Computation of Alias Sets from Shape Graphs for Comparison of Shape Analysis Precision

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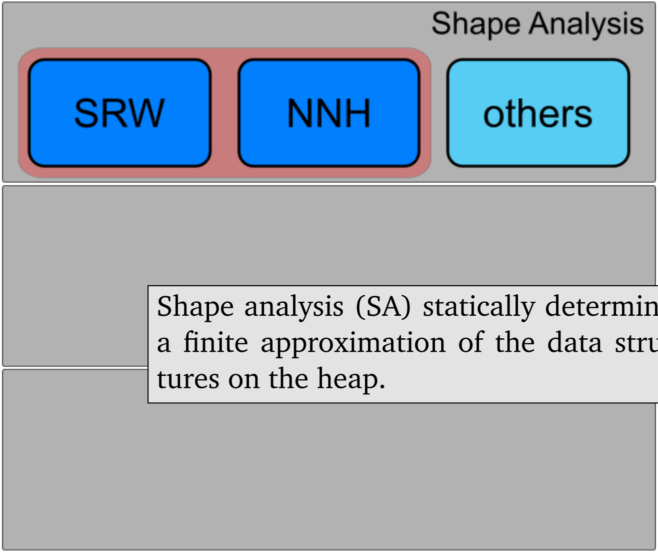
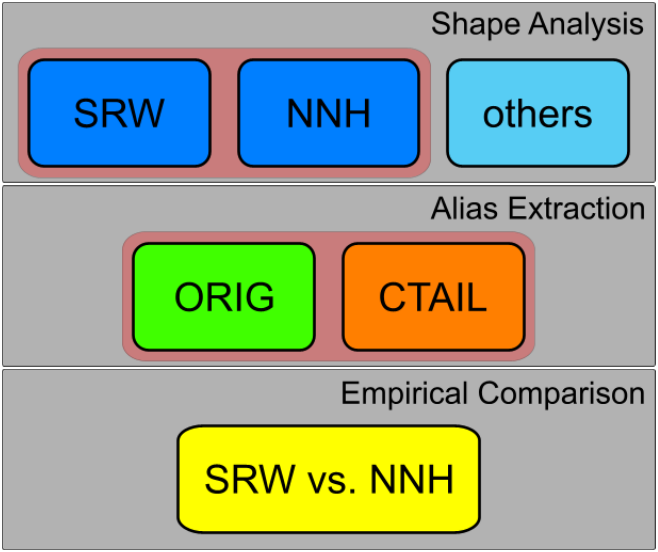
September 2011

Overview



Shape analysis (SA) statically determines a finite approximation of the data structures on the heap.

Overview



Shape Analysis
SRW
NNH
others
Alias Extraction
ORIG
CTAIL
Empirical Comparison
SRW vs. NNH

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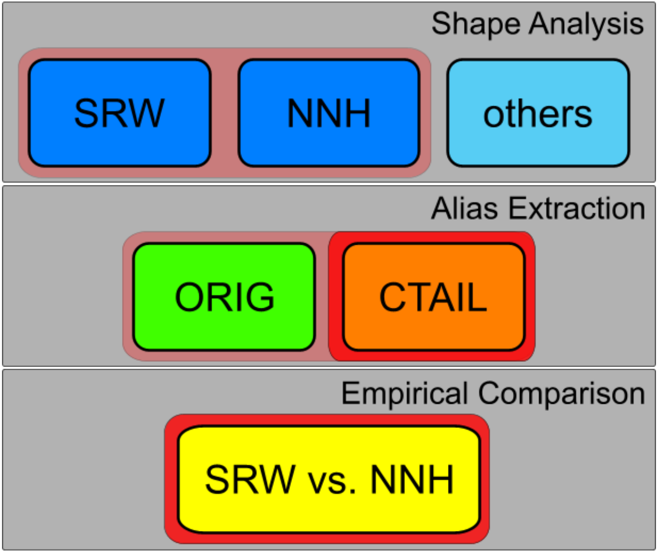
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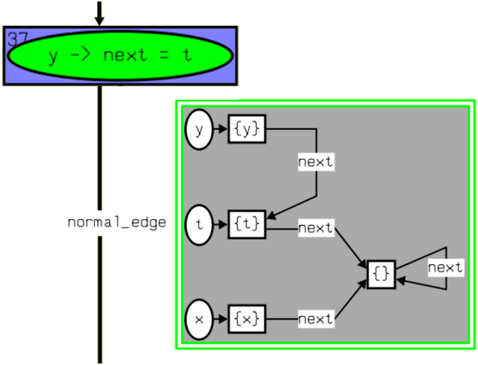
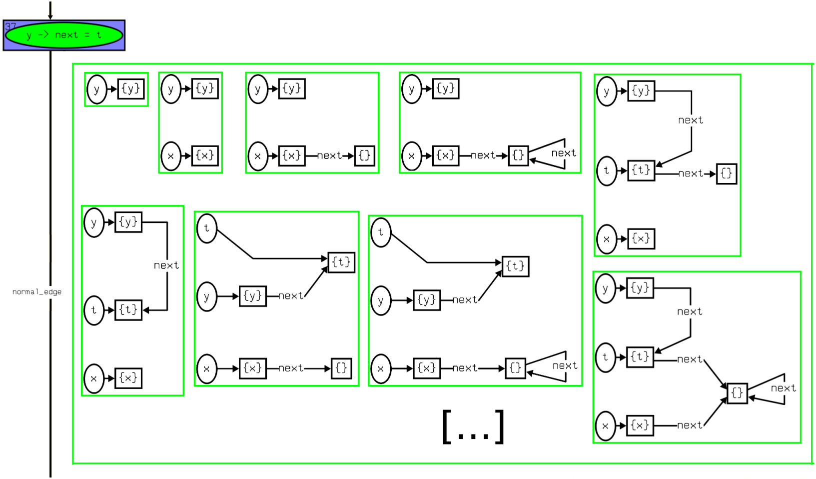
SRW Shape Analysis

[SRW98] Mooly Sagiv, Thomas W. Reps, and Reinhard Wilhelm. Solving shape-analysis problems in languages with destructive updating. ACM Transactions on Programming Languages and Systems (TOPLAS), 20(1):1–50, January 1998.



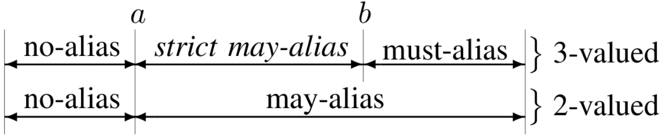
NNH Shape Analysis

[NNH05] Flemming Nielson, Hanne Riis Nielson, and Chris Hankin. Principles of Program Analysis, chapter Shape Analysis, pages 102–129. Springer, 2005.



Comparing the Precision of Shape Analyses

- Comparing Shape Analysis results directly does not work.
- Naive idea: convert representation, then compare.
  - ➥ Compare usefulness for a specific application
  - ➥ In our work: Aliasing Information for Compiler Optimizations



Relation between 2-valued and 3-valued alias sets.

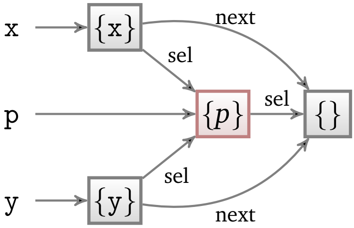
Benchmarks for Graph-based Shape Analyses

- [RS01] Noam Rinetzky, Mooly Sagiv. Interprocedural Shape Analysis for Recursive Programs. LNCS 2027, 133–149, 2001.
- [SRW98] Mooly Sagiv, Thomas W. Reps, and Reinhard Wilhelm. Solving shape-analysis problems in languages with destructive updating. ACM Transactions on Programming Languages and Systems (TOPLAS), 20(1):1–50, January 1998.

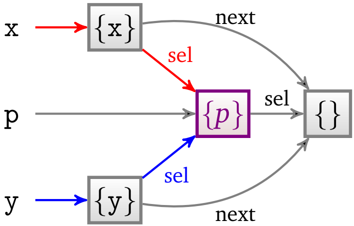
Operations on Linked Lists

- `insert`, `append`, `remove`, `delall`, `search`, `reverse`, `merge`
- Two versions each: with loops (`lp`), and unrolled (`nb`)

Existing Approach (RSW02):
Do path expressions refer to same node?



Alias Computation for a single SG_i



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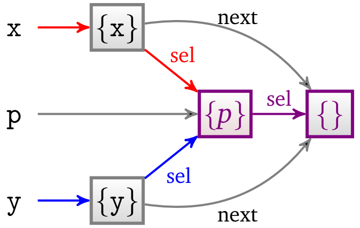

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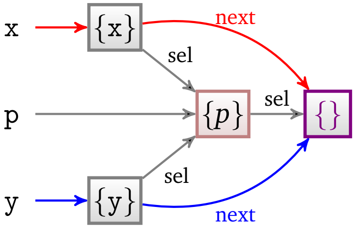

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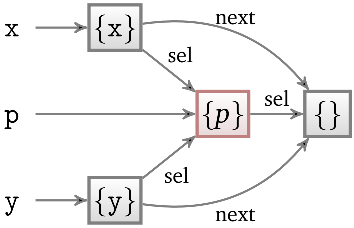

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Our "Common Tail" Improvement:
Do path expressions meet at same named node and share a common tail of selectors?

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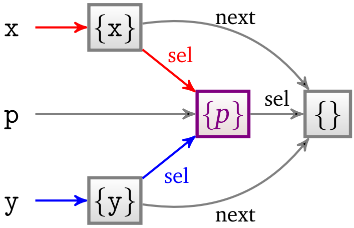

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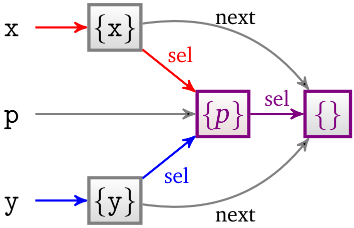

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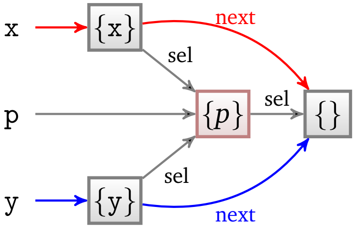

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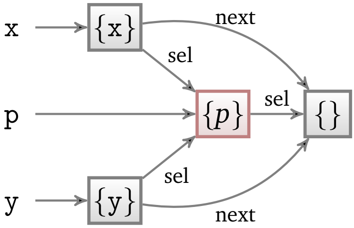

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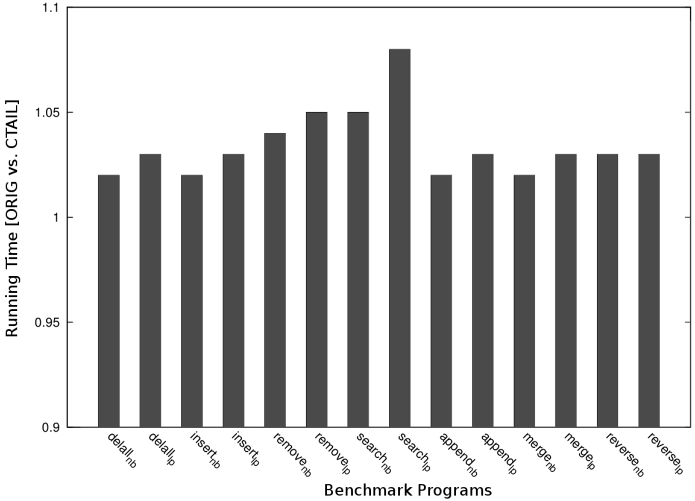
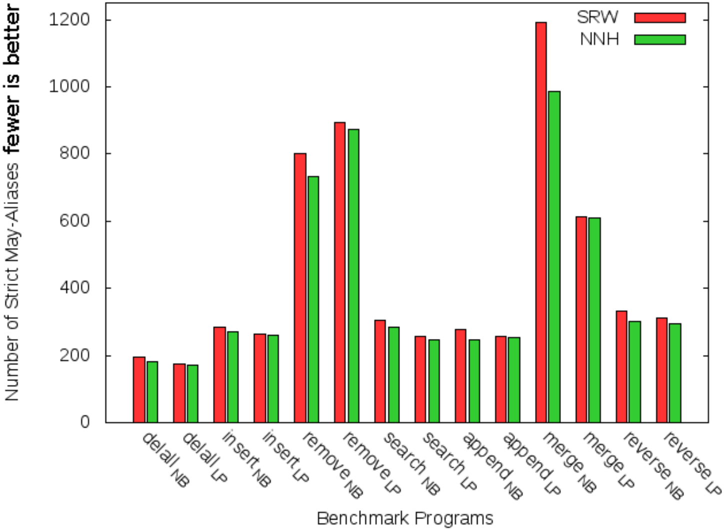
$$

Runtime of CTAIL vs. ORIG

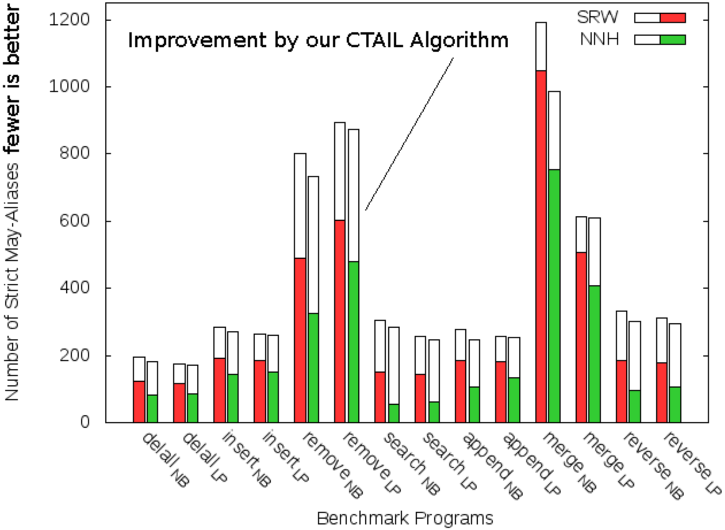
- Path-Checks not too expensive
- Overhead for CTAIL well below 10% of ORIG's runtime



SRW vs. NNH – using ORIG



SRW vs. NNH – using CTAIL



Conclusion

Contributions

- Improved Alias Extraction Algorithm of [RSW02] comparing paths instead of only the final nodes
- Up to $5\times$ more precise with only $< 10\%$ runtime overhead
- First implementation of the NNH Shape Analysis algorithm
- Empirical comparison of SRW and NNH Shape Analyses

Result

- With CTAIL we can extract from NNH shape graphs $1.62\times$ more precise aliasing information than from SRW results on average for our benchmarks.
- Without CTAIL (ORIG) only $1.06\times$ more precise aliasing information can be extracted.

Some More Pointers

http://www.complang.tuwien.ac.at/vpavlu

Bibliography:

- [NNH05] Flemming Nielson, Hanne Riis Nielson, and Chris Hankin. Principles of Program Analysis, chapter Shape Analysis, pages 102–129. Springer, 2005.
- [RSW02] Thomas W. Reps, Mooly Sagiv, and Reinhard Wilhelm. Shape analysis and applications. In The Compiler Design Handbook: Optimizations and Machine Code Generation, pages 175–218. CRC Press, 2002.
- [SRW98] Mooly Sagiv, Thomas W. Reps, and Reinhard Wilhelm. Solving shape-analysis problems in languages with destructive updating. ACM Transactions on Programming Languages and Systems (TOPLAS), 20(1):1–50, January 1998.

Improved Precision with CTAIL

	Algorithm: ORIG		Algorithm: CTAIL	
	$n_\emptyset \notin is$	$n_\emptyset \in is$	$n_\emptyset \notin is$	$n_\emptyset \in is$
with	$\frac{1}{2}$	$\frac{1}{2}$	1	1
without	$\frac{1}{2}$	$\frac{1}{2}$	0	$\frac{1}{2}$

$n_\emptyset \in (\notin)\ is$: the summary location is shared (unshared).
with (without): there is a (no) intermediate node from which both expressions share a common tail of selectors.