



Leveraging Field Data for Impact Analysis and Regression Testing

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joint work with

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Motivation

Fundamental shift in SW development

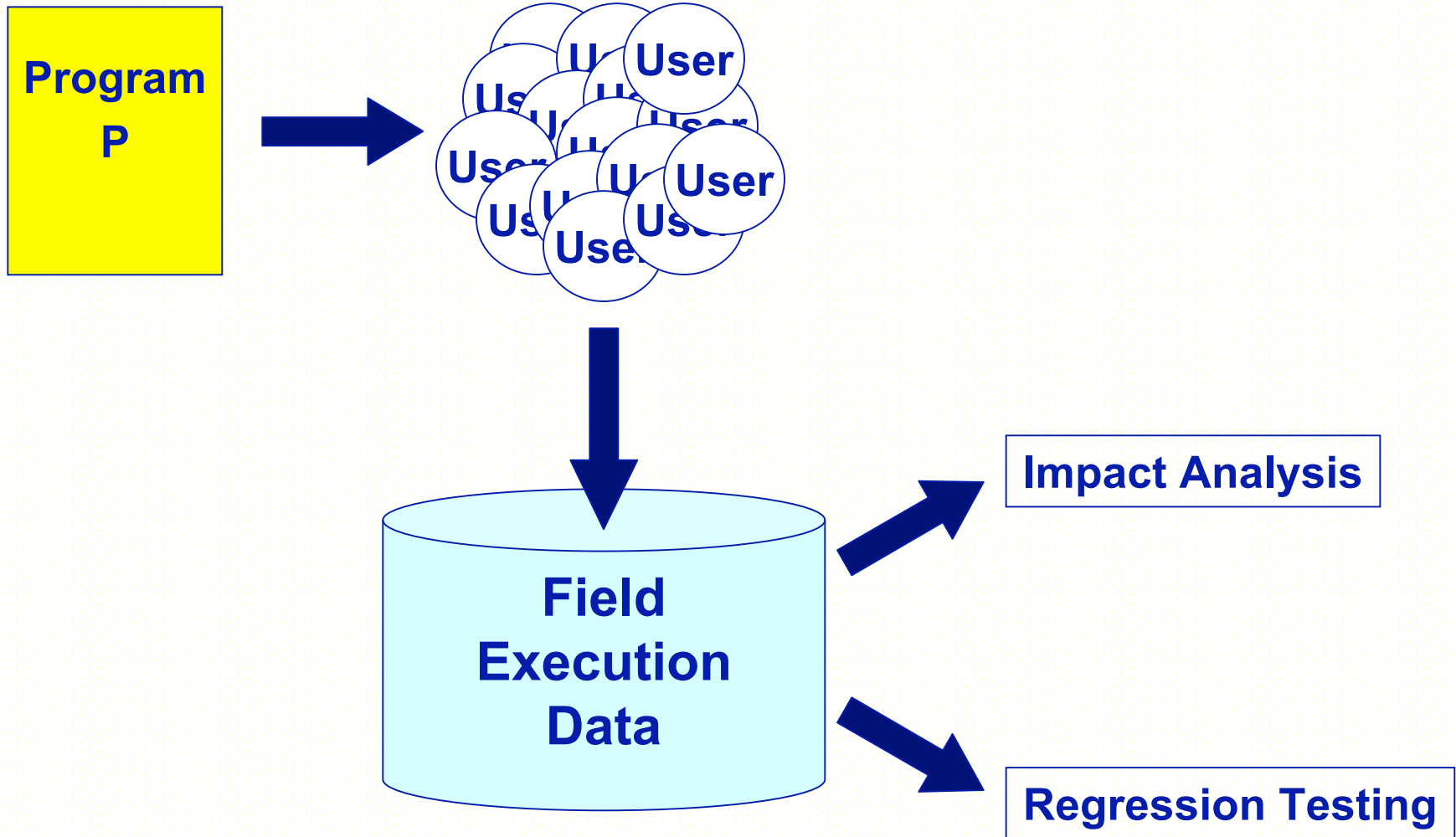
- Software virtually everywhere
- Most computers interconnected
- Large amount of user resources

Opportunity to use field data and resources in SE

- Testing and analysis limited by the use of in-house inputs and configurations
- Limits can be overcome by augment these tasks with field data

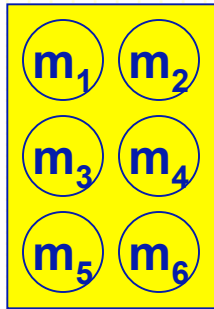


Overall Picture

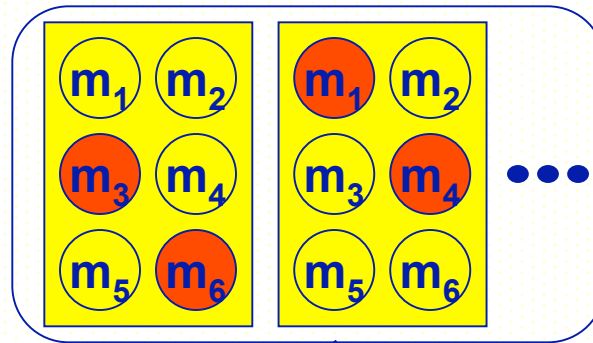


Gathering Field Data

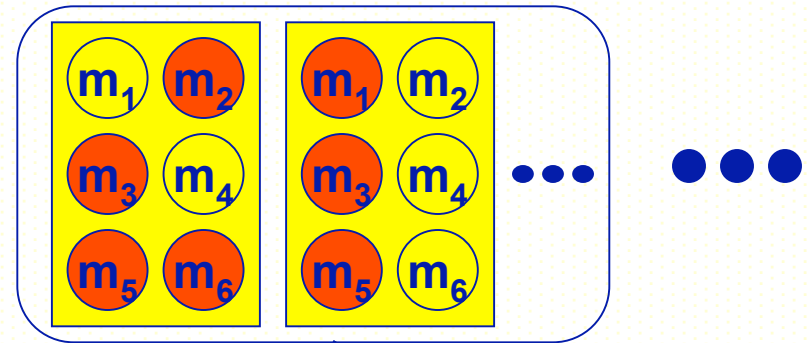
Program P



User A



User B



execution data

	m_1	m_2	m_3	m_4	m_5	m_6
A1			X			X
B1		X	X		X	X
B2	X	X	X			
A2	X			X		
C1				X		X



Impact Analysis

Assesses the effects of changes on a software system

Predictive: help decide which changes to perform and how to implement changes

Our approach

- Program-sensitive impact analysis
- User-sensitive impact analysis



Program Sensitive Impact Analysis

Input:

1. Field execution data

	m ₁	m ₂	m ₃	m ₄	m ₅	m ₆
A1			X			X
B1		X	X		X	X
B2	X	X	X			
A2	X			X		
C1				X		X

2. Change

$C = \{m_2, m_5\}$

Output:

$Impact\ set = \{m_2, m_5, m_6\}$

Step 1

- Identify user executions through methods in C
- Identify methods covered by such executions

$covered\ methods = \{m_1, m_2, m_3, m_5, m_6\}$

Step 2

- Static forward slice from C

$forward\ slice = \{m_2, m_4, m_5, m_6\}$

Step 3

- Intersect covered methods and forward slice



User-sensitive Impact Analysis

Input:

1. Field execution data

	m ₁	m ₂	m ₃	m ₄	m ₅	m ₆
A1			X			X
B1		X	X		X	X
B2	X	X	X			
A2	X			X		
C1				X		X

2. Change

$C = \{m_5, m_6\}$

Output:

1. Collective impact = **60%**

2. Affected users = **100%**

Collective impact

- Percentage of executions through at least one changed method

$$3/5 = 60\%$$

Affected users

- Percentage of users that executed at least once one changed method

$$3/3 = 100\%$$



Regression Testing

Performed after P is changed to P' to provide confidence that

- Changed parts behave as intended
- Unchanged parts are not adversely affected by modifications

Three important issues

- Tests in T to rerun on P' (*selection*)
- New tests for P' (*augmentation*)
- Order of execution of tests (*prioritization*)



Regression Testing Using Field Data

Input:

1. Field execution data

	m ₁	m ₂	m ₃	m ₄	m ₅	m ₆
A1			X			X
B1		X	X		X	X
B2	X	X	X			
A2	X			X		

2. Change

$C = \{m_2, m_4\}$

3. In-house tests for P

	m ₁	m ₂	m ₃	m ₄	m ₅	m ₆
t1	X		X		X	
t2		X		X		X
t3	X	X				X

Output:

1. Tests T' to be rerun on $P' = \{t_2, t_3\}$
2. Critical methods =
 $CM[m_2] = \{m_3, m_5\}$
 $CM[m_4] = \{m_1\}$

For each changed method m in C

- Add all tests through m to T'
- Compute the impact set for m
impact set = $\{m_1, m_2, m_3, m_5, m_6\}$
- For each t in T' mark methods in impact set exercised by t
- Remove marked methods from impact set



Regression Testing Using Field Data

Input:

1. Field execution data

	m ₁	m ₂	m ₃	m ₄	m ₅	m ₆
A1			X			X
B1		X	X		X	X
B2	X	X	X			
A2	X			X		

2. Change

$C = \{m_2, m_4\}$

3. In-house tests for P

	m ₁	m ₂	m ₃	m ₄	m ₅	m ₆
t1	X		X		X	
t2		X		X		X
t3	X	X				X

Output:

1. Tests T' to be rerun on $P' = \{t_2, t_3\}$

2. Critical methods =

$CM[m_2] = \{m_3, m_5\}$

$CM[m_4] = \{m_1\}$

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Empirical Studies

Subject

- JABA: Java Architecture for Bytecode Analysis
- 60 KLOC, 550 classes, 2,800 Methods

Data

- Field data: 1,100 executions (14 users, 12 weeks)
- In-house data: 195 test cases, 63% method coverage
- Changes: 20 real changes extracted from JABA's CVS repository



Study 1: Impact Analysis

Research question

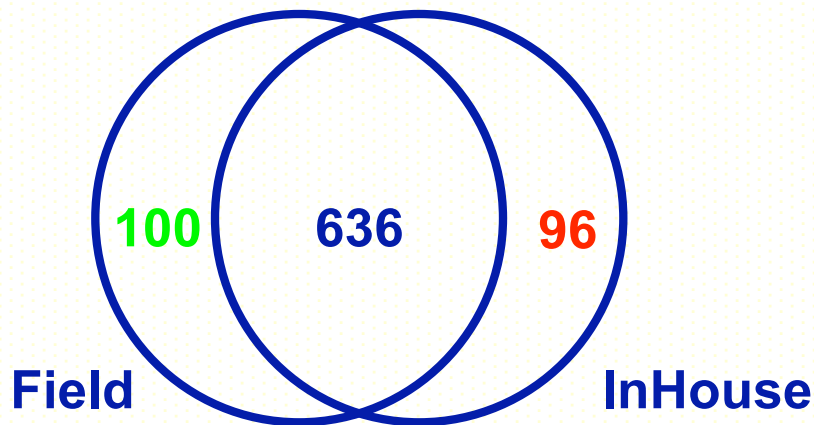
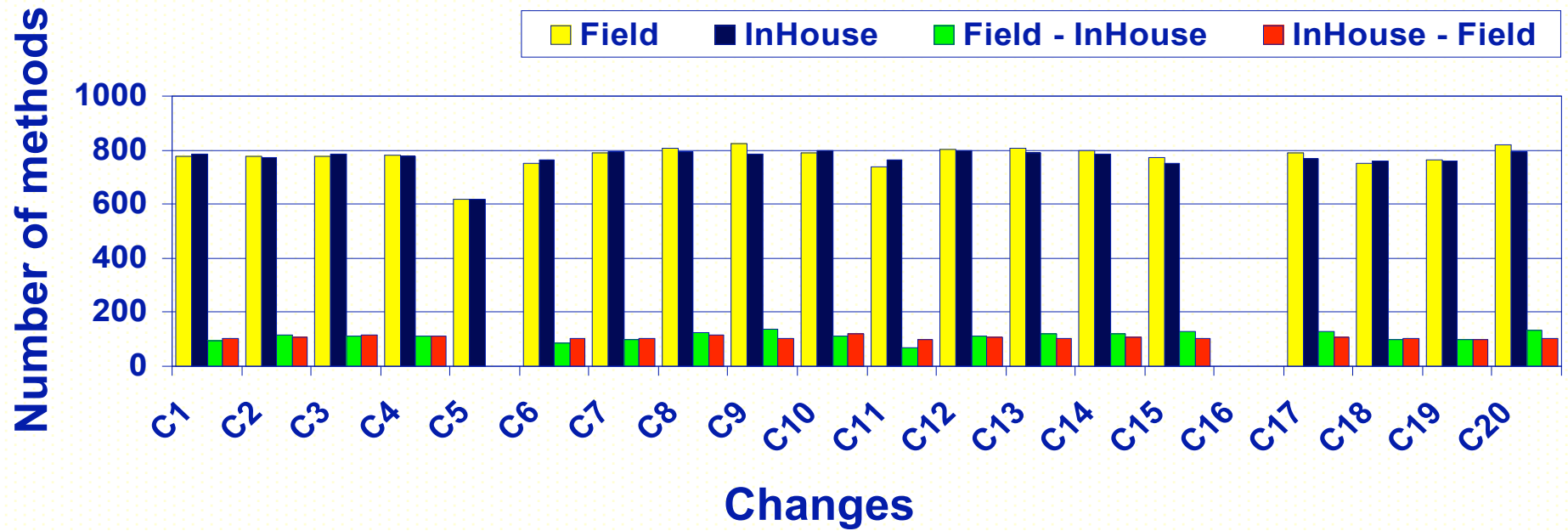
Does field data yield different results than in-house data in terms of impact sets?

Experimental setup

- Computed impact sets for the 20 changes
 - Using field data
 - Using in-house data
- Compared impact sets for the two datasets



Study 1: Impact Analysis



Study 2: Regression Testing

Research question

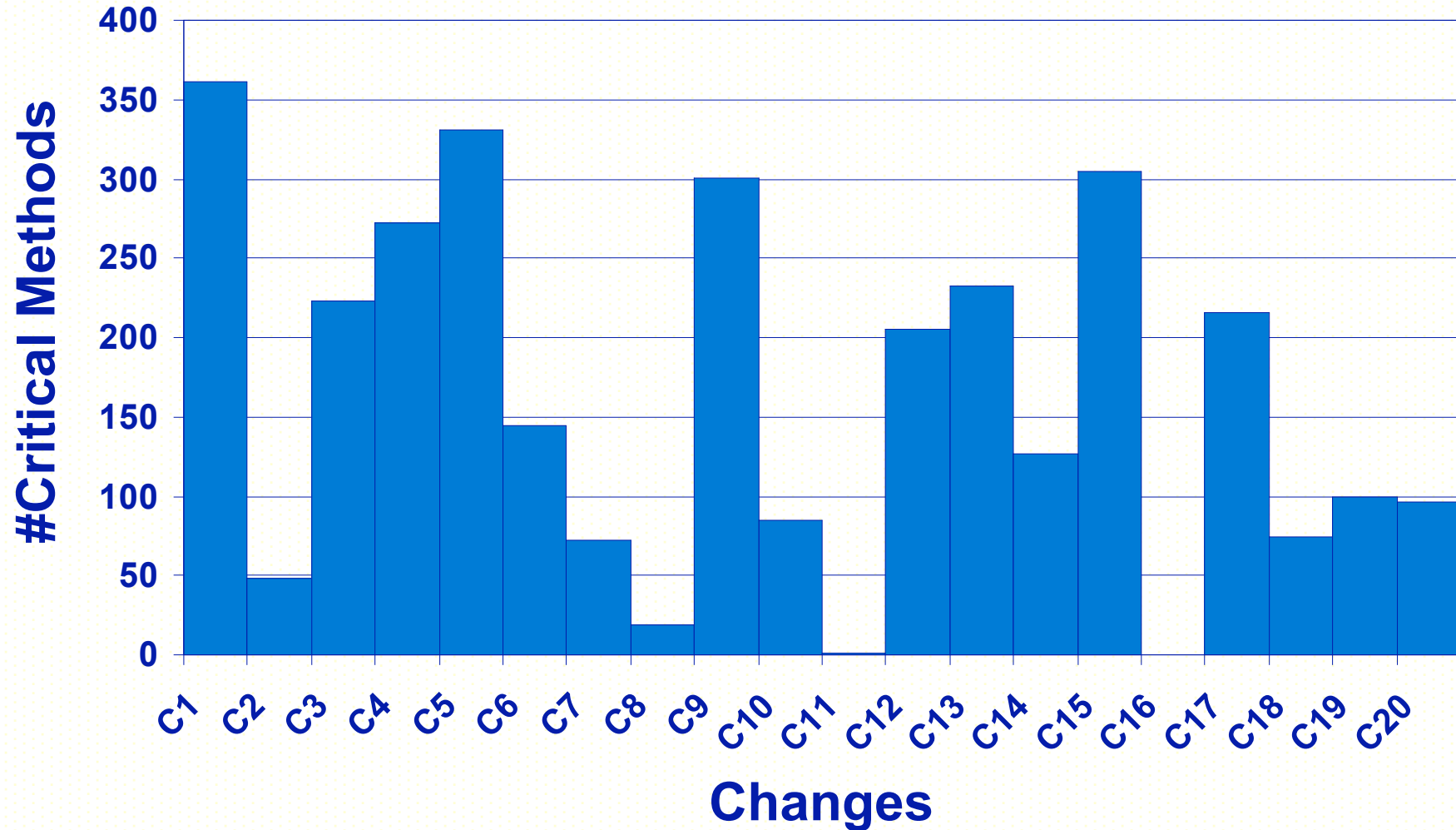
Does the use of field data actually result in additional testing requirements?

Experimental setup

Computation of the set of critical methods for the 20 real changes



Study 2: Regression Testing



Related Work

- **Perpetual/Residual testing**
(Clarke, Osterweil, Richardson, and Young)
- **Expectation-Driven Event Monitoring (EDEM)**
(Hilbert, Redmiles, and Taylor)
- **Echelon**
(Srivastava and Thiagarajan)
- **Impact analysis based on whole-path profiling**
(Law and Rothermel)



Final Remarks

Conclusion

- Two new techniques for impact analysis and regression testing based on field data
- Empirical evaluation on a real subject with real users
- Results showing that using field data considerably affect these tasks

Open Issues and future work

- Study on the stability of user behaviors
- Collection of additional data
- Clustering of field data
- Capture and replay of users' executions





For more information:

<http://gamma.cc.gatech.edu>

Questions?

