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
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
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)
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Application Structure

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

Batch Application
- Data Files
  - ECLiPSe Application
LSCO Structure

- prepare data
- create variables
- create constraints
- find solution
- 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
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

:- 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. ...
    ")
## 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 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
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
     )
  ).
Input/Output

- 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
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Style Guide

- 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!
Style Guide Examples

- 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...

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Other Sources

- 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