Integrating Customized Test Requirements with Traditional Requirements in Web Application Testing

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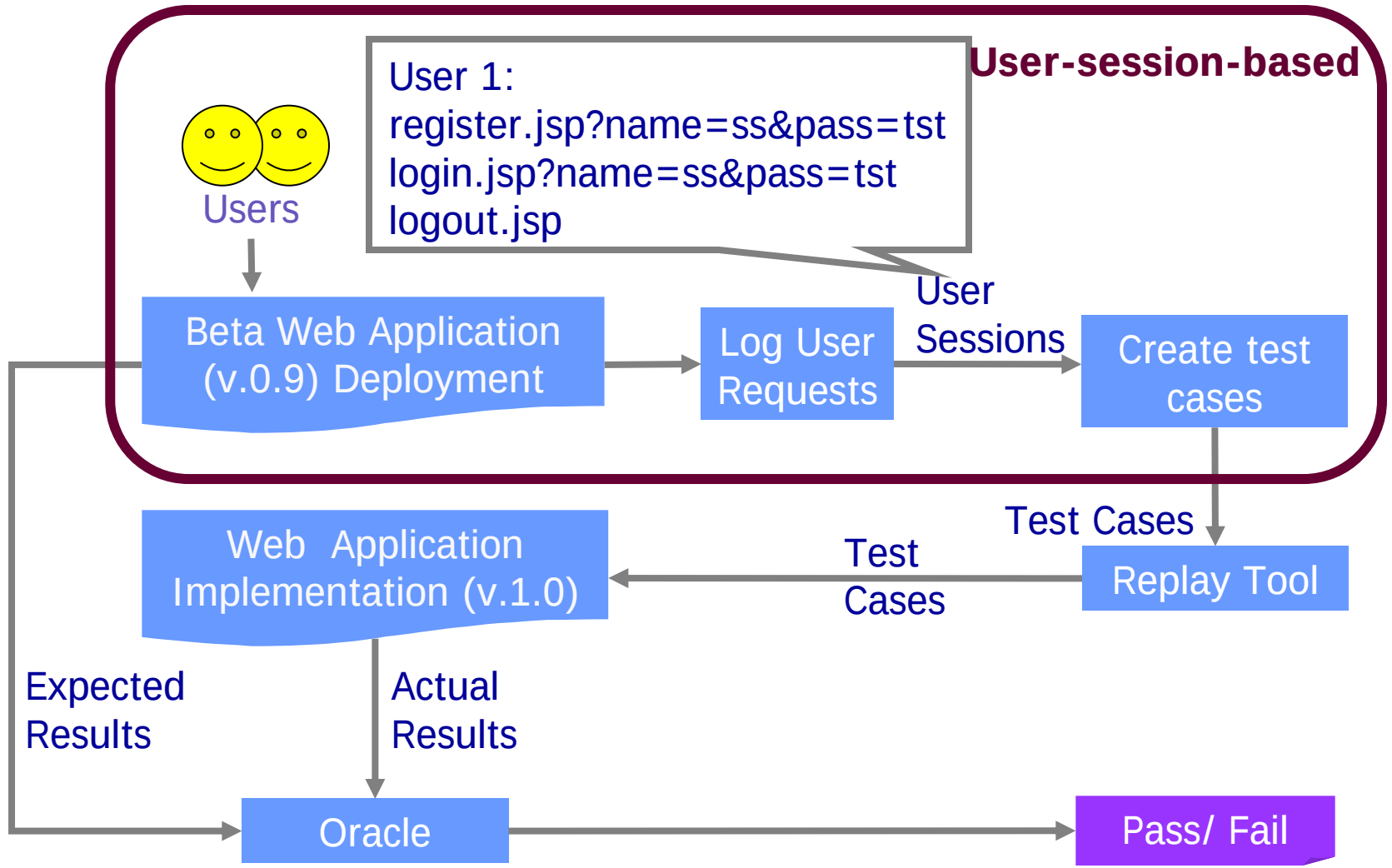
Need for Reliable Web Applications

- *Expedia* sells more than $35 million in tickets every week[1]
- In 1999 *KBKids.com* $10 off 30 dollars or cents?[2]
- Huge losses on web site failure[3]
  - Financial services: $6.5 million per hour
  - Credit card sales applications: $2.4 million per hour
  - Media companies: $150,000 per hour
- Large number of failures during maintenance[4]

1. e-Business 2.0: Roadmap for Success (2nd Edition) by M. Robinson, D. Tapscott, R. Kalakota . 2000
2. More Web sites turn to test tools by Carol Sliwa in CNN.com. 1999
3. Web Application Development - Bridging the Gap between QA and Development by Michal Blumenstyk
4. Causes of Failures in Web Applications by Solia Pertet and Priya Narsimhan. December 2005

User-session-based Testing Process



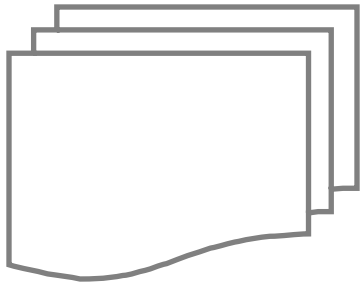
Measure Quality of Test Suites

- Test requirement coverage
  - When to stop testing
  - Which test cases to select
  - How to reduce a test suite
- Coverage and data flow-based requirements
  - Statement
  - Method
  - Branch
  - Def-use
- Covering all the statement requirements ensures the statement coverage criterion is satisfied

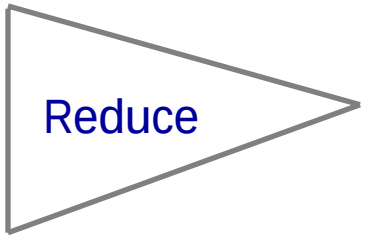
Program Coverage-based Test Requirement

Requirement: statement

Create reduced suite that covers all statements in code covered by original suite



Original Test Suite
(set of test cases)



Reduced Test Suite

Advantage

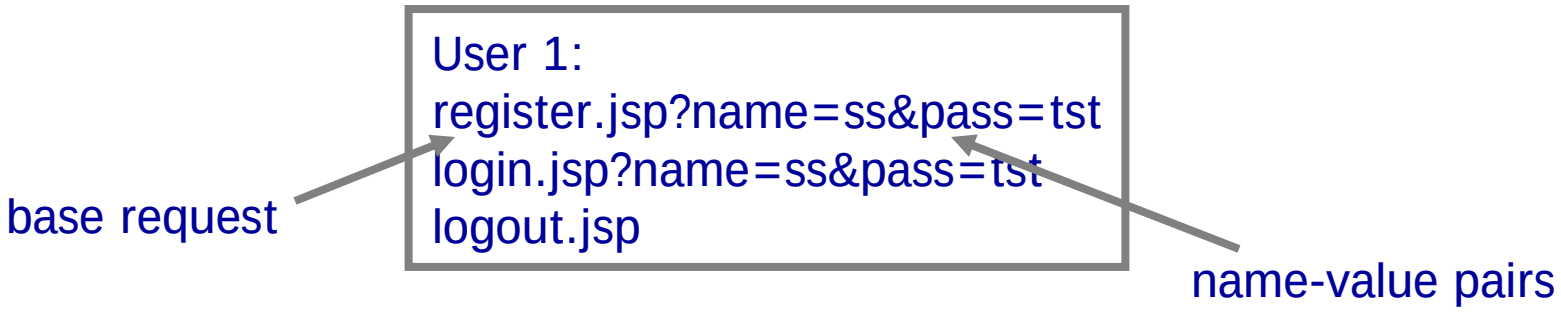
\+ Guaranteed program coverage by reduced suite

Disadvantage

\- Expensive to execute the original test suite prior to reduction

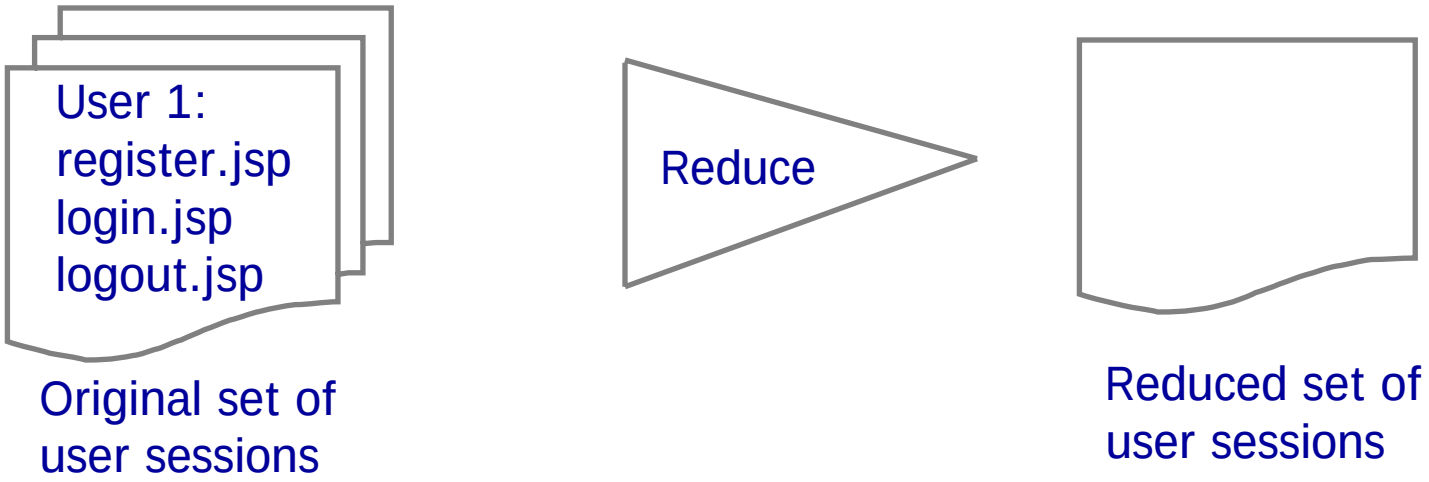
Measure Quality of Test Suites

- Test requirement coverage
  - When to stop testing
  - Which test cases to select
  - How to reduce a test suite
- Coverage and data flow-based requirements
- We proposed usage-based test requirements
  - Derived from usage-data
  - base, name, seq2, namevalue, seq2name



Usage-based Test Requirement

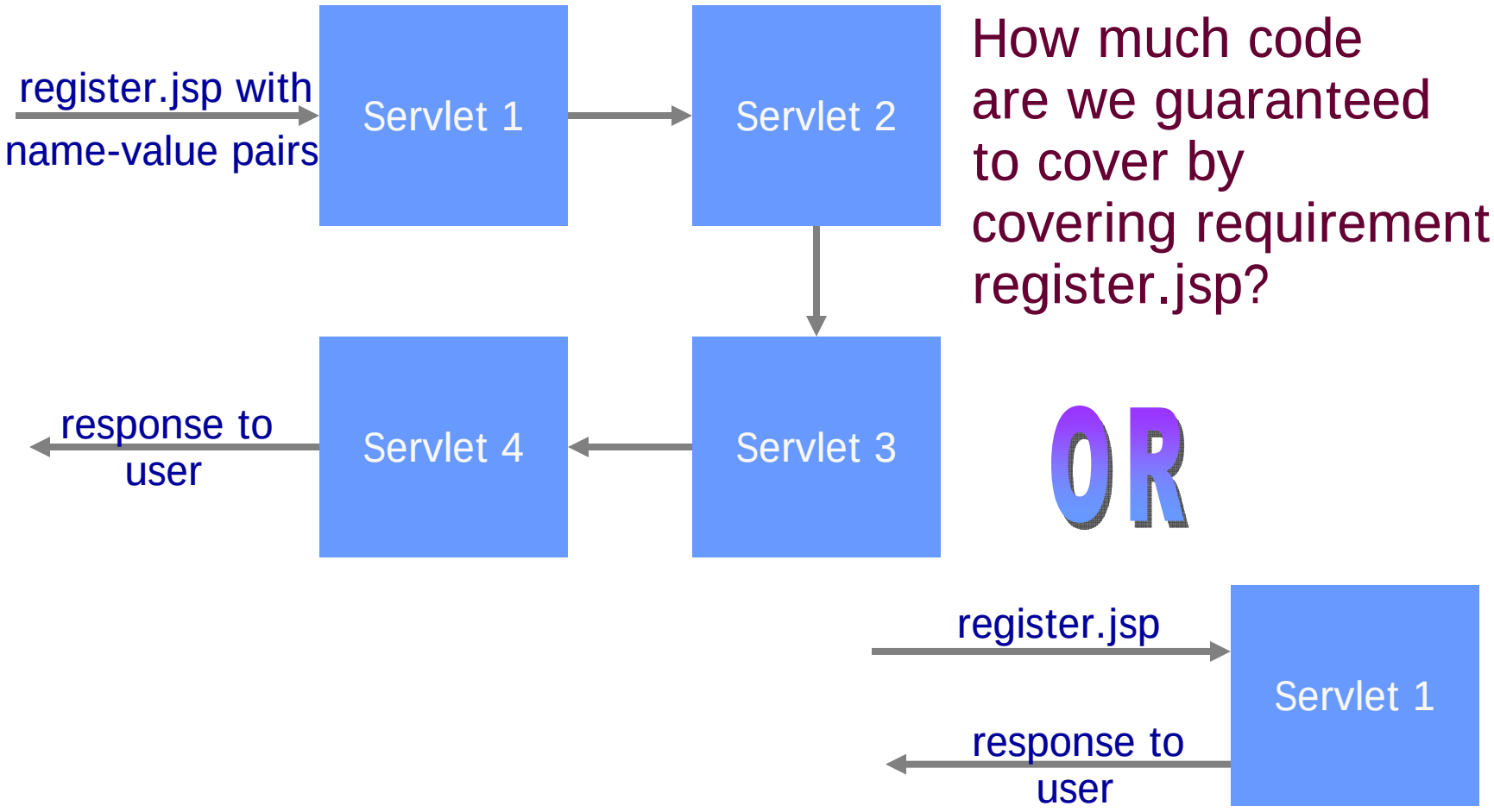
Requirement: base request
Create reduced suite that covers all base requests covered by original suite



Advantages

+ Information present in the user session itself
+ No need to execute original suite, cost-effective

Disadvantage of Usage-based Test Requirements



Integrate Program-based and Usage-based Requirements

We want to achieve a balance between

Cost of generating reduced suite and size of reduced suite

Program coverage and fault detection effectiveness of reduced suite

Our Research: Strategies for Integration

Integrate program coverage-based and usage-based test requirements to

1. Compare test suites to identify the better suite
2. Combine test requirements for reduction
3. Augment existing reduction algorithm

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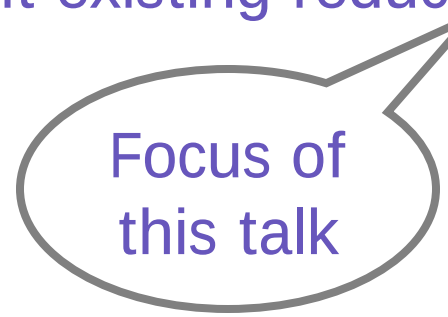


Usage-based Test Requirement: seqk

- Example test case

< GET login.jsp?name=xxx&pass=yyy,
GETshop.jsp?item_no=aaa&book_name=ccc&price=60 >

- seqk: cover all size *k* sequences of base requests

  for k=2,

  <{GET login.jsp, GET shop.jsp}>

Usage-based Test Requirement: name

- Example test case

< GET login.jsp?name=xxx&pass=yyy,
GETshop.jsp?item_no=aaa&book_name=ccc&price=60 >

- name: cover all base requests and names

{GET login.jsp?name&pass,
GET shop.jsp?item_no&book_name&price}

Usage-based Test Requirement: namevalue

- Example test case

< GET login.jsp?name=xxx&pass=yyy,
GETshop.jsp?item_no=aaa&book_name=ccc&price=60 >

- namevalue: cover all base requests and name and value pairs

{GET login.jsp?name=xxx&pass=yyy,
GET shop.jsp?item_no=aaa&book_name=ccc&price=60}

Usage-based Test Requirement: seqkname

- Example test case

< GET login.jsp?name=xxx&pass=yyy,
GETshop.jsp?item_no=aaa&book_name=ccc&price=60 >

- seqkname: cover all size k sequences of base requests and names

for k = 2,
{<GET login.jsp?name&pass,
GET shop.jsp?item_no&book_name&price>}

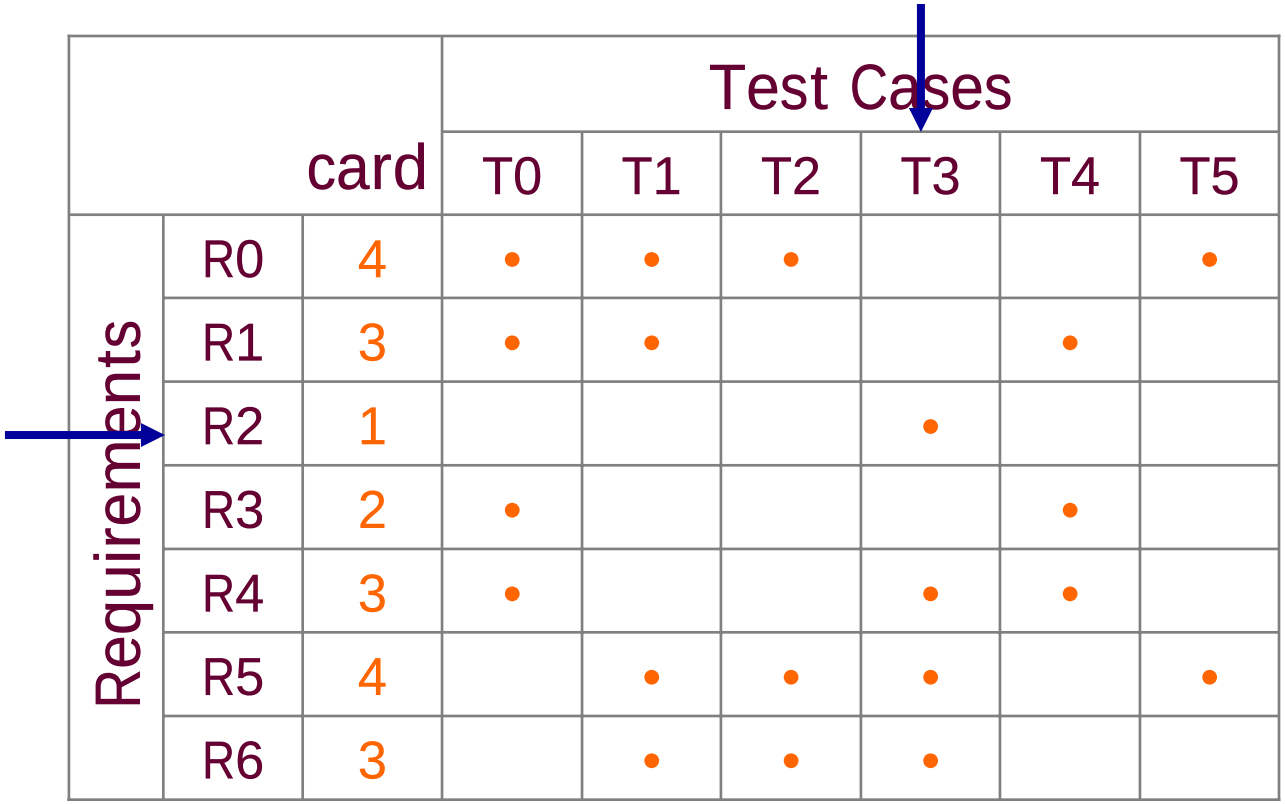
Traditional HGS

- Augment HGS [Harrold et al.] with usage-based requirements as tie breakers
- Select next test case to cover the least-covered requirement

Cardinality: number of test cases that cover each requirement

		card	Test Cases					
			T0	T1	T2	T3	T4	T5
Requirements	R0	4	⊙	⊙	⊙			⊙
	R1	3	•	•			•	
	R2	1				•		
	R3	2	•				•	
	R4	3	•			•	•	
	R5	4		•	•	•		•
	R6	3		•	•	•		

Traditional HGS



Start with requirement with least cardinality

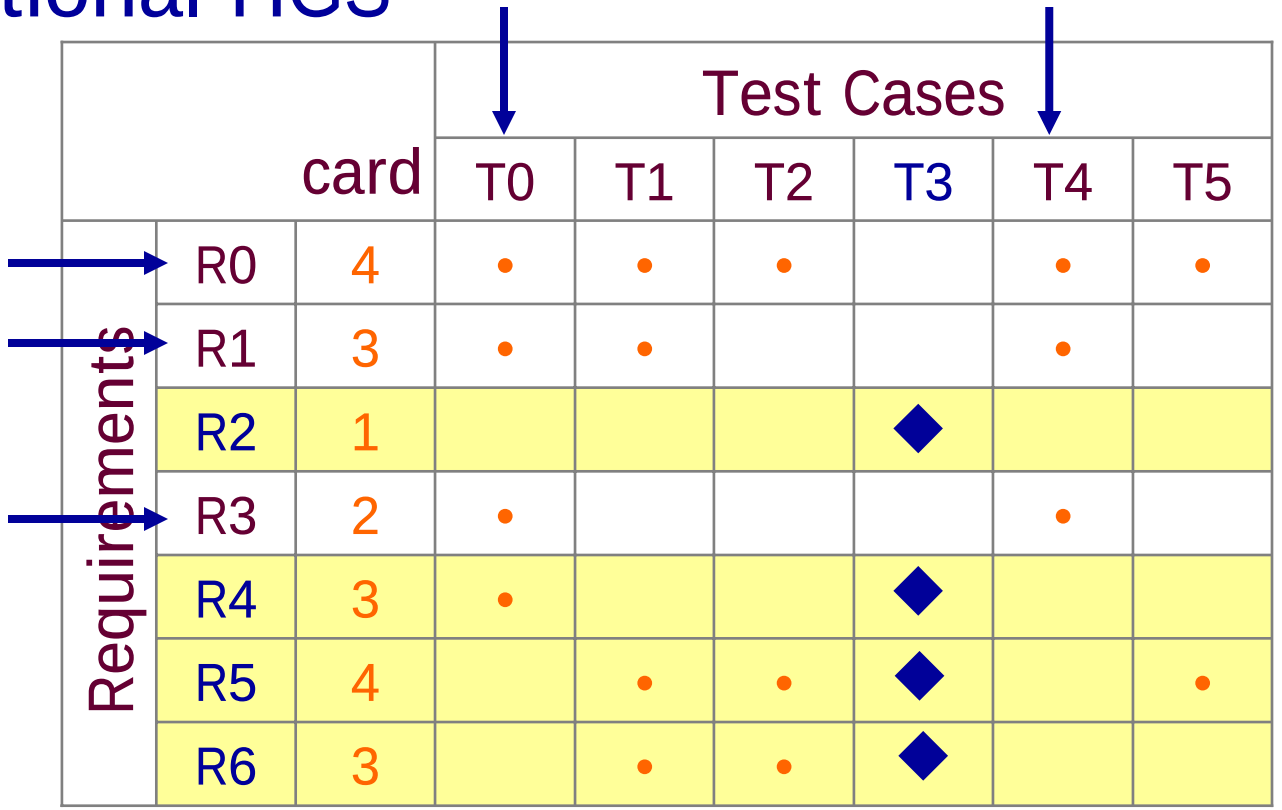
Only T3 covers R2

Traditional HGS

		card	Test Cases					
			T0	T1	T2	T3	T4	T5
Requirements	R0	4	•	•	•			•
	R1	3	•	•			•	
	R2	1				◆		
	R3	2	•				•	
	R4	3	•			◆	•	
	R5	4		•	•	◆		•
	R6	3		•	•	◆		

Choosing T3 covers R2, R4, R5, R6

Traditional HGS



- R3 is covered by two test cases, T0 and T4
- Choose test case that covers most uncovered requirements
  - Tie between T0 and T4, Go to next higher cardinality
  - Eventually, select randomly from tied test cases

Modified HGS

		card	Test Cases T0	T1	T2	T3	T4	T5
Requirements	R0	4	•	•	•		•	•
	R1	3	•	•			•	
	R2	1				◆		
	R3	2	•				•	
	R4	3	•			◆		
	R5	4		•	•	◆		•
	R6	3		•	•	◆		

Usage-based requirement coverage

T0

GET login.jsp
GET shop.jsp

T4

GET login.jsp

- Select T0 for the reduced suite
- More effective when large number of ties encountered

Case Study

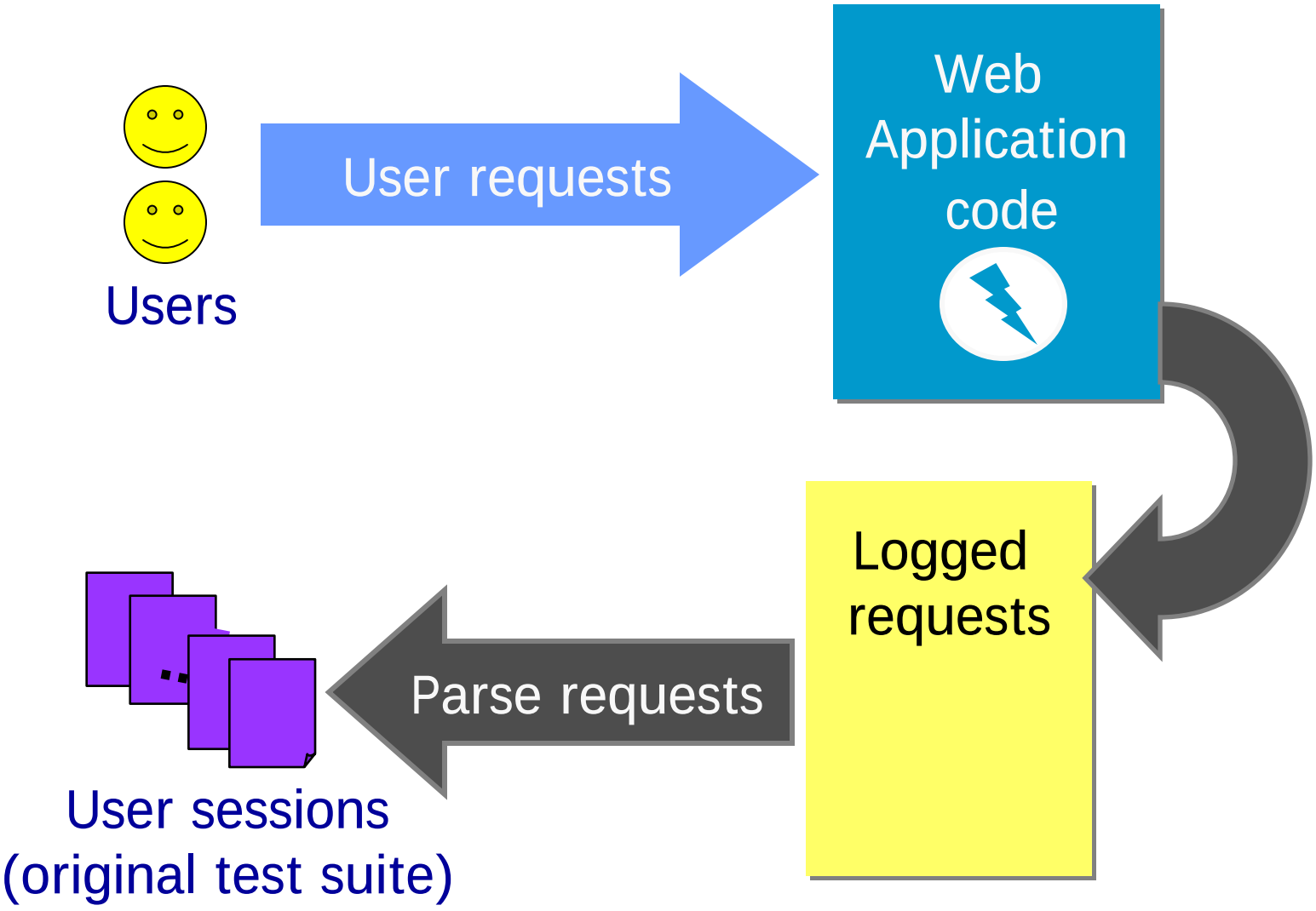
- Compare reduced suites from
  - Traditional HGS with program coverage-based requirements
  - Traditional HGS with usage-based requirements
  - Modified HGS with program coverage-based requirement (method) and usage-based tie breakers
- Metrics
  - Reduced suite size
  - Program coverage
  - Fault detection

Subject Application

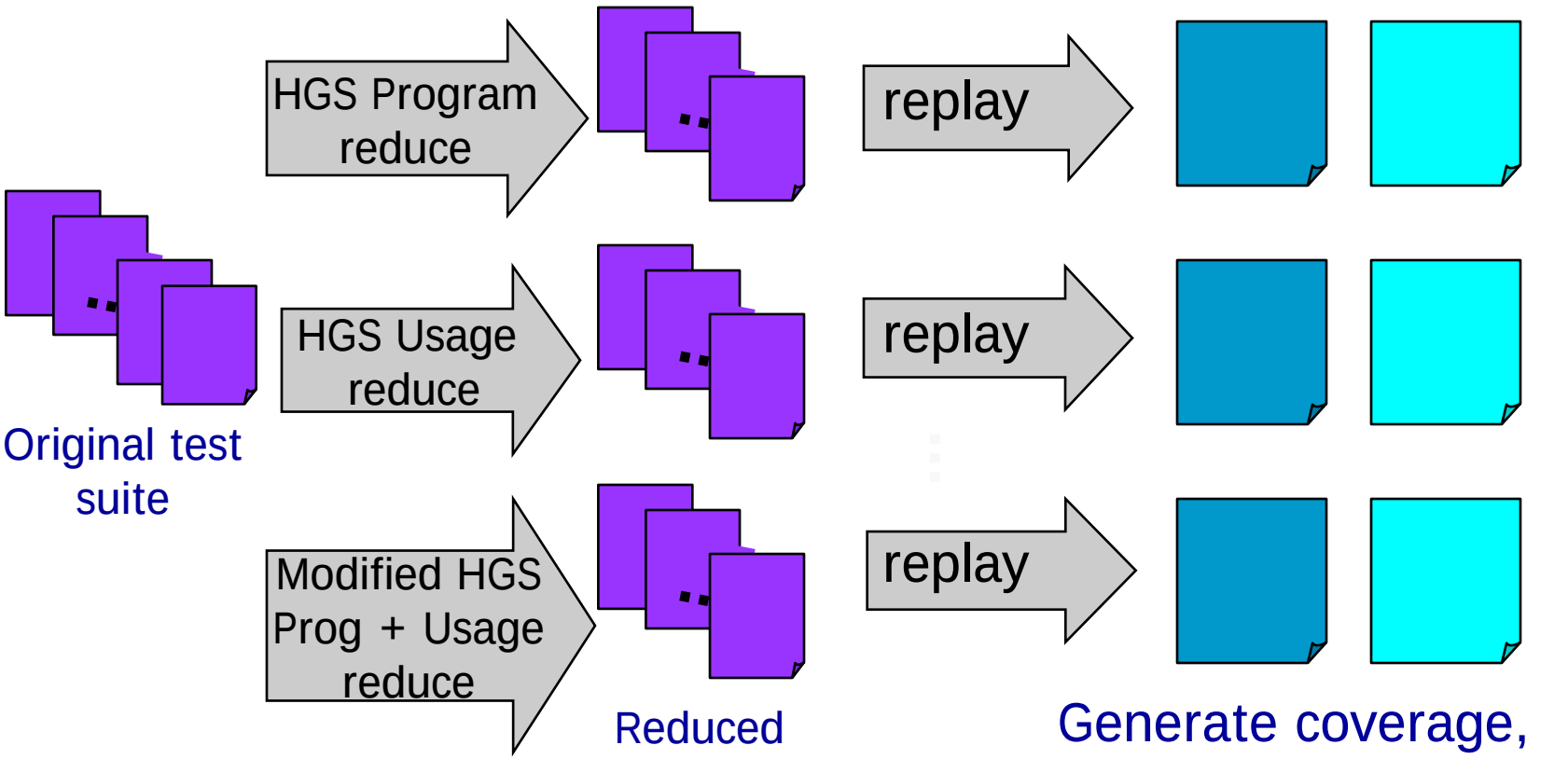
Course Project Manager (CPM)

Number of classes	75
Number of methods	172
Non-commented LOC	8947
Number of seeded faults	135
Number of user sessions	890
Total number of URLs	12,352

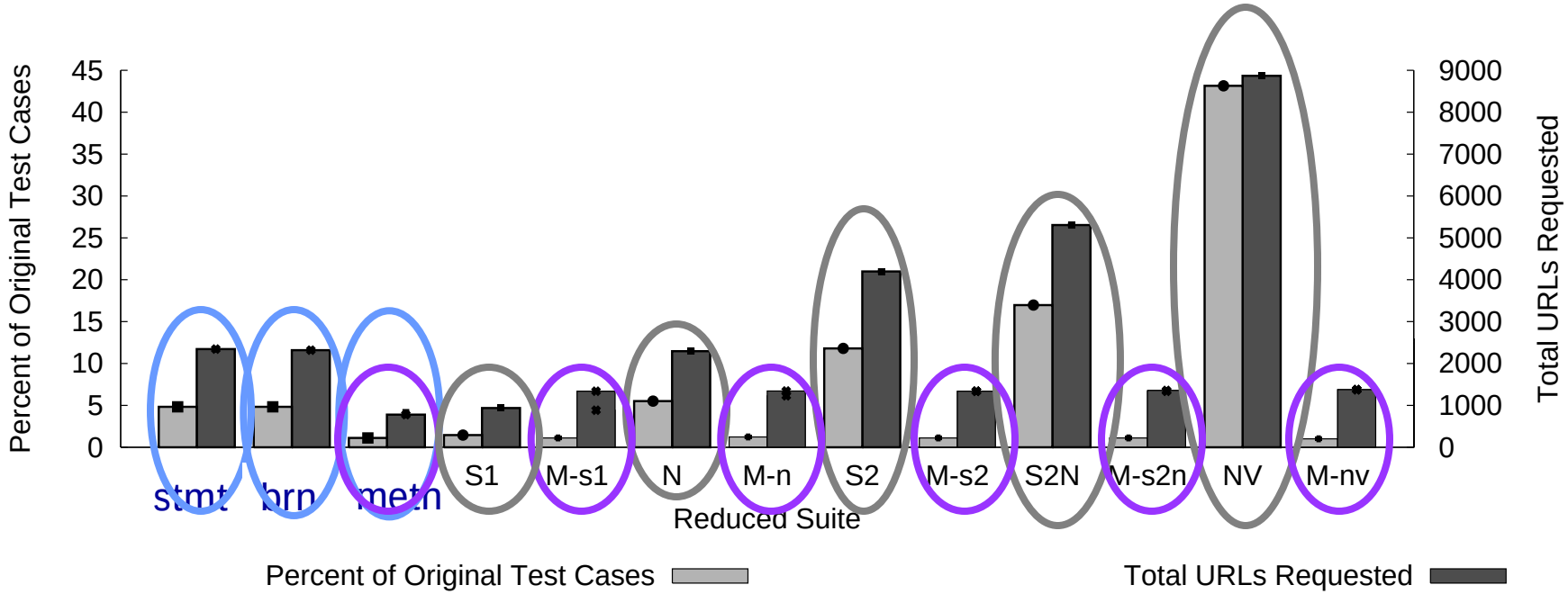
Case Study: Methodology (1)



Case Study: Methodology (2)



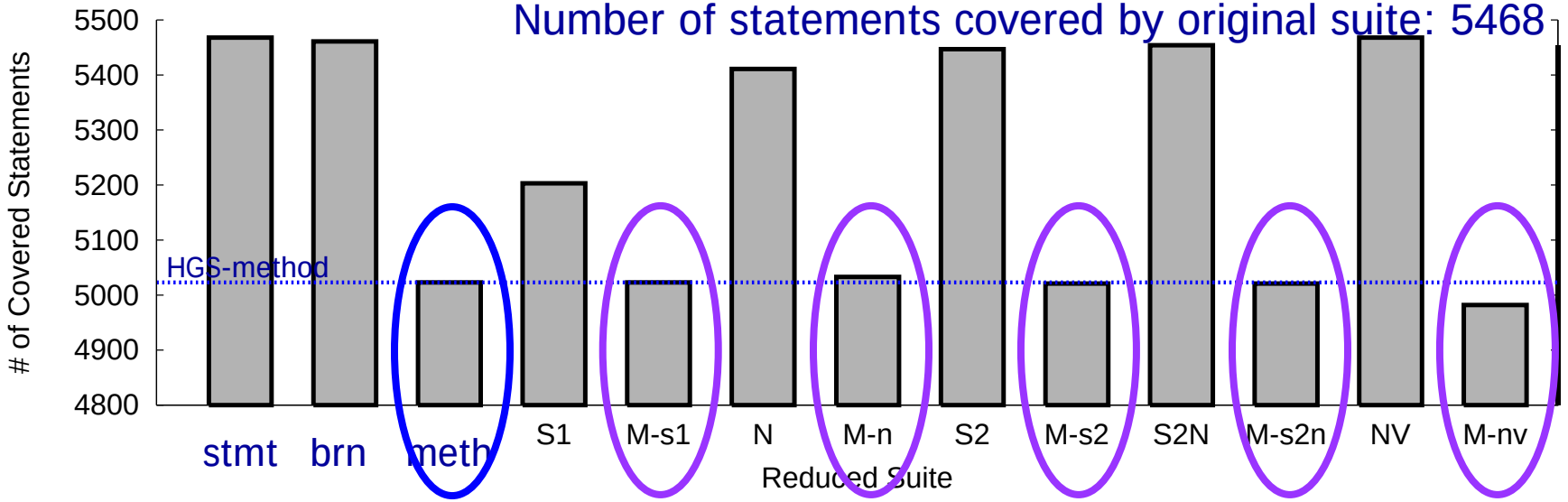
Results: Reduced Test Suite Size



Modified HGS		
Label in graph	**Prog cvg req.**	**Tie breaker**
M-s1	method	base request
M-n	method	name
M-s2	method	seq2
M-s2n	method	seq2name
M-nv	method	namevalue

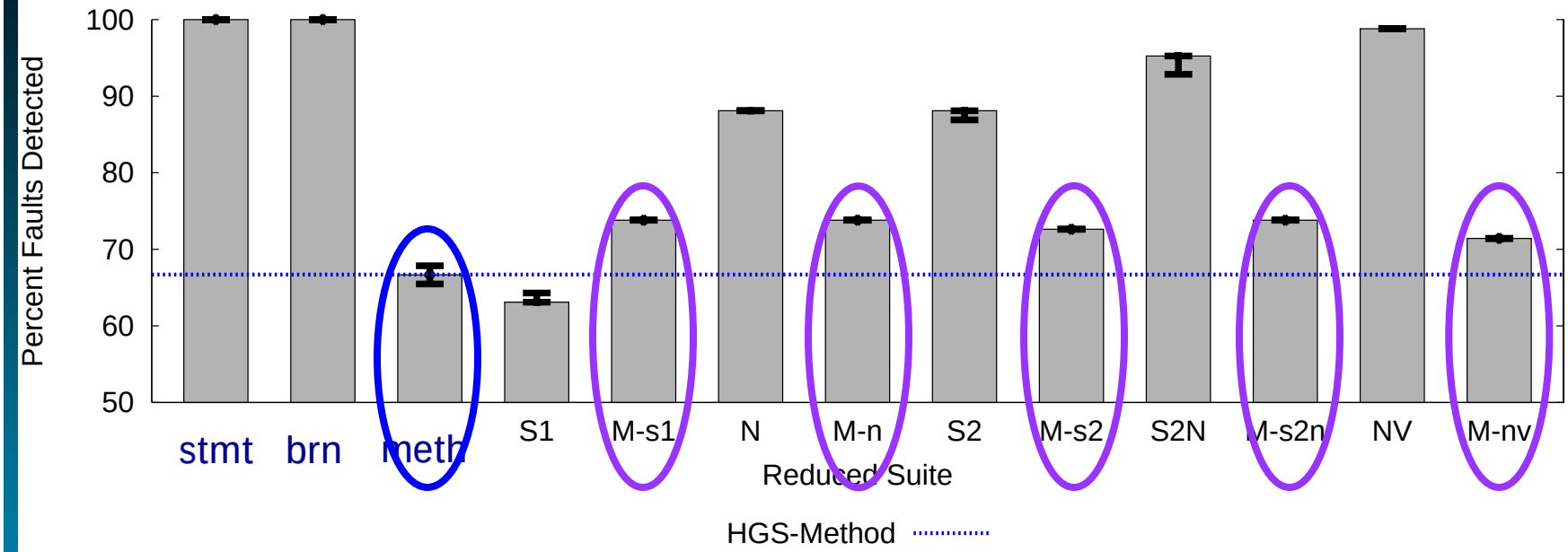
Results: Program Coverage Effectiveness

Total Number of statements in CPM: 6966
Number of statements covered by original suite: 5468



Modified HGS		
Label in graph	**Prog cvg req.**	**Tie breaker**
M-s1	method	base request
M-n	method	name
M-s2	method	seq2
M-s2n	method	seq2name
M-nv	method	namevalue

Results: Fault Detection Effectiveness



Modified HGS		
Label in graph	**Prog cvg req.**	**Tie breaker**
M-s1	method	base request
M-n	method	name
M-s2	method	seq2
M-s2n	method	seq2name
M-nv	method	namevalue

Results: Summary

- Fault detection of Modified HGS better than Traditional HGS for same suite size and generation cost
- Usage-based requirement alone more effective than using Modified HGS with program-based and usage-based tie breakers but test suite size increases
- Type of usage-based requirement -- no effect on effectiveness of Modified HGS reduced suites

Conclusions and Future Work

- Presented three strategies to integrate usage-based and program-based requirements in paper
- Experimentally evaluated the strategies
  - Instead of using method requirement, use customized requirement alone
  - Combining requirements better than HGS-method
  - Modified HGS better than traditional HGS
- Future Work
  - Extend study to other applications
  - Augment test cases from models of application with usage-based requirements