

Figure 1: timing-pattern

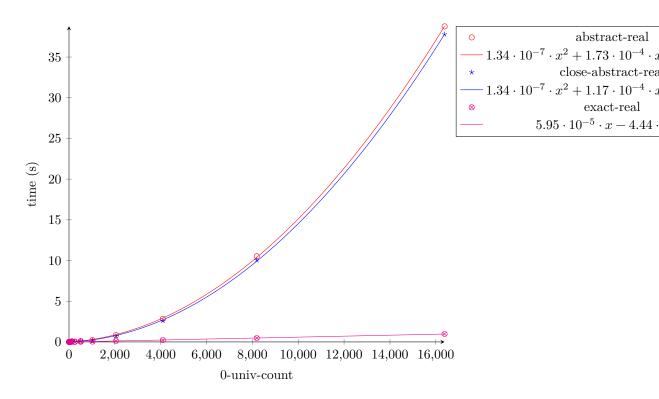
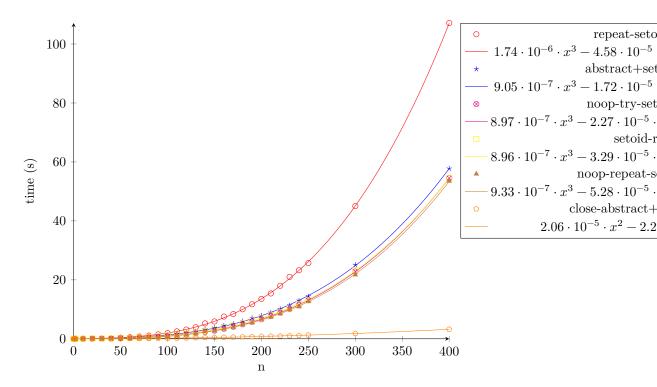
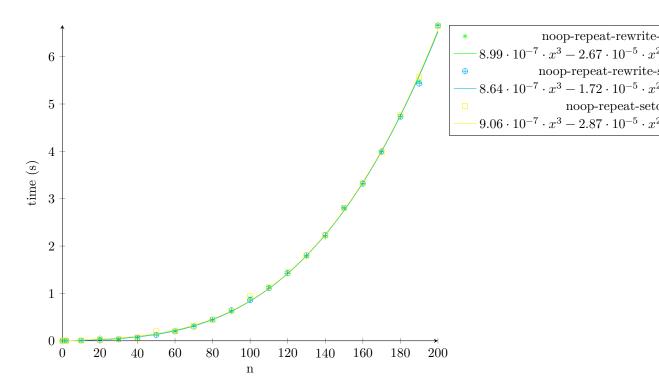


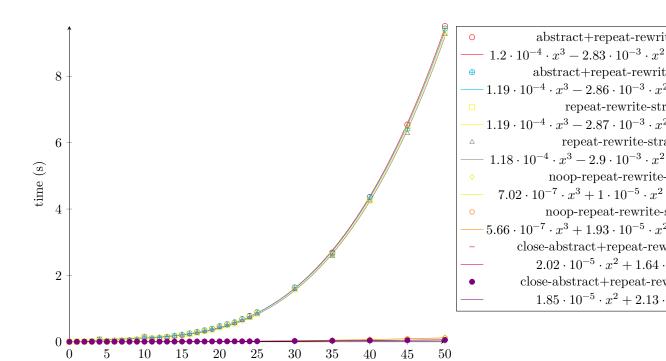
Figure 2: timing-n-polymorphic-universes param-1-n  $\,0\,$ 



 $Figure \ 3: \ timing-repeat-setoid-rewrite-under-binders$ 

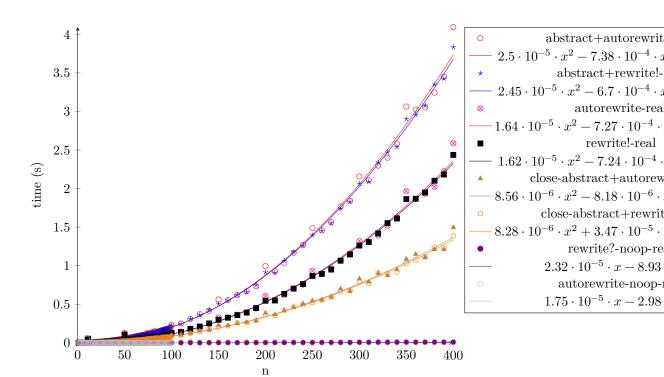


 $Figure\ 4:\ timing-repeat-setoid-rewrite-under-binders-noop$ 

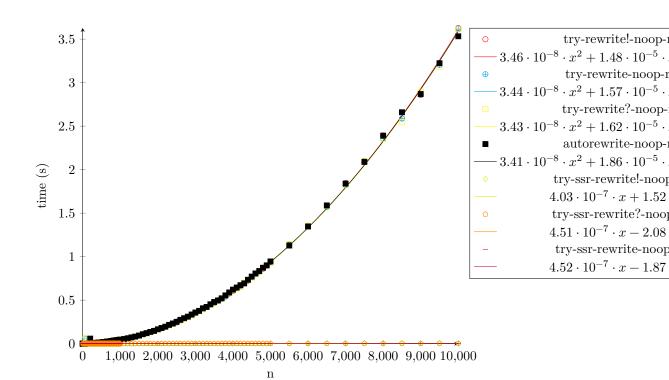


 $Figure\ 5:\ timing-rewrite-strat-under-binders$ 

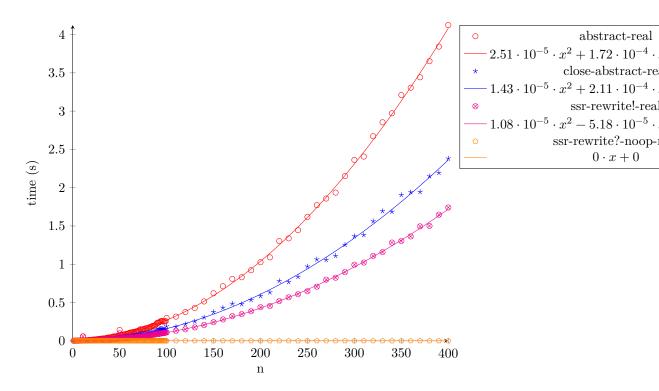
n



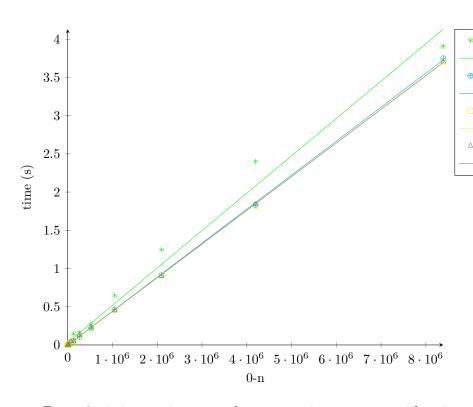
 $Figure \ 6: \ timing-rewrite-repeated-app-autorewrite \\$ 



 $Figure~7:~timing\mbox{-rewrite-repeated-app-autorewrite-noop}$ 



 $Figure \ 8: \ timing-rewrite-repeated-app-ssrrewrite \\$ 



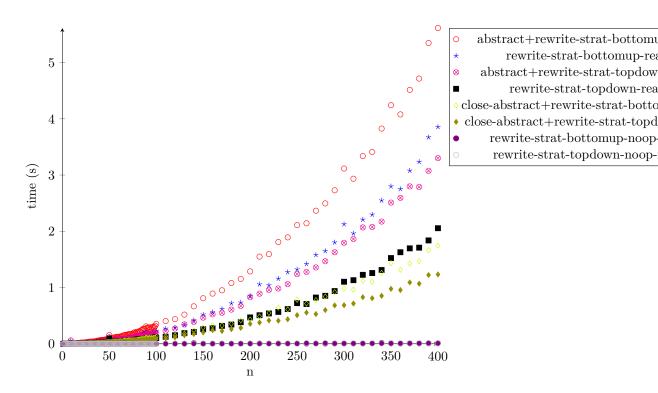
try-ssr-rewrite!-cold-noop-rea  $4.89 \cdot 10^{-7} \cdot x + 2.85 \cdot 10^{-2}$ try-ssr-rewrite?-noop-real

 $\begin{array}{l} 4.45 \cdot 10^{-7} \cdot x - 3.3 \cdot 10^{-3} \\ \text{try-ssr-rewrite-noop-real} \end{array}$ 

 $\begin{array}{l} 4.4\cdot 10^{-7}\cdot x - 2.78\cdot 10^{-3} \\ \text{try-ssr-rewrite!-noop-real} \end{array}$ 

 $4.41\cdot 10^{-7}\cdot x - 5.34\cdot 10^{-4}$ 

Figure 9: timing-rewrite-repeated-app-ssrrewrite-noop param-1-lgn  $\ 1$ 



rewrite-strat-bottomup-real

rewrite-strat-topdown-rea

 $Figure~10:~timing\mbox{-rewrite-repeated-app-rewrite-strat}$ 

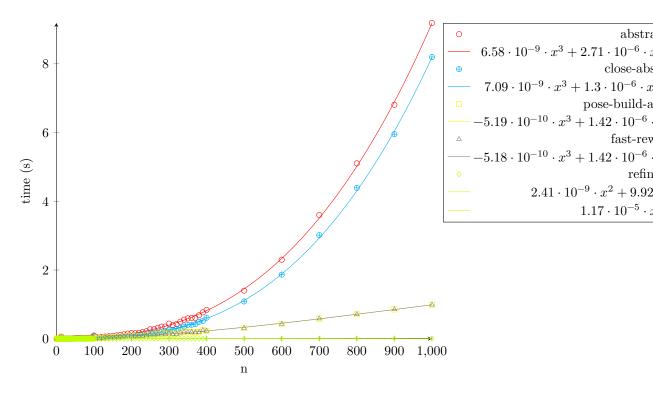
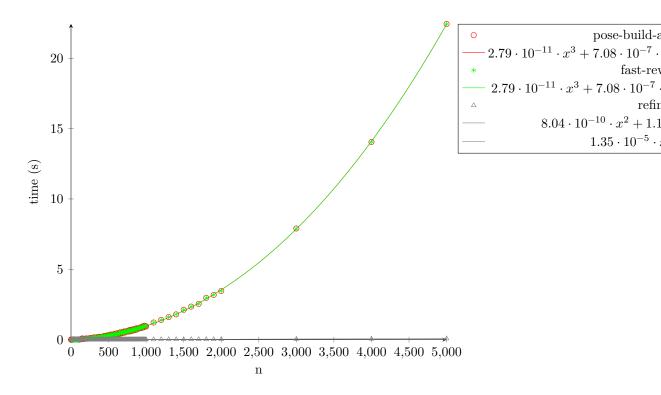
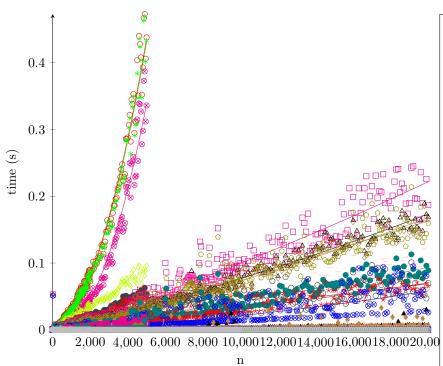


Figure 11: timing-rewrite-repeated-app-fast-rewrite



Figure~12:~timing-rewrite-repeated-app-fast-rewrite-no-abstract



reif-for-beta-Para  $1.55 \cdot 10^{-8} \cdot x^2 + 9$ norm-reif-for-beta-I  $1.55 \cdot 10^{-8} \cdot x^2 + 8$ eval-lazy-for-beta-F  $1.51 \cdot 10^{-8} \cdot x^2 - 8$ cbv-for-beta-Par  $7.99 \cdot 10^{-11} \cdot x^2 + 1$ actual-reif-for-beta- $4.13 \cdot 10^{-10} \cdot x^2 + 1$ norm-reif-for-beta-Pa  $2.44 \cdot 10^{-10} \cdot x^2 + 9$ reif-for-beta-Paran  $3.01 \cdot 10^{-10} \cdot x^2 + 9$ actual-reif-for-beta-Pa  $2.33 \cdot 10^{-10} \cdot x^2 + 8$ lazy-beta-iota-for-beta  $6.5 \cdot 10^{-11} \cdot x^2 + 7$ reif-for-Parametr  $1.11 \cdot 10^{-10} \cdot x^2 + 8$ reif-for-Parametric  $1.02 \cdot 10^{-10} \cdot x^2 + 6$ norm-reif-for-Paramet  $1.02 \cdot 10^{-10} \cdot x^2 + 6$ norm-reif-for-Param  $3.51 \cdot 10^{-11} \cdot x^2 + 7$ actual-reif-for-Paramet  $7.38 \cdot 10^{-11} \cdot x^2 + 3$ actual-reif-for-Paran  $4.46 \cdot 10^{-11} \cdot x^2 + 3$ eval-lazy-for-Param

cbv-for-beta-Paran  $9.33 \cdot 10^{-11} \cdot x^2 + 2$ cbv-for-Parametric  $1.03 \cdot 10^{-11} \cdot x^2 + 3$ cbv-for-Parametr

 $5.71 \cdot 10^{-12} \cdot x^2 + 3$ lazy-beta-iota-for-beta-l  $1.46 \cdot 10^{-10} \cdot x^2 - 1$ 

lazy-beta-iota-for-Param  $4.05 \cdot 10^{-12} \cdot x^2 + 1$ 

eval-lazy-for-beta-Par  $8.57 \cdot 10^{-11} \cdot x^2 + 3$ 

\* transitivity-(Denote-rv)-for-b  $8.57 \cdot 10^{-11} \cdot x^2 + 3$ 

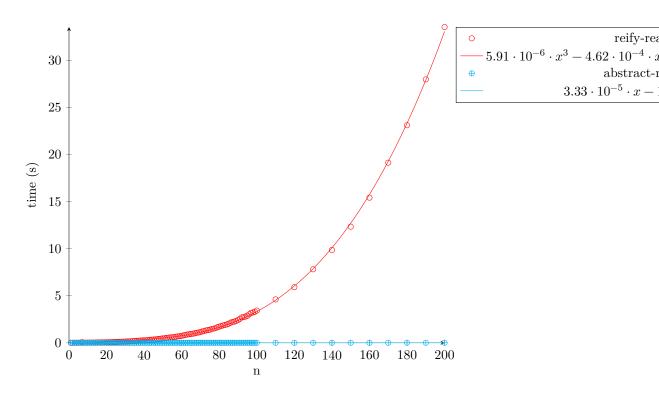
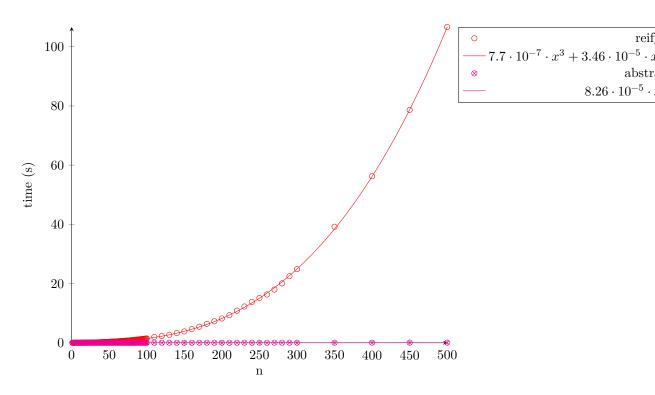
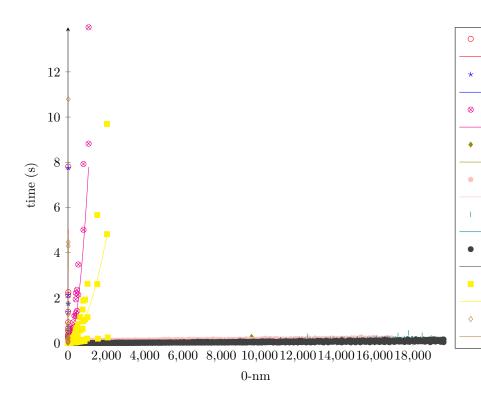


Figure 14: timing-typeclass-reification-let-in-HOAS



 ${\bf Figure~15:~timing-type class-reification-let-in-PHOAS}$ 



rewrite-strat(topdown-bot  $5.19 \cdot 10^{-3} exp(0.46 \cdot ($ 

rewrite-strat (bottomup-bot  $4.82\cdot 10^{-3} \exp{\left(0.46\cdot ($ 

 $6.91 \cdot 10^{-6} \cdot x^2 - 2.18 \cdot 10^{-4} \cdot x^2 = 0.00 \cdot 10^{-4} \cdot x^2 - 10^{-4}$ 

 $1.69 \cdot 10^{-10} \cdot x^2 + 5.14 \cdot 10^{-6} \cdot$ 

 $8.28\cdot 10^{-11}\cdot x^2 + 5.48\cdot 10^{-6}\cdot \\$ 

 $1.92 \cdot 10^{-10} \cdot x^2 + 4.58 \cdot 10^{-6} \cdot$ 

 $1.17 \cdot 10^{-10} \cdot x^2 + 3.12 \cdot 10^{-6} \cdot$ 

 $9.84 \cdot 10^{-7} \cdot x^2 + 3.5 \cdot 10^{-4} \cdot x^2$ 

 $-6.26 \cdot 10^{-3} \cdot x^3 + 0.2 \cdot x^2 - \\$ 

cps+cbn-real

cps+vm-compute-

cps+native-compute

cps+lazy-real

cps+cbv-real

cps+simpl-real

setoid-rewrite-re

Figure 16: timing-rewrite-lift-lets-map param-1-n 1, param-2-m 1

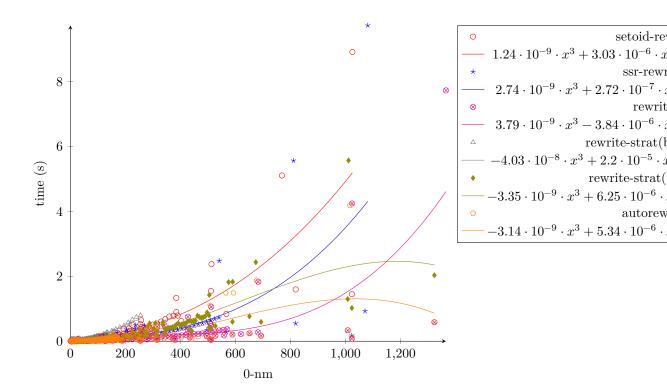
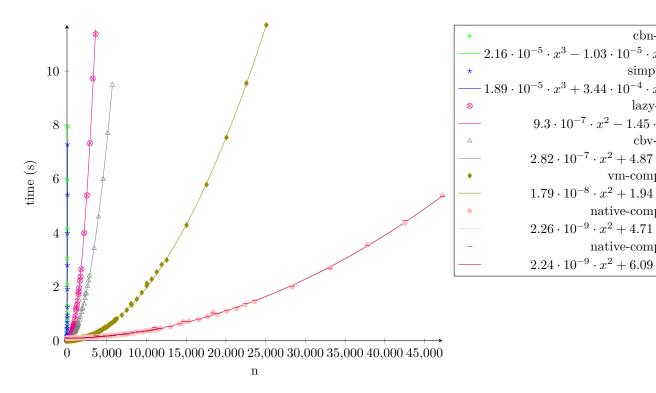


Figure 17: timing-rewrite-plus-0-tree param-1-n 0, param-2-m 1, param-3-input-size 5, param-4-output-size 3, param-5-num-rewrites 1



cbn-

simp

vm-com

native-comp

native-comp

 $9.3 \cdot 10^{-7} \cdot x^2 - 1.45 \cdot$ 

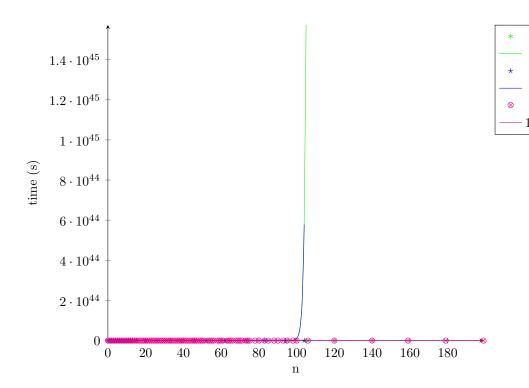
 $2.82 \cdot 10^{-7} \cdot x^2 + 4.87$ 

 $1.79 \cdot 10^{-8} \cdot x^2 + 1.94$ 

 $2.26\cdot 10^{-9}\cdot x^2 + 4.71$ 

 $2.24 \cdot 10^{-9} \cdot x^2 + 6.09$ 

Figure 18: timing-sieve-of-eratosthenes



rewrite-

rewrite-s

Figure 19: timing-rewrite-under-lets-plus-0  $\,$ 

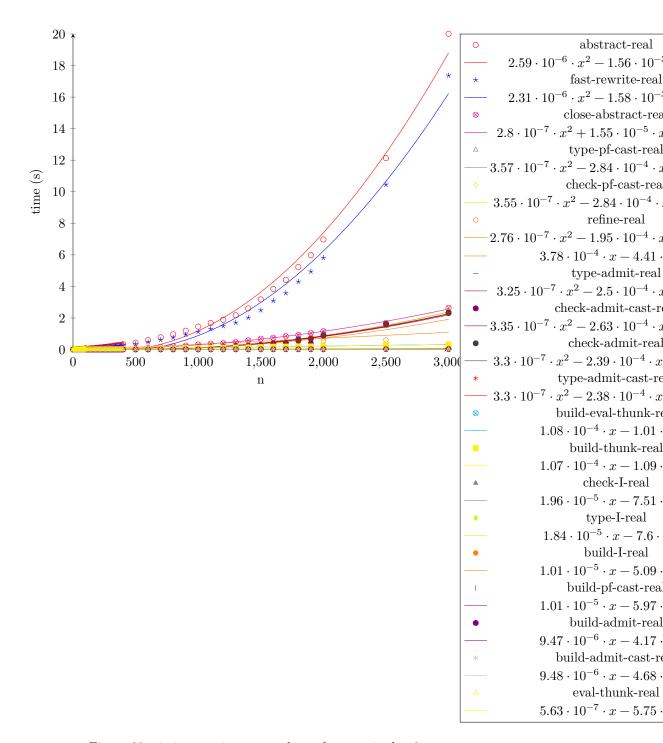


Figure 20: timing-rewrite-repeated-app-fast-rewrite-ltac2