A MultiBody Performance Story

Adrian Pop

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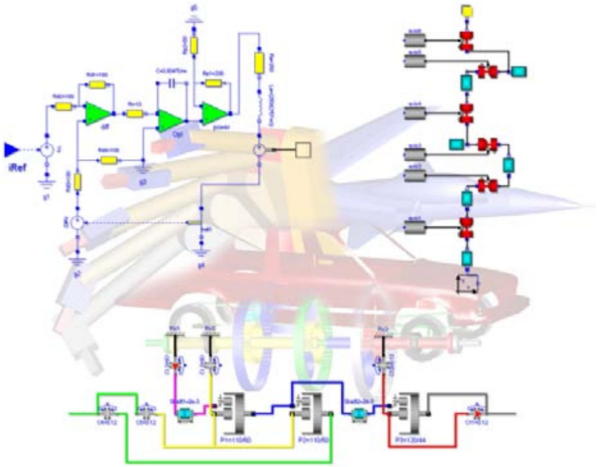
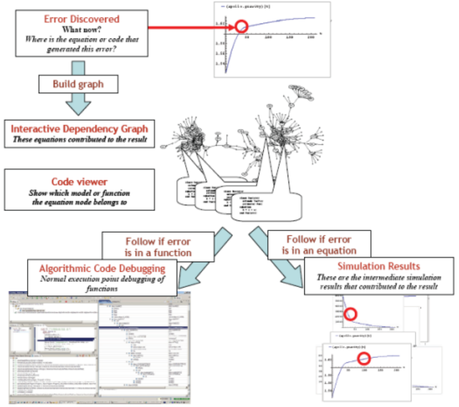
Open Source Modelica Consortium
Programming Environment Laboratory
Department of Computer and Information Science
Linköping University

www.OpenModelica.org




Error Discovered
What now?
Where is the equation or code that generated this error?

Build graph

Interactive Dependency Graph
These equations contributed to the result

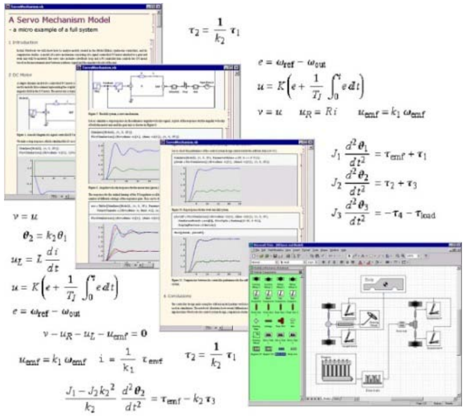
Code viewer
Show which model or function the equation node belongs to

Follow if error is in a function

Algorithmic Code Debugging
Normal execution point debugging of functions

Follow if error is in an equation

Simulation Results
These are the intermediate simulation results that contributed to the result



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Outline

- Multi Body Engine V6 Example

- First Run
- Performance Analysis

- Action Plan (performance enhancement)
- Performance Results

- Conclusions

Once upon a time, early 2010 ...

MultiBody Engine V6

- An example in the Modelica MultiBody library
- Modelica.Mechanics.MultiBody.Examples.Loops.EngineV6
  has **12491** equation(s) and **12491** variable(s).
  8732 of these are trivial equation(s).

First Run

Early 2010 situation

- Flattening of EngineV6 took
  - 430 minutes, ~7.2hours
  - *Very disappointing! (Drama)*
  - [the actual first run took ~2 days]
- Flattening performance **had to be addressed**

Testing System

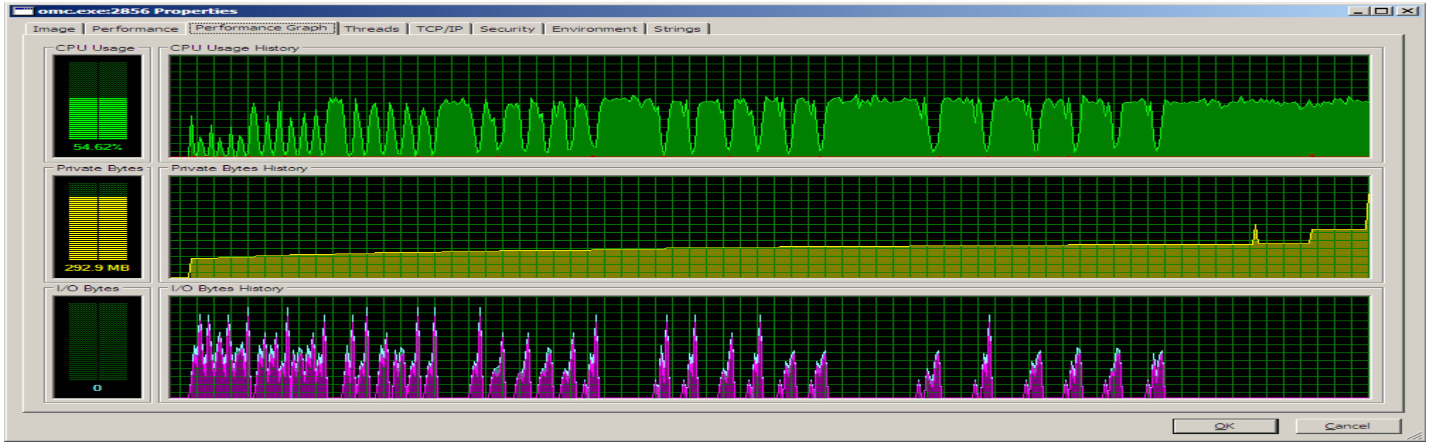
All tests were done on my laptop

- HP EliteBook 8440p, RAM 8Gb, HDD 160 SSD
- Intel® Core™ i7-620M Processor at 2.66 GHz

Performance Analysis

What took most of the time when flattening

- Inner-Outer handling
- Constant function evaluation via dll loading



- Handling of connections sets
- Handling of conditional components
- Handling of component reference equality
- Parsing

Action Plan (I)

Inner-Outer handling

- Complete redesign
- Do not instantiate the outer at all, just use the cached instantiation of the inner (when we do not have inner outer)
- Performance impact
  - Depends on the number of outer models
  - ~65% faster
- Implemented by adrpo

Action Plan (II)

Constant function evaluation via dll loading

- Do not use this at all, instead do function interpretation
- Function interpretation had to be improved as the previous implementation was rather naive
- Performance impact
  - ~40% faster

- Implemented by Per Östlund

Action Plan (III)

Handling of connection sets

- A redesign came up while planning the implementation of stream connectors
- Handling of default set-to-zero connections
- Performance impact
  - ~30% faster
- Implemented by Per Östlund

Action Plan (IV)

Handling of conditional components

- A redesign came up while planning the implementation of stream connectors
- Do not instantiate conditional components at all when condition is false
- Performance impact
  - ~70% faster

- Implemented by Per Östlund

Action Plan (V)

Handling of component reference equality

- Better functionality for checking component reference equality
- Compare structures first then strings
- Performance impact
  - ~93% faster
- Implemented by adrpo

Action Plan (VI)

Parsing MSL 3.1 (everything)

- The old parser based on ANTLR2 was rather slow (~23 seconds)
- The new parser based on ANTLR3 was much better (~4 seconds)
- Performance impact
  - ~82% faster for parsing

- Implemented by Martin Sjölund & adrpo

Performance Results

Early 2011 situation

- Flattening of EngineV6 now takes
  - ~20 seconds
- Flattening of EngineV6 took
  - 430 minutes, ~7.2hours

- Flattening performance impact
  - **~99.92% faster / ~1290 times faster**
  - **Is this a happy ending for the MultiBody story? Not yet ☺ I would say. It could be even better.**

Conclusion

A MultiBody Story – Happy End?

- Took ~1 year and a lot of re-design and new implementation to make the flattening of MultiBody Engine V6 ~**1290 times faster**.

- It was less time than that, as we handled many other things during this time.

Thank You!
Questions?

OpenModelica Project
http://www.OpenModelica.org

Disclaimer

The numbers in this story are approximations and any resemblance to real data, is purely coincidental.