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Modules in SWI Prolog

Creating and Populating Modules

Special Modules and Default Import

Predicate Lookup (Static and Dynamic Binding)

Using Modules like Objects

Why Modules?

- Different Scopes / Namespaces
  - No name collisions
  - User-Defined Predicates
  - Library Predicates
- Structuring Large Applications
  - Separation of concerns
- Object-oriented Programming???

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Creating and Populating Modules

module/2 directive

use_module/1

use_module/2

import/1

Modules

- Module = name space for predicate definitions

- Each file has an associated module
  - either the explicitly declared module

```
:- module( JTmeta,                                        <-- Module name
        [ ast_node_template/4     % (?Lang, ?NodeType, ?Arity, ?Template)
Export  , ast_arg_nr_name/4       % (?Lang, ?NodeType, ?ArgNumber, ?ArgName)
list    , ast_parent/3            % (?Lang, ?Id, ?ParentId)
        , ...
        ]
).                         Document the arguments and modes of exported predicates!

...
```

  - or otherwise the implicit default module 'user'

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Exporting and Importing

- A module defines predicates that it exports

- Syntax
  - `:- module( name, [exported/1, …]).`
  - This directive must precede any other directive or declaration in a file.
  - The module name does not need to be the same as the containing filename (but it is strongly recommended to keep them consistent!).

- Semantics
  - Exported predicates will be visible in the module that loads name via `consult(filename)` or `use_module(filename)`.
  - It is an error if two modules export the same predicates (name/arity) into the same importing module.
  - All non-exported predicates are not visible outside name
    - ⇨ … unless some other module uses import/2 to bypass the protection

Implicit import

- Let M be a module declared in the file `filename`.
  - Exported predicates of M will be visible in any Importer module in whose context `consult(filename)` or `use_module(filename)` i is executed
  - This is called “implicit import”.

- Importing modules can use the imported predicates internally …

```
:- module( pureImporter, [ myownstuff/4 ] ).

:- use_module(JTmeta).

... internal use of predicates from JTmeta ...
```

- … but can also re-export (some of) them

```
:- module( 're-exporter',    [ myownstuff/4
                             , ast_node_template/4
                             ] ).
:- use_module(JTmeta).

... internal use of predicates from JTmeta ...
```

Reexported predicate from JTmeta

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Re-Export Shortcut

- Re-Exporting all predicates of an imported module
  - `reexport(+Files)`
    - ⇨ Import all predicates from the export list of each file in Files like use_module/1
    - ⇨ ... but additionally re-export all imported predicates
    - ⇨ ... without having to manually list them in the export list of the importing module!

```
:- module(cultivate_concepts, []).

:- reexport( [term_cache, term_metrics, term_graph] ).
```

  - `reexport(+File, ImportList)`
    - ⇨ Import only predicates from ImportList, like use_module/2
    - ⇨ ... but additionally re-export all imported predicates

```
:- module(cultivate_concepts, []).

:- reexport( module_4, [ pred/1 ] ).
:- reexport( module_5,  except([do_not_use/1]).
```

“use_module” versus “consult”

- Think of “use_module/1” as defined by

```
use_module(File) :-
    contains_module(File)
    -> consult(File)
     ; report_missing_module(File)
     .
```

- Recommended was of loading module files:
  - Better because it checks that there is actually a module and also makes the intention explicit → easier to understand code

```
:- module( pureImporter, [ myownstuff/4 ] ).

:- use_module(JTmeta).
```

- This also works, but lacks the above advantages:

```
:- module( pureImporter, [ myownstuff/4 ] ).

:- consult(JTmeta).
```

Name Clashes

- Name Clash Rule: The same predicate may not be imported into the same module from two different modules!
  - Similar to exclusion of multiple inheritance in Java.

- Note: It is legal that different modules offer to export the same predicate:

```
% In file f1:
:- module( m1, [ p/1 ] ).
p(m1).
```

```
% In file f2:
:- module( m2, [ p/1 ] ).
p(m2).
```

- Only importing into the same module is illegal

```
% In file "ambiguous":
:- module( 'ambiguous', [...] ).
:- use_module(m1).                 % implicitly imports p/1
:- use_module(m2).                 % implicitly imports p/1
...
```

```
?- use_module( 'ambiguous').
```

Explicit Import: Avoiding Name Clashes (1)

- use_module(+File, +ImportList)
  - Consults File, importing only the predicates in ImportList
  - Also allows for renaming or "import-everything-except":

New name in importing module

```
:- use_module(library(lists), [ member/2
                              , append/2 as list_concat
                              ]).
:- use_module(library(option), except([meta_options/3])).
```

  - Warns if a predicate in ImportList is not in the ExportList of the module defined in File (but imports it nevertheless)
  - Only works for static modules (declared in a file)

- import(+QualifiedHead)
  - QualifiedHead = Module:Head
  - Imports definition of Head from any module Module
  - … also from dynamically created modules
  - … also for predicates that are not exported

Explicit Import: Avoiding Name Clashes (2)

- import(+QualifiedHead)
  - QualifiedHead = Module:Head
  - Imports definition of Head from any module Module
  - … also from dynamically created modules
  - … also for predicates that are not exported

Static use

```
% In file "noexport.pl":
:- module(noexport, []).

p(noexport).
```

```
% In file "explicit_static_import":
:- module(import, []).

% Assumes noexport has been loaded:
:- import(noexport:p/1).

:- p(X), write(X).
```

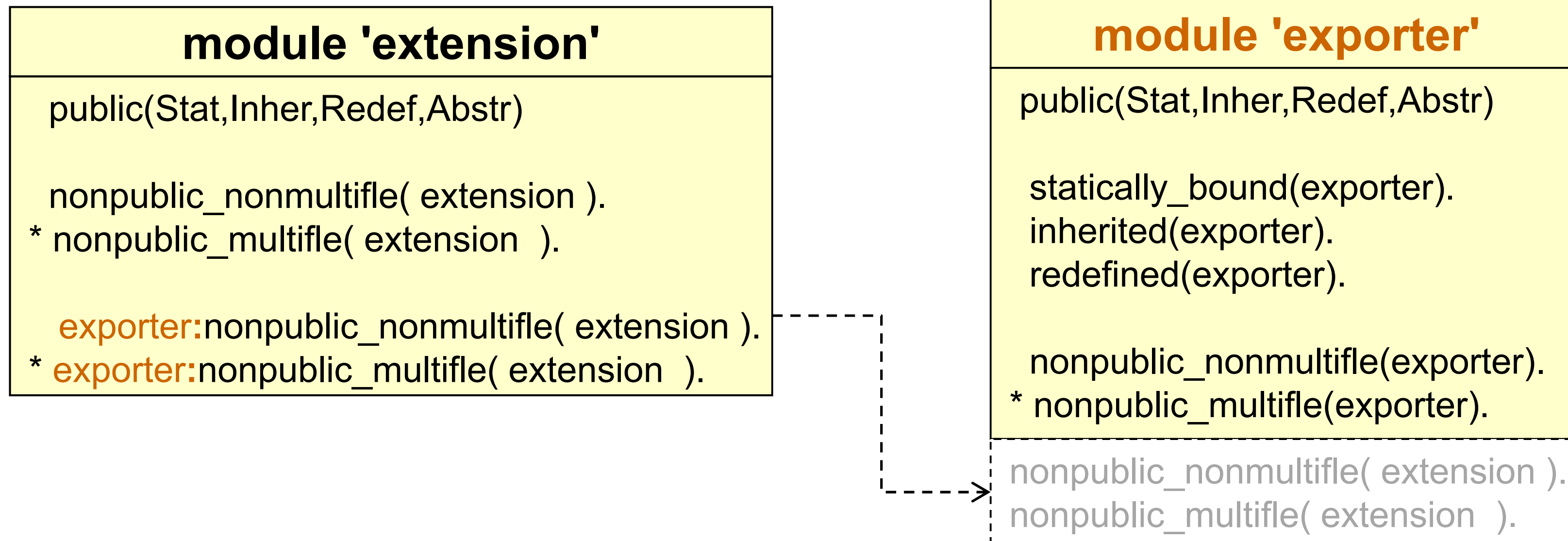
Dynamic use

```
:- % anytime:
   assert(newm:p(dynamic) ),
   newm:import(noexport:p/1)).
```

Creates a new module "newm" and imports into it the predicate "p" from module "noexport"

A module can declare clauses for others

by prepending a module qualifier to a clause head



- One module "injects" definitions into another one
  - This is akin of "aspect-oriented introduction" mechanism
- May be as powerful and as confusing as aspect-orientation
  - Use it sparingly and document it thoroughly!!!

Summary: Populating Modules

- Predicate `P` is defined in module `M` if it is
  - declared in M's file, without module qualifier in clause heads
    - ⇨ `P :- Body.`
  - declared in another file with clause heads qualified with `M`
    - ⇨ `M:P :- Body.`
  - asserted dynamically into M
    - ⇨ `M:assert((P :- Body))` or `assert(M:(P :- Body))`

- Predicate `P` (that is not defined in `M`) is visible to `M` if it is imported
  - `use_module(+FileOfM)`
    - ⇨ consults FileOfM and imports predicates from the export list of `M`
  - `use_module(+FileOfM, +ImportList)`
    - ⇨ consults File and imports only the predicates in ImportList
  - `import(+QualifiedHead)`
    - ⇨ QualifiedHead = `M:P`
    - ⇨ imports definition of `P` from already created module module `M`

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Special Modules

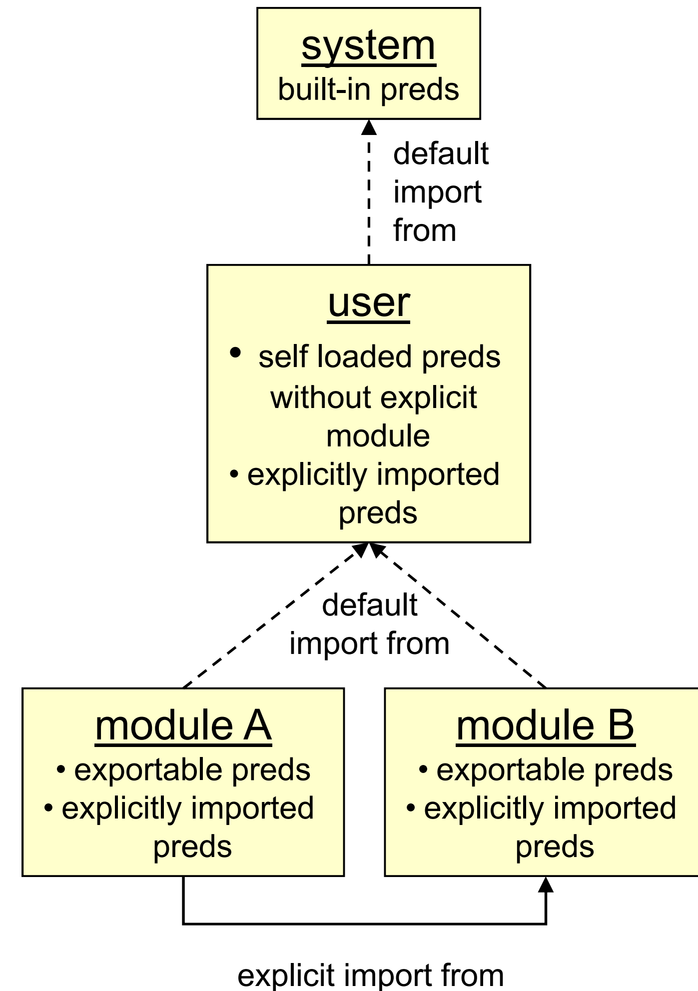
Special modules and default import

Import to “user” ‣ When to do and when to avoid

Special Modules and Default Import

- SWI-Prolog has two special modules
  - "system"
    - ⇨ contains all built-in predicates
  - "user"
    - ⇨ module that the user addresses through the console or from files with no explicit module declaration

- Default import
  - "user" automatically imports from "system"
  - All other modules automatically import from "user"
    - ⇨ Thus they can use all predicates imported into user without explicitly importing them
    - ⇨ This includes the built-in predicates imported from "system" to "user"



Importing to „User“

- Intention
  - distribute common definitions over all program modules
  - … without the need to import them each time explicitly

- Typical uses
  - import your own global libraries / utilities
  - import SWI-Prolog libraries
  - redefine built-in predicates
  - Typically, the load file of a large application looks like this:

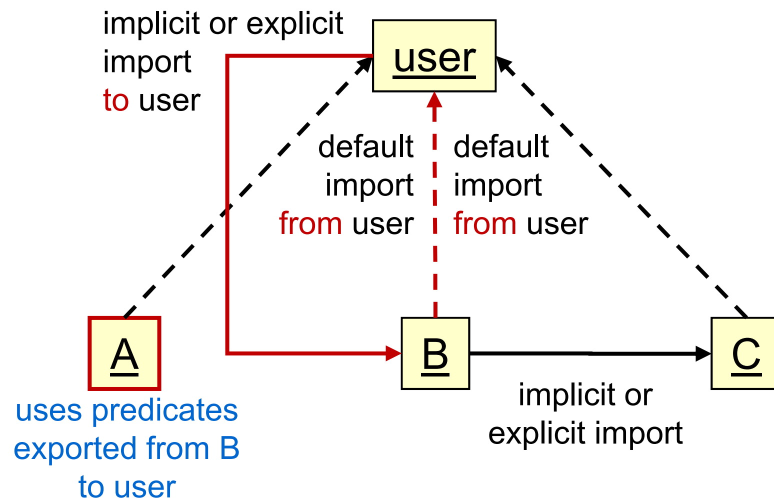
```
:- use_module(compatibility).    % load XYZ-Prolog compatibility

:- use_module(                   % load generic parts
       [ error                   % errors and warnings
       , goodies                 % general goodies (library extensions)
       , debug                   % application specific debugging
       , virtual_machine         % virtual machine of application
       , ...                     % other generic stuff
       ]).
```

Importing to „User“: Use it sparingly!

Import to “user”

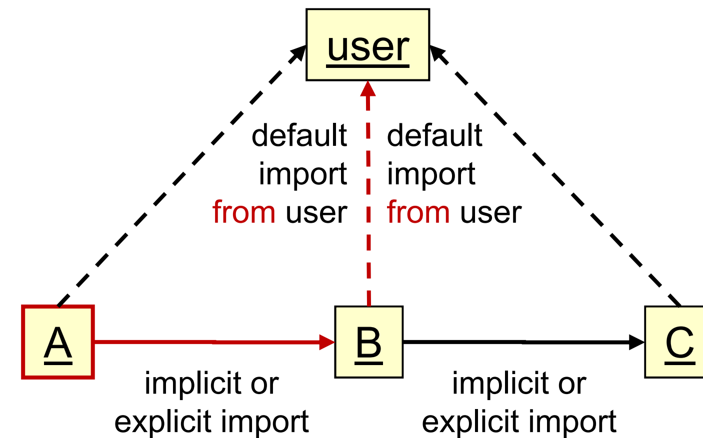
- Only use import to “user” for truly global library predicates!



- It creates bad dependencies
  - Hidden dependencies ☹
  - Cyclic dependencies ☹

Import to real clients

- Better architecture: Import from B to its real client A



- Better dependencies
  - explicit
  - acyclic

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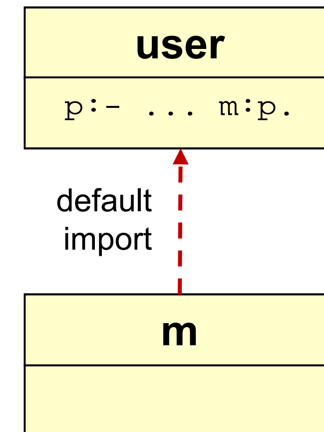
More Cyclic Dependencies: Invocation-Forwarding Cycles

- Invocation-Forwarding Cycle
  - Invocation of predicate P to some module M
    - ⇨ ... within a definition of P in "user"
  - Forwarding from M back to "user"
    - ⇨ Happens if M has no declaration of P
    - ⇨ Then the default import from "user" is used



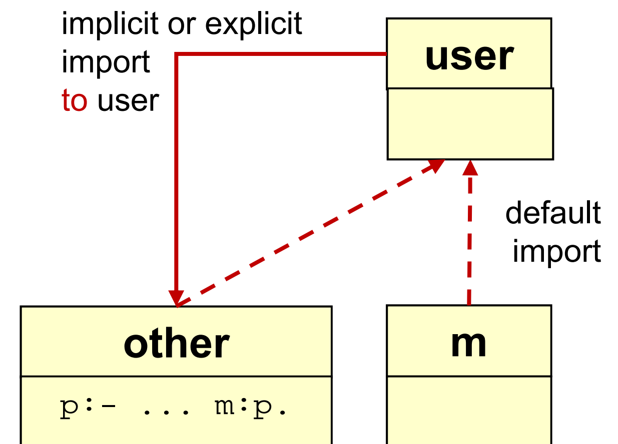
- Example
  - ?- loop(X) produces infinitely many results because m has no definition of loop/1
    - ⇨ Thus the invocation in the second clause is actually a recursive one, although it does not look like that ☹
  - ?- no_loop(X) produces no forwarding loop because a declaration of the called predicate exists in the target module.
    - ⇨ Note that a declaration suffices, m does not need to contain any clauses!

```
% Implicitly in "user":
loop(user).
loop(X) :- m:loop(X).

no_loop(user).
no_loop(X) :- m:no_loop(X).
```

```
:- module(m,[]).

:- dynamic no_loop/1.
```

More Cyclic Dependencies: Import-Invocation-Forwarding Cycles

- Invocation-Forwarding Cycle
  - Invocation of predicate P to some module M
    - ⇨ ... within a definition of P imported into “user”
  - Forwarding from M back to “user”
    - ⇨ Happens if M has no declaration of P
    - ⇨ Then the default import from “user” is used



- Example
  - The same as on previous slide, but even harder to detect because the problematic code resided in another module.

```
% Implicitly in "user":
:- use_module(other).
```

```
:- module(other, [loop/1, no_loop/1]).

loop(user).
loop(X) :- m:loop(X).

no_loop(user).
no_loop(X) :- m:no_loop(X).
```

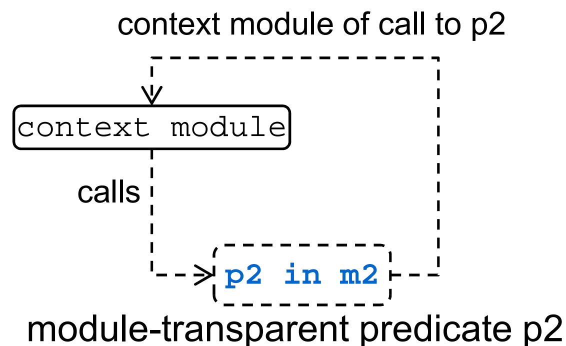
```
:- module(m,[]).

:- dynamic no_loop/1.
```

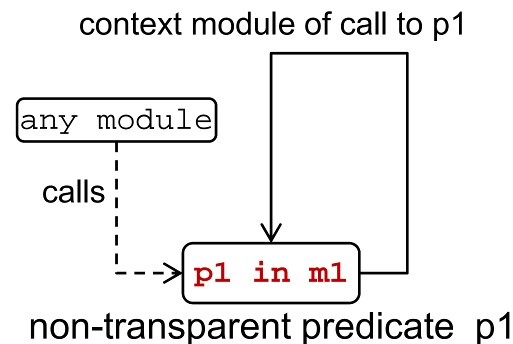
Predicate Lookup
or “How to find my predicate?”

The context module ▸ module_transparent/1 and context_module/1
Predicate lookup ▸ Meta-Predicates and the context module
Static and dynamic binding ▸ Dynamic binding idiom
Defining own meta-predicates

„Context Module“ of a Goal G

- Semantics
  - Module that is used as the starting point for searching clauses for dynamically bound (see page 22 ff) predicate calls during execution of G
- Definition
  - The context module of a module-qualified goal “Module:Goal” is “Module”
  - The context module of any non-qualified goal in the body of predicate P
    - ⇨ is the textually containing module if P is not “module-transparent”
    - ⇨ is the context module of the call to P if P is “module-transparent”





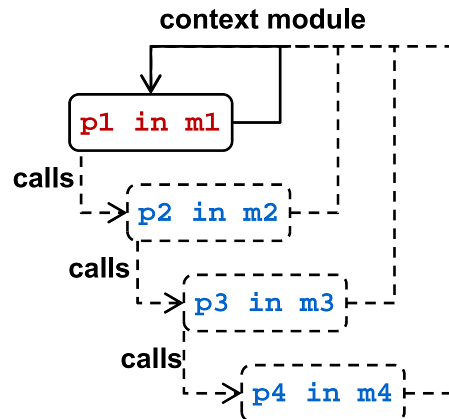
„Context Module“ of a Goal G ▸ Context Propagation

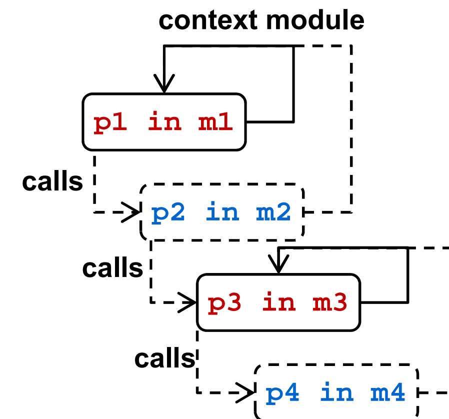
Propagation

- The context module propagates through an uninterrupted sequence of calls of module-transparent predicates

No Propagation

- The context module is reset by a module-qualified call or a call to a non-transparent predicate
- These interrupt the context propagation





Legend: `p2 in m2` module-transparent predicate `p1 in m1` non-transparent predicate

Context Module ▸ Example

```
:- module(context_demo, [ is__transparent/1 , transp_calls_transp/1
                        , non_transparent/1 , nontransp_calls_transp/1
                        ]
  ).

:- module_transparent is__transparent/1, transp_calls_transp/1.

non_transparent(M) :- context_module(M).          % 1) textual   context
is__transparent(M) :- context_module(M).          % 2) call      context

transp_calls_transp(M) :- is__transparent(M).     % 3) transitive call context
nontransp_calls_transp(M) :- is__transparent(M).  % 4) non-trans. call context
```

```
?- non_transparent(Context).               % 1)
Context = context_demo.
```

```
?- is__transparent(Context).               % 2)
Context = user.
```

```
?- nontransp_calls_transp(Context). % 4)
Context = context_demo.
```

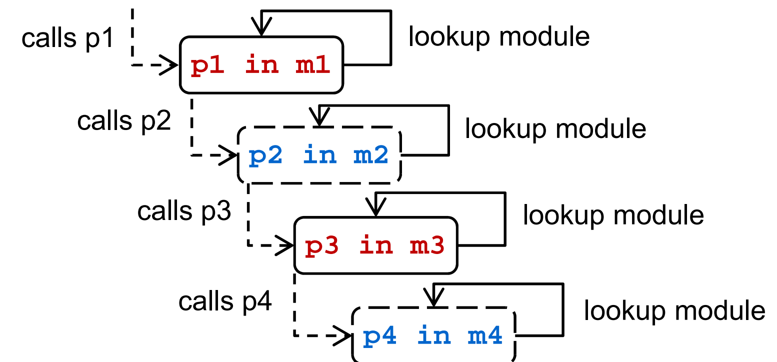
```
?- transp_calls_transp(Context). % 3)
Context = user.
```

Predicate Lookup and Context Module

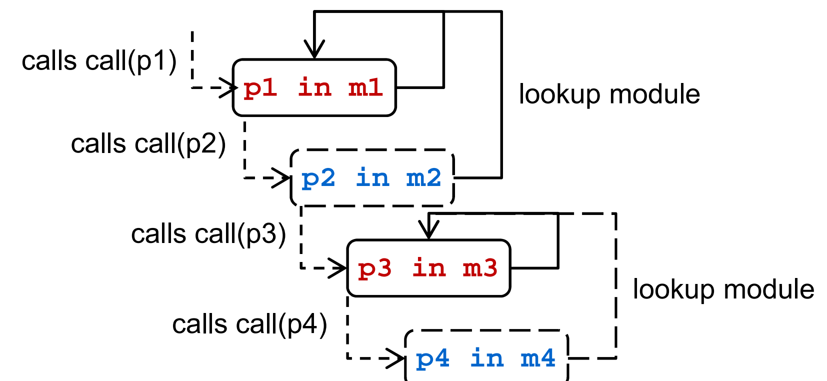
- Every direct predicate call
  - starts searching for predicate definitions in its textually containing module
  - ... hence is statically bound to the textually containing module
  - ... no matter whether the called predicate is module-transparent or not

- Every predicate call via a meta-predicate
  - starts searching for predicate definitions in the context module
  - ... hence is dynamically bound to the context module

Lookup module = textually containing



Lookup module = context module



Legend: `p2 in m2` module-transparent predicate `p1 in m1` non-transparent predicate

Static versus Dynamic Binding

Case 1 and 2

- Every non-meta call is bound statically
  (to the textually containing module)

Case 1 and 3

- Every call in a non-transparent predicate is bound statically
  (to the textually containing module)

Case 4

- Every meta call in a transparent predicate is bound dynamically
  (to the context module)

Containing predicate	Kind of call	
	non-meta	meta
non-transparent	1. static binding	3. static binding
transparent	2. static binding	4. dynamic binding

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Predicate Lookup ▸ Example

```
  :- module(called, [ is__transparent/1 , transp_calls_transp/1
                    , non_transparent/1 , nontransp_calls_transp/1 ]).

  :- module_transparent is__transparent/1, transp_calls_transp/1.

non_transparent(M,B) :- context_module(M),       p(B) .
non_transparent(M,B) :- context_module(M), call(p(B)).

is__transparent(M,B) :- context_module(M),       p(B) .
is__transparent(M,B) :- context_module(M), call(p(B)).

transp_calls_transp(M,B)    :- is__transparent(M,B).
nontransp_calls_transp(M,B) :- is__transparent(M,B).

p(called).
```

```
  :- module(caller, []).
  p(caller).
```

```
?- consult(called).
?- consult(caller).

?- caller:non_transparent(Context,Lookup).
Context = called, Lookup = called ;
Context = called, Lookup = called.
```

Predicate Lookup ► Example

```
  :- module(called, [ is__transparent/1 , transp_calls_transp/1
                    , non_transparent/1 , nontransp_calls_transp/1 ]).

  :- module_transparent is__transparent/1, transp_calls_transp/1.

non_transparent(M,B) :- context_module(M),      p(B) .
non_transparent(M,B) :- context_module(M), call(p(B)).

is__transparent(M,B) :- context_module(M),      p(B) .
is__transparent(M,B) :- context_module(M), call(p(B)).

transp_calls_transp(M,B)    :- is__transparent(M,B).
nontransp_calls_transp(M,B) :- is__transparent(M,B).

p(called).
```

```
  :- module(caller, []).
  p(caller).
```

```
?- consult(called).
?- consult(caller).

?- caller:is__transparent(Context,Lookup).
Context = caller, Lookup   = called ;
Context = caller, Lookup   = caller.
```


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Predicate Lookup ▸ Example

```
  :- module(called, [ is__transparent/1 , transp_calls_transp/1
                    , non_transparent/1 , nontransp_calls_transp/1 ]).

  :- module_transparent is__transparent/1, transp_calls_transp/1.

non_transparent(M,B) :- context_module(M),       p(B) .
non_transparent(M,B) :- context_module(M), call(p(B)).

is__transparent(M,B) :- context_module(M),       p(B) .
is__transparent(M,B) :- context_module(M), call(p(B)).

transp_calls_transp(M,B)    :- is__transparent(M,B).
nontransp_calls_transp(M,B) :- is__transparent(M,B).

p(called).
```

```
  :- module(caller, []).
  p(caller).
```

```
?- consult(called).
?- consult(caller).

?- caller:transp_calls_transp(Context,Lookup).
Context = caller, Lookup   = called ;
Context = caller, Lookup   = caller.
```

Predicate Lookup ▸ Example

```
  :- module(called, [ is__transparent/1 , transp_calls_transp/1
                    , non_transparent/1 , nontransp_calls_transp/1 ]).

  :- module_transparent is__transparent/1, transp_calls_transp/1.

non_transparent(M,B) :- context_module(M),       p(B) .
non_transparent(M,B) :- context_module(M), call(p(B)).

is__transparent(M,B) :- context_module(M),       p(B) .
is__transparent(M,B) :- context_module(M), call(p(B)).

transp_calls_transp(M,B)     :- is__transparent(M,B).
nontransp_calls_transp(M,B) :- is__transparent(M,B).

p(called).
```

```
  :- module(caller, []).
  p(caller).
```

```
?- consult(called).
?- consult(caller).

?- caller:nontransp_calls_transp(Context,Lookup).
Context = called, Lookup    = called ;
Context = called, Lookup    = called.
```

Predicate Lookup ▸ Dynamic Binding Idiom

- Making a non-metapredicate call in a transparent predicate be dynamically bound is easy
  - Use the context_module/1 predicate to get the current context module
  - ... then explicitly invoke the call in the context module

	non-meta	meta
non-transparent	static binding	static binding
transparent	dynamic binding	dynamic binding

```
:- module(called, [ transp/1]).
:- module_transparent transp/1.

transp(M,B) :-
   context_module(M), M:p(B).

p(called).
```

```
 :- module(caller, []).

 p(caller).
```

```
?- consult(called).
?- consult(caller).

?- caller:transp(Context,Lookup).
Context = caller,
Lookup  = caller.
```


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Remember

- Module-sensitive metapredicates are documented by prepending ":" to the module-sensitive meta-arguments
  - call(:Goal),
  - assert(:Clause)
  - retract(:Head)
  - findall(Template, :Goal, List)
  - catch(:Goal,Exception,:Catcher)
  - …

- Any predicate, that calls a module-sensitive metapredicate must be declared module_transparent.
  - Otherwise, it won't work properly, trying to resolve meta-arguments in its own containing module instead of the invoking module.
  - This is awkward...

Defining own Meta-Predicates

meta_predicate +Head_1, +Head_2, …

- Define the predicate referenced by Head_i as a meta-predicate
- Each argument of Head_i is a meta argument specifier
  - - / + / ?
    - ⇨ The argument is not module sensitive and free / bound / unspecified at call time
  - :
    - ⇨ The argument is module sensitive, but does not directly refer to a predicate.
      - – For example: consult(:).
  - 0..9
    - ⇨ The argument term will reference a predicate with N more arguments than itself
      - – For example: call(0) or maplist(1, +).
- Each argument marked : or 0..9 is module-sensitive
  - It is qualified with the context module of the caller <module>:<term>, where <atom> is a module name and <term> is not a :/2 term.

Example

```
:- meta_predicate reportMetaArgument(0).

reportMetaArgument(Module:Term) :-
   format('Module=~w, Term = ~q~n',[Module,Term]).
```

```
?- reportMetaArgument(test).
Module = user, Term = test         % no module specified -> user Module

?- reportMetaArgument(m1:test).
Module = m1, Term = test           % module m1 specified for test

?- m2:reportMetaArgument(test).
Module = m2, Term = test           % context for reportMetaArgument is m2
                                   % no module specified for test -> also m2
?- m1:reportMetaArgument(m2:test).
Module = m2, Term = test           % module m1 specified for test

?- reportMetaArgument(m1:m2:test).
Module = m2, Term = test           % innermost module counts
```

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Using Modules like Objects

Class instances versus Prototypes

Modules versus Prototypes

Inheritance and dynamic binding

Object-oriented Programming? ▸ Which one?

Comparing Prolog to objects without getting confused requires in the first place to know both families of object-oriented languages:

- Class-based languages ▸ Oranges
  - Java, C++, Smalltalk, Simula, Eiffel, ...
- Prototype-based languages ▸ Apples
  - Self, Newton Script, Java Script, ...

Schedule for this section

1) Class-based versus prototype-based objects
2) Prototype-based language concepts in Prolog
3) Object-oriented design for Prolog
4) Using UML for Prolog designs
5) Adapting UML for Prolog

Class Instances versus Prototypes

Class instances

- Contain fields and methods
- Are encapsulated
- Interact by dynamically bound invocations
- Are defined by classes
- Structure and behaviour are fixed
- Are instantiated from class
- Share structure and behaviour defined by their class
- Cannot delegate to other objects (inheritance only among classes)

Prototypes

- Contain fields and methods
- Are encapsulated
- Interact by dynamically bound invocations
- Are self-contained
- Structure and behaviour can change at any time
- Are gradually modified or cloned or both
- Are unique
- Delegate to other objects (= object-based inheritance)

→ Read about delegation: http://roots.iai.uni-bonn.de/research/darwin/delegation

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SWI-Prolog Modules versus Prototypes

SWI-Prolog Modules

- Contain stat. and dyn. predicates
- Are not encapsulated
- Interact by statically or dynamically bound invocations
- Are self-contained
- Structure and behaviour can change at any time (assert, ...)
- Are gradually modified or cloned or both
- Are unique
- Import from other modules
  - Local definitions hide / override those from other modules

Prototypes

- Contain fields and methods
- Are encapsulated
- Interact by dynamically bound invocations
- Are self-contained
- Structure and behaviour can change at any time
- Are gradually modified or cloned or both
- Are unique
- Delegate to other objects
  - Local definitions override those from other objects

SWI-Prolog Modules versus Prototypes ▸ The Similarities

SWI-Prolog Modules	Prototypes
Contain stat. and dyn. predicates	Contain fields and methods
Are self-contained	Are self-contained
Structure and behaviour can change at any time (assert, ...)	Structure and behaviour can change at any time
Are gradually modified or cloned or both	Are gradually modified or cloned or both
Are unique	Are unique

SWI-Prolog Modules versus Prototypes ▸ The Similarities → Adapted UML

SWI-Prolog Modules

Module	
dynPred(Arg1, ...)	<---- Data
statPred(Arg1, ...)	<---- Operations

(Module <---- Name)

- Are self-contained
- Structure and behaviour can change at any time (assert, ...)
- Are gradually modified or cloned or both
- Are unique prototypes
- Contain stat. and dyn. predicates

Prototypes

Prototype	
field	<---- Data
meth(Arg1, ...)	<---- Operations

(Prototype <---- Name)

- Are self-contained
- Structure and behaviour can change at any time
- Are gradually modified or cloned or both
- Are unique prototypes
- Contain fields and methods

SWI-Prolog Modules versus Prototypes ▸ The Differences – No Encapsulation

Logic Modules

Module
statPred(Arg1, ...)
dynPred(Arg1, ...)

<---- Name
<---- Data
<---- Operations

- Are not encapsulated

"Pure" Objects

Prototype
field
meth(Arg1, ...)

<---- Name
<---- Data
<---- Operations

- Are encapsulated

Modules are not a protection mechanism!

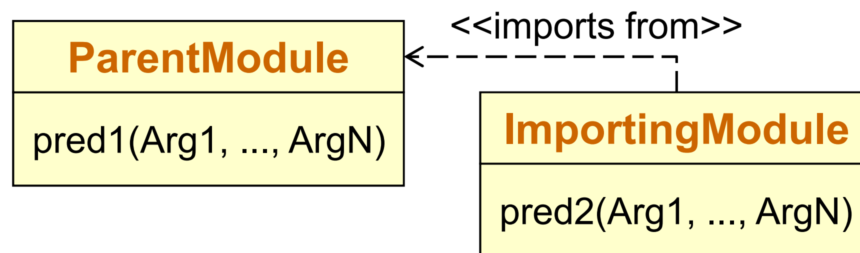
- The notions "public", "protected" and "private" make no sense.
- The export list is not the list of public predicates
- It is just the list of predicates that the module *recommends* others to import.
- Predicates in the export list can be excluded from import and predicates that are not in the list can be imported. The importing module decides!

Nevertheless, we should be able to express the recommendation.

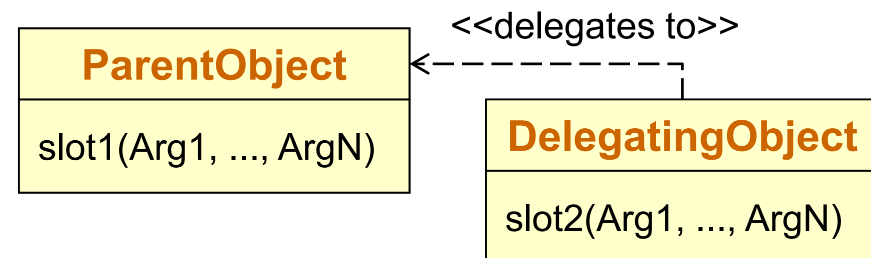
It is still up to the clients to comply with it, but to comply they must at least know it!

SWI-Prolog Modules versus Prototypes ▸ The Differences – Dynamic Binding

Logic Modules



"Pure" Objects



- Interact by statically or dynamically bound invocations
- Import from other modules
  - Local definitions hide or override those from other modules

- Interact by dynamically bound invocations
- Delegate to other objects
  - Local definitions override those from other objects

➢ If predicate calls in a module are bound
- → statically, import is invocation and local definitions hide those from parent modules
- ↪ dynamically, import is delegation and local definitions override those from parent modules

Normal calls are statically bound ► Always!

➢ Definition

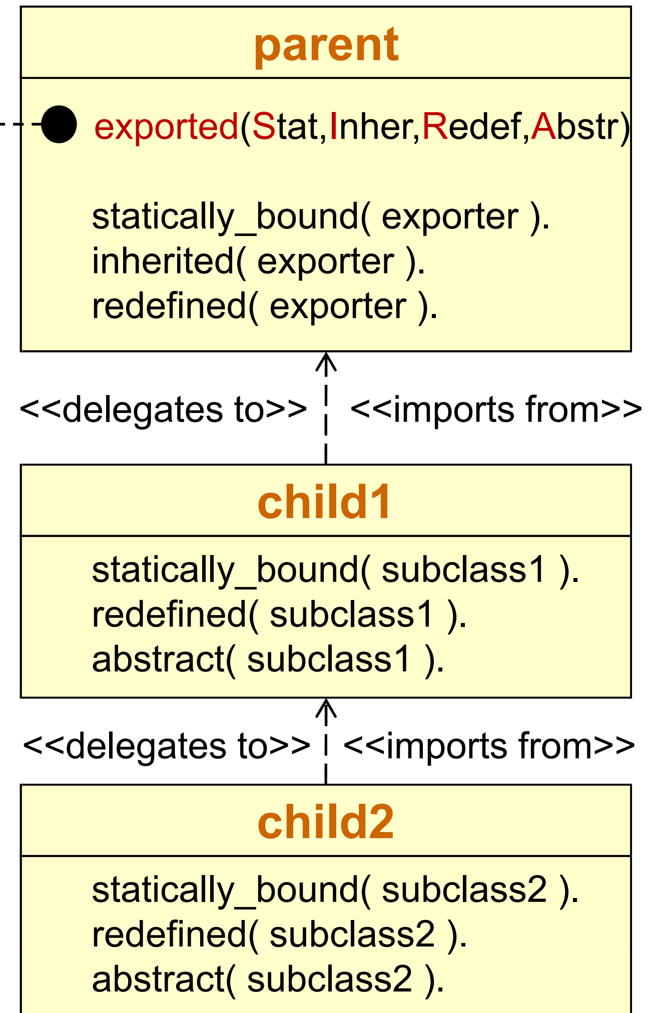
```
:- module_transparent public/4.

exported(S,I,R,A) :-
  → statically_bound(S),  % normal call: statically bound
  → inherited(I) ,        % normal call: statically bound
  → redefined(R) ,        % normal call: statically bound
  → abstract(A) .         % normal call: statically bound
```

➢ Query

```
?- child2:public(S,I,R,A).
S = parent,
I = parent,
R = parent,
A = parent,
Yes
```

➢ Rule ► Normal calls are statically bound to the containing module

➢ "module_transparent" has no effect

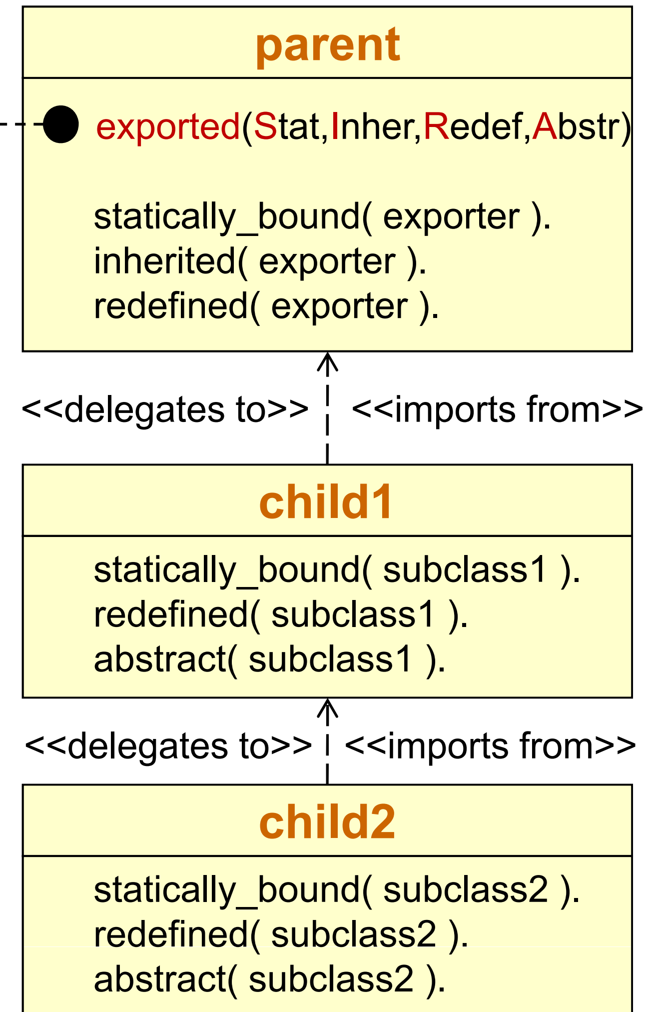


Meta-calls are dynamically bound

if the containing predicate is "module_transparent"

- Definition

```
:- module_transparent public/4.

public(S,I,R,A) :-
    statically_bound(S),   % normal call: statically bound
 ↪  call( inherited(I) ),  % metacall: dynamically bound
 ↪  call( redefined(R) ),  % metacall: dynamically bound
 ↪  call( abstract(A) ).   % metacall: dynamically bound
```



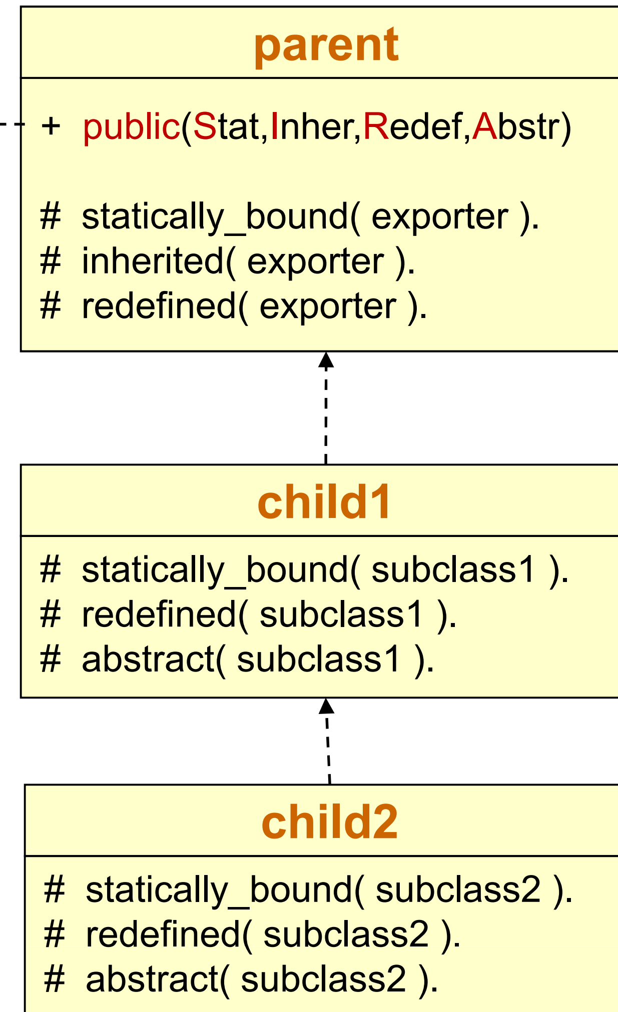
- Query

```
?- child2:public(S,I,R,A).
S = parent,
I = parent,
R = parent,
A = parent,
Yes
```

- Rule ► Normal calls are statically bound to the textually containing module
  - "module_transparent" has no effect

Meta-calls are dynamically bound
if the containing predicate is “module_transparent”

```
:- module_transparent public/4.

public(S,I,R,A) :-
   statically_bound(S), % normal call: statically bound
↪ call( inherited(I) ),   % metacall: dynamically bound
↪ call( redefined(R) ),% metacall: dynamically bound
↪ call( abstract(A) ).   % metacall: dynamically bound
```

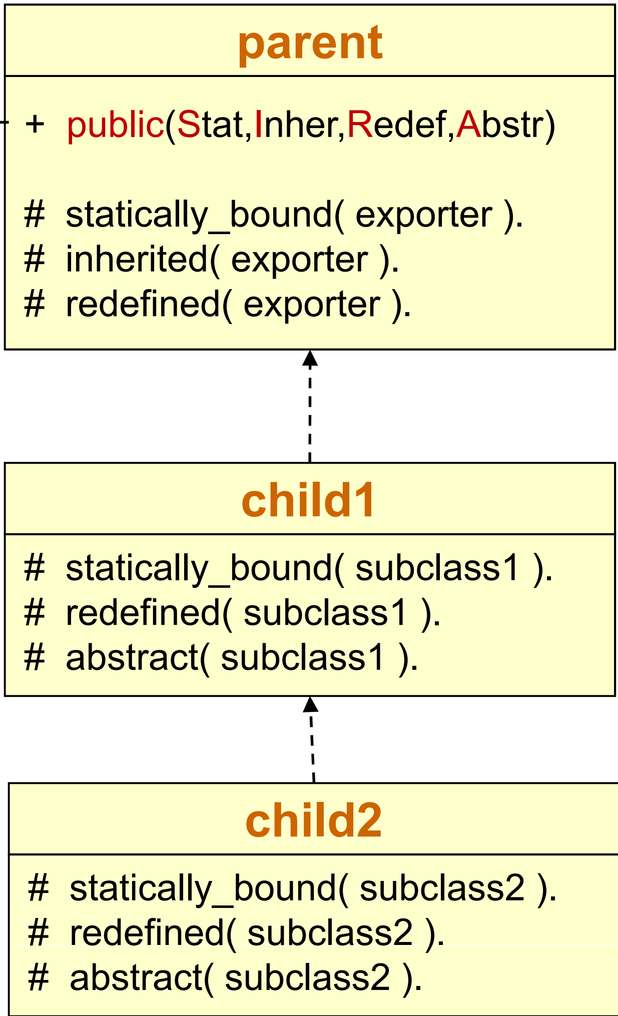



```
?- subclass2:public(S,I,R,A).
S = exporter,
I = exporter,
R = subclass2,
A = subclass2,
Yes
```

Every call can be dynamically bound

if the containing predicate is “module_transparent” and the call is addressed explicitly to the context module

```
:- module_transparent public/4.

public(S,I,R,A) :-  context_module(M),
   M:statically_bound(S), % explicitly dynamically bound
   M:inherited(I) ),       % explicitly dynamically bound
   M:redefined(R) ),       % explicitly dynamically bound
   M:abstract(A) ).        % explicitly dynamically bound
```




```
?- subclass2:public(S,I,R,A).
S = subclass2,
I = exporter,
R = subclass2,
A = subclass2,
Yes
```

Summary

- Modules are a namespace mechanism, not for protection
  - avoid name clashes
  - control visibility, not accessibility
- Modules are like non-encapsulated, class-less objects
  - Module name = object identity
  - Predicates = methods and fields
- Object-oriented programming in Prolog is possible subject to some idioms
  - Dynamic binding via module-transparent predicates and context_module/1
  - Delegation via import of predicates containing dynamically bound calls
  - Forwarding via import of predicates containing statically bound calls
- Use OOP principles to structure large Prolog projects!

More on Modules

- Modules have very different semantics in different Prolog implementations
  - See the online documentation of Quintus, YAP, XSB, LPA, ...
- The SWI module system is one of the most advanced one (or even *the* most advanced?)
  - "Module-Transparent" seems to be unique
  - Separate compilation is supported also for meta-predicates
- Fear of non-portability should not stop you from using modules
  - An unmanageable, badly structured program is unusable even on a single platform