Selective-X Analysis Guided by Impact Pre-Analysis

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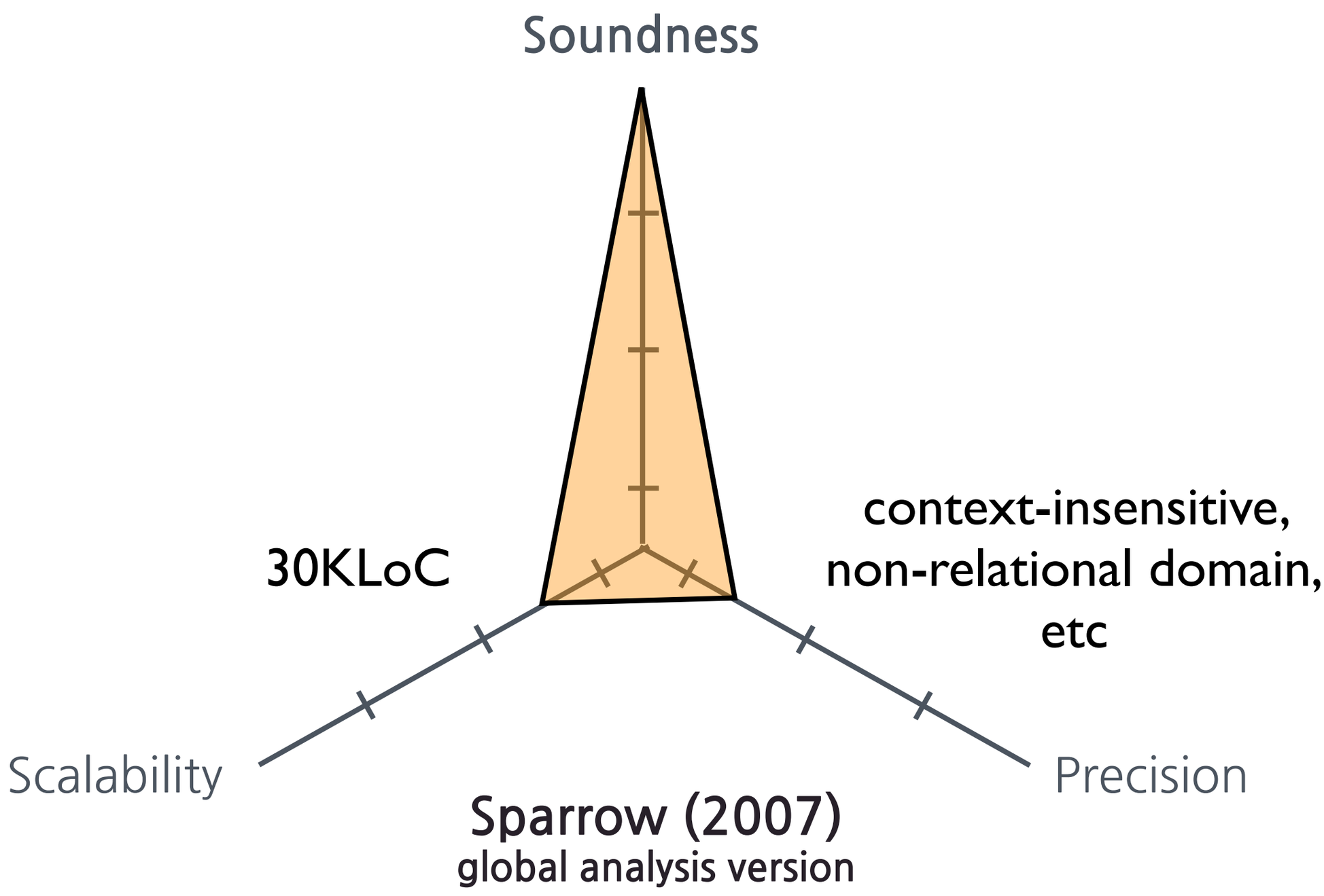
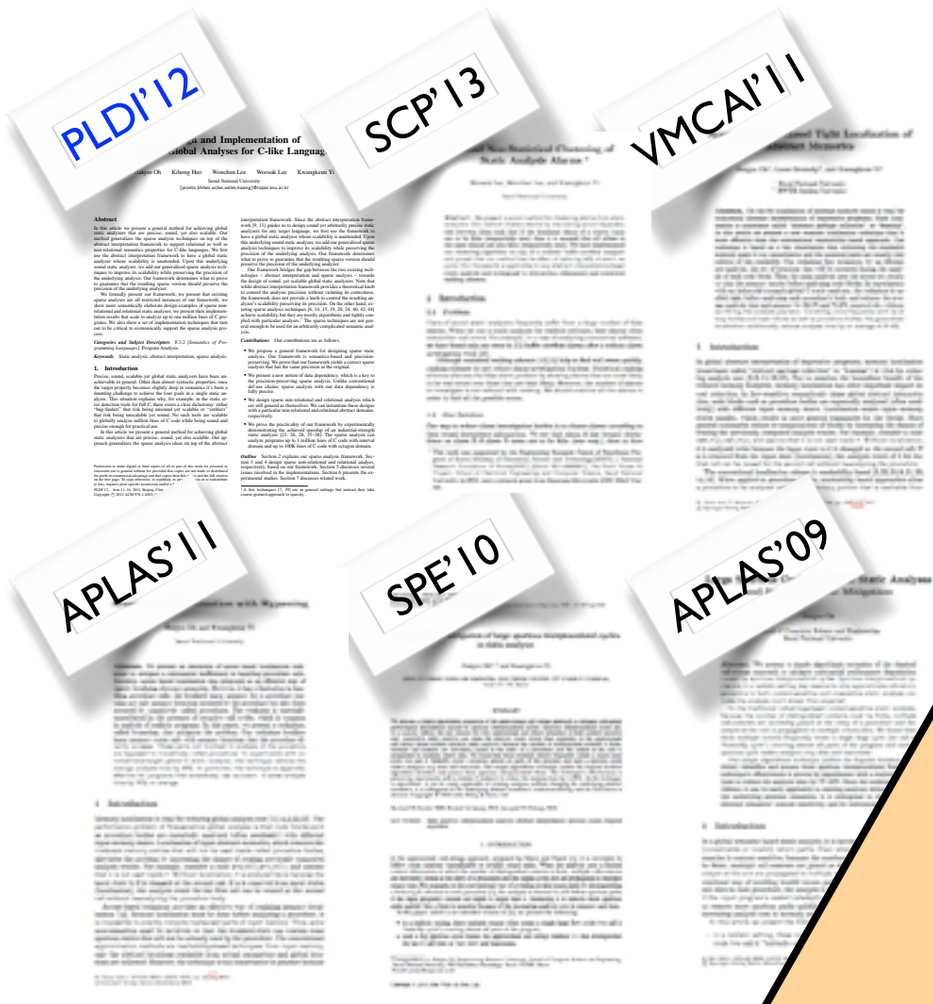
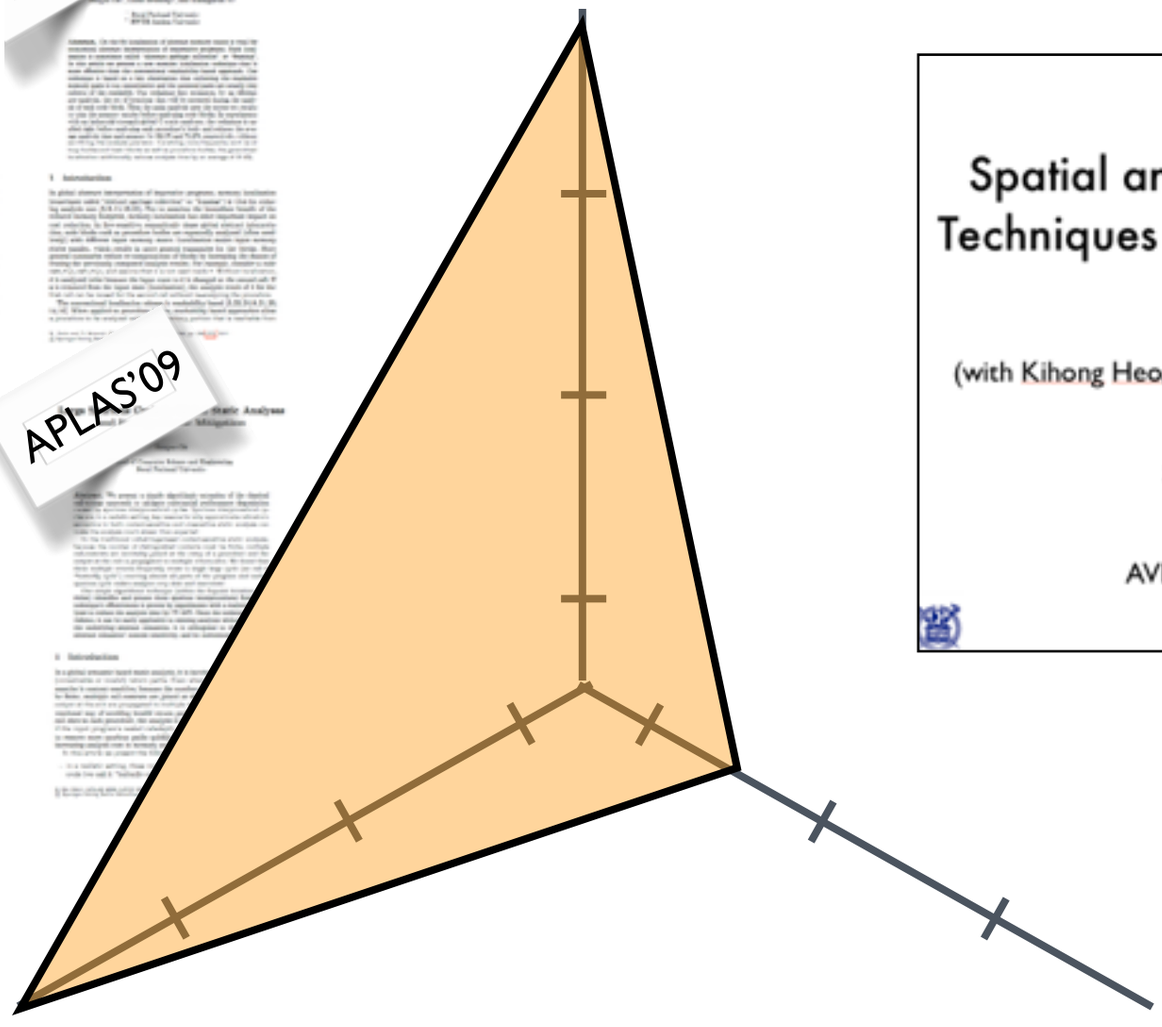
Dec. 23, 2013 @SNU

Motivation


Soundness
30KLoC
context-insensitive,
non-relational domain,
etc
Scalability
Precision
Sparrow (2007)
global analysis version

Motivation





Spatial and Temporal Localization Techniques for Global Static Analysis

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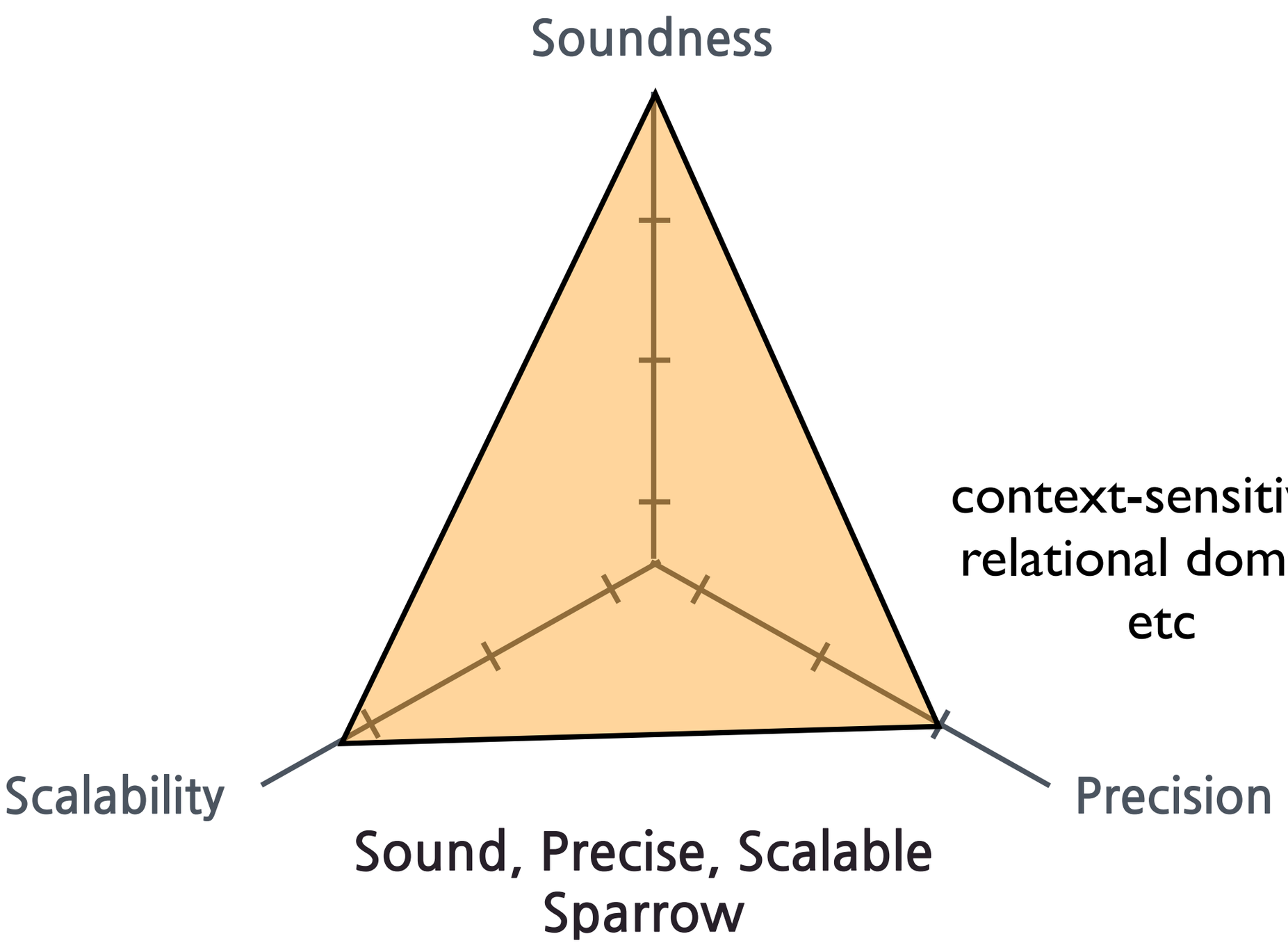
(with Kihong Heo, Wonchan Lee, Woosuk Lee, Kwangkeun Yi)

ROSAEC Center
Seoul National University

Oct. 26, 2012
AVDCPS 2012, Changsha, China

Motivation



context-sensitivity,
relational domain,
etc

Selective-X Analysis Guided by Impact Pre-Analysis

- Selectively apply a higher precision only when it is likely to benefit the final analysis results
- The selection is guided by an impact pre-analysis
- Two instances
  - selective context-sensitive analysis
  - selective relational analysis

Selective Context-Sensitive Analysis

Example Program

```
     void main() {
c1:    f(4);
c2:    f(8);
c3:    f(2);
     }
```

```
     void f(int a) {
c4:    b = g(a);
       assert (b > 1); // Query1
c5:    b = g(input());
       assert (b > 1); // Query2
     }

     void g(int a) {
       return a;
     }
```

Context-Insensitive Analysis

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     void main() {
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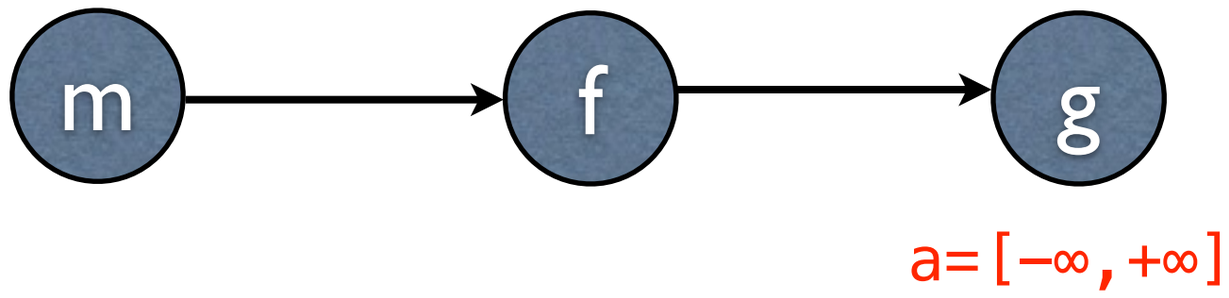

Context-Insensitive Analysis

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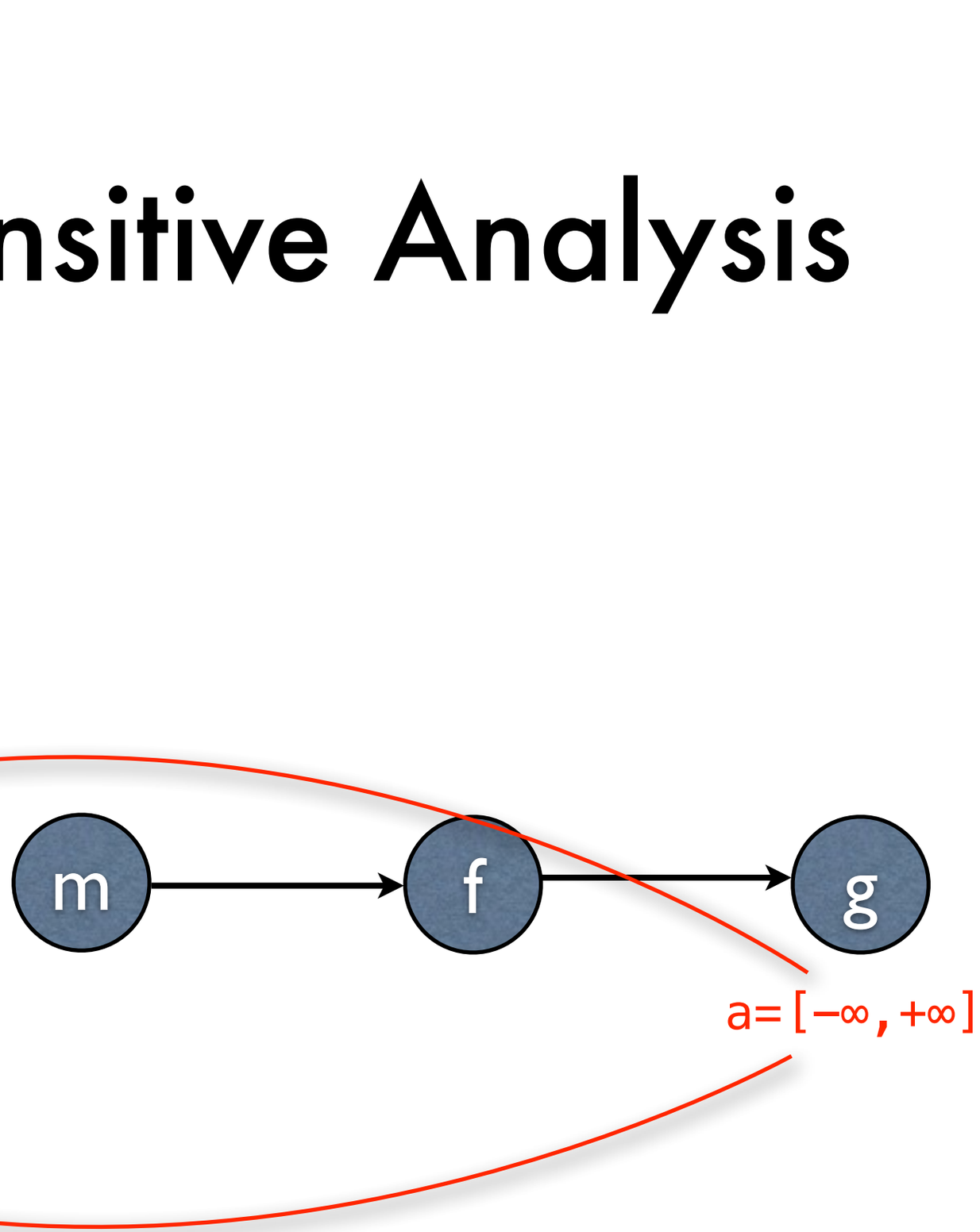

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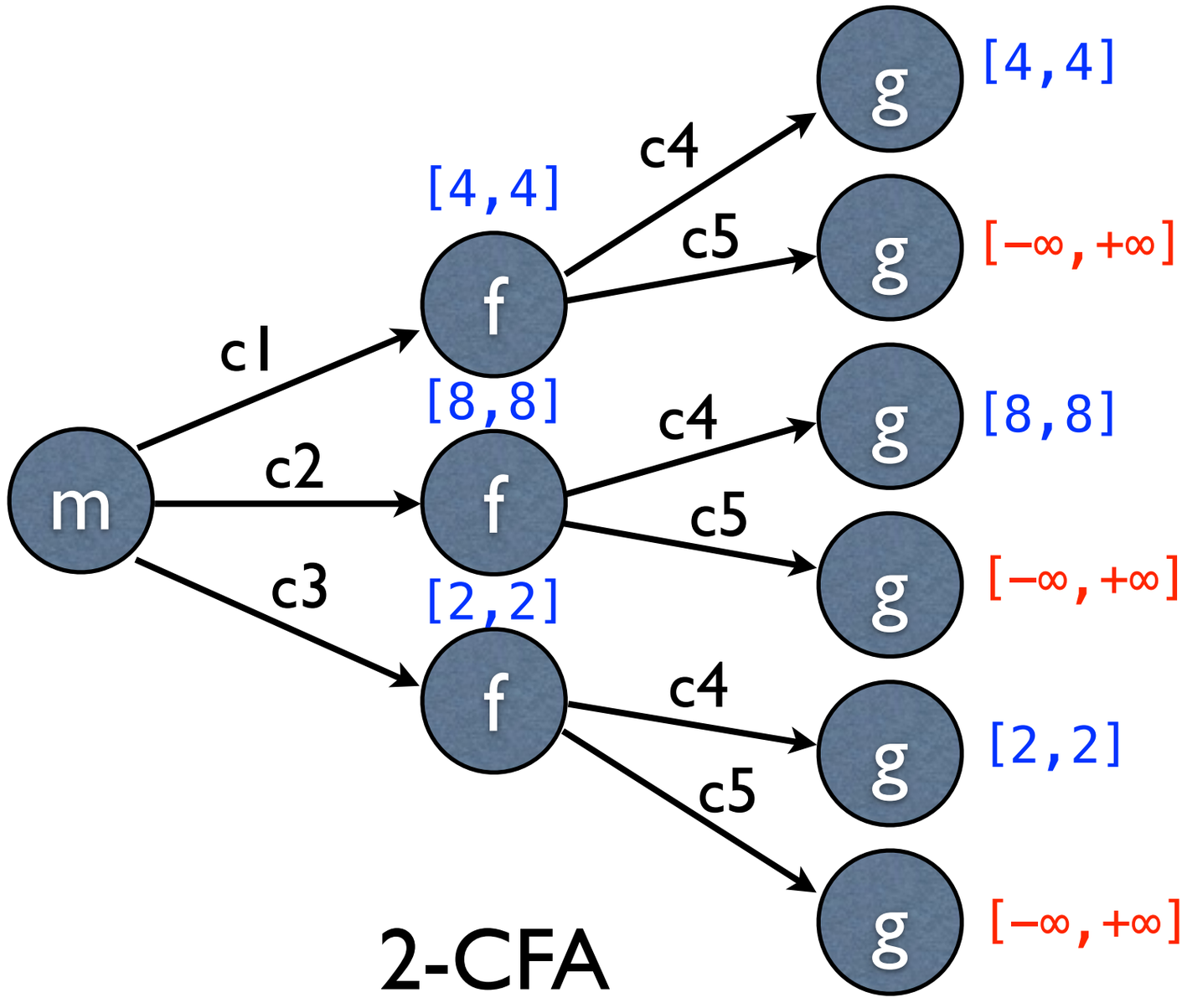

2-CFA

Context-Sensitive Analysis

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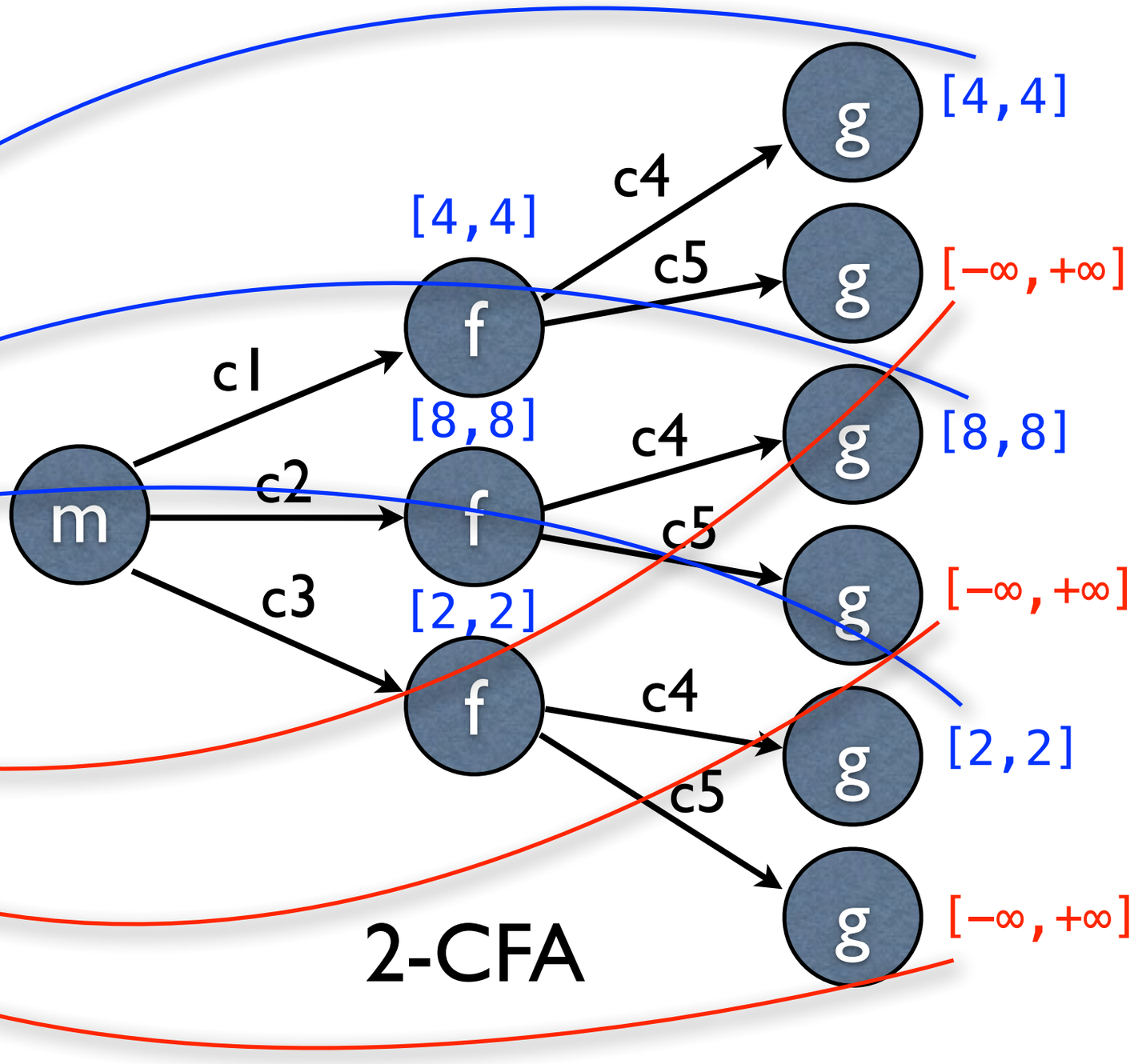

Unnecessarily precise

- Thus, too expensive
  - ex) Sparrow with 3-CFA does not stop after 30min for 10K programs

Selective Context-Sensitive Analysis

```
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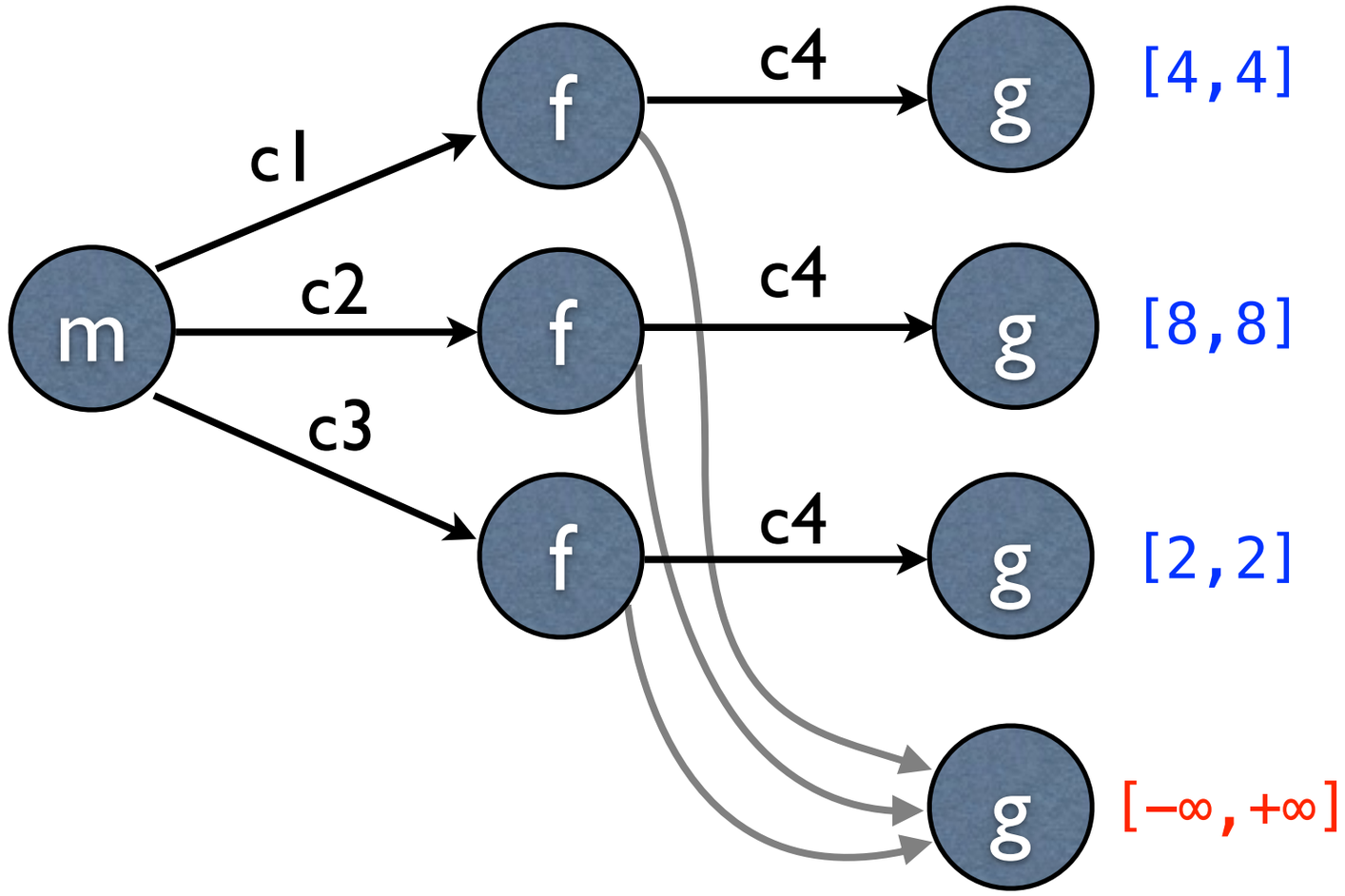

Selective Context-Sensitive Analysis

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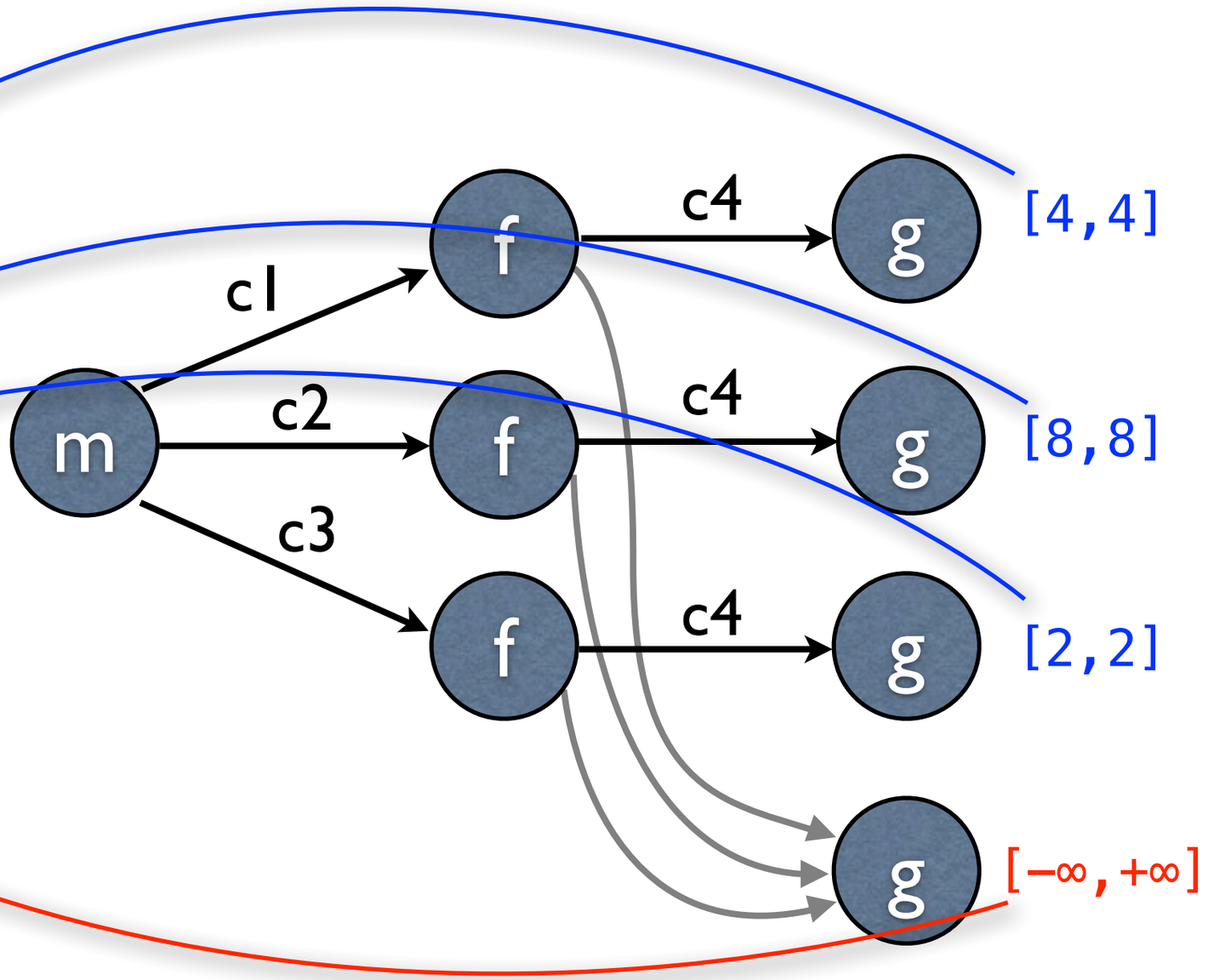
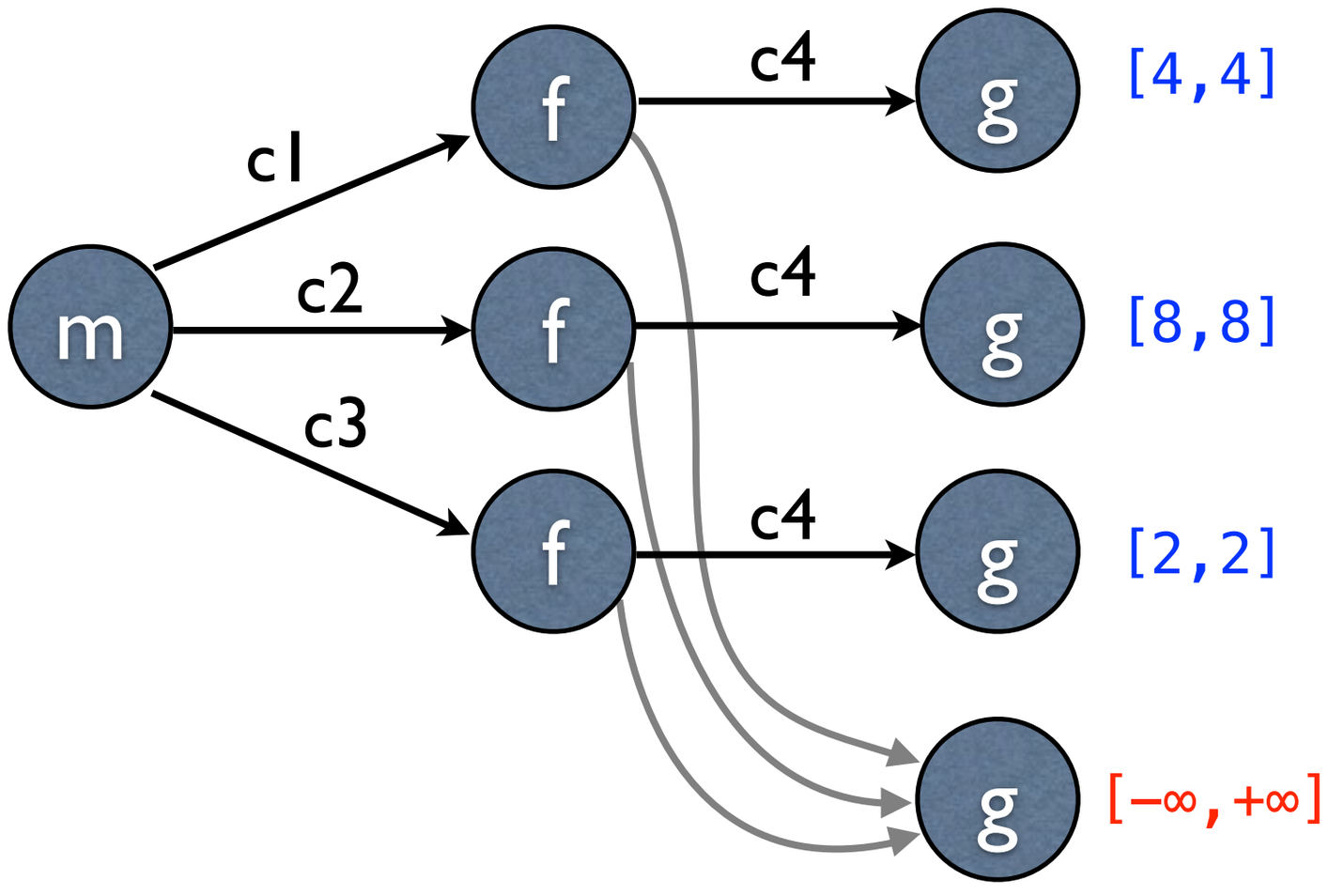


Problem

- How to select the contexts?



Our Solution: Impact Pre-Analysis

- An over-approximation of the fully context-sensitive main analysis
- An impact pre-analysis for interval analysis
  - abstract domain: approximation of intervals

$$\mathbb{V} = \{\bot_v, \bigstar, \top_v\}$$

$$\gamma_v(\bigstar) = \{[a, b] \in \mathbb{I} \mid 0 \leq a\},$$

  - instead, fully context-sensitive

Example

```
     void main() {
c1:    f(4);
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     }

     void f(int a) {
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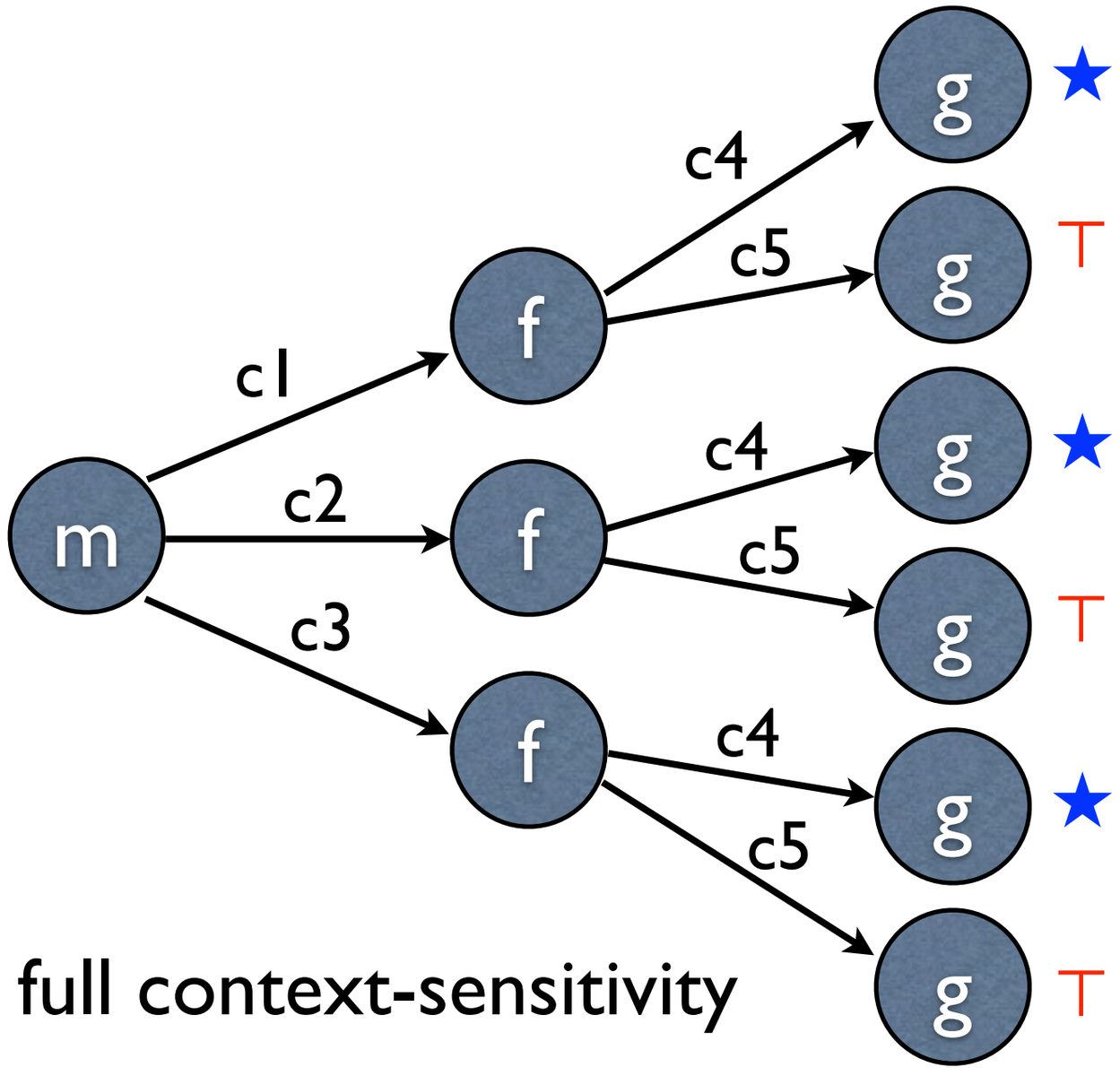

full context-sensitivity

Example

```
     void main() {
c1:    f(4);
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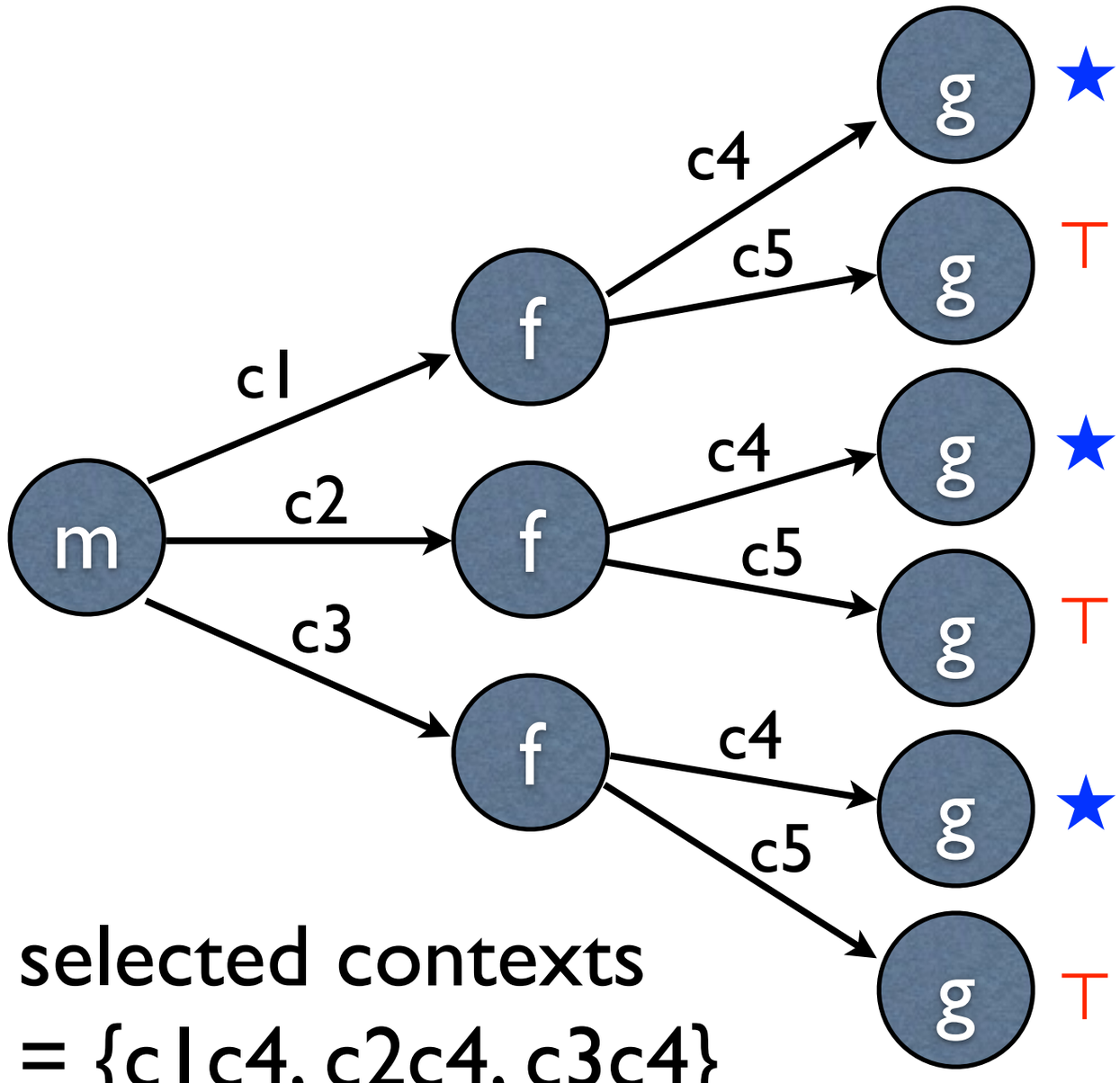

selected contexts
= {c1c4, c2c4, c3c4}

Experiments

Program	LOC	Baseline		Our Selectively Context-Sensitive Analysis						imprvd	overhead$_1$	overhead$_2$
		#alarm	time	#alarm	pre	main	total	#selected call-sites	depth			
spell-1.0	2,213	58	0.6	30	0.1	0.8	0.9	25 / 124 (20.2 %)	1.08 (3)	48.3%	16.7%	33.3%
bc-1.06	13,093	606	14.0	483	1.9	14.3	16.2	29 / 777 (3.7 %)	1.16 (2)	20.3%	13.6%	2.1%
tar-1.17	20,258	940	42.1	799	5.4	41.8	47.2	51 / 1213 (4.2 %)	1.02 (3)	15.0%	12.8%	−0.7%
less-382	23,822	654	123.0	562	3.3	163.1	166.4	51 / 1,522 (3.4 %)	1.71 (4)	14.1%	2.7%	32.6%
sed-4.0.8	26,807	1,325	107.5	1,238	7.4	110.2	117.6	25 / 868 (2.9 %)	1.4 (3)	6.6%	6.9%	2.5%
make-3.76.1	27,304	1,500	84.4	1,028	7.1	99.1	106.2	67 / 1,050 (6.4 %)	1.20 (2)	31.5%	8.4%	17.4%
grep-2.5	31,495	735	12.1	653	2.4	13.5	15.9	33 / 530 (6.2 %)	1.16 (3)	11.2%	19.8%	11.6%
wget-1.9	35,018	1,307	69.0	942	12.5	69.6	82.1	79 / 1,973 (4.0 %)	1.39 (5)	27.9%	18.1%	0.9%
a2ps-4.14	64,590	3,682	118.1	2,121	29.5	148.2	177.7	237 / 2,450 (9.7 %)	2.20 (9)	42.4%	25.0%	25.5%
bison-2.5	101,807	1,894	136.3	1,742	34.6	138.8	173.4	173 / 2,038 (8.5 %)	1.54 (4)	8.0%	25.4%	1.8%
Total	346,407	12,701	707.1	9,598	104.2	799.4	903.6	770 / 12,545 (6.1 %)		**24.4%**	**14.7%**	**13.1%**

24.4% reduction with 27.9% overhead

Summary

- Selective context-sensitivity guided by impact pre-analysis
- General idea for other selective analyses
  - selective relational analysis with octagons
  - selective flow-sensitive analysis
  - etc