Programming languages

- The programming language is the notation that defines the syntax and semantics of programs.
- Our programming language is Eiffel.
- There are many programming languages, some “general”, some “specialized”.
- Programming languages are artificial notations, designed for a specific purpose (programming).

Object technology

- Source: Simula 67 language, Oslo, mid-sixties.
- Spread very slowly in the seventies.
- Smalltalk, developed at Xerox PARC in late seventies, made O-O hip by combining it with visual technologies.
- First OOPSLA conference in 1986 revealed O-O to the masses.
- Spread quickly in 1990s through O-O languages like Objective C, C++, Eiffel, Java, C#, as well as O-O tools, O-O databases, O-O analysis...
- Largely accepted today.
- Non O-O approaches are also called “procedural”.
About Eiffel

First version 1985, constantly refined and improved since
Fully O-O; not a hybrid with other approaches
Focus: software quality, especially reliability, extendibility, reusability
Emphasizes simplicity
Used for mission-critical projects in industry
Based on concepts of “Design by Contract”.
Implementations: from Eiffel Software, Object Tools, University of Nancy (“SmartEiffel”)
International standard: ECMA

Some Eiffel-based projects

Axa Rosenberg
Investment management: from $2 billion to >$100 billion
2 million lines
Chicago Board of Trade
Price reporting system
Eiffel + CORBA + Solaris + Windows + ...
Xontech (for Boeing)
Large-scale simulations of missile defense
Swedish social security: accident reporting & management etc.

So, why use Eiffel?

- Simple, clean O-O model
- Enables you to focus on concepts, not language
- Little language “baggage”
- Development environment (EiffelStudio)
- Portability: Windows / Linux / Mac / VMS & others
- Realism: not an “academic” language

Prepares you to learn other O-O languages, e.g. C++, Java, C# if you need to

Course series (3rd year and up): “Languages in Depth”.
Currently C#, Java and Eiffel.
Instructions

Basic operations are called instructions.
Our first example had five instructions:

- Paris\_display
- Louvre\_spotlight
- Line8\_highlight
- Route1\_animate
- Console\_show(Route1\_origin)

Successive instructions

You may write them one after the other without semicolons:

- Paris\_display
- Louvre\_spotlight
- Line8\_highlight
- Route1\_animate
- Console\_show(Route1\_origin)

You may use semicolons to separate them:

- Paris\_display; Louvre\_spotlight;
- Line8\_highlight; Route1\_animate;
- Console\_show(Route1\_origin);

Style rule

Write one instruction per line.
Omit semicolons.

If you ever feel it’s clearer to have more than one instruction on a line (e.g. in a paper report) use semicolons:

\[ f(x) : g(y) \]
Intro. to Programming, lecture 3: Dealing with objects II

Expressions

An expression is a program element denoting possible run-time values.

Examples:

- Console.show(Route1.origin)

Also, standard mathematical expressions: \( a + b \).

Definitions

In program texts:

- An instruction denotes a basic operation to be performed during the program’s execution.
- An expression denotes a value used by an instruction for its execution.

Syntax and semantics

An expression, e.g. Route1.origin is not a value but denotes future run-time values

An instruction, e.g. Paris.display denotes an operation to be executed at run time.
Syntax and semantics

The syntax of a program is the structure and form of its text.
The semantics of a program is the set of properties of its potential executions.

Syntax is the way you write a program: characters grouped into words grouped into bigger structures.
Semantics is the effect you expect from this program.

Syntax and semantics

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Command</td>
</tr>
<tr>
<td>Expression</td>
<td>Query</td>
</tr>
</tbody>
</table>

Syntax structure of a class

```
class C1
inherit C2
feature
  explore is
    -- Show city info.
    do
      Paris display
      Louvre spotlight
    end
end
```
Programming vs natural languages: similarities

- Overall form of texts: succession of words
- Distinction between syntax and semantics
- Some words predefined, others user-defined

Programming vs natural languages: differences

- Power of expression much higher with natural languages
- Precision much higher in programming languages

Programming languages are extensions of mathematical notation

Comments are bits of natural language appearing in programs

Style rule

Use words from natural language (e.g. English, German) for the names you define

Examples:
- Paris, Route 1
- Feature names: show, origin

Eiffel keywords are English words: inherit, do, end...

All single words except elseif
Intro. to Programming, lecture 3: Dealing with objects II

Syntax structure of a class

Specimens

Specimen: a syntactic element; for example:
- A class name, e.g. `PREVIEW`
- An instruction, e.g. `Paris.display`
- Any of the boxes on the previous page
- The whole class text!
Specimens may be nested (or embedded)

Delimiters, such as keywords (`do`, `end`, ...), semicolons, periods `.` etc. are not specimens.

Specimens and constructs

A construct is a certain type of syntactic element
Every syntactic element is a specimen of a certain construct
For example:
- `display` is a specimen of the construct `Feature_name`
- The class text as a whole is a specimen of the construct `Class`
Syntax structure

Other representation: abstract syntax tree

Abstract syntax tree

Shows the syntax structure.
Specimens only: no keywords or other delimiters
(That's why it's abstract)
Uses the notion of tree as in organizational charts of companies.
Trees that grow down...

Trees in computer science

- Represent hierarchical or nested structures
- Similar to e.g. organizational charts (previous page)
- Pictured top-down or left-to-right

Tree properties

Tree rules:
- Every branch connects two nodes
- Every node can have any number (including none) of outgoing branches
- Every node has at most one incoming branch

Types of node:
- Root: node with no incoming branch
- Leaf: node with no outgoing branches
- Internal node: neither root nor leaf

A tree has exactly one root (Otherwise it would be a forest)
Abstract syntax tree

- Root represents overall specimen (outermost rectangle)
- Internal nodes (nonterminals) represent substructures containing specimens themselves
- Leaves (terminals) represent specimens with no more nesting

The syntax of a programming language is defined by a set of constructs and the structure of these constructs.

Syntax structure

class PREVIEW inherit TOURISM

feature explore is
  -- Show city info and route.
  do
    Paris display
    Louvre spotlight
  end
end
The lower level: lexical structure

The basic elements of a program text are **tokens**:

- **Terminals**
  - **Identifiers**: names chosen by the programmer, e.g., `Paris` or `display`
  - **Constants**: self-explanatory values, e.g., `34`

- **Keywords**, e.g., `class`

- **Special symbols**: colon, `•` of feature calls.

Tokens define the language's **lexical structure**.

---

Three levels of description

Semantic rules define the effect of programming satisfying the syntax rules.

Syntax rules define how to make up specimens out of tokens satisfying the lexical rules.

Lexical rules define how to make up tokens out of characters.

---

Lexical rule for identifiers

**Identifiers**

An identifier starts with a letter, followed by zero or more characters, each of which may be:

- A letter.
- A digit (0 to 9).
- An underscore character `•`.

You may choose your own identifiers as you please, excluding keywords.
**Style rules**

- Always choose identifiers that clearly identify the intended role.
- For features, use full names, not abbreviations.
- For multi-word identifiers, use underscores:
  ```
  bus_station
  ```
- Use all upper case for classes:
  ```
  PREVIEW
  ```

**What we have seen in this lecture**

- Programming language concepts
- Eiffel basics
- Syntax (including lexical level) vs semantics
- Trees
- Tree terminology: root, leaf, node...
- Abstract Syntax Trees (AST)
- Basic lexical elements
- Basic style rules

**What to do for next week**

Read chapters 1 to 5 of *Touch of Class*

Make sure you know all the terminology introduced so far.
End of lecture 3