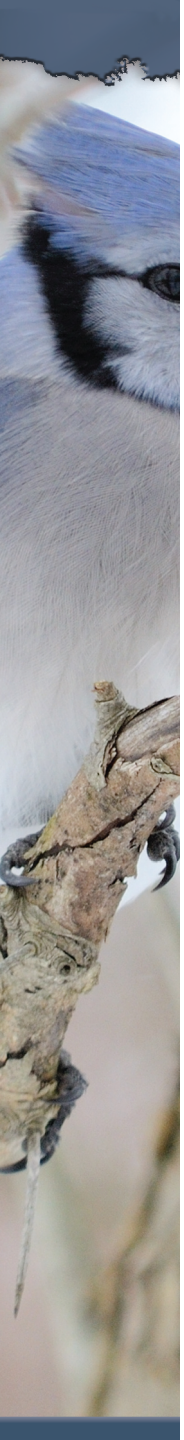
Assertions

- Used for *internal* consistency checks.
  - E.g. object state following mutation.
- Used during development and normally removed in production version.
  - E.g. via a compile-time option.
- Java has an *assert statement*.



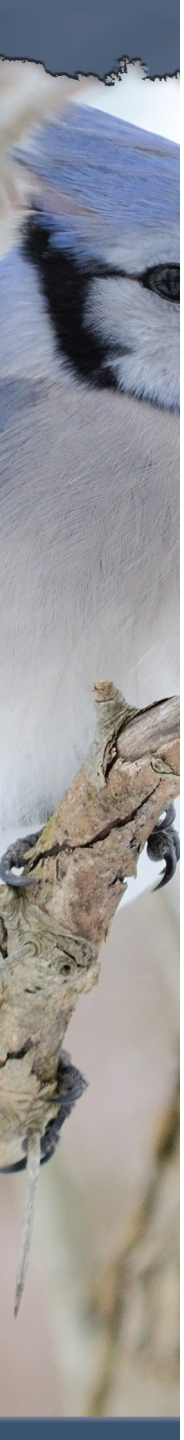
Java Assertion Statement

- Two forms available:
  - **`assert`** *boolean-expression*
  - **`assert`** *boolean-expression* **`:`** *expression*
- The *boolean-expression* expresses something that should be true at this point.
- An **`AssertionError`** is thrown if the expression evaluates to false.



Assert Statement

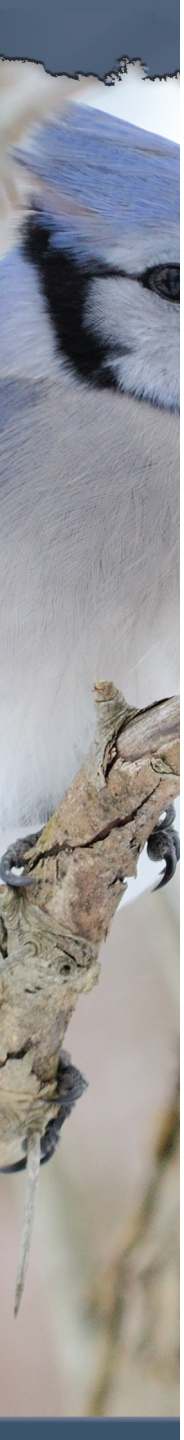
```
void removeDetails(String key) {
    if (key == null){
        throw new IllegalArgumentException("...");
    }
    if (keyInUse(key)) {
        ContactDetails details = book.get(key);
        book.remove(details.getName());
        book.remove(details.getPhone());
        numberOfEntries--;
    }
    assert !keyInUse(key);
    assert consistentSize() :
           "Inconsistent book size in removeDetails";
}
```



Guidelines for Assertions

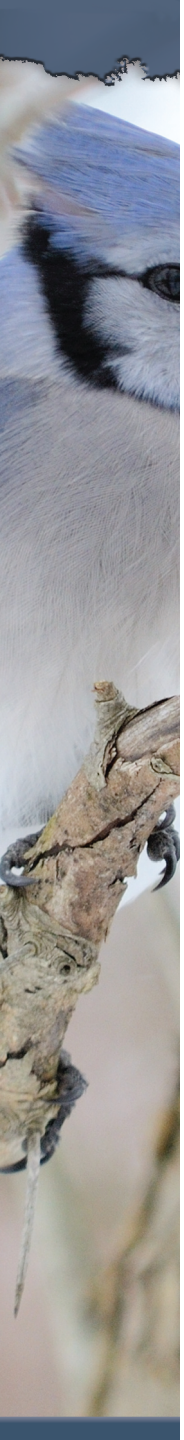
- They are *not* an alternative to throwing exceptions.
- Use for internal checks.
- Remove from production code.
- Don’t include normal functionality:

```
// Incorrect use:
assert book.remove(name) != null;
```



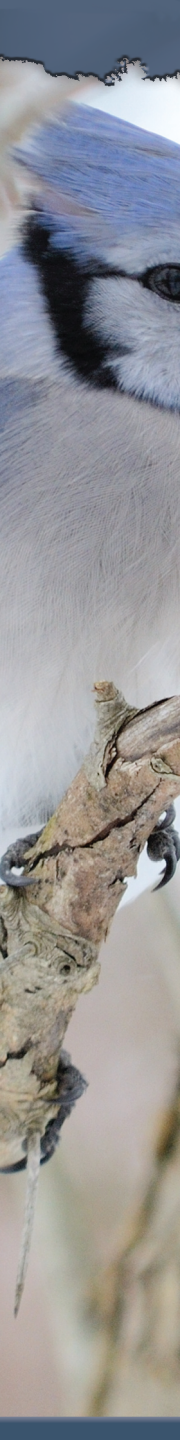
Error recovery

- Clients should take note of error notifications.
  - Check return values.
  - Don’t ‘ignore’ exceptions.
- Include code to attempt recovery.
  - Will often require a loop.



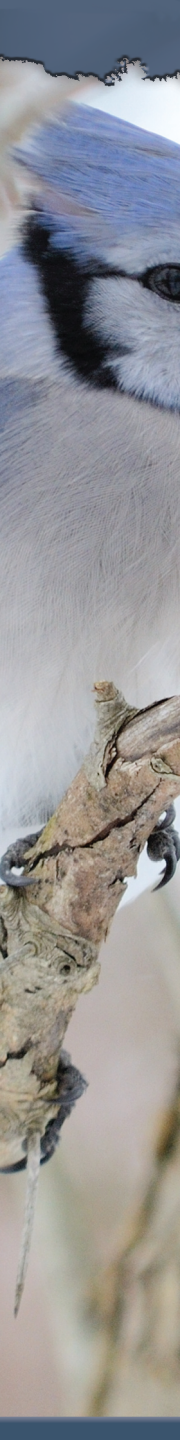
Attempting recovery

```
// Try to save the address book.
boolean successful = false;
int attempts = 0;
do {
    try {
        contacts.saveToFile(filename);
        successful = true;
    } catch(IOException e) {
        System.out.println("Unable to save to " + filename);
        attempts++;
        if(attempts < MAX_ATTEMPTS) {
            filename = an alternative file name;
        }
    }
} while(!successful && attempts < MAX_ATTEMPTS);

if (!successful) {
    Report the problem and give up;
}
```



Error avoidance

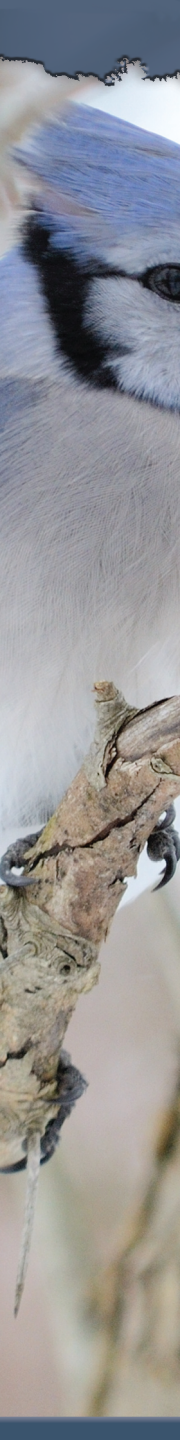
- Clients can often use server query methods to avoid errors.
  - More robust clients mean servers can be more trusting.
  - Unchecked exceptions can be used.
  - Simplifies client logic.
- May increase client-server coupling.



Avoiding an exception

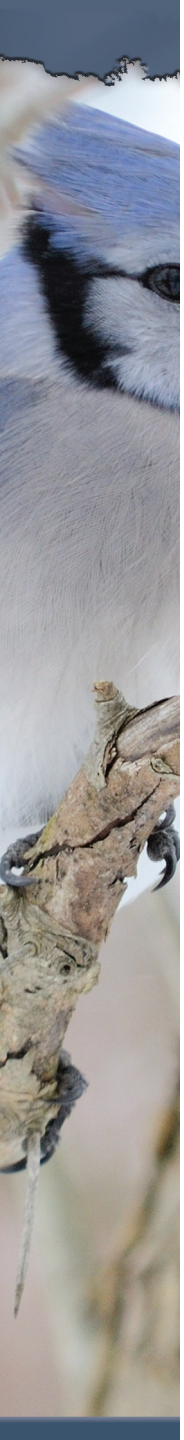
```
// Use the correct method to put details
// in the contacts list.
if (contacts.keyInUse(details.getName() ||
        contacts.keyInUse(details.getPhone()) {
    contacts.changeDetails(details);
} else {
    contacts.addDetails(details);
}
```

The **`addDetails`** method could now throw an *unchecked* exception.



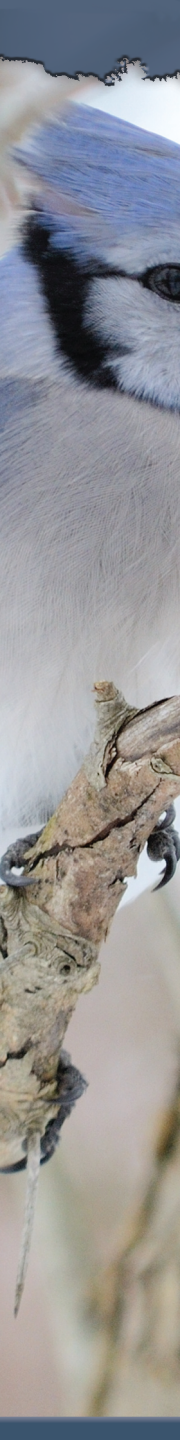
Review

- Runtime errors arise for many reasons.
  - An inappropriate client call to a server object.
  - A server unable to fulfill a request.
  - Programming error in client and/or server.



Review

- Runtime errors often lead to program failure.
- Defensive programming anticipates errors – in both client and server.
- Exceptions provide a reporting and recovery mechanism.



File-based input-output

- Input-output is particularly error-prone because it involves interaction with the external environment.
- The **`java.io`** package supports input-output.
- **`java.io.IOException`** is a checked exception.
- The **`java.nio`** packages.

IO*
(The March of Progress**

- **Pour affichage formaté : 123.45**
  - C

```
printf("%10.2f", x);
```

  - C++

```
cout << setw(10) << setprecision(2) << showpoint << x;
```

** Input / Output*

*** http://www.horstmann.com*

The March of Progress

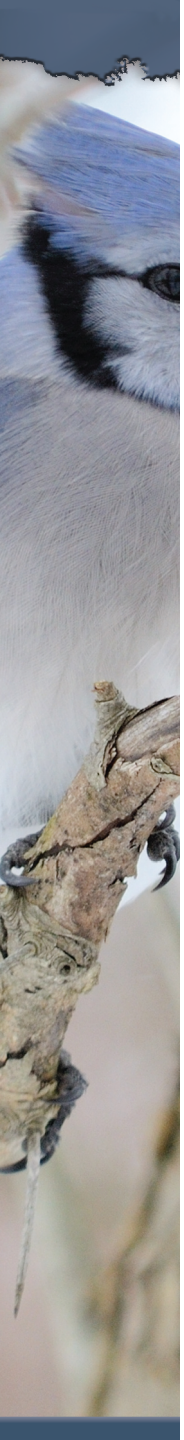
- Java <= 1.4

```
java.text.NumberFormat formatter =
   java.text.NumberFormat.getNumberInstance();
formatter.setMinimumFractionDigits(2);
formatter.setMaximumFractionDigits(2);
String s = formatter.format(x);
for (int i = s.length(); i < 10; i++)
   System.out.print(' ');
System.out.print(s);
```

IO
The March of Progress)

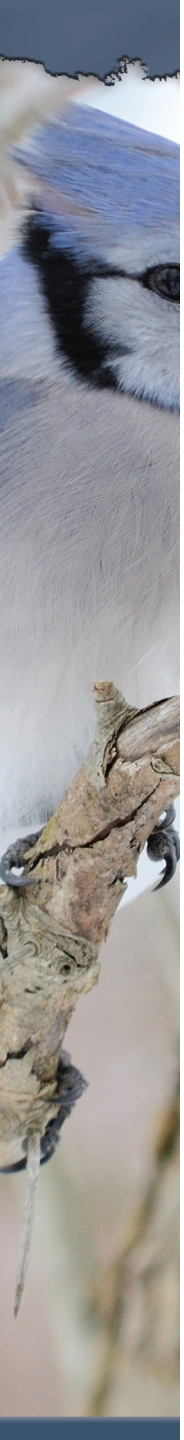
- Java 1.5

```
System.out.printf("%10.2f", x);
```



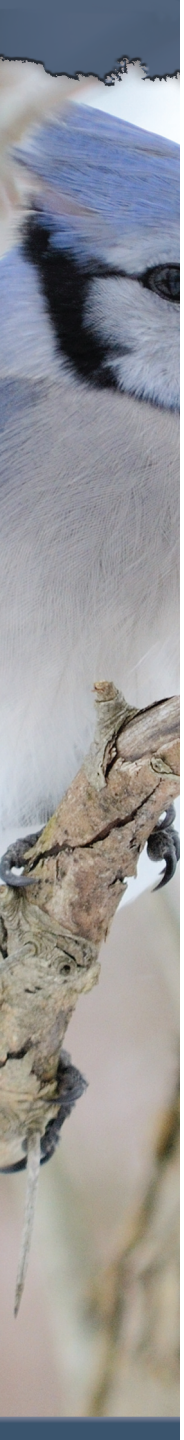
`File` and `Path`

- **`java.io.File`** provides information about files and folders/directories.
- **`java.nio.file.Path`** is a modern alternative.
- **`File`** is a class; **`Path`** is an interface.
- The **`Files`** and **`Paths`** (NB: plurals) classes are in **`java.nio.file`**.



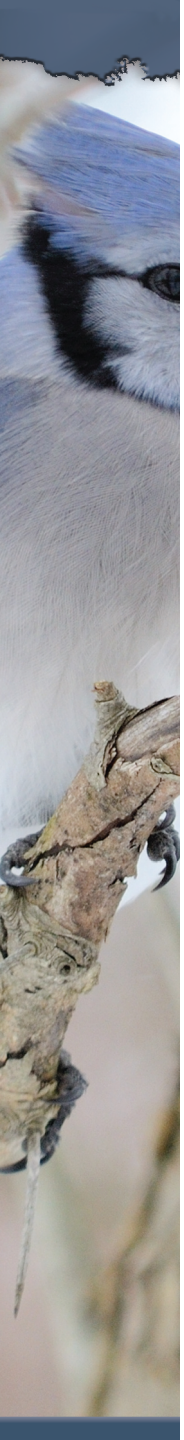
Readers, writers, streams

- Readers and writers deal with textual input.
  - Based around the **`char`** type.
- Streams deal with binary data.
  - Based around the **`byte`** type.
- The *address-book-io* project illustrates textual I/O.



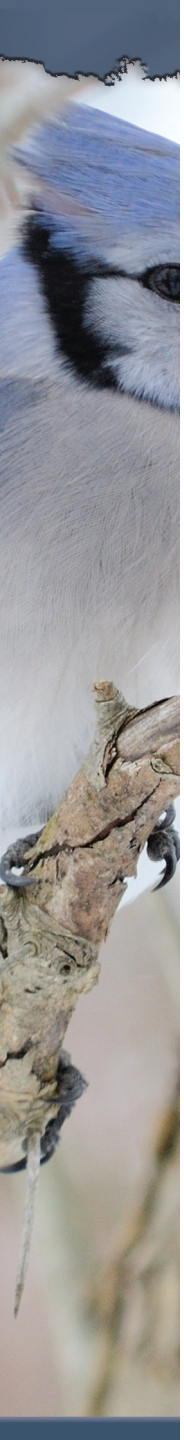
File output

- The three stages of file output.
  - Open a file.
  - Write to the file.
  - Close the file.
- Failure at any point results in an **`IOException`**.
- Use **`FileWriter`** for text files.



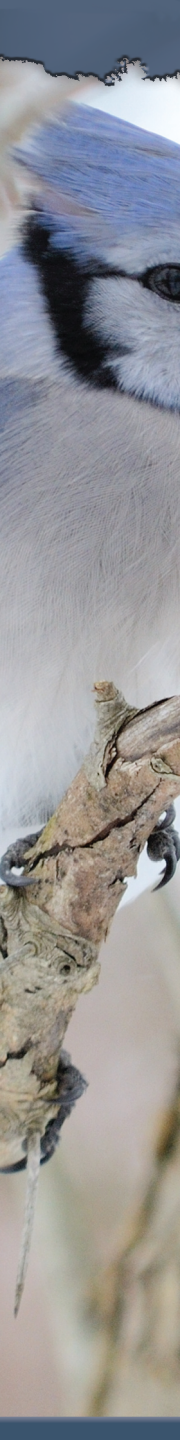
Text output to file

```
try {
    FileWriter writer = new FileWriter("name of file");
    while (there is more text to write) {
        ...
        writer.write(next piece of text);
        ...
    }
    writer.close();
} catch(IOException e) {
    something went wrong with accessing the file
}
```



Try-with-resource

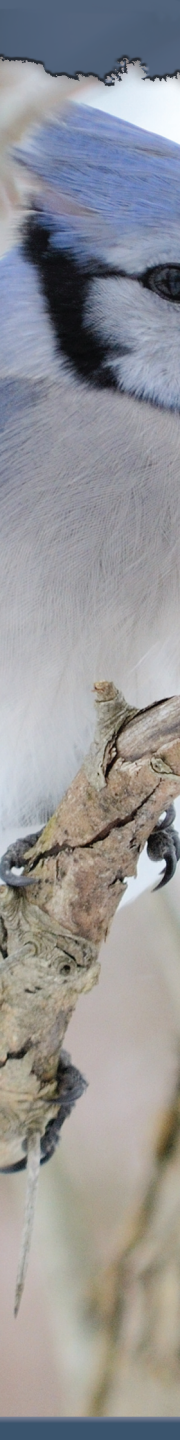
- Used for ensuring ‘resources’ are closed after use.
- Removes need for explicit closure on both successful and failed control flows.
- Also known as ‘automatic resource management’ (ARM).



Try-with-resource

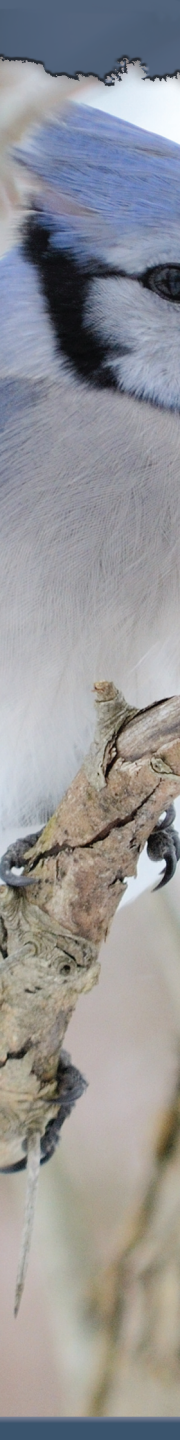
```
try (FileWriter writer = new FileWriter("name of file")) {
    while(there is more text to write) {
        ...
        writer.write(next piece of text);
        ...
    }
} catch (IOException e) {
    something went wrong with accessing the file
}
```

No close() call required in either clause.
See *weblog-analyzer*.



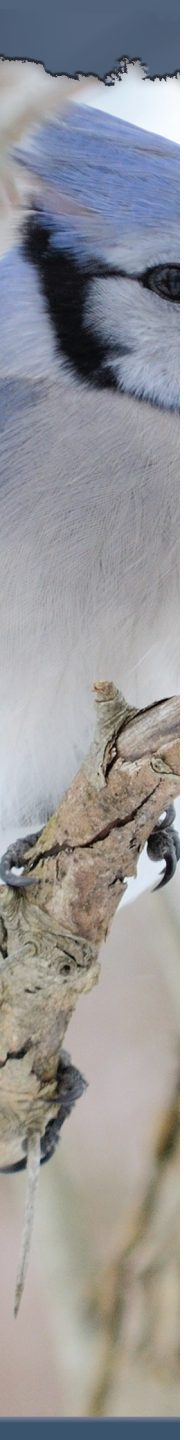
Text input from file

- Use **`BufferedReader`** for line-based input.
  - Open a file.
  - Read from the file.
  - Close the file.
- Failure at any point results in an **`IOException`**.



Text input from file

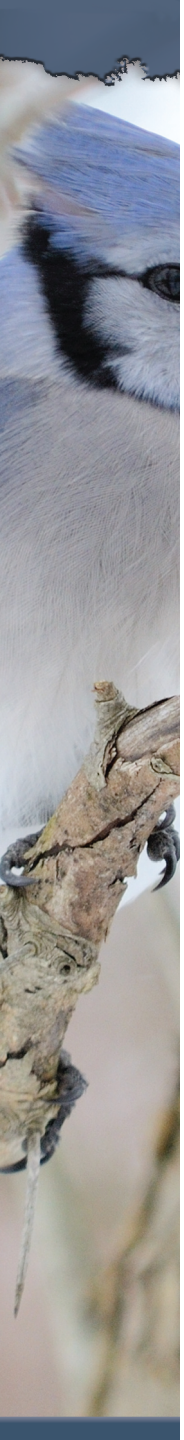
- **`BufferedReader`** created via static **`newBufferedReader`** method in the **`java.nio.file.Files`** class.
- Requires a **`Charset`** from **`java.nio.charset`**, e.g.:
  - **`"US-ASCII"`**
  - **`"ISO-8859-1"`**



Text input from file

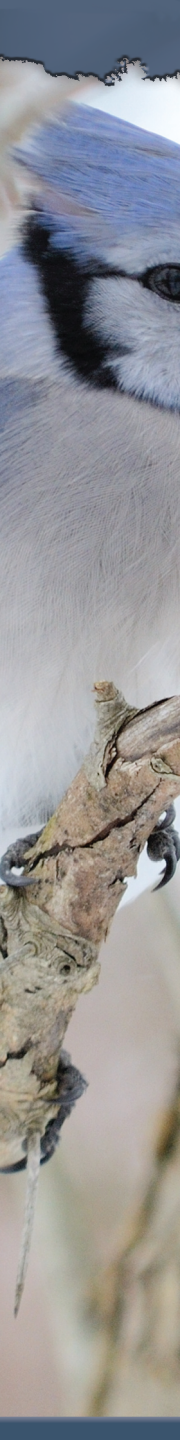
```
Charset charset =
        Charset.forName("US-ASCII");
Path path = Paths.get("file");
try (BufferedReader reader =
      Files.newBufferedReader(path, charset)) {
    use reader to process the file
} catch (FileNotFoundException e) {
   deal with the exception
} catch (IOException e) {
   deal with the exception
}
```

See tech-support-io



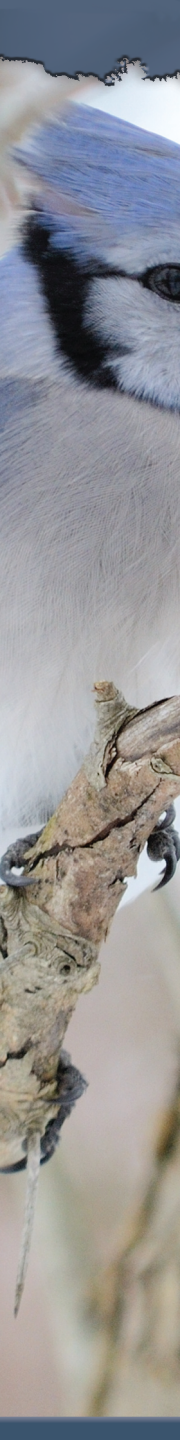
Text input from the terminal

- **`System.in`** maps to the terminal:
  - Its type is **`java.io.InputStream`**
- It is often wrapped in a **`java.util.Scanner`**.
- **`Scanner`** with **`File`** is an alternative to **`BufferedReader`**.



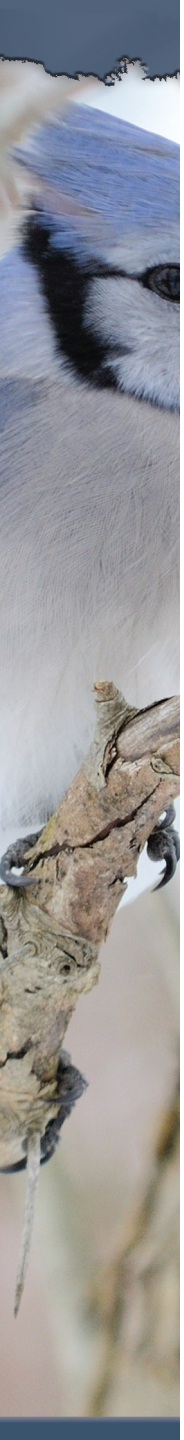
Scanner: parsing input

- **`Scanner`** supports *parsing* of textual input.
  - **`nextInt`**, **`nextLine`**, etc.
- Its constructors support **`String`**, **`File`** and **`Path`** arguments.



Review

- Input/output is an area where errors cannot be avoided.
- The environment in which a program is run is often outside a programmer's control.
- Exceptions are typically *checked*.



Review

- Key classes for text input/output are **`FileReader`**, **`BufferedReader`**, **`FileWriter`** and **`Scanner`**.
- Binary input/output involves **`Stream`** classes.
- The **`Path`** interface is an alternative to **`File`**.
- try-with-resource simplifies closing.