Termination Competition 2015

Jürgen Giesl    Frederic Mesnard
Albert Rubio    René Thiemann    Johannes Waldmann

RWTH Aachen    HTWK Leipzig    Universite de la Reunion
UPC BarcelonaTech    University of Innsbruck    HTWK Leipzig

August, 2015. CADE-25
The Halting Problem
The Halting Problem

The longer it keeps you waiting
the more you appreciate a termination analysis
History of the Termination Competition

• Started in 2003.

• From 2004 to 2009: executed online on all benchmarks

• From 2009 on: random selection of benchmarks

• From 2010 on: Live execution during a conference.

• 2014: First time running under StarExec
Competition areas

- **Term Rewriting and Transition systems**
  - TRS (Standard, Context-Sensitive, Higher-Order, Integer, **Cycles**, ...)
  - String Rewrite Systems
  - Certified categories
  - Integer Transition Systems

- **Complexity analysis**
  - Runtime complexity (TRS)
  - Derivational complexity (TRS)
  - Certified categories

- **Programming Languages**
  - C, **Integer C**, Java, Haskell, Prolog.
15 tools from 13 teams

1. AProVE (Aachen, Germany)
2. AutoNon (Amsterdam, The Netherlands)
3. Ctrl (Innsbruck, Austria)
4. cycsrs (Frankfurt, Germany and Eindhoven, The Netherlands)
5. HipTNT+ (Singapore)
6. matchbox (Leipzig, Germany)
7. muterm (Valencia, Spain)
8. NaTT, (Nagoya, Japan)
9. T2 (Microsoft Cambridge, UK)
10. TCT2 and TCT3 (Innsbruck, Austria)
11. TTT2 (Innsbruck, Austria)
12. UltimateBuchiAutomizer (+Joogie) (Freiburg, Germany and Canberra, Australia)
13. Wanda (Innsbruck, Austria)
Running Competition

- Execution organizer:
  Johannes Waldmann

- Second time running under StarExec Platform.

- An important reimplementation effort needed.

- Unexpectedly many more problems appeared in this second use of StarExec
  Solving platform problems until the very last moment.
Running Competition

- Benchmarks taken form the Termination Problem Data Base (TPDB)
- Timeout 300 seconds
- Only categories with at least two participants (from different teams) are run in the competition.

There is a full demonstration run afterwards with all categories.
## Termination Competition 2015

### General Information
- wc = 300 a = 1 b = 1 c = 0.1
- 51787 pairs, 12024641.5 / 6232857.3 s finished in 399686h 5m 50s

### Termination of Term Rewriting (and Transition Systems)

<table>
<thead>
<tr>
<th>Category</th>
<th>Post-proc Rankings</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRS Standard</td>
<td>plain 3</td>
<td>AProVE 2015 (1310), NaTT 1.3 (1023), TTT2 (989), muterm 5.17 (834), Wanda (636), matchbox2015-07-26.1 (524), AutoNon 1.21 (228), 10486 pairs, 1666958.3 / 824051.3 s</td>
</tr>
<tr>
<td>SRS Standard</td>
<td>plain 3</td>
<td>AProVE 2015 (832), TTT2 (598), matchbox2015-07-26.1 (365), NaTT 1.3 (202), muterm 5.17 (135), AutoNon 1.21 (58), 7890 pairs, 257023.5 / 1324912.6 s</td>
</tr>
<tr>
<td>Cycles</td>
<td>matchbox2015-07-26.1 (646), cycsrs-29-07-2015.5 (422), 2630 pairs, 950125.9 / 453572.0 s</td>
<td></td>
</tr>
<tr>
<td>TRS Relative</td>
<td>plain 3</td>
<td>NaTT 1.3 (70), AProVE 2015 (55), TTT2 (41), matchbox2015-07-26.1 (40), 392 pairs, 77146.9 / 34711.5 s</td>
</tr>
<tr>
<td>SRS Relative</td>
<td>AProVE 2015 (88), matchbox2015-07-26.1 (32), TTT2 (24), NaTT 1.3 (17), 820 pairs, 274225.6 / 145649.5 s</td>
<td></td>
</tr>
<tr>
<td>TRS Standard certified</td>
<td>ceta-2.20-2 AProVE certified TRS Standard (1223), TTT2 (962), 2996 pairs, 251319.4 / 124453.7 s</td>
<td></td>
</tr>
<tr>
<td>SRS Standard certified</td>
<td>AProVE 2015 (816), TTT2 (570), 2630 pairs, 486311.2 / 223843.9 s</td>
<td></td>
</tr>
<tr>
<td>TRS Relative certified</td>
<td>ceta-2.20-2 AProVE certified (51), TTT2 (41), 196 pairs, 29112.5 / 17896.6 s</td>
<td></td>
</tr>
<tr>
<td>SRS Relative certified</td>
<td>ceta-2.20-2 AProVE certified (88), TTT2 (20), 410 pairs, 76372.8 / 46591.8 s</td>
<td></td>
</tr>
<tr>
<td>TRS Equational</td>
<td>AProVE 2015 (67), muterm 5.17 (63), 152 pairs, 3067.0 / 3466.0 s</td>
<td></td>
</tr>
<tr>
<td>TRS Conditional</td>
<td>muterm 5.17 (101), AProVE 2015 (85), 234 pairs, 5576.4 / 5099.8 s</td>
<td></td>
</tr>
<tr>
<td>TRS Context Sensitive</td>
<td>muterm 5.17 (98), AProVE 2015 (97), 216 pairs, 7100.2 / 5007.1 s</td>
<td></td>
</tr>
<tr>
<td>TRS Innermost</td>
<td>AProVE 2015 (273), muterm 5.17 (203), 732 pairs, 102735.3 / 77628.8 s</td>
<td></td>
</tr>
<tr>
<td>Integer Transition Systems</td>
<td>T2 - 2015-07-09 - 13745bd6 (1061), AProVE 2015 (1034), Ctrl (423), 3666 pairs, 212567.8 / 200512.7 s</td>
<td></td>
</tr>
<tr>
<td>Integer TRS</td>
<td>AProVE 2015 (102), Ctrl (85), 234 pairs, 13954.0 / 6549.1 s</td>
<td></td>
</tr>
</tbody>
</table>

### Complexity Analysis of Term Rewriting

<table>
<thead>
<tr>
<th>Category</th>
<th>Post-proc Rankings</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Derivational Complexity - Full Rewriting</td>
<td>plain 3</td>
<td>TCT3_2015 (833), matchbox2015-07-26.1 (369), TCT2_20150725 (0), 5427 pairs, 2534205.9 / 1205378.3 s</td>
</tr>
<tr>
<td>Runtime Complexity - Full Rewriting</td>
<td>plain 3</td>
<td>AProVE 2015 (1218), TCT3_2015 (414), TCT2_20150725 (0), 2877 pairs, 791627.1 / 439245.3 s</td>
</tr>
<tr>
<td>Runtime Complexity - Innermost Rewriting</td>
<td>plain 3</td>
<td>AProVE 2015 (2102), TCT3_2015 (759), TCT2_20150725 (0), 3246 pairs, 916945.1 / 491516.2 s</td>
</tr>
<tr>
<td>Runtime Complexity - Innermost Rewriting certified</td>
<td>ceta-2.20-2 TCT3_2015 (689), AProVE certified (495), TCT2_20150725 (0), 3246 pairs, 898136.9 / 471493.2 s</td>
<td></td>
</tr>
</tbody>
</table>

### Termination of Programming Languages

<table>
<thead>
<tr>
<th>Category</th>
<th>Post-proc Rankings</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>plain 3</td>
<td>UltimateBuchiAutomizer (277), AProVE 2015 (252), HipTNT+ v3 (249), 1416 pairs, 84389.0 / 85616.8 s</td>
</tr>
<tr>
<td>C Integer Programs</td>
<td>plain 3</td>
<td>HipTNT+ v3 (305), UltimateBuchiAutomizer (285), AProVE 2015 (289), 1005 pairs, 40026.8 / 22753.0 s</td>
</tr>
<tr>
<td>Java Bytecode</td>
<td>plain 3</td>
<td>AProVE 2015 (410), UltimateBuchiAutomizer (141), 886 pairs, 32502.0 / 22906.2 s</td>
</tr>
</tbody>
</table>

Termination Competition 2015 data is produced on StarExec at UIowa, and aggregated on star-exec-presenter at F-IMN, HTWK Leipzig.
Competition Data

- 15 tools
- > 15,000 problems from the TPDB (benchmarks library)
- 120 execution nodes (StarExec).
- \(\sim\) 14 hours of live execution (would be 10 weeks in single node!)
- CeTA is the certifier in use (Christian Sternagel and René Thiemann)
TermComp 2015 Winners. Term Rewriting (and Transition Systems)
TermComp 2015 Winners. Term Rewriting (and Transition Systems)

TRS Standard:
1st AProVE
2nd NaTT
3rd TTT2

SRS Standard:
1st AProVE
2nd TTT2
3rd matchbox

Cycles:
1st matchbox
2nd cycsrs

TRS Relative:
1st NaTT
2nd AProVE
3rd TTT2

SRS Relative:
1st AProVE
2nd matchbox
3rd TTT2

TRS Equational:
1st AProVE
2nd muterm

TRS Conditional:
1st muterm
2nd AProVE

TRS Context Sensitive:
1st muterm
2nd AProVE

TRS Innermost:
1st AProVE
2nd muterm
TermComp 2015 Winners. Term Rewriting (and Transition Systems)

TRS Standard:
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TermComp 2015 Winners. Term Rewriting (and Transition Systems)

TRS Standard:
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3rd matchbox

Cycles:
1st matchbox
2nd cycsrs
TermComp 2015 Winners. Term Rewriting (and Transition Systems)

**TRS Standard:**
- 1st AProVE
- 2nd NaTT
- 3rd TTT2

**TRS Relative:**
- 1st NaTT
- 2nd AProVE
- 3rd TTT2

**SRS Standard:**
- 1st AProVE
- 2nd TTT2
- 3rd matchbox

**Cycles:**
- 1st matchbox
- 2nd cycsrs
TermComp 2015 Winners. Term Rewriting (and Transition Systems)

<table>
<thead>
<tr>
<th>TRS Standard:</th>
<th>TRS Relative:</th>
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<tbody>
<tr>
<td>1st AProVE</td>
<td>1st NaTT</td>
</tr>
<tr>
<td>2nd NaTT</td>
<td>2nd AProVE</td>
</tr>
<tr>
<td>3rd TTT2</td>
<td>3rd TTT2</td>
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<table>
<thead>
<tr>
<th>SRS Standard:</th>
<th>SRS Relative:</th>
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<tbody>
<tr>
<td>1st AProVE</td>
<td>1st AProVE</td>
</tr>
<tr>
<td>2nd TTT2</td>
<td>2nd matchbox</td>
</tr>
<tr>
<td>3rd matchbox</td>
<td>3rd TTT2</td>
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</table>

Cycles:

| 1st matchbox |
| 2nd cycsrs   |
## TermComp 2015 Winners. Term Rewriting (and Transition Systems)

<table>
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<tr>
<th>Category</th>
<th>TRS Standard</th>
<th>TRS Relative</th>
<th>SRS Standard</th>
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<tr>
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<td>2nd matchbox</td>
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<td>1st AProVE</td>
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<table>
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<th>First</th>
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<td>TTT2</td>
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<tr>
<td><strong>SRS Standard:</strong></td>
<td>AProVE</td>
<td>TTT2</td>
<td>matchbox</td>
</tr>
<tr>
<td><strong>Cycles:</strong></td>
<td>matchbox</td>
<td>cycsrs</td>
<td></td>
</tr>
<tr>
<td><strong>TRS Relative:</strong></td>
<td>NaTT</td>
<td>AProVE</td>
<td>TTT2</td>
</tr>
<tr>
<td><strong>SRS Relative:</strong></td>
<td>AProVE</td>
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<table>
<thead>
<tr>
<th>SRS Standard:</th>
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<th>TRS Context Sensitive:</th>
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<td>1st muterm</td>
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<table>
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<tr>
<th>Cycles:</th>
<th>TRS Equational:</th>
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<tbody>
<tr>
<td>1st matchbox</td>
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<tr>
<td>2nd cycsrs</td>
<td>2nd muterm</td>
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<td>AProVE</td>
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<td>AProVE</td>
<td></td>
</tr>
<tr>
<td><strong>TRS Innermost:</strong></td>
<td>AProVE</td>
<td>muterm</td>
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</table>
TermComp 2015 Winners. Term Rewriting (and Transition Systems)

1st T2
2nd AProVE
3rd Ctrl

Integer TRS:
1st AProVE
2nd Ctrl

TRS Standard certified:
1st AProVE
2nd TTT2

SRS Standard certified:
1st AProVE
2nd TTT2

TRS Relative certified:
1st AProVE
2nd TTT2

SRS Relative certified:
1st AProVE
2nd TTT2
Integer Transition Systems:

1st  T2
2nd  AProVE
3rd  Ctrl
Integer Transition Systems:

1st T2
2nd AProVE
3rd Ctrl

Integer TRS:

1st AProVE
2nd Ctrl
TermComp 2015 Winners. Term Rewriting (and Transition Systems)

Integer Transition Systems:
- 1st T2
- 2nd AProVE
- 3rd Ctrl

Integer TRS:
- 1st AProVE
- 2nd Ctrl

TRS Standard certified:
- 1st AProVE
- 2nd TTT2

SRS Standard certified:
- 1st AProVE
- 2nd TTT2

SRS Relative certified:
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- 2nd TTT2
TermComp 2015 Winners. Term Rewriting (and Transition Systems)

Integer Transition Systems:

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TermComp 2015 Winners. Term Rewriting (and Transition Systems)

Integer Transition Systems:

1st  T2
2nd  AProVE
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Integer TRS:

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TRS Standard certified:

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TRS Relative certified:

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2nd  TTT2

SRS Standard certified:

1st  AProVE
2nd  TTT2

SRS Relative certified:

1st  AProVE
2nd  TTT2
TermComp 2015 Winners. Complexity Analysis

Runtime Complexity
Full Rewriting:
1st AProVE
2nd TCT3

Runtime Complexity
Innermost Rewriting:
1st AProVE
2nd TCT3

Runtime Complexity
Innermost Rewriting certified:
1st TCT3
2nd AProVE

Derivational Complexity
Full Rewriting:
1st TCT3
2nd matchbox
Runtime Complexity

Full Rewriting:

1st  AProVE
2nd  TCT3
Runtime Complexity
Full Rewriting:
  1st  AProVE
  2nd  TCT3

Runtime Complexity
Innermost Rewriting:
  1st  AProVE
  2nd  TCT3
TermComp 2015 Winners. Complexity Analysis

Runtime Complexity
Full Rewriting:
1st AProVE
2nd TCT3

Runtime Complexity
Innermost Rewriting:
1st AProVE
2nd TCT3

Runtime Complexity
Innermost Rewriting certified:
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2nd AProVE
TermComp 2015 Winners. Complexity Analysis

Runtime Complexity
Full Rewriting:
1st AProVE
2nd TCT3

Runtime Complexity
Innermost Rewriting:
1st AProVE
2nd TCT3

Runtime Complexity
Innermost Rewriting certified:
1st TCT3
2nd AProVE

Derivational Complexity
Full Rewriting:
1st TCT3
2nd matchbox
TermComp 2015 Winners. Programming Languages

- C:
  1st UltimateBuchiAutomizer
  2nd AProVE
  3rd HipTNT+

- C Integer Programs:
  1st HipTNT+
  2nd UltimateBuchiAutomizer
  3rd AProVE

- Java Bytecode:
  1st AProVE
  2nd UltimateBuchiAutomizer+Joogie
TermComp 2015 Winners. Programming Languages

- C:
  - 1st UltimateBuchiAutomizer
  - 2nd AProVE
  - 3rd HipTNT+
TermComp 2015 Winners. Programming Languages

- C:
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  2nd AProVE
  3rd HipTNT+

- C Integer Programs:
  1st HipTNT+
  2nd UltimateBuchiAutomizer
  3rd AProVE
TermComp 2015 Winners. Programming Languages

- **C:**
  1st UltimateBuchiAutomizer
  2nd AProVE
  3rd HipTNT+

- **C Integer Programs:**
  1st HipTNT+
  2nd UltimateBuchiAutomizer
  3rd AProVE

- **Java Bytecode:**
  1st AProVE
  2nd UltimateBuchiAutomizer+Joogie
TermComp 2015 Leaders

- Term Rewriting: AProVE
- Complexity Analysis: TCT3
- Programming Languages: UltimateBuchiAutomizer

But up to 8 tools out of 13 won at least one category!

Check complete results in
http://nfa.imn.htwk-leipzig.de/termcomp-2015/competitions/4
Acknowledgments

Thanks to all participants
And thanks a lot to
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Termination Competition 2015. CADE-25
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