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Modules in SWI Prolog

– **Updated July 2, 2013** –

Creating and Populating Modules

Special Modules and Default Import

~~Predicate Lookup (Static and Dynamic Binding)~~

Using Modules like Objects

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)
        , ast_arg_nr_name/4     % (?Lang, ?NodeType, ?ArgNumber, ?ArgName)
        , ast_parent/3          % (?Lang, ?Id, ?ParentId)
        , ...
        ]
).

...
```

Export list

Document the arguments and modes of exported predicates!

  - or otherwise the implicit default module 'user'

Why Modules?

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

Creating and Populating Modules

module/2 directive

use_module/1

use_module/2

import/1

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

“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 way 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').
```

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

Re-Export Shortcut

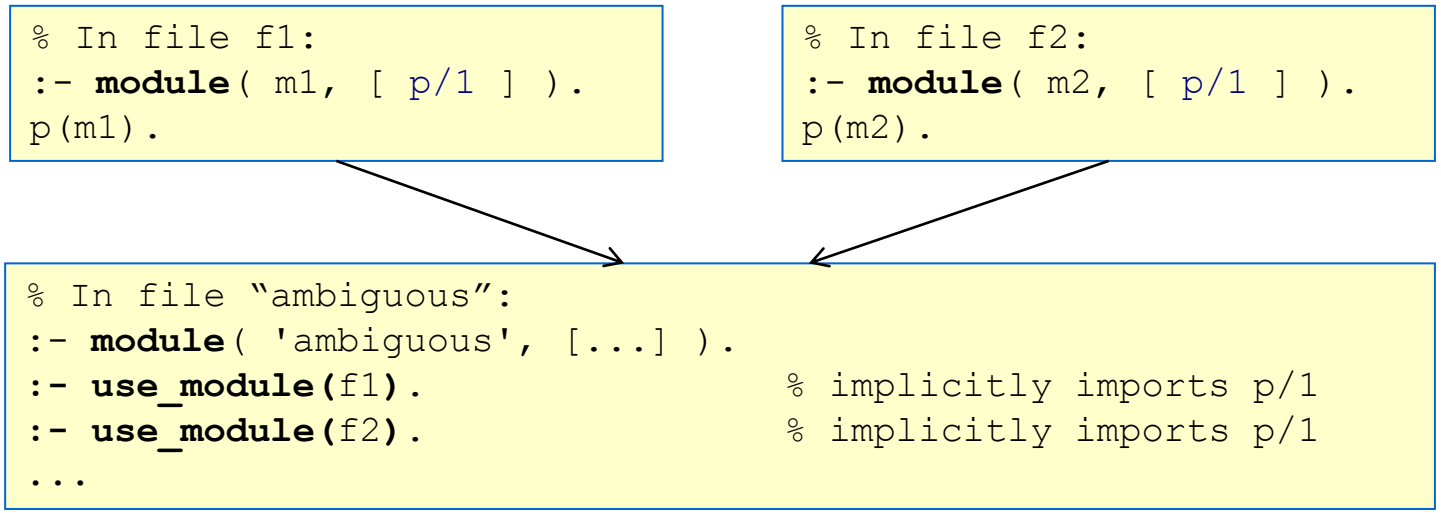
- Re-Exporting all predicates of an imported module
  - `reexport(+Files)`
    - ⇨ Import all predicates from the export list of each file in Files like use_module/1
    - ⇨ ... but additionally re-export all imported predicates
    - ⇨ ... without having to manually list them in the export list of the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

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

:- 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_naming, []).

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

Exports of the “same” predicate



Question:

What happens in “ambiguous”?

Name Clash Rule: The same predicate may not be imported into the same module from two different modules!

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)

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).
```

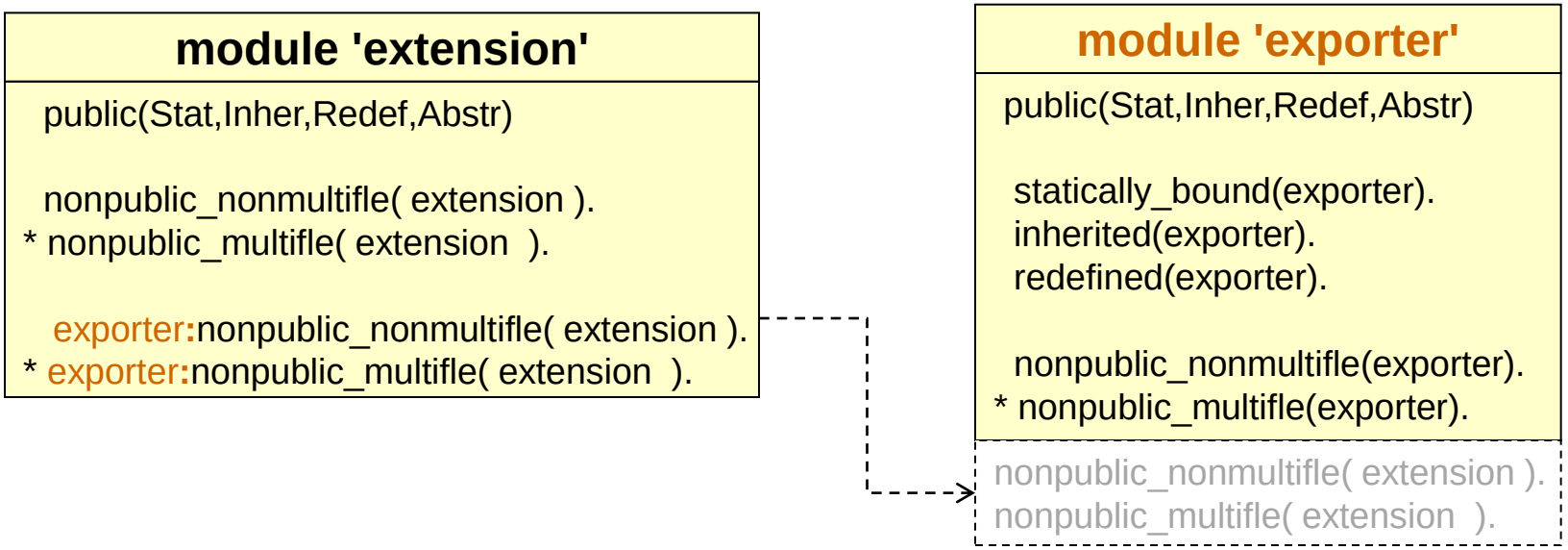
```
% In file "explicit_static_import":
:- module(import, []).

% 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`

Special Modules

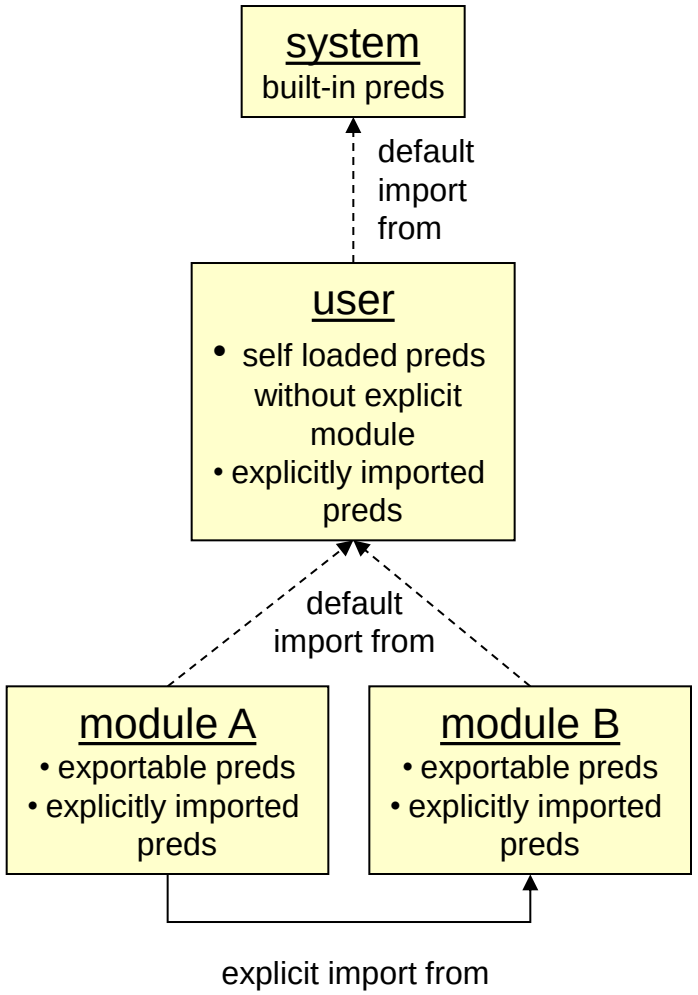
Special modules and default import

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“:

```
:- module(a,[]).
q(N):- p(N).
```

```
:- module(c,[]).
r(1).
r(2).
```

```
:- module(b,[p/1]).
p(N):- c:r(N)
```

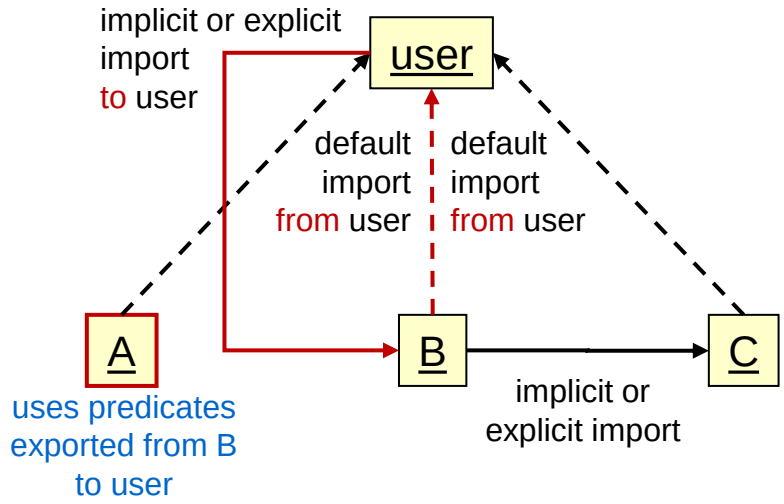
Question:

What is the issue?

Importing to „User“: Use it sparingly!

Import to “user”

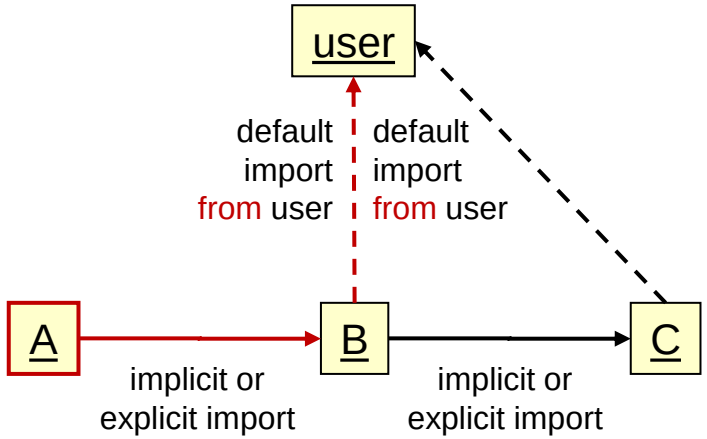
- Only use import to “user” for truly global library predicates!



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

Import to real clients

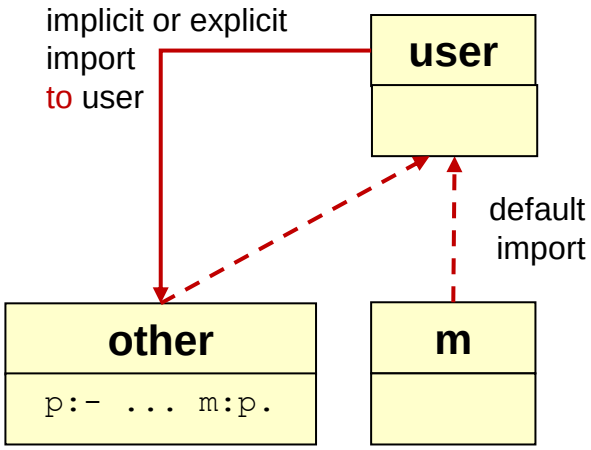
- Better architecture:
  Import from B to its real client A



- Better dependencies
  - explicit
  - acyclic

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.

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

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

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

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

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

:- dynamic no_loop/1.
```

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

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

SWI-Prolog Modules versus Prototypes

SWI-Prolog Modules

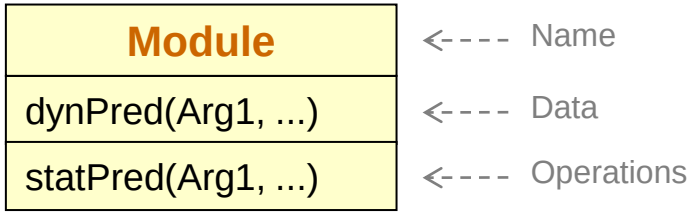
- Contain dyn. and stat. predicates
- Are not encapsulated
- Interact by statically ~~or dynamically~~ bound invocations
- Are self-contained
- Structure and behaviour can change at any time (assert, ...)
- Are gradually modified or cloned or both
- Are unique
- Import from other modules
  - Local definitions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

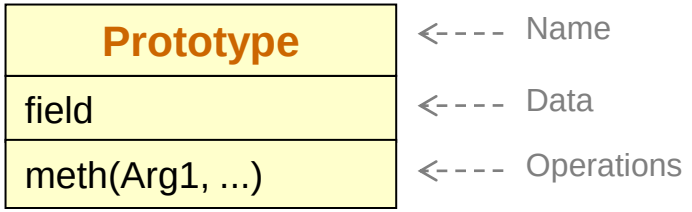
SWI-Prolog Modules versus Prototypes ▸ The Similarities → Adapted UML

SWI-Prolog Modules



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

Prototypes



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

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

SWI-Prolog Modules

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

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

- Are not encapsulated

Prototypes

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 are 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!

Summary

- Modules are a very weak namespace mechanism, not for protection
  - They avoid name clashes (just partly)
  - They control visibility, not accessibility

- Modules are like non-encapsulated prototypes
  - Module name = object identity
  - Predicates = methods and fields

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 ones
  - Separate compilation is supported also for meta-predicates
  - “Module-Transparent” is supported only in SWI- and Eclipse-Prolog
- Fear of non-portability should not stop you from using modules
  - An unmanageable, badly structured program is unusable even on a single platform