Lecture 3: Language constructs for modularity and information hiding

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Overview

Review of modularity and information hiding (discussed in previous lecture)
Information hiding mechanisms in Eiffel
Information hiding mechanisms in Java
Comparison: Eiffel vs. Java
Information hiding mechanisms in C#
Modularity and information hiding in Ada 83
Wrap-up
Modularity

Reusability + Extendibility

Some principles of modularity:

- Decomposability
- Composability
- Continuity
- Information hiding
- The open-closed principle
- The single choice principle
Information hiding

Underlying question: how does one “advertise” the capabilities of a module?

Every module should be known to the outside world through an official, “public” interface.

The rest of the module’s properties comprises its “secrets”.

It should be impossible to access the secrets from the outside.
Information Hiding Principle

The designer of every module must select a subset of the module's properties as the official information about the module, to be made available to authors of client modules.
How to ensure information hiding

NOT through management or marketing policies
BUT through language rules
Wrapping data and routines within classes in combination with information hiding is often called “encapsulation.” However, “encapsulation” is often used as a synonym for information hiding.
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Possible client privileges in Eiffel

If class \( A \) has an attribute \( \text{att} : \text{SOME\_TYPE} \), what may a client class \( C \) with \( a : A \) do with \( a \cdot \text{att} \)?

The attribute may be:

- Secret
- Read-only
- Read, restricted write
- Full write

Modify through \( a \cdot \text{some\_procedure} \)
Modify through \( a \cdot \text{set\_att}(v) \)

\( a \cdot \text{att} \) invalid
\( a \cdot \text{att} \) permitted in \( C \) (for access)
Abstraction and client privileges

If class \( A \) has an attribute \( \texttt{att : SOME\_TYPE} \), what may a client class \( C \) with
\[
\texttt{a : A}
\]
do with \( \texttt{a \cdot att} \)?

Read access if attribute is exported

- \( \texttt{a.att} \) is an expression.
- An assignment \( \texttt{a.att := v} \) would be syntactically illegal!

(It would assign to an expression, like \( \texttt{x + y := v} \).)
Applying abstraction principles

Beyond read access: full or restricted write, through exported procedures.

Full write privileges: \textit{set\_attribute} procedure, e.g.

\begin{verbatim}
set_temperature (u: REAL) is
  -- Set temperature value to \textit{u}.
  do
    temperature := u
  ensure
    temperature_set: temperature = u
  end
\end{verbatim}

Client will use e.g. \texttt{x.set\_temperature} (21.5).
Other uses of a setter procedure

\textit{set_temperature} (u : \texttt{REAL}) \textbf{is}

\begin{verbatim}
  -- Set temperature value to u.

  require

  not_under_minimum: u >= -273
  not_above_maximum: u <= 2000

  do

  temperature := u
  update_database

  ensure

  temperature_set: temperature = u

  end
\end{verbatim}
Having it both ways

Make it possible to call a setter procedure

\[ \text{temperature: REAL } \text{assign set_temperature} \]

Then the syntax

\[ x.\text{temperature} := 21.5 \]

is accepted as a shorthand for \[ x.set\_temperature(21.5) \]

Retains contracts etc.
Status of calls in a client with \texttt{a1: A}:

- \texttt{a1.f, a1.g}: valid in any client

- \texttt{a1.h}: invalid everywhere (including in \texttt{A}'s own text!)

- \texttt{a1.j}: valid only in \texttt{B, C} and their descendants (not valid in \texttt{A}!)

- \texttt{a1.m}: valid in \texttt{B, C} and their descendants, as well as in \texttt{A} and its descendants
**LINKABLE** exports its features to **LINKED_LIST**

- Does not export them to the rest of the world
- Clients of **LINKED_LIST** don't need to know about **LINKABLE** cells.
Exporting selectively

class LINKABLE[G]

feature {LINKED_LIST}

put_right(...) is do ... end

right: G is do ... end

...

der

Information hiding

Information hiding only applies to use by clients, using dot notation or infix notation, as with \texttt{a1.f} (\textbf{Qualified} calls).

\textbf{Unqualified} calls (within class) not subject to information hiding:

```plaintext
class A feature {NONE}
    h is ... do ... end
feature
    f is
        do
            ...; h; ... 
        end
end
```
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Access specifiers (placed in front of each definition for each member of the class):

- **public**
- **protected**
- **Package access (no keyword)**
- **private**
Access specifiers

public
- The member declared to be public is available to everyone

private
- No one can access that member except the class that contains that member, inside methods of that class

protected
- Member can be accessed by
  - Descendants of the class
  - Classes in the same package

Package access
- Default
- Also called “friendly”
- All other classes in current package have access to that member
- To all classes outside of current package, the member appears to be private
Access modifiers at the class level

Either `public` or default (no access modifier)

- **public**
  - Appears before the `class` keyword
  - Makes the class available to a client programmer

- **No access modifier**
  - Makes the class available only within the package

No `private` and `protected`!
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## Comparison: Eiffel vs. Java

<table>
<thead>
<tr>
<th>Access level</th>
<th>Eiffel</th>
<th>Java</th>
</tr>
</thead>
<tbody>
<tr>
<td>only current class</td>
<td>-</td>
<td>private</td>
</tr>
<tr>
<td>only current class and its descendants</td>
<td>feature {NONE}</td>
<td>-</td>
</tr>
<tr>
<td>current class + &quot;friends&quot;</td>
<td>feature {B, C} (&quot;friends&quot; = B, C and their descendants)</td>
<td>default (&quot;friends&quot; = classes in the same package)</td>
</tr>
<tr>
<td>current class + its descendants + &quot;friends&quot;</td>
<td>feature {A, B, C} (&quot;friends&quot; = B, C and their descendants, A = current class)</td>
<td>protected (&quot;friends&quot; = classes in the same package)</td>
</tr>
<tr>
<td>everyone</td>
<td>feature {ANY}</td>
<td>public</td>
</tr>
</tbody>
</table>
More comparison: Eiffel vs. Java

Eiffel - no package mechanism
Eiffel - no way of hiding a feature from your descendants
  ➢ Module viewpoint: If B inherits from A, all the services of A are available in B (possibly with a different implementation).

Java - no way of exporting a member only to self and descendants
Java - no language rule to distinguish between access to attributes for reading and for writing
Java - additional way of making a class available outside its package or not
Access control more fine grained in Eiffel
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C# access modifiers

C# adds the internal access modifier, which restricts access within the assembly.

Classes can be:
- public
- internal

Class members can be:
- public – accessible to everyone
- internal – accessible only from current assembly
- protected – accessible only from containing class or types derived from containing class (a.k.a. “family” export status)
- protected internal – accessible only from current assembly or types derived from the containing class
- private – accessible only from containing type
The problem with attribute export status

If an attribute is exported, clients can both read it and assign any value that they want to it.

Ex: heater.temperature := 19
public class Heater {
    private int TemperatureInternal;
    public int Temperature {
        get { return TemperatureInternal; }
        set {
            if (!InRange(value)) {
                throw new ArgumentException("Temperature out of range");
            }
            TemperatureInternal = value;
            NotifyObservers();
        }
    }
}
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Construct for grouping logically related program elements
Purely syntactic notion
Only needed for readability and manageability of the software
The decomposition of a system into packages does not affect its semantics
Unlike the classes of object-oriented languages, a package does not by itself define a type
Every package has 2 parts:

- **“specification”**
  - Introduced by the keyword `package`
  - Contains the interface
  - Lists the public properties of the package: exported variables, constants, types, and routines (only headers)

- **“body”**
  - Introduced by the keywords `package body`
  - Provides the routines’ implementations
  - Adds any needed secret elements
  - Needs to repeat most of the interface information (routine headers) that already appeared in the interface
Ada - the private story

The problem:
- Declaring a type in the interface part of a package gives clients unrestricted access to the type, and not declaring it hides it completely from the clients

The solution:
- The **private** part of the interface (introduced by the **private** keyword)
- Any declaration appearing in the private part is unavailable to clients
Ada - an example of a package interface

generic
type \( G \) is private;
package \textit{STACKS} is
  type \textit{STACK} (capacity: \textit{POSITIVE}) is \textit{private};
  procedure \textit{put} (x: in \( G \); s: in out \textit{STACK});
  procedure \textit{remove} (s: in out \textit{STACK});
  function \textit{item} (s: \textit{STACK}) return \( G \);
  function \textit{empty} (s: \textit{STACK}) return \textit{BOOLEAN};
  \textit{Overflow}, \textit{Underflow}: \textit{EXCEPTION};
private
  type \textit{STACK\_VALUES} is array (\textit{POSITIVE} range <>) of \( G \);
  type \textit{STACK} (capacity: \textit{POSITIVE}) is
    record
      \textit{implementation}: \textit{STACK\_VALUES} (1..\textit{capacity});
      \textit{count}: \textit{NATURAL} := 0;
    end record
end \textit{STACKS};
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Why control access to features?

- to allow the class designer to change the internal workings of the class without worrying about how it will affect the client programmer (service to class designer)
- to show a client programmer what is important to him/her and what not (service to client programmer)

Levels of access for clients may vary from no access to full read and write.

Not all languages allow all levels of access.