Chapter 12: Systematic Development

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ECLiPSe ELearning Overview

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### Outline

1. **Introduction**
2. **Application Structure**
3. **Documentation**
4. **Data Representation**
5. **Programming Concepts**
6. **Style Guide**

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### Overview

- How to develop large applications in ECLiPSe
- Software development issues for Prolog
- This is essential for large applications
  - But it may show benefits already for small programs
- This is not about problem solving, but the *boring bits* of application development

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Helmut Simonis  
*Systematic Development*
Disclaimer

- This is not *holy writ*
  - But it works!
- This is a team issue
  - People working together must agree
  - Come up with a local style guide
- Consistency is not optional
  - Every shortcut must be paid for later on
- This is an appetizer only
  - The real story is in the tutorial Developing Applications with ECLiPSe (part of the ECLiPSe documentation)

Application Structure

Full Application

- Java Application
  - User
- ECLiPSe/Java Interface
- ECLiPSe Application

Batch Application

- Data Files
- ECLiPSe Application
LSCO Structure

1. prepare data
2. create variables
3. create constraints
4. find solution
5. output results

Top-Down Design

- Design queries
- UML static class diagram (structure definitions)
- API document/test cases
- Top-level structure
- Data flow analysis
- Allocate functionality to modules
- Syntactic test cases
- Module expansion
  - Using programming concepts where possible
  - Incremental changes
Modules

- Grouping of predicates which are related
- Typically in a single file
- Defined external interfaces
  - Which predicates are exported
  - Mode declaration for arguments
  - Intended types for arguments
  - Documentation
- Helps avoid Spaghetti structure of program

Creating Documentation

- Your program can be documented in the same way as ECLiPSe library predicates
- Comment directives in source code
- Tools to extract comments and produce HTML documentation with hyper-links
- Quality depends on effort put into comments
- Every module interface should be documented
Example

```prolog
:- comment(prepare_data/4,[
    summary:"creates the data structures 
    for the flow analysis",
    amode:prepare_data(+,+,+,-),
    args:[
        "Dir":"directory for report output",
        "Type":"the type of report to be generated",
        "Summary":"a summary term",
        "Nodes":"a nodes data structure"],
    desc:html("This routine creates the data 
    structures for the flow analysis.
...
"
]
)

see_also:[hop/3]
```

### External Data Representation

<table>
<thead>
<tr>
<th>Property</th>
<th>Argument</th>
<th>Data File</th>
<th>Term File</th>
<th>Facts</th>
<th>EXDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple runs</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Debugging</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Test generation</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Java I/O Effort</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>ECLiPSe I/O Effort</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Memory</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Development Effort</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>
Internal Data Representation

- Named structures
  - Define & document properly
- Lists
  - Do not use for fixed number of elements
- Hash tables, e.g. lib(hash)
  - Efficient
  - Extensible
  - Multiple keys possible
- Vectors & arrays
  - Requires that keys are integers (tuples)
- Multi-representation
  - Depending on key use one of multiple representations

Internal Representation Comparison

<table>
<thead>
<tr>
<th></th>
<th>Named Structures</th>
<th>Lists</th>
<th>Hash Tables</th>
<th>Vectors Arrays</th>
<th>Multi-representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>hold disparate data</td>
<td>++</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>access specific info</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>add new entries</td>
<td>–</td>
<td>+</td>
<td>++</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>do loops</td>
<td>+</td>
<td>++</td>
<td>–</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>sort entries</td>
<td>–</td>
<td>++</td>
<td>–</td>
<td>–</td>
<td>++</td>
</tr>
<tr>
<td>index calculations</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>
Getting it to work

- **Early testing** `lib(test_util)`
  - Define what a piece of code should do by example
  - May help to define behaviour

- **Stubs**

- **Line coverage** `lib(coverage)`
  - Check that tests cover code base

- **Heeding warnings of compiler,** `lib(lint)`
  - Eliminate all causes of warnings
  - Singleton warnings typically hide more serious problems

- **Small, incremental changes**
  - Matter of style
  - Works for most people

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Programming Concepts

- Many programming tasks are similar
  - Finding the right information
  - Putting things together in the right sequence

- We don’t need the fastest program, but the easiest to maintain
  - Squeezing the last 10% improvement normally does not pay

- Avoid unnecessary inefficiency
  - `lib(profile), lib(port_profiler)`
List of concepts

- Alternatives
- Iteration (list, terms, arrays)
- Transformation
- Filtering
- Combine
- Minimum/Best and rest
- Sum
- Merge
- Group
- Lookup
- Cartesian
- Ordered pairs

Example: Cartesian

:-mode cartesian(+,+,-).
cartesian(L,K,Res):-
  (foreach(X,L),
   fromto([],In,Out,Res),
   param(K) do
     (foreach(Y,K),
      fromto(In,In1,[pair(X,Y)|In1],Out),
      param(X) do
        true
      )
  ).
Section on DCG use
  Grammars for parsing and generating text formats
XML parser in ECLiPSe
  `lib(xml)`
EXDR format to avoid quoting/escaping problems
Tip:
  Generate hyper-linked HTML/SVG output to present data/results as development aid

If it doesn’t work

Understand what happens
  Which program point should be reached with which information?
  Why do we not reach this point?
  Which data is wrong/missing?

Do not trace through program!
Debugging is like solving puzzles
  Pick up clues
  Deduce what is going on
  Do not simulate program behaviour!
Correctness and Performance

- Testing
- Profiling
- Code Reviews
  - Makes sure things are up to a certain standard
  - Don’t expect reviewer to find bugs
- Things to watch out for
  - Unwanted choice points
  - Open streams
  - Modified global state
  - Delayed goals

Did I mention testing?

- Single most important/neglected activity
- Re-test directly after every change
  - Identifies faulty modification
  - Avoids lengthy debugging session after making 100s of changes
- Independent verification
  - Check results by hand (?)
  - By other program (??)
  - Use constraint solver as checker
Rules that should be satisfied by finished program
Things may be relaxed during prototyping
Often, choice among valid alternatives is made arbitrarily, so that a consistent way is defined
If you don’t like it, change it!
  But: better a bad rule than no rule at all!

There is one directory containing all code and its documentation (using sub-directories).
Filenames are of form \([a-z][a-z_]+\) with extension .ecl.
One file per module, one module per file.
Each module is documented with comment directives.

  Don’t use ‘,’/2 to make tuples.
  Don’t use lists to make tuples.
  Avoid append/3 where possible, use accumulators instead.
Layout rules

- How to format ECLiPSe programs
- Pretty-printer format
- Eases
  - Exchange of programs
  - Code reviews
  - Bug fixes
  - Avoids extra reformatting work

Core Predicates List

- Alphabetical predicate index lists 2940 entries
  - You can’t possibly learn all of them
  - Do you really want to know what `set_typed_pool_constraints/3` does?
- List of Prolog predicates you need to know
  - 69 entries, more manageable
- Ignores all solver libraries
- If you don’t know what an entry does, find out about it
  - what does `write_exdr/2` do?
- If you use something not on the list, start to wonder...
Developing Applications with ECLiPSe
- H. Simonis
- http://www.eclipse-clp.org

Constraint Logic Programming Using ECLiPSe
- K. Apt, M. Wallace
- Cambridge University Press

The Craft of Prolog
- R.O'Keefe, MIT Press

Conclusions
- Large scale applications can be built with ECLiPSe
- Software engineering is not that different for Prolog
- Many tasks are similar regardless of solver used
- Correctness of program is useful even for research work