A Framework for Cost-effective Dependence-Based Dynamic Impact Analysis

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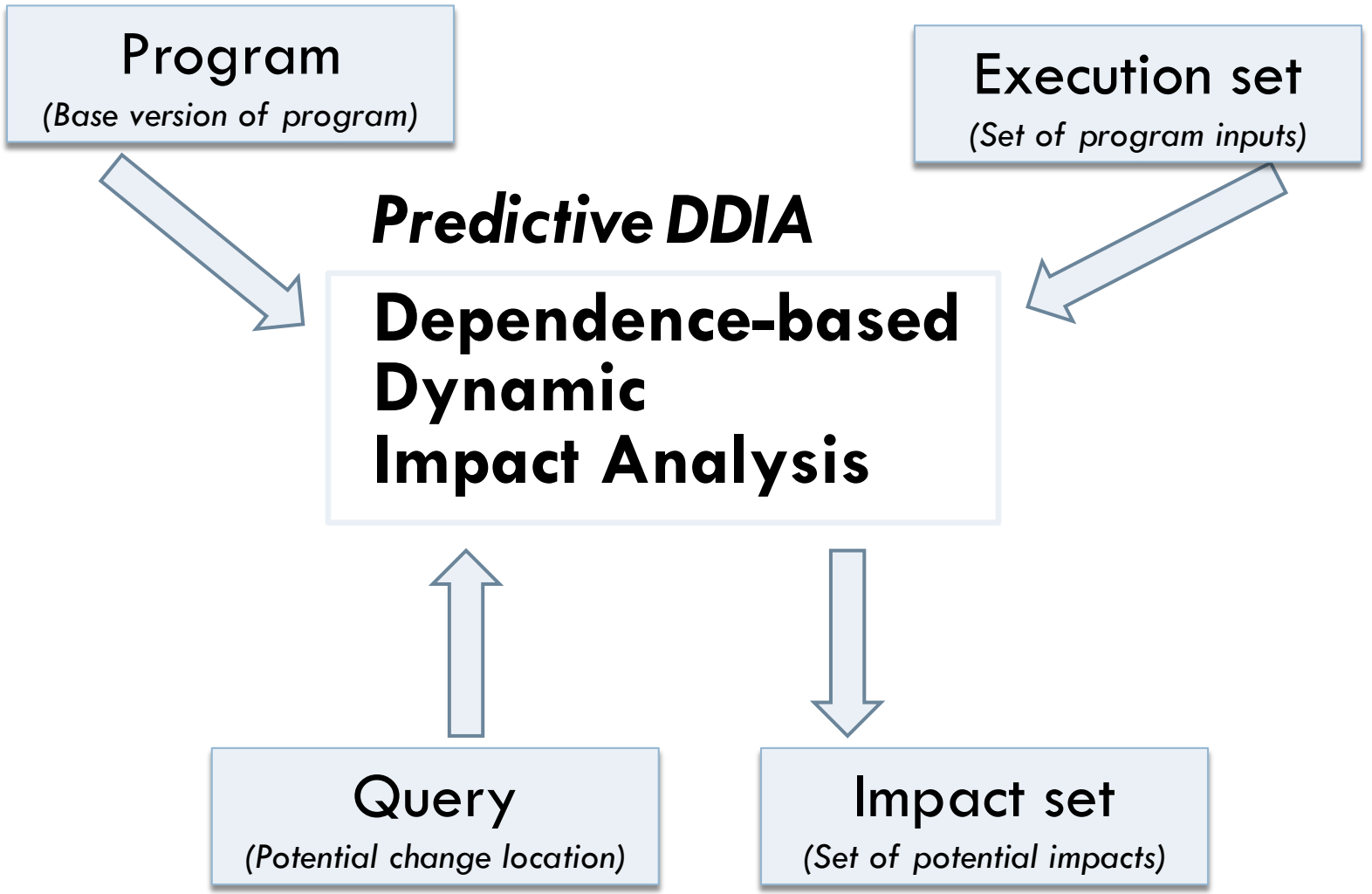
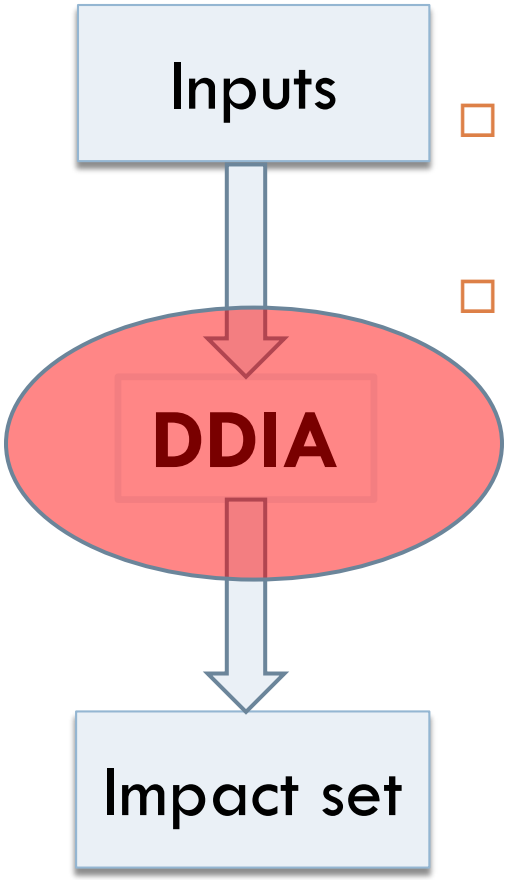
Background

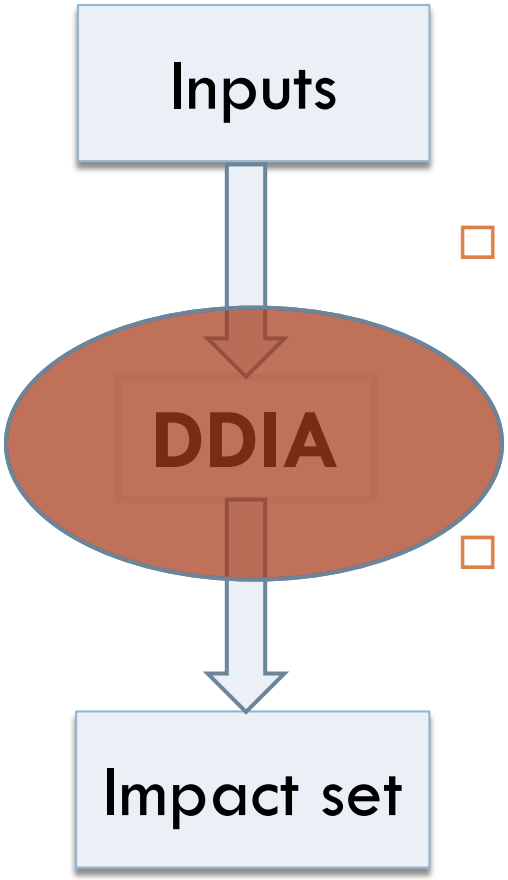

Program
(Base version of program)
Execution set
(Set of program inputs)
Predictive DDIA
Dependence-based
Dynamic
Impact Analysis
Query
(Potential change location)
Impact set
(Set of potential impacts)

Problem



- Efficient approaches are too imprecise
  (e.g., PathImpact/EAS [T. Apiwattanapong et al., 2005])
- Precise approaches are too expensive
  (e.g., dynamic slicing [X. Zhang et al., 2004])
- Developers need techniques of multiple levels of cost-effectiveness tradeoffs for diverse needs
  (e.g., budgets versus the level of precision needed) [C.R. Souza et al., 2008]

Approach

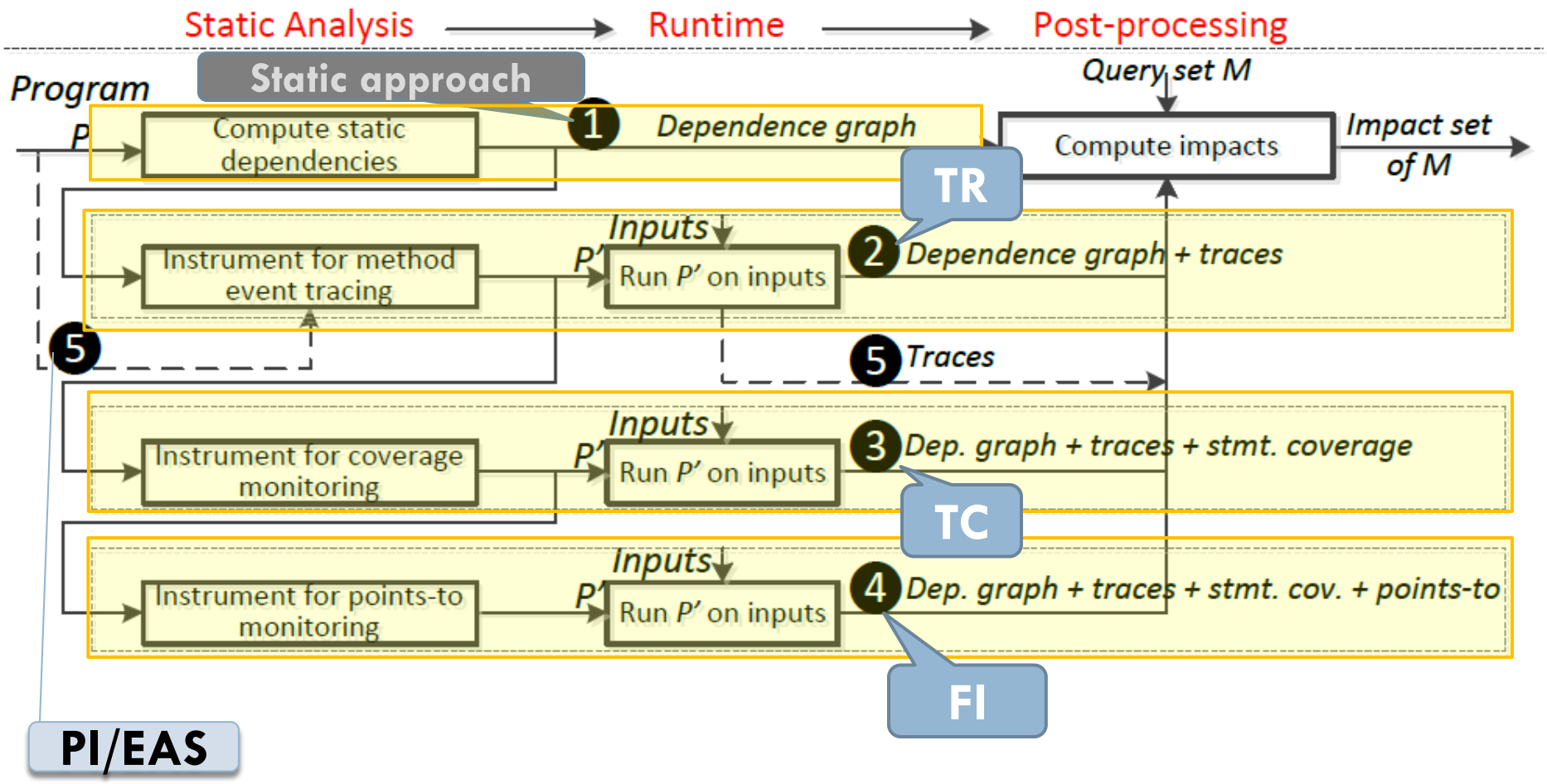


- Utilize static dependencies in collaboration with method-level execution traces (i.e., hybrid approach)
- Exploit additional dynamic information
  - Statement coverage
  - Dynamic points-to data [M. Mock et al., 2005]
- Guide trace-based impact computation with both static and dynamic information

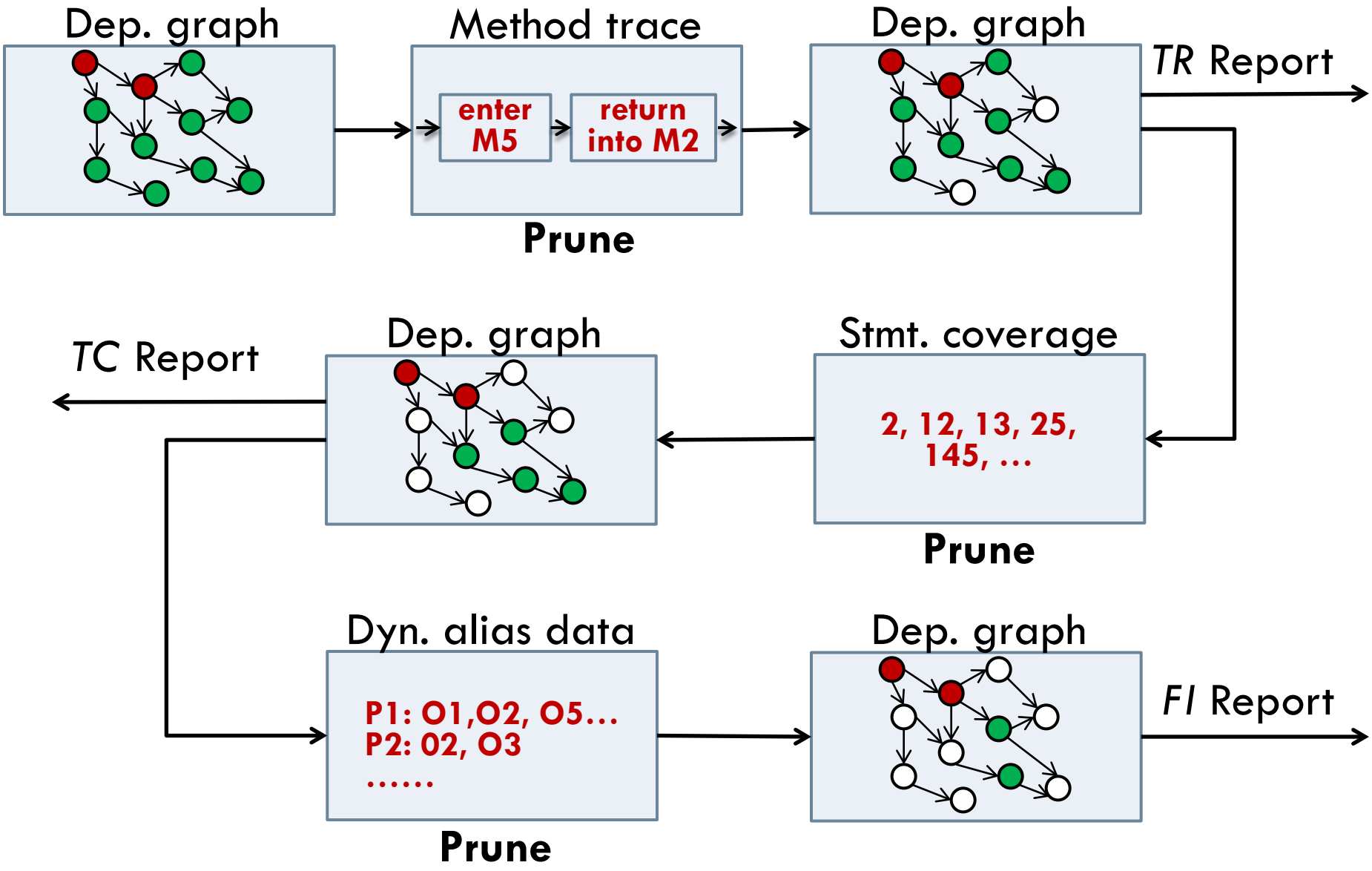
Solution

- A framework that unifies analysis techniques of various cost-effectiveness tradeoffs
  - Including existing representative options (PI/EAS)
  - Spawning three new instances
- Three new instances
  - TR: static dependencies + method TRaces
  - TC: TR + statement Coverage
  - FI: Full Information -- TC + dynamic points-to data

The Framework



Algorithm


Dep. graph
Method trace
enter M5
return into M2
Prune
Dep. graph
TR Report
TC Report
Dep. graph
Stmt. coverage
2, 12, 13, 25, 145, …
Prune
Dyn. alias data
P1: O1,O2, O5…
P2: 02, O3
……
Prune
Dep. graph
FI Report

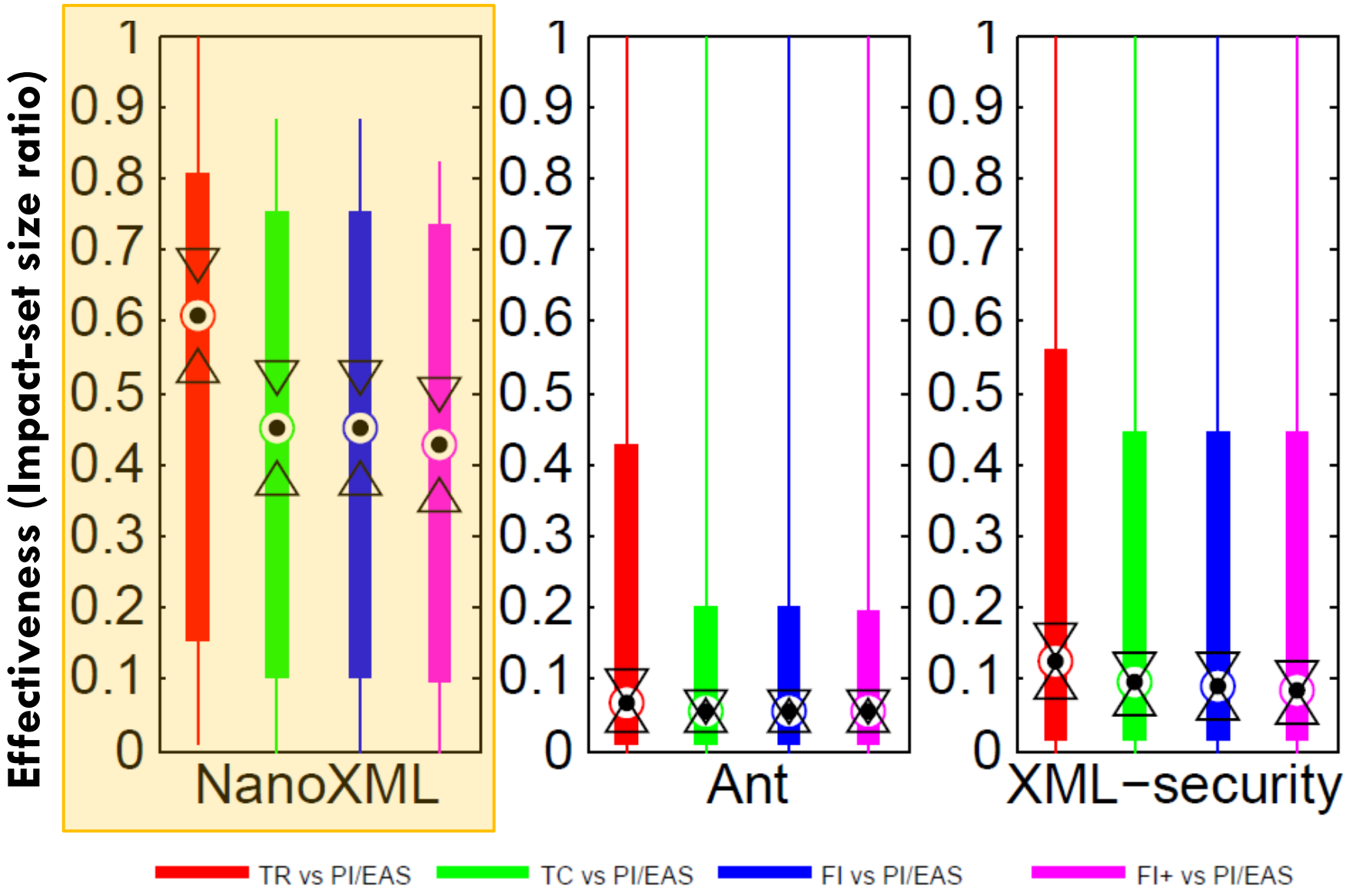
Experimental setup

- Subjects
  - 7 Java programs
  - Up to 212 KLOC in size (1k ~ 100k)
- Techniques
  - PI/EAS (baseline), TR, TC, FI (, FI+)
- Metrics
  - Effectiveness
    - Impact-set size ratios to baseline
  - Cost
    - Computation time
    - Storage space
  - Average cost-effectiveness
    - $$\frac{\text{Percentage of impact-set reduction}}{\text{factor of time cost increase}}$$

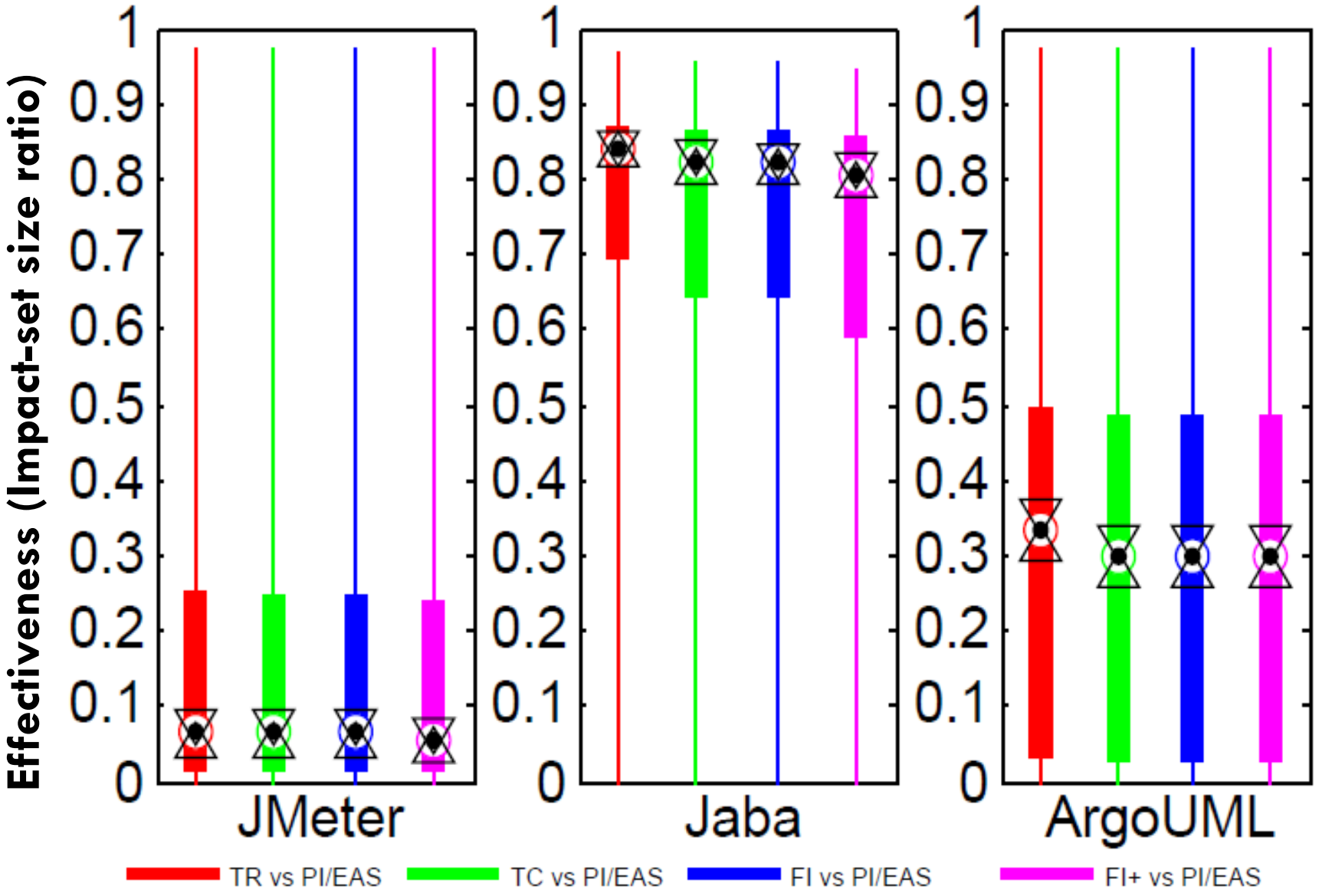
Research questions

- How do the techniques compare in terms of effectiveness?
- How do the techniques compare in terms of costs?
- What are the effects of different forms of dynamic data on the DDIA cost-effectiveness?

Result: effectiveness



Result: effectiveness



Research questions

- How do the techniques compare in terms of effectiveness?
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Result: querying cost

Subject	PI/EAS (seconds)	Query time of our techniques (seconds)			
		TR	TC	FI	FI+
Schedule1	0.70	14.60	15.72	19.24	44.26
NanoXML	0.07	6.24	6.35	5.60	7.97
XML-security	0.04	7.43	8.01	8.15	16.89
JMeter	0.02	2.25	2.30	1.82	2.18
Ant-v0	0.05	3.19	3.39	3.31	5.24
Jaba	0.29	78.34	99.68	82.55	105.18
ArgoUML	0.05	15.95	15.98	12.60	15.82
Overall	0.11	26.33	31.96	26.62	35.04

Result: other costs

- Static-analysis costs in seconds

Subject	PI/EAS	TR	TC	FI/FI+
Schedule1	5	6	11	17
NanoXML	11	14	25	39
Ant	27	142	170	311
XML-security	33	158	190	280
JMeter	38	372	408	764
Jaba	55	289	326	600
ArgoUML	172	7,465	7,542	11,998
Overall	73	2,047	2,115	3,392

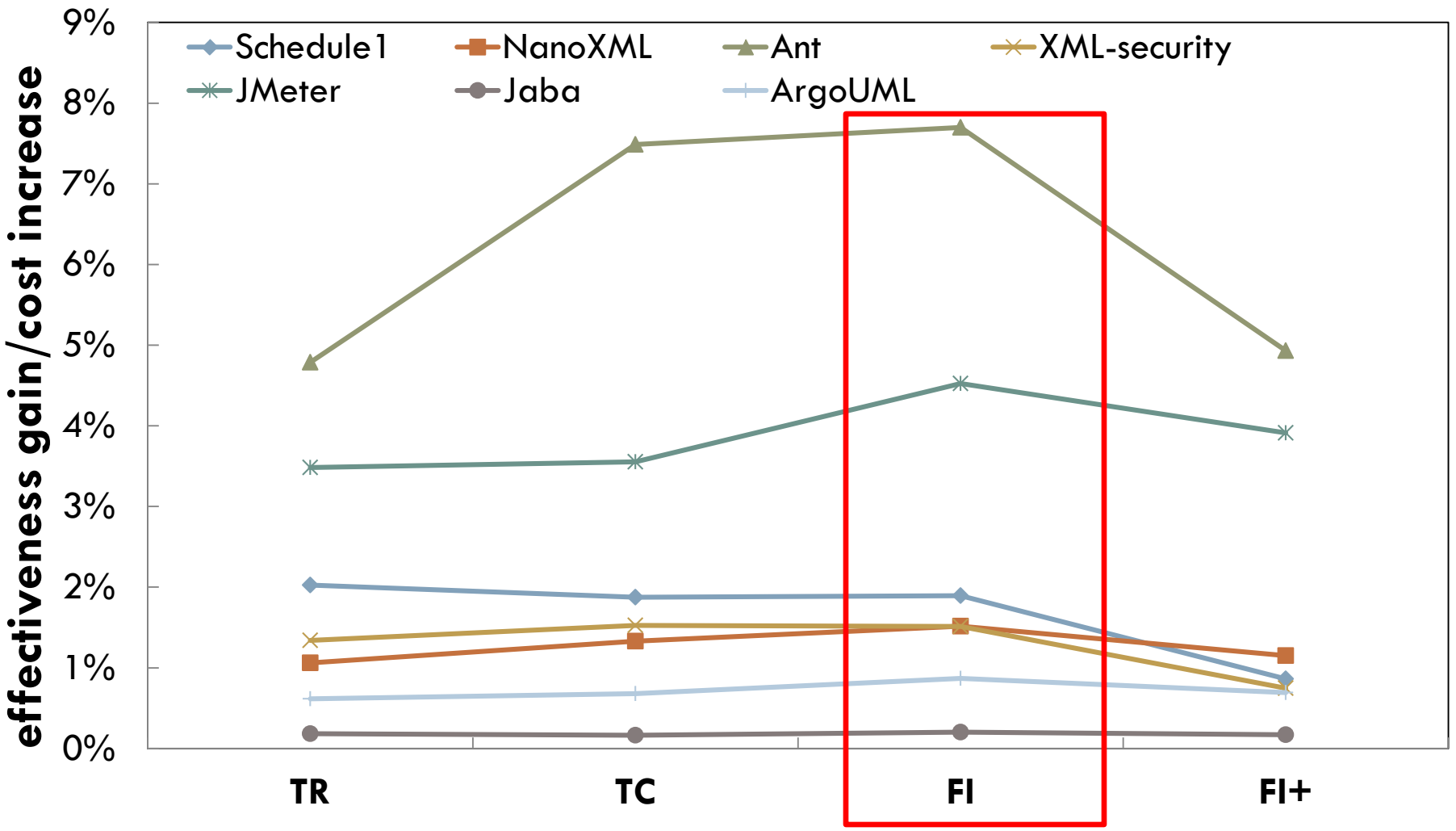
- Runtime costs: < 1m
- Space costs: < 4MB

Research questions

- How do the techniques compare in terms of effectiveness?
- How do the techniques compare in terms of costs?
- What are the effects of different forms of dynamic data on the DDIA cost-effectiveness?

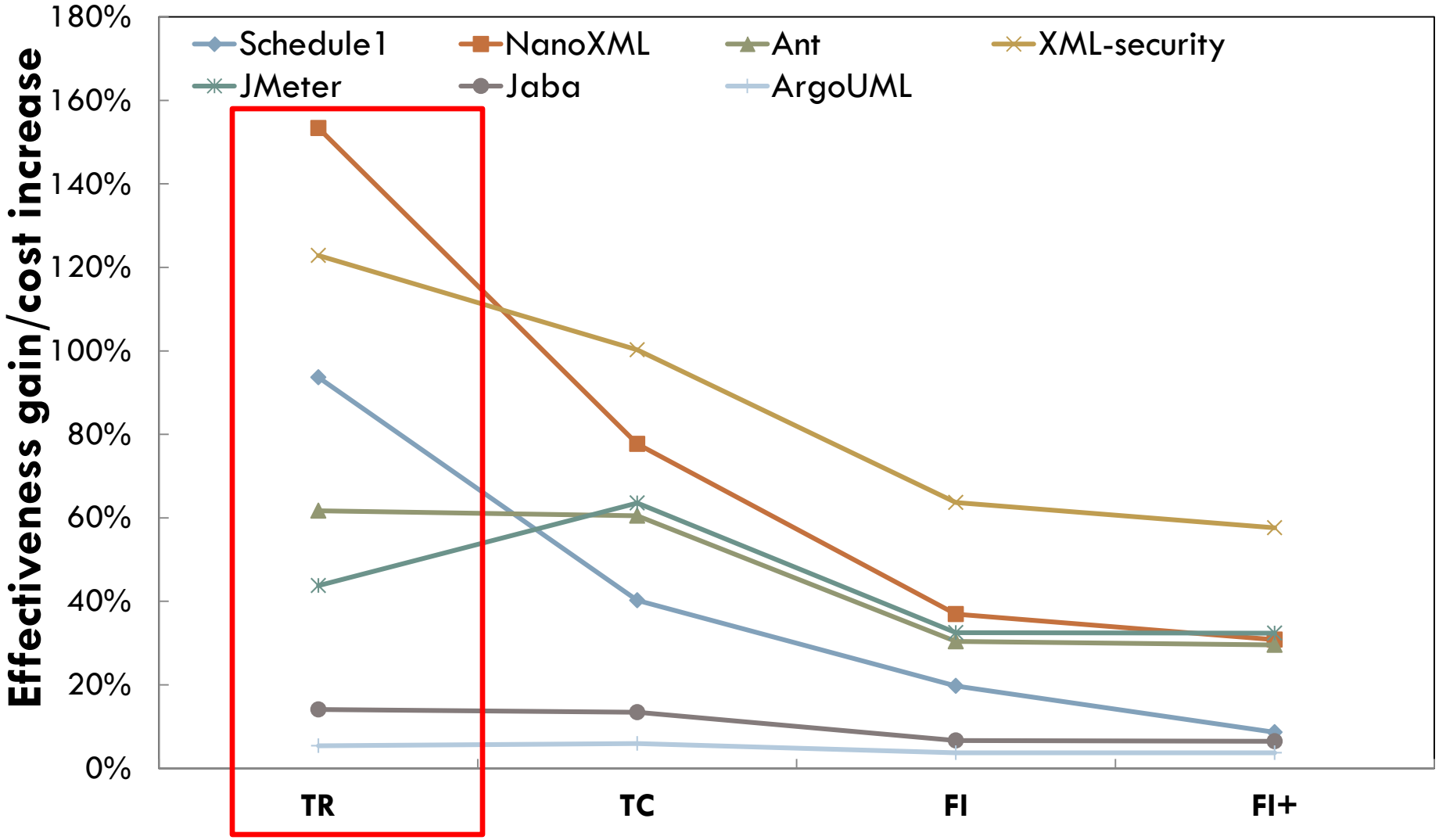
Result: cost-effectiveness

- With respect to querying costs



Result: cost-effectiveness

- With respect to other costs



Conclusions

- A framework that unifies existing and new DDIA techniques, and offers multiple-level cost-effectiveness options
- New techniques greatly reducing impact-set sizes, implying large improvement in precision
- Statement coverage has generally stronger effects on DDIA cost-effectiveness than dynamic points-to data

Acknowledgements

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Q&A

The proposed framework offers multiple-level trade-offs between cost and effectiveness of dynamic impact analysis.

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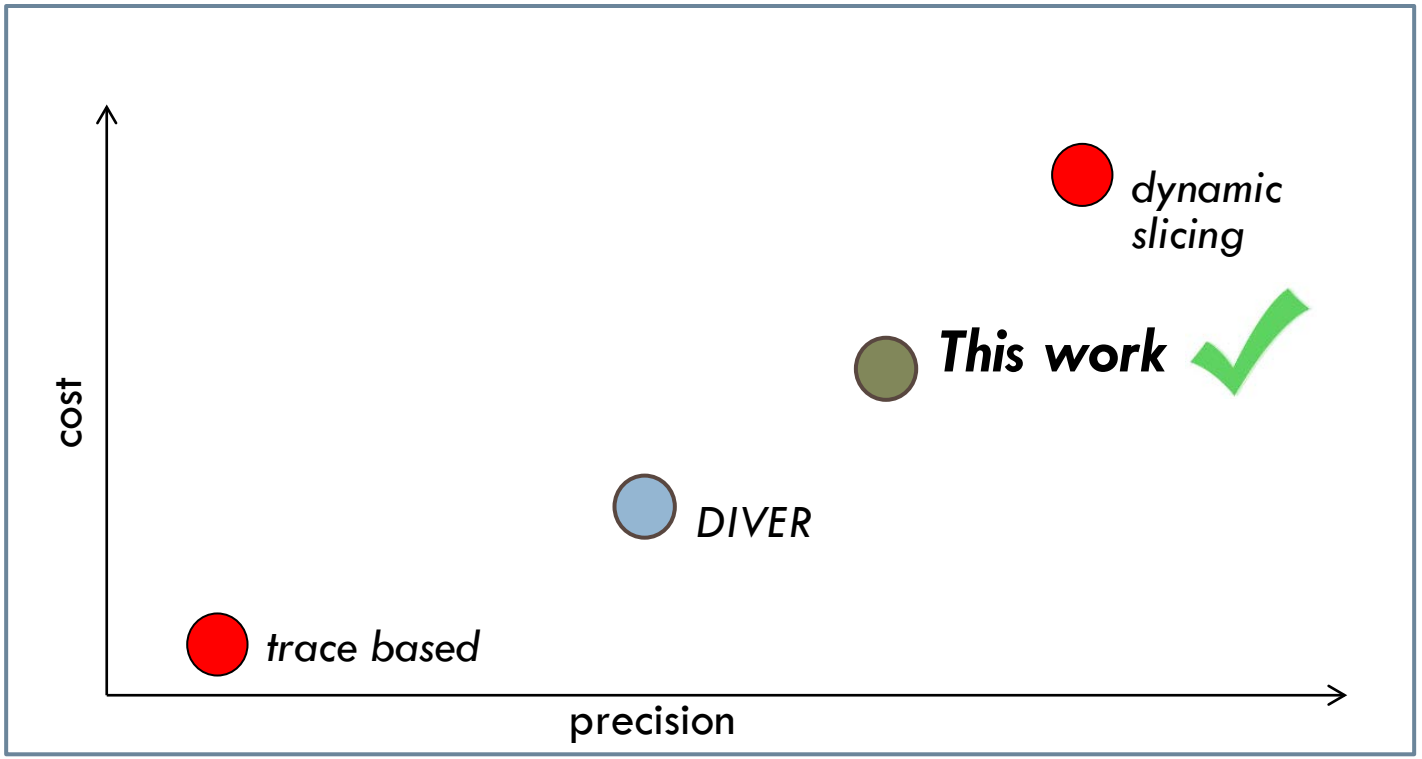
Subject programs

Subject	KLOC	#Methods	#Tests
Schedule1	0.3	24	2,650
NanoXml	3.5	282	214
Ant-v0	18.8	1,863	112
XML-security-v1	22.4	1,928	92
JMeter-v2	35.5	3,054	79
Jaba	37.9	3,332	70
ArgoUML-r3121	102.4	8,856	211

Controversial/provocative statement

- Achieving 100% recall *with respect to actual impacts* for dynamic dependence analysis is impossible.
- Impact analysis is being emphasized all the time but practitioners mostly still stick to old-fashioned ways relying on manual efforts, what are possible obstacles there?

Design space of cost-effective DDIA



Key idea:

Incrementally **prune** methods NOT dependent on the query