# JAVA

## Source files

# Unicode

- programs ~ Unicode
  - comments, identifiers, char and string constants
  - the rest is in ASCII (<128)
    - or Unicode escape sequences < 128
- Unicode escape sequences
  - `\uxxxx`
  - `\u0041 .... A`
- the expanded sequence is not used for following ones
  - `\u005cu005a` results in six chars
    - `\ u 0 0 5 a`

# Source code file processing

1. translation of unicode escape sequences (and all of the source code) into a sequence of unicode chars
2. the sequence from (1) is translated into a sequence of chars and line-terminating chars
3. the sequence from (2) is translated into a sequence of input tokens (without white-spaces and comments)

- line-terminating chars
  - CR LF
  - CR
  - LF

# Test

```
public class Test {
  public static void main(String[] argv) {
    int i = 1;
    i += 1; // is the same as \u000A i = i + 1;
    System.out.println(i);
  }
}
```

- Program prints out:
  a) 1
  b) 2
  c) 3
  d) cannot be compiled
  e) a runtime exception

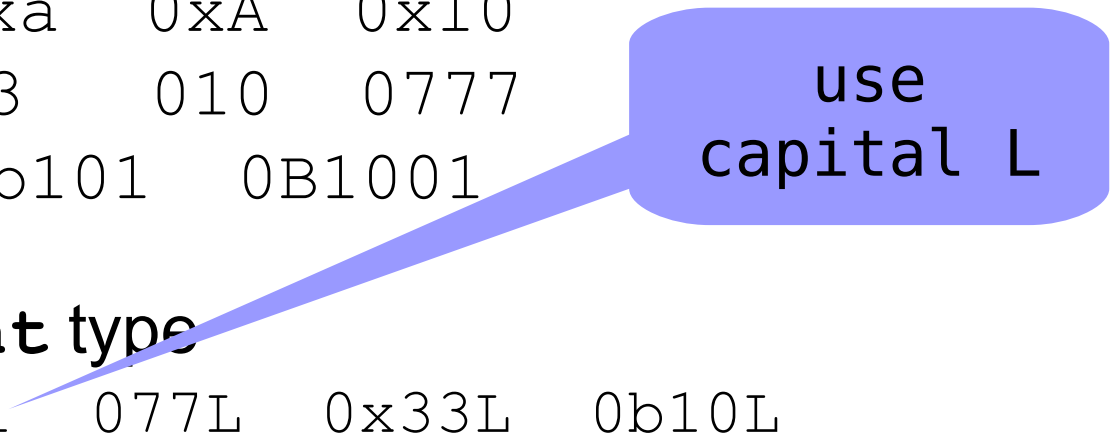
# Encoding

- argument of javac `-encoding`
  - encoding of source files
  - without it – default encoding

- in IDE – typically a project property

# Literals

- integer literals
  - decimal … `0  1  23  -3`
  - hexadecimal ... `0xa  0xA  0x10`
  - octal … `03  010  0777`
  - binary ... `0b101  0B1001`
    - since Java 7
  - by default of the **`int`** type
    - **`long`** ... `1L  33l  077L  0x33L  0b10L`
- floating-point literals
  - `0.0  2.34  1.  .4  1e4  3.2e-4`
  - by default **`double`**
    - **`float`** ... `2.34f  1.F  .4f  1e4F  3.2e-4f`
- boolean literals
  - `true, false`



# Literals

- underscores in numerical literals
  - since Java 7
  - for better readability

```
1234_5678_9012_3456L
999_99_9999L
3.14_15F
0xFF_EC_DE_5E
0xCAFE_BABE
0x7fff_ffff_ffff_ffffL
0b0010_0101
0b11010010_01101001_10010100_10010010
```

# Literals

- char literals
  - `'a'  '%'  '\\'  '\''  '\u0045'  '\123'`
  - escape sequences

| | | |
|---|---|---|
| `\b` | `\u0008` | back space |
| `\t` | `\u0009` | tab |
| `\n` | `\u000A` | line feed |
| `\f` | `\u000C` | form feed |
| `\r` | `\u000D` | carriage return |
| `\"` | `\u0022` | |
| `\'` | `\u0027` | |
| `\\` | `\u005c` | |

# Literals

- String literals
  - `""  "\""  "this is a String"`
- `null` literal

# Identifiers

- identifier
  - name of class, method, field,...

- allowed characters
  - letters and digits
    - digit cannot be first character
  - special characters only _ and $
    - standalone underscore is not allowed
      - since Java 9

# Identifiers

- naming
  - packages – lowercase letters
    - `cz.cuni.mff.java`
  - class, interface – `ListArray, InputStreamReader`
    - composed words
    - mixed case
    - first letter capital
  - methods, fields – `getSize, setColor`
    - composed words
    - mixed case
    - first letter lower case
  - constants – `MAX_SIZE`
    - all letters upper case
    - composing via underscore

# Assertions

# Assertion

- since Java 1.4
- the statement with a **`boolean`** expression
- a developer supposes that the expression is always satisfied (evaluates to **true**)
- if it is evaluated to **false** -> error
- intended for debugging
  - assertions can be enabled or disable
    - for whole program or for several classes only
  - disabled by default

  - ***must not*** have any side effects

# Usage

```
assert Expression1;
assert Expression1 : Expression2;
```

- disabled assertions – the statement does nothing
  - expressions are not evaluated
- enabled assertions
  - Expression1 is **true** – program continues normally
  - Expression1 is **false**
    - Expression2 is presented
      `throw new AssertionError(Expression2)`
    - Expression2 is not presented
      `throw new AssertionError()`

# Enabling and disabling

- arguments for the virtual machine
- enabling
  -ea[:PackageName...|:ClassName]
  -enableassertions[:PackageName...|:ClassName]
- disabling
  -da[:PackageName...|:ClassName]
  -disableassertions[:PackageName...|:ClassName]
- without class or package – for all classes
- assertions in "system" classes
  -esa | -enablesystemasserions
  -dsa | -disablesystemasserions

- decision whether the assertions are enabled, is evaluated just once during initialization of a class (before anything is called/used on this class)

# java.lang.AssertionError

- extends `java.lang.Error`
- constructors

```
AssertionError()
AssertionError(boolean b)
AssertionError(char c)
AssertionError(double d)
AssertionError(float f)
AssertionError(int i)
AssertionError(long l)
AssertionError(Object o)
```

# Examples

- invariants

```
if (i%3 == 0) {
   ...
} else if (i%3 == 1) {
   ...
} else {
   assert i%3 == 2;
   ...
}
```

# Examples

- "unreachable places" in a program

```
class Directions {
  public static final int RIGHT = 1;
  public static final int LEFT = 2;
}
...
switch(direction) {
  case Directions.LEFT:
    ...
  case Directions.RIGHT:
    ...
  default:
    assert false;
}
```

# Examples

- preconditions
  - testing arguments of `private` methods

```
private void setInterval(int i) {
  assert i>0 && i<=MAX_INTERVAL;
  ...
}
```

  - unrecommended for testing arguments of public methods

```
public void setInterval(int i) {
  if (i<=0 && i>MAX_INTERVAL)
    throw new IllegalArgumentException();
  ...
}
```

# Examples

- postconditions

```
public String foo() {
   String ret;
   ...
   assert ret != null;
   return ret;
}
```

# Generics

# Introduction

- since Java 5
- similar to the generics in C#
- typed arguments
- goal
  - clear code
  - type safety

# Motivational example

- without generics (<=Java 1.4)

```
List myIntList = new LinkedList();
myIntList.add(new Integer(0));
Integer x = (Integer) myIntList.iterator().next();
```

- >= Java 5

```
List<Integer> myIntList = new LinkedList<Integer>();
myIntList.add(new Integer(0));
Integer x = myIntList.iterator().next();
```

  - no explicit casting
  - type checks during compilation

# Definition of generics

```
public interface List<E> {
  void add(E x);
  Iterator<E> iterator();
  E get(int i);
}
public interface Iterator<E> {
  E next();
  boolean hasNext();
}
```

- `List<Integer>` can be seen as

```
public interface IntegerList {
  void add(Integer x);
  Iterator<Integer> iterator();
}
```

  - but in reality no such code exists

# Compilation of gen. types

- to simplify – during compilation, all information about generic types are erased
  - "erasure"

```
List<Integer> myIntList = new LinkedList<Integer>();
myIntList.add(new Integer(0));
Integer x = myIntList.iterator().next();
```

- at runtime, it behaves as

```
List myIntList = new LinkedList();
myIntList.add(new Integer(0));
Integer x = (Integer) myIntList.iterator().next();
```

# Compilation of gen. types

- always the same class, even if parametrized by anything
  - `LinkedList<String>`
  - `LinkedList<Integer>`
  - `LinkedList<Foo>`
  - …
- just a single byte-code

- **primitive types cannot be used as type parameters**
  - ~~List<int>~~

# New instances

```
ArrayList<Integer> list = new ArrayList<Integer>();
ArrayList<ArrayList<Integer>> list2 =
new ArrayList<ArrayList<Integer>>();
HashMap<String, ArrayList<ArrayList<Integer>>> h =
new HashMap<String, ArrayList<ArrayList<Integer>>>();
```

- since Java 7 (“diamond” operator)

```
ArrayList<Integer> list = new ArrayList<>();
ArrayList<ArrayList<Integer>> list2 =
new ArrayList<>();
HashMap<String, ArrayList<ArrayList<Integer>>> h =
new HashMap<>();
```

# Type relations

- no changes in typed arguments are allowed

```
List<String> ls = new ArrayList<String>();
List<Object> lo = ls;
```

```
lo.add(new Object());
String s = ls.get(0);
```

error – assigning `Object` to `String`

- second line causes compilation error

# Type relations

- example – printing all elements in a collection

  <= Java 1.4

```
void printCollection(Collection c) {
  Iterator i = c.iterator();
  for (k = 0; k < c.size(); k++) {
   System.out.println(i.next());
  }
}
```

  naive attempt in Java 5

```
void printCollection(Collection<Object> c) {
  for (Object e : c) {
    System.out.println(e);
  }
}
```

  - does not work (see the previous example)

# Type relations

- `Collection<Object>` is not supertype of all collections
- correctly

```
void printCollection(Collection<?> c) {
  for (Object e : c) {
    System.out.println(e);
  }
}
```

- `Collection<?>` is supertype of all collections
  - collection of unknown
  - any collection can be assigned there
- BUT – to `Collection<?>` nothing can be added

```
Collection<?> c = new ArrayList<String>();
c.add(new Object());
```

<= compilation error

- `get()` can be called – return type is `Object`

# Type relations

- ? - wildcard
- bounded wildcard

```
public abstract class Shape {
  public abstract void draw(Canvas c);
}
public class Circle extends Shape { ... }
public class Canvas {
  public void drawAll(List<Shape> shapes) {
    for (Shape s:shapes) {
      s.draw(this)
    }
}}
```

- can draw lists of the type `List<Shape>` only but not e.g. `List<Circle>`

# Type relations

- solution – bounded ?

```
public void drawAll(List<? extends Shape> shapes){
   for (Shape s:shapes) {
      s.draw(this)
}}
```

- but still you cannot add to this List

```
shapes.add(0, new Rectangle());
```
compilation error

# Generic methods

```
static void fromArrayToCollection(Object[] a,
  Collection<?> c) {
  for (Object o : a) {
    c.add(o);
  }
}
```

← compilation error

```
static <T> void fromArrayToCollection(T[] a,
  Collection<T> c) {
  for (T o : a) {
    c.add(o);
  }
}
```

← OK

# Generic methods

- usage
  - the compiler determines actual types automatically

```
Object[] oa = new Object[100];
Collection<Object> co = new ArrayList<Object>();
fromArrayToCollection(oa, co); // T → Object
String[] sa = new String[100];
Collection<String> cs = new ArrayList<String>();
fromArrayToCollection(sa, cs); // T → String
fromArrayToCollection(sa, co); // T → Object
```

- bounds can be used with methods also

```
class Collections {
  public static <T> void copy(List<T> dest, List<?
  extends T> src){...}
}
```

# Array and generics

- array of generics
  - can be declared
  - cannot be instantiated

```
List<String>[] lsa = new List<String>[10];
List<?>[] lsa = new List<?>[10];
```

wrong

OK + warning

- why? arrays can be cast to Object

```
List<String>[] lsa = new List<String>[10];
Object[] oa = (Object[]) lsa;
List<Integer> li = new ArrayList<Integer>();
li.add(new Integer(3));
oa[1] = li;
String s = lsa[1].get(0);
```

ClassCastException

# “Old” and “new” code

- “old” code without generics

```
public class Foo {
  public void add(List lst) { ... }
  public List get() { ... }
}
```

- “new” code that uses the “old” one

```
List<String> lst1 = new ArrayList<String>();
Foo o = new Foo();
o.add(lst1);    ← OK - List corresponds to  List<?>
List<String> lst2 = o.get(); ← compilation warning
```

# “Old” and “new” code

- “new” code with generics

```
public class Foo {
  public void add(List<String> lst) { ... }
  public List<String> get() { ... }
}
```

- “old” code that uses the “new” one

```
List lst1 = new ArrayList();
Foo o = new Foo();
o.add(lst1);    ← compilation warning
List lst2 = o.get(); ← OK - List  corresponds to  List<?>
```

# Additional type relations

```
class Collections {
  public static <T> void copy(List<T> dest, List<?
  extends T> src){...}
}
```

- actual declaration is

```
class Collections {
  public static <T> void copy(List<? super T> dest,
  List<? extends T> src){...}
}
```