Empirical Study of Crash-inducing Commits in Mozilla Firefox

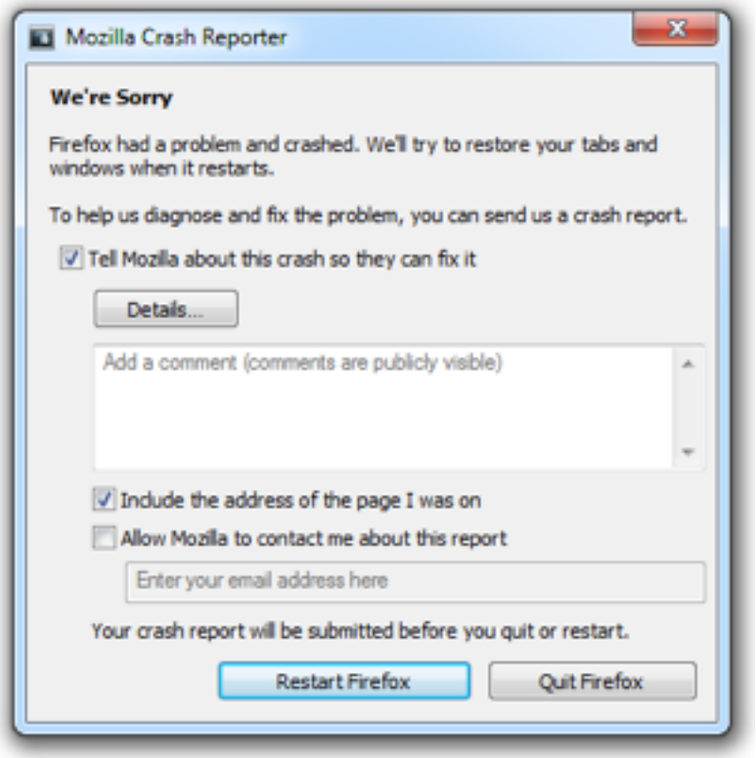
Le An and Foutse Khomh
Polytechnique Montréal

21 October, Beijing, China

Outline

- Background (Mozilla crash collecting system)
- Challenge
- Research questions
- Study design
- Case study results
- Future work
- Conclusion

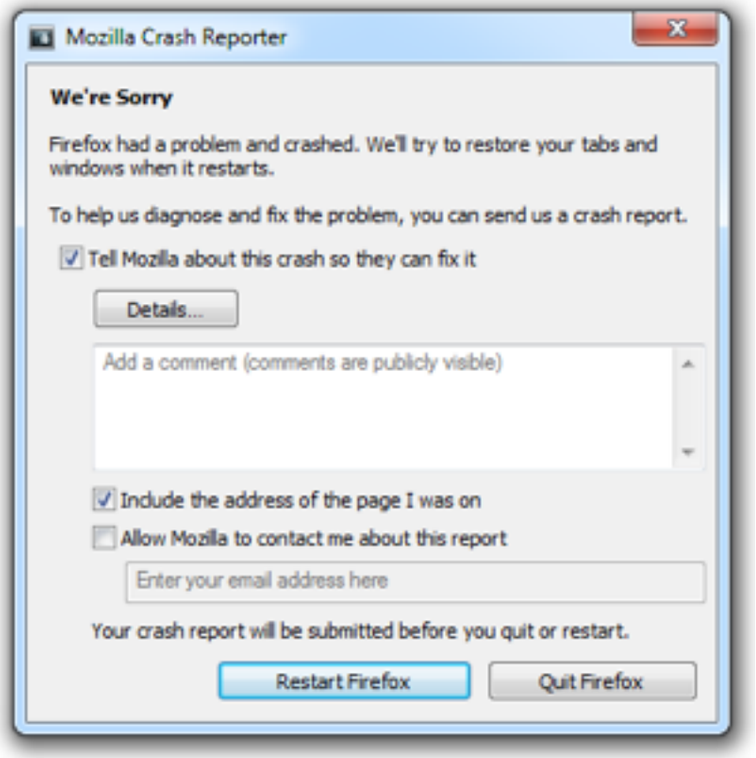
Crash Collecting System



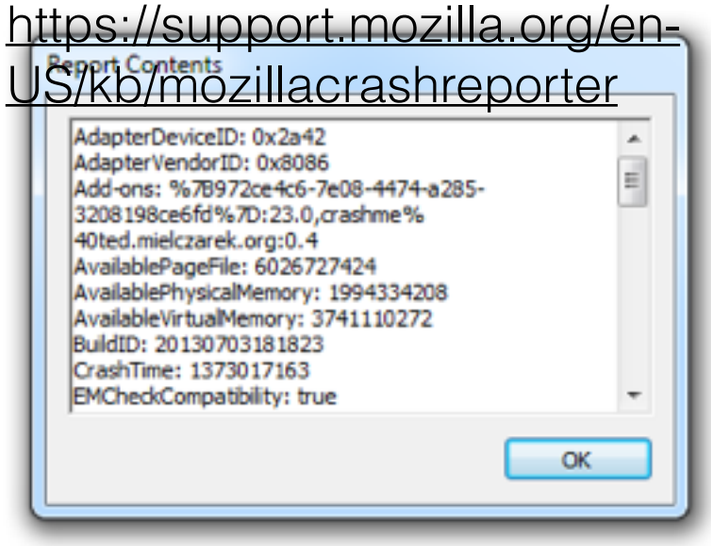
https://support.mozilla.org/en-US/kb/mozillacrashreporter

https://crash-stats.mozilla.com/

Crash Collecting System

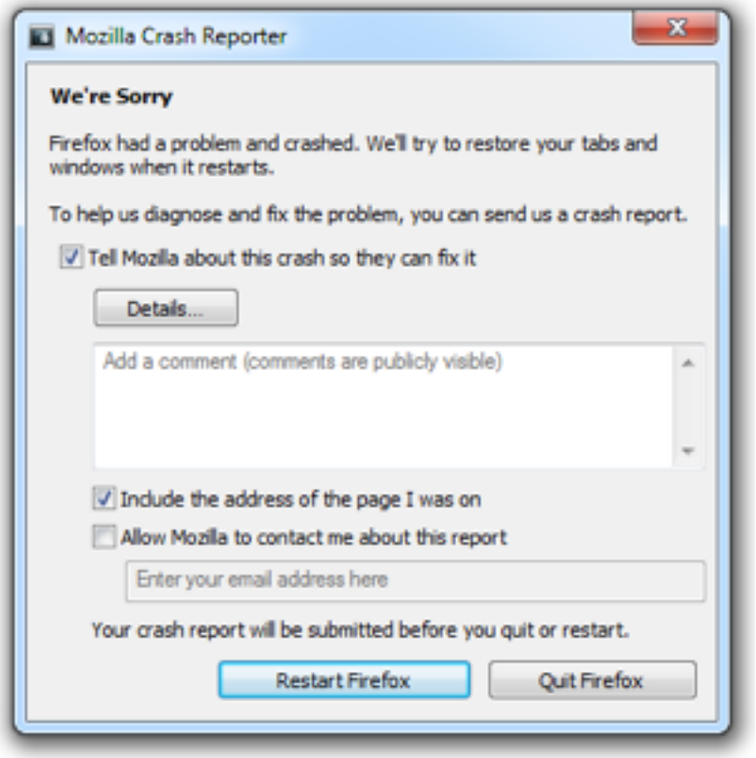


https://support.mozilla.org/en-US/kb/mozillacrashreporter

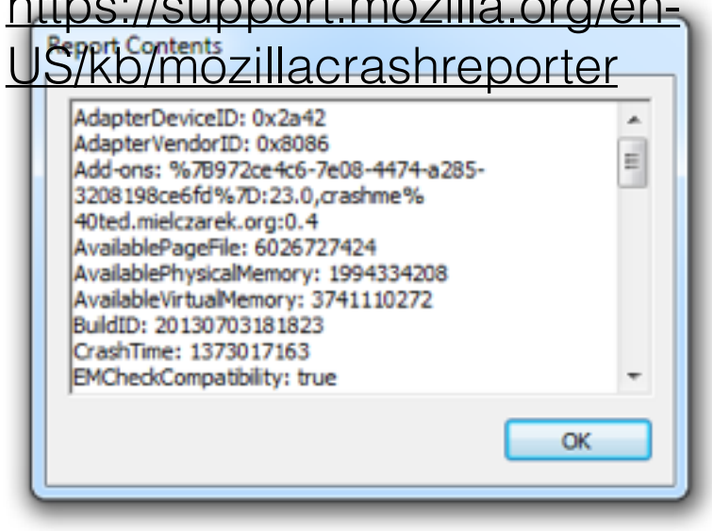


https://crash-stats.mozilla.com/

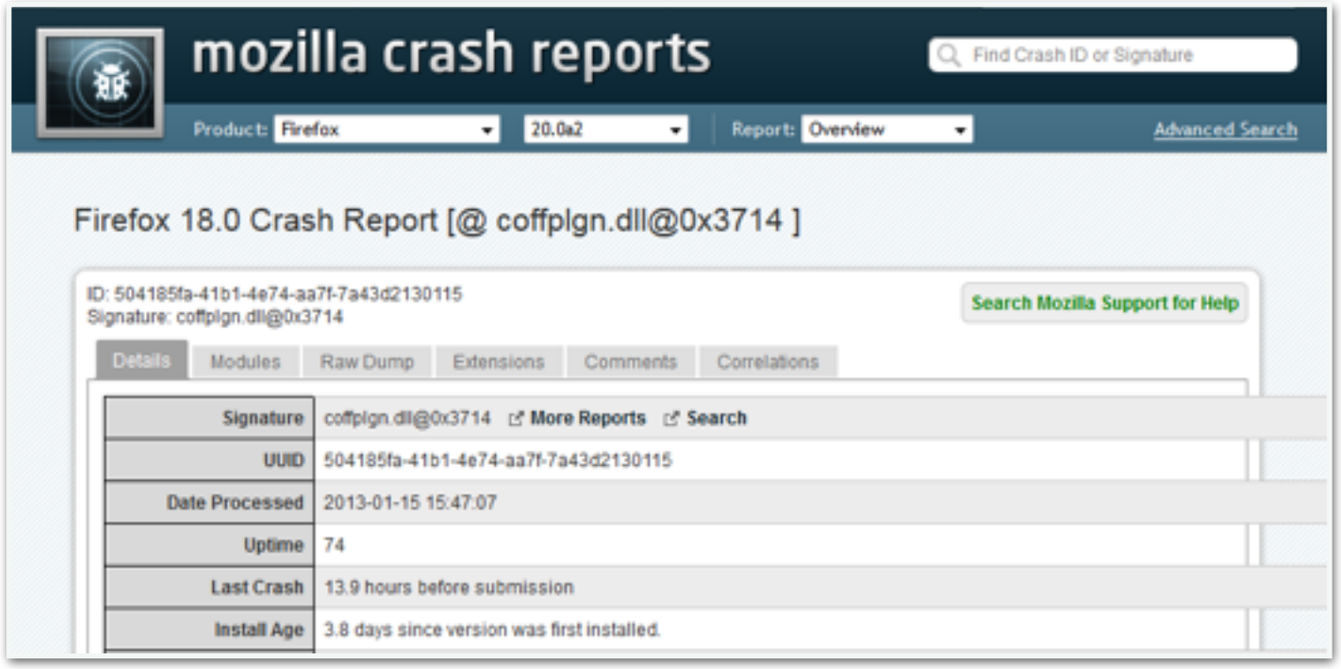
Crash Collecting System



https://support.mozilla.org/en-US/kb/mozillacrashreporter



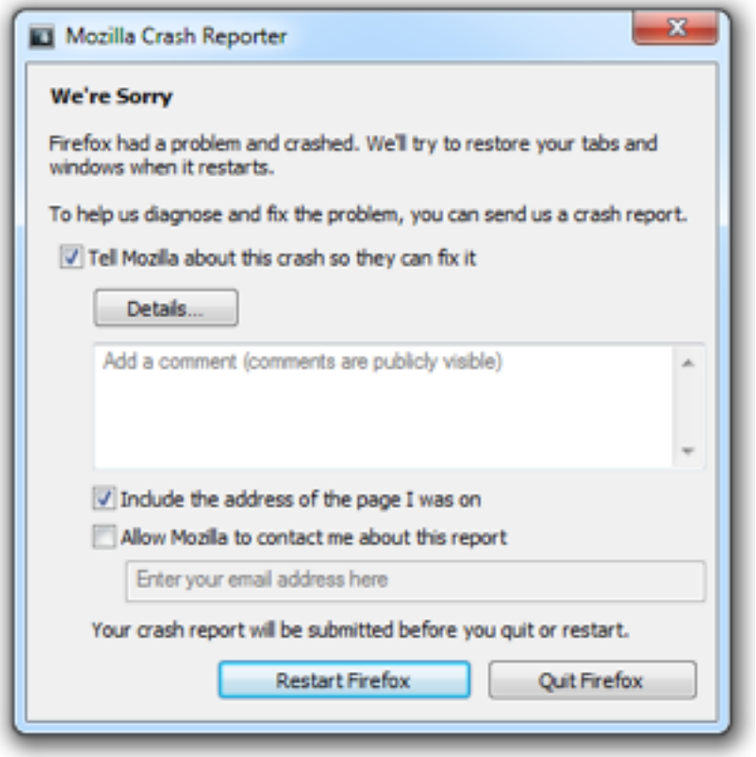
Socorro

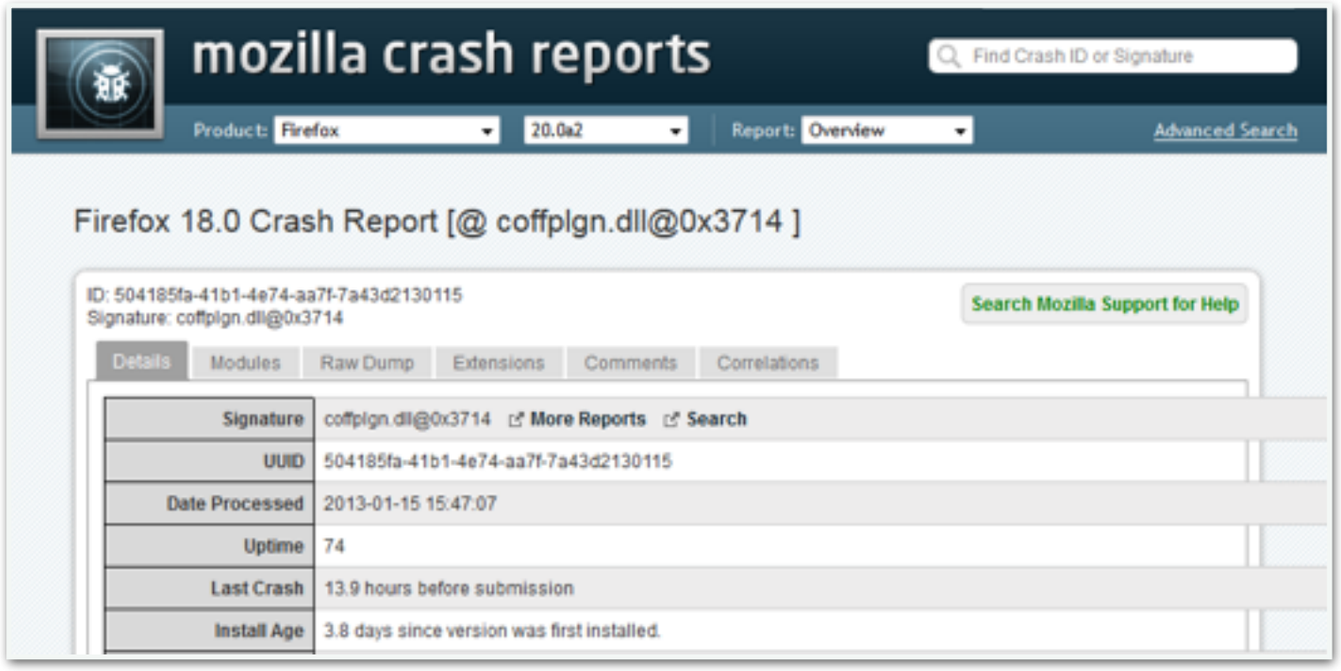


https://crash-stats.mozilla.com/

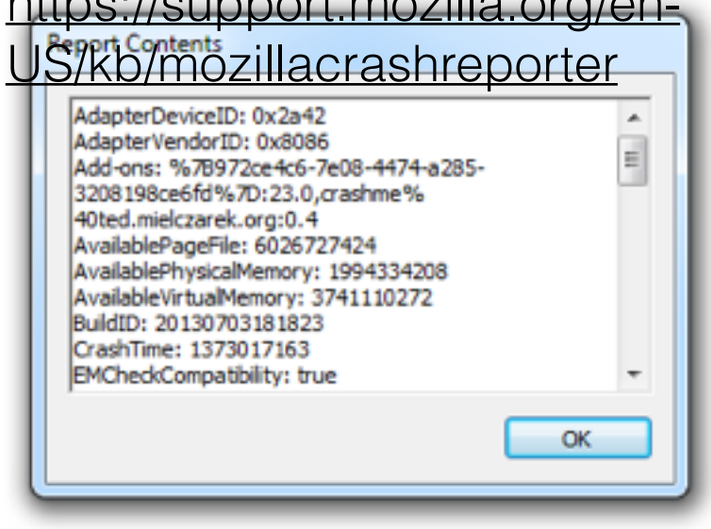
Crash Collecting System

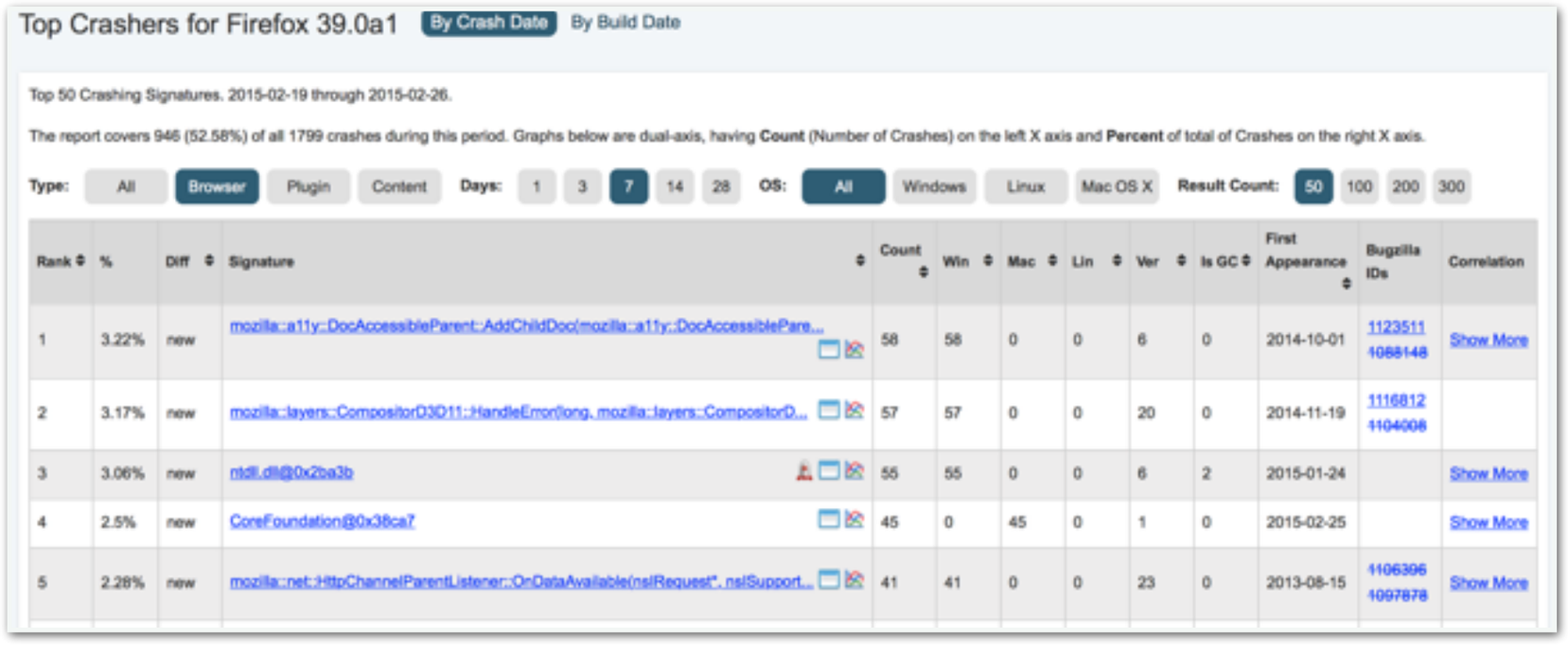
Socorro





https://support.mozilla.org/en-US/kb/mozillacrashreporter

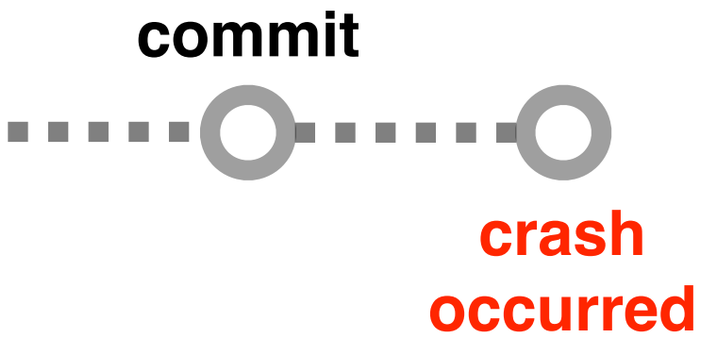




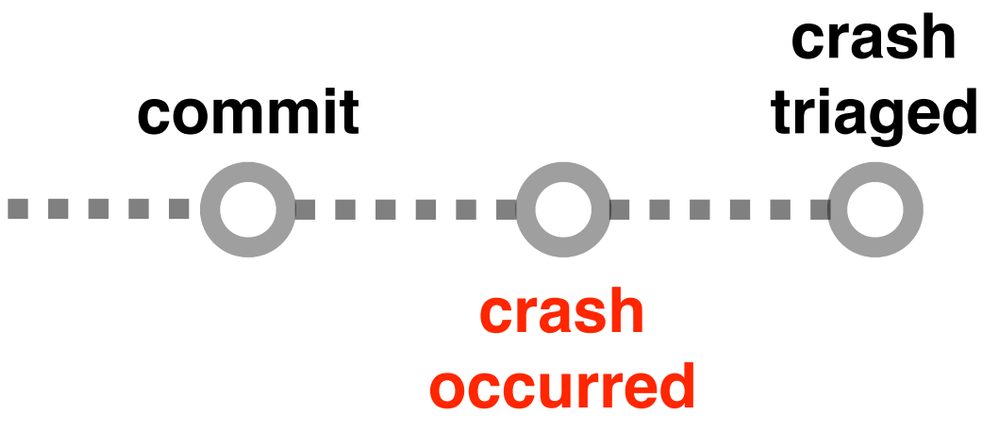
https://crash-stats.mozilla.com/

Challenge

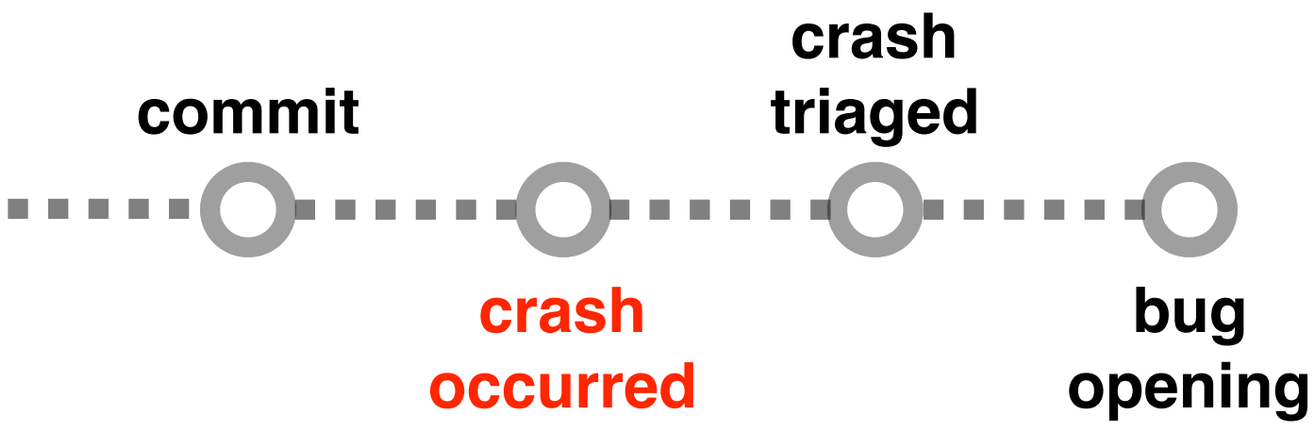
Challenge



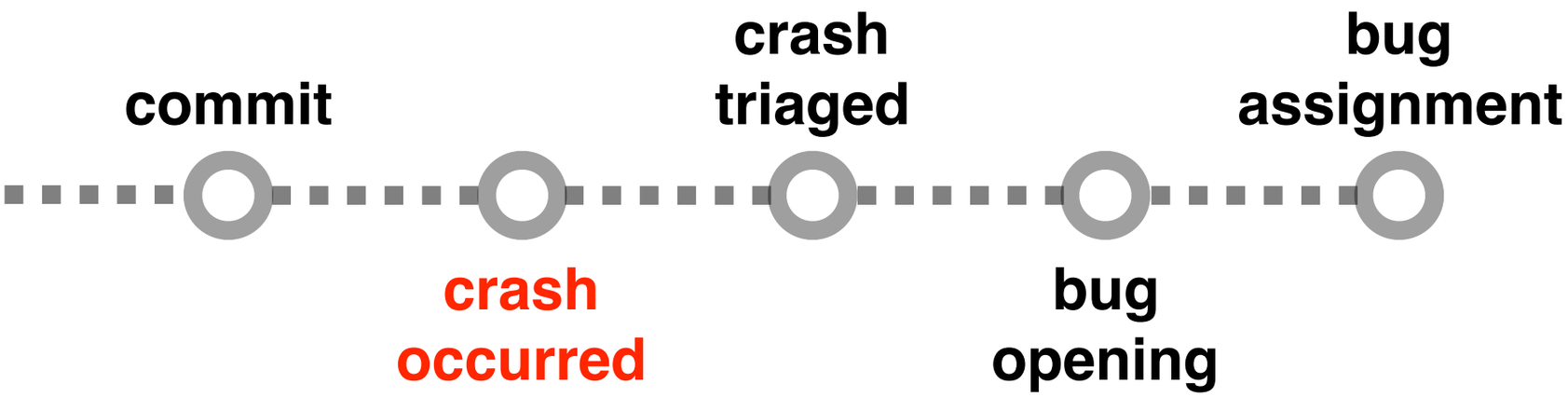
Challenge



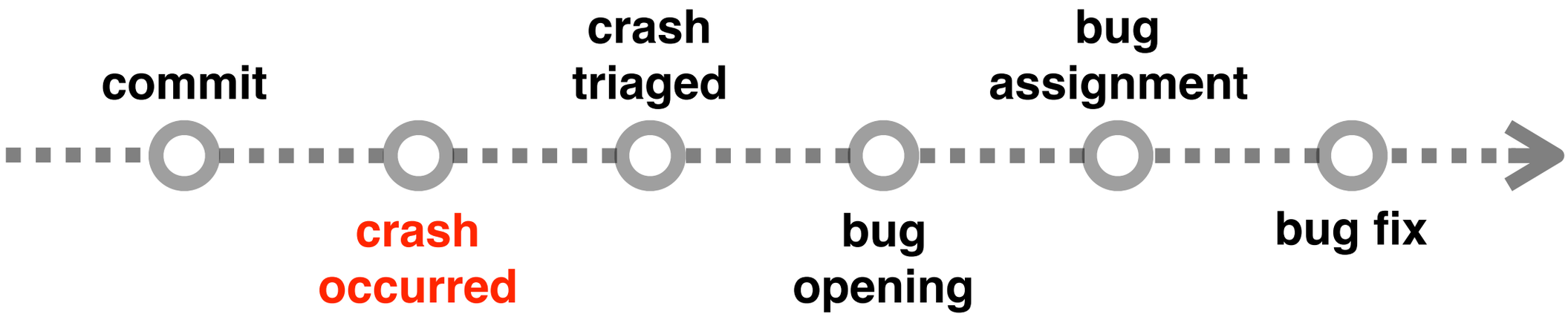
Challenge



Challenge


commit
crash
triaged
bug
assignment
crash
occurred
bug
opening

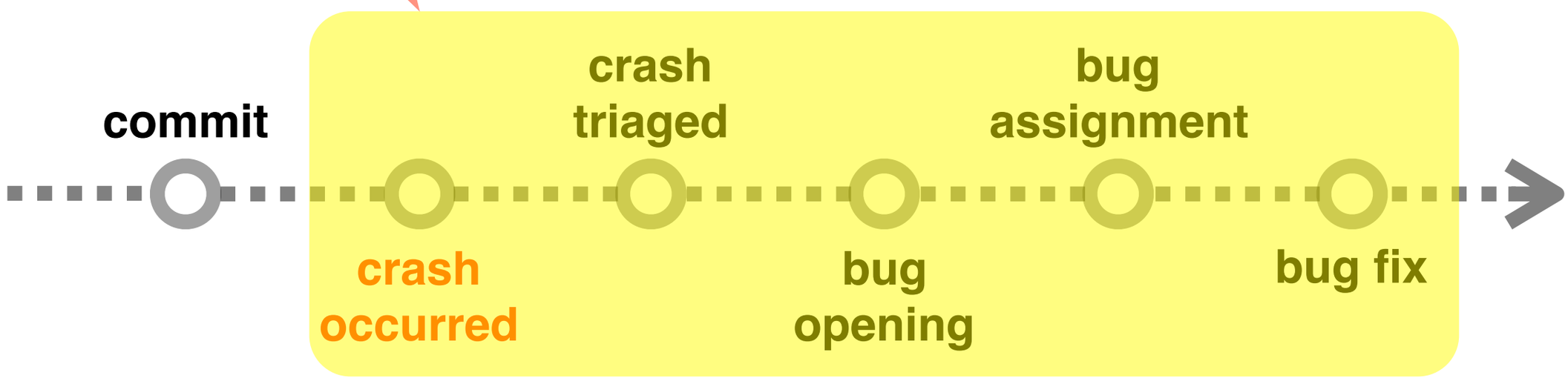
Challenge


commit
crash
occurred
crash
triaged
bug
opening
bug
assignment
bug fix

Challenge

Defects only prioritised by their crash frequency

Users have to wait for a long period until a crash-related bug gets fixed



Related Work

Foutse Khomh, Brian Chan, Ying Zou, Ahmed E. Hassan, **An Entropy Evaluation Approach for Triaging Field Crashes**, Proceedings of the 18th Working Conference on Reverse Engineering (WCRE)

Should we triage crash-related defects only by their crashing frequency?

Related Work

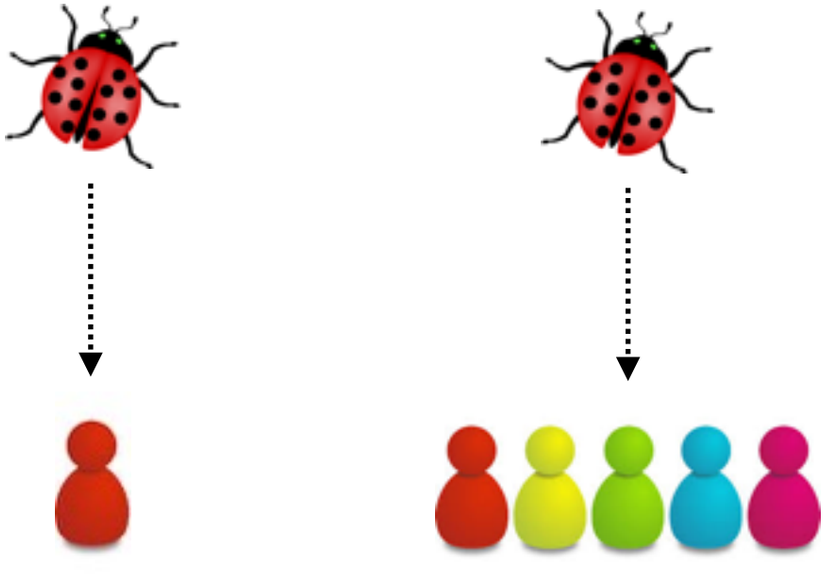
Foutse Khomh, Brian Chan, Ying Zou, Ahmed E. Hassan, **An Entropy Evaluation Approach for Triaging Field Crashes**, Proceedings of the 18th Working Conference on Reverse Engineering (WCRE)

Should we triage crash-related defects only by their crashing frequency?

Related Work

Foutse Khomh, Brian Chan, Ying Zou, Ahmed E. Hassan, **An Entropy Evaluation Approach for Triaging Field Crashes**, Proceedings of the 18th Working Conference on Reverse Engineering (WCRE)

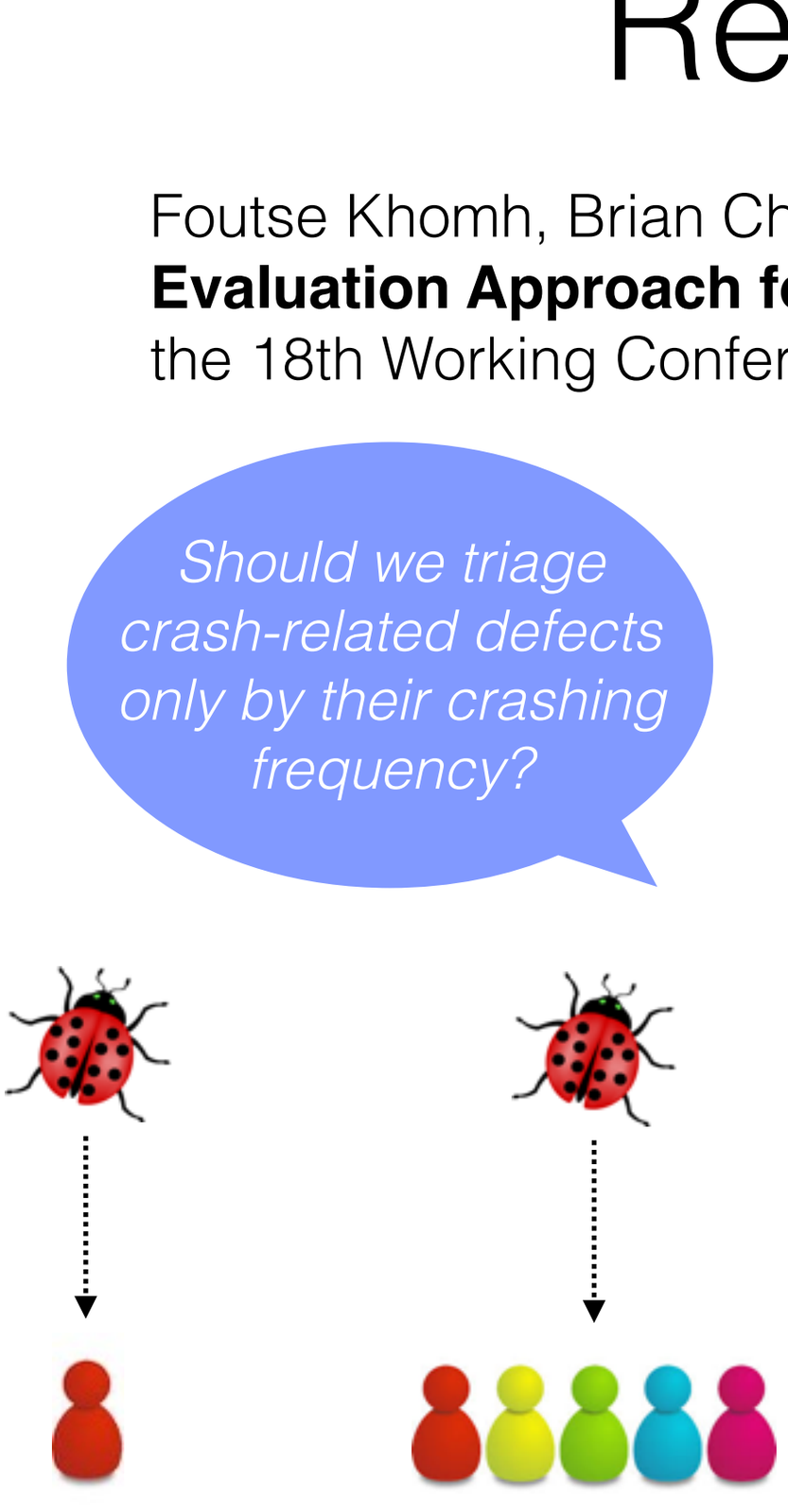
Should we triage crash-related defects only by their crashing frequency?

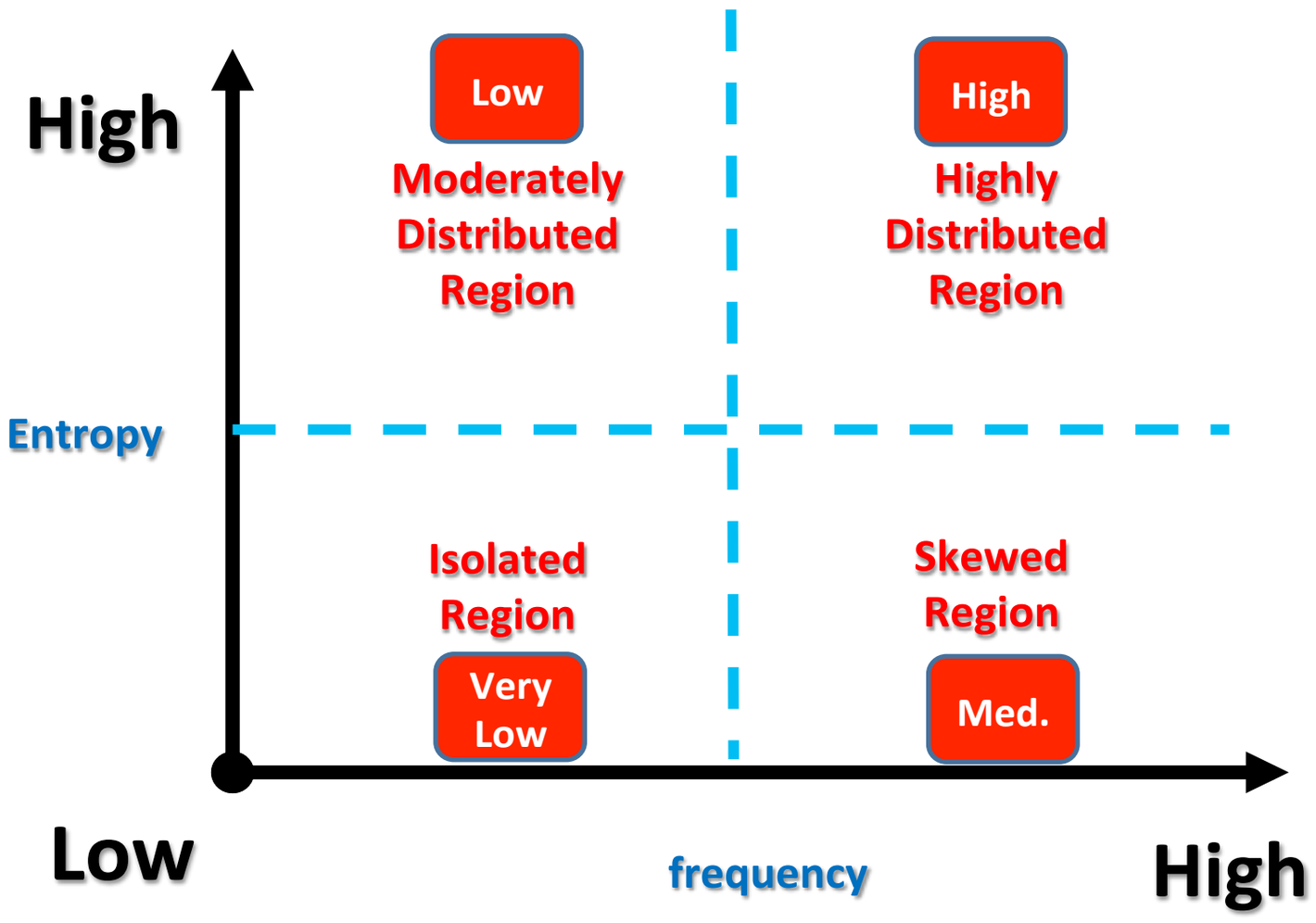


Related Work

Foutse Khomh, Brian Chan, Ying Zou, Ahmed E. Hassan, **An Entropy Evaluation Approach for Triaging Field Crashes**, Proceedings of the 18th Working Conference on Reverse Engineering (WCRE)

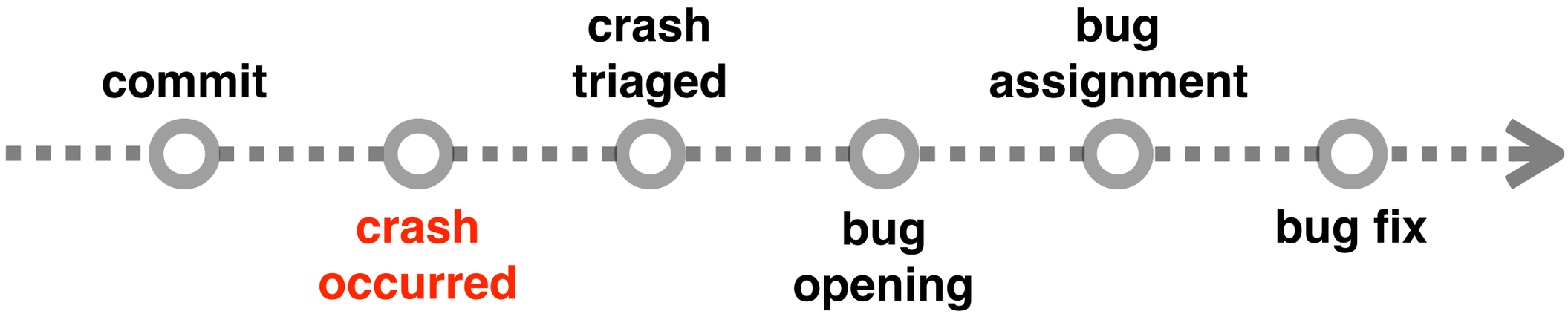
Should we triage crash-related defects only by their crashing frequency?

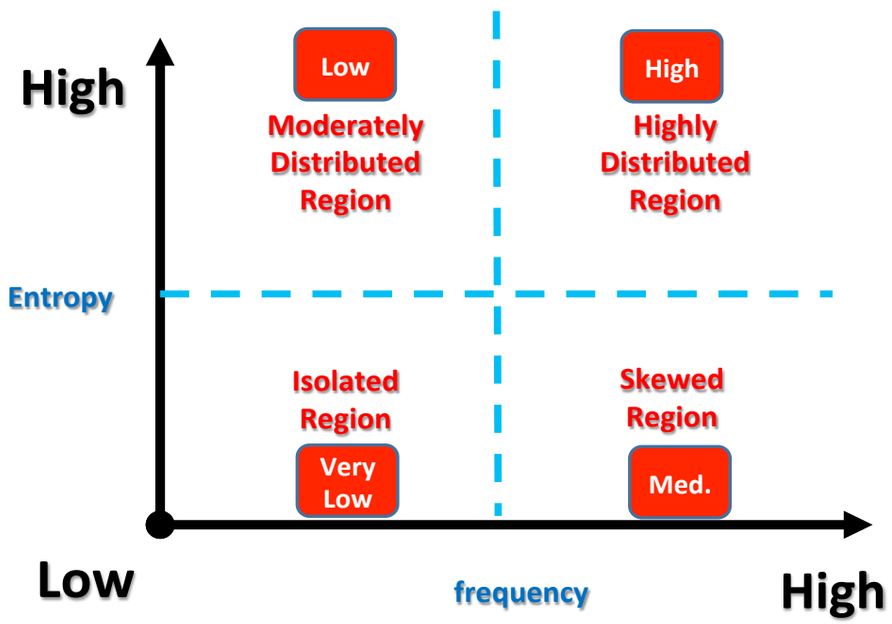




Related Work

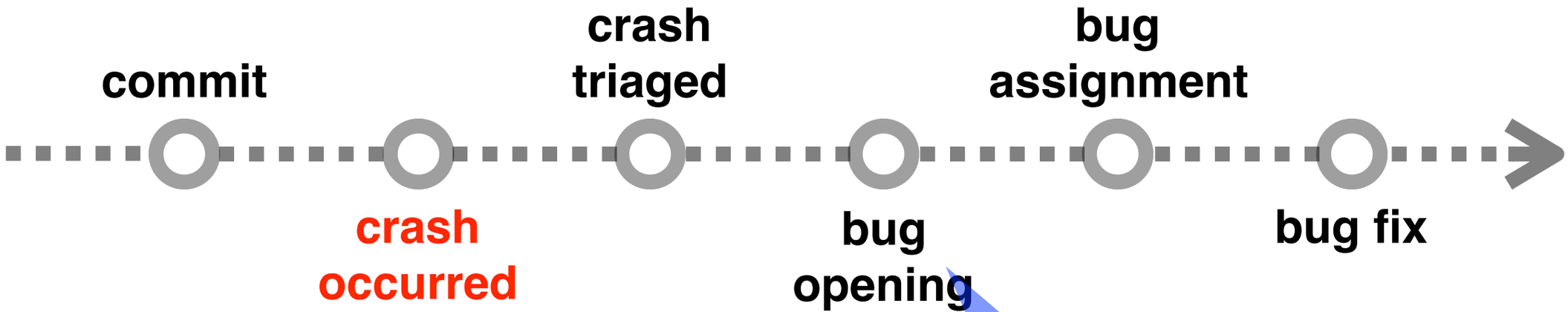
Le An and Foutse Khomh, **An Empirical Study of Highly-impactful Bugs in Mozilla Projects**, Proceedings of the 2015 IEEE International Conference on Software Quality, Reliability and Security (QRS)

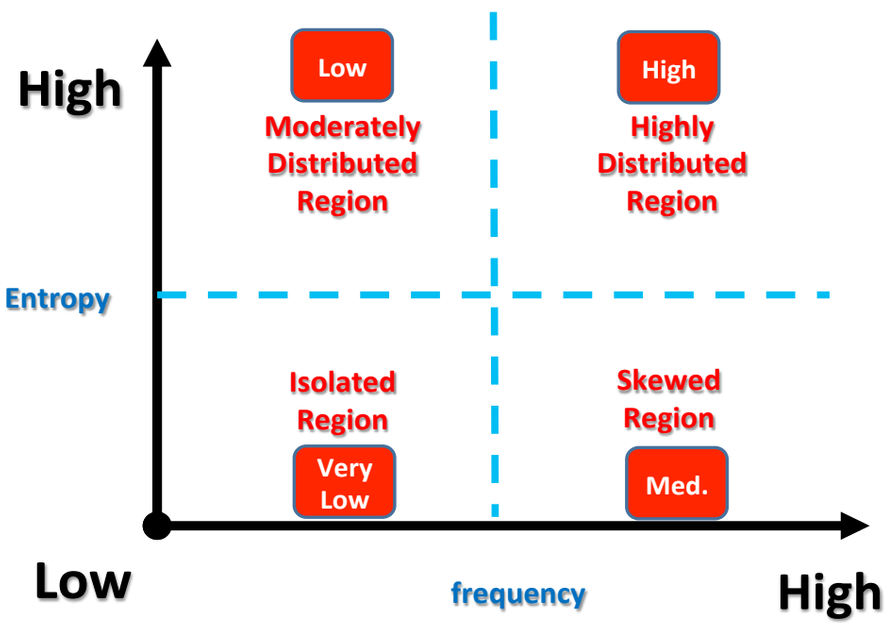




Related Work

Le An and Foutse Khomh, **An Empirical Study of Highly-impactful Bugs in Mozilla Projects**, Proceedings of the 2015 IEEE International Conference on Software Quality, Reliability and Security (QRS)

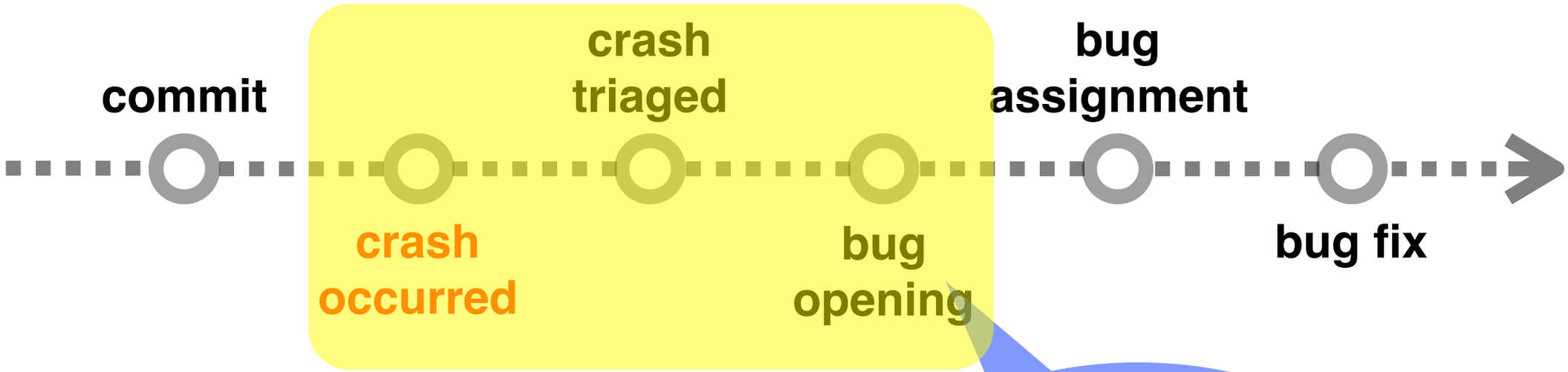


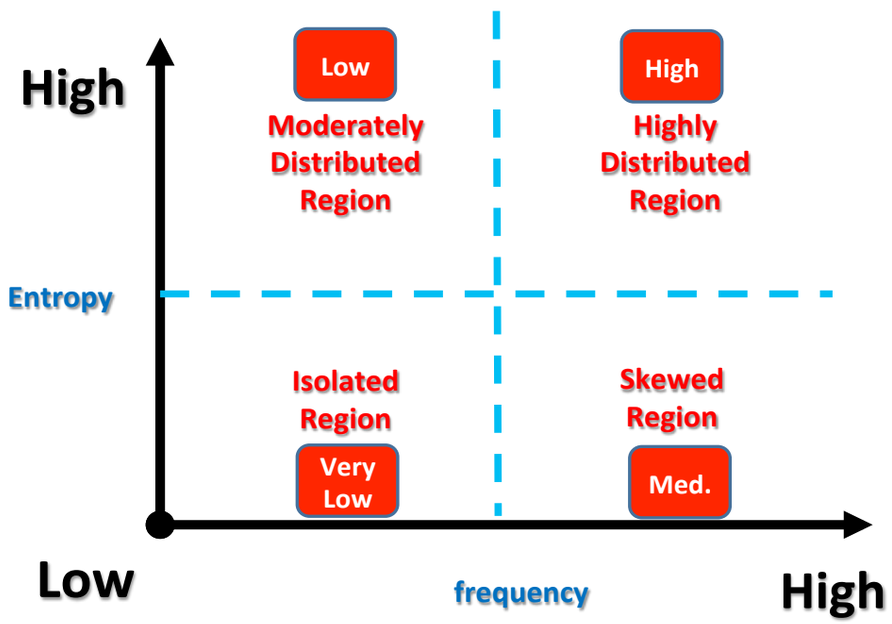


Identify and prioritise bugs that crash frequently and affect a large user base

Related Work

Le An and Foutse Khomh, **An Empirical Study of Highly-impactful Bugs in Mozilla Projects**, Proceedings of the 2015 IEEE International Conference on Software Quality, Reliability and Security (QRS)





Identify and prioritise bugs that crash frequently and affect a large user base

Research Questions?

What is the percentage of crash-inducing commits?

What are the characteristics of crash-inducing commits?

How well could we predict crash-inducing commits?

Study Design

Subject System

Mozilla Firefox

Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?**
In ACM sigsoft software engineering notes (SZZ algorithm)

crash-related bug

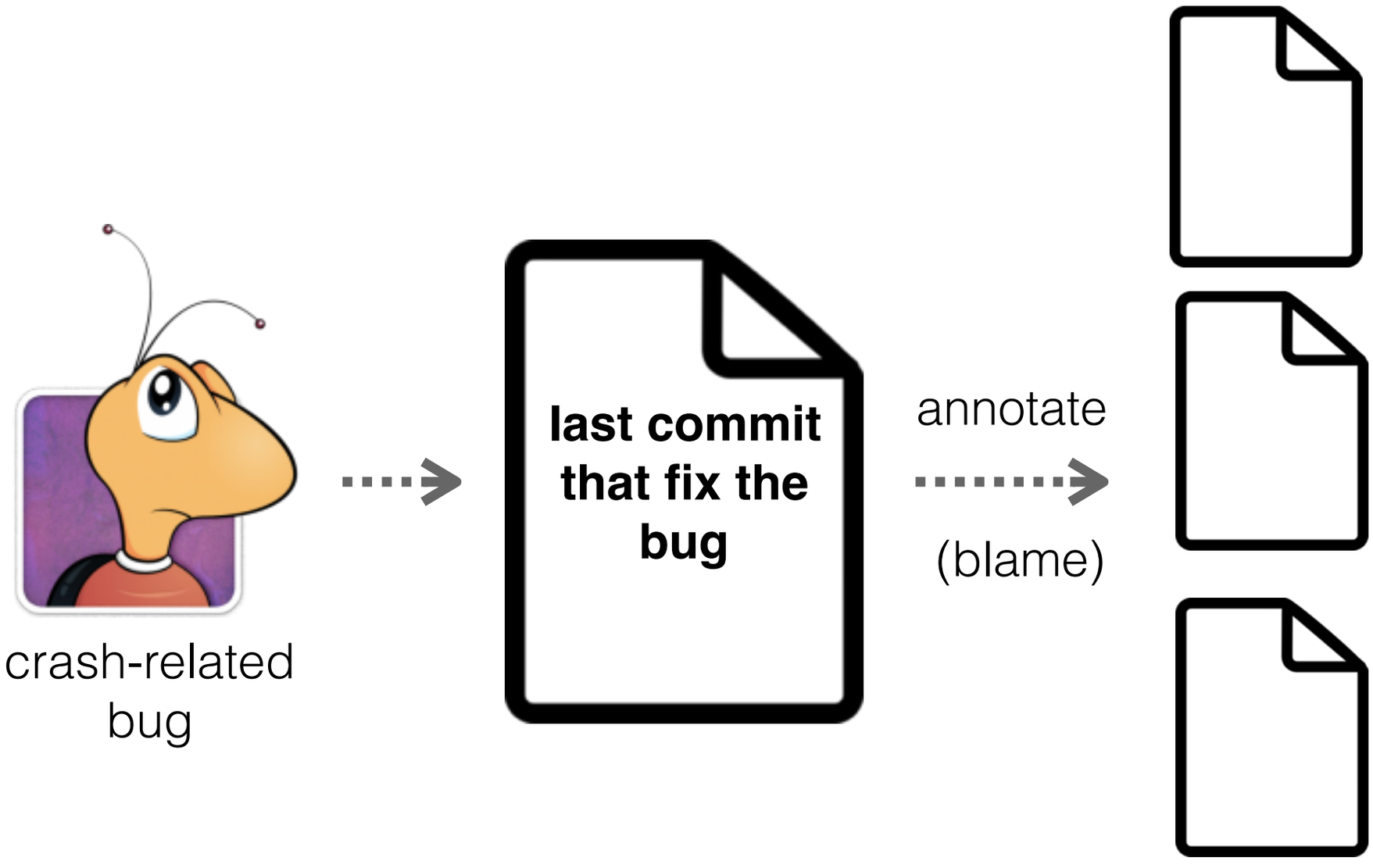
Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?**
In ACM sigsoft software engineering notes (SZZ algorithm)

crash-related bug

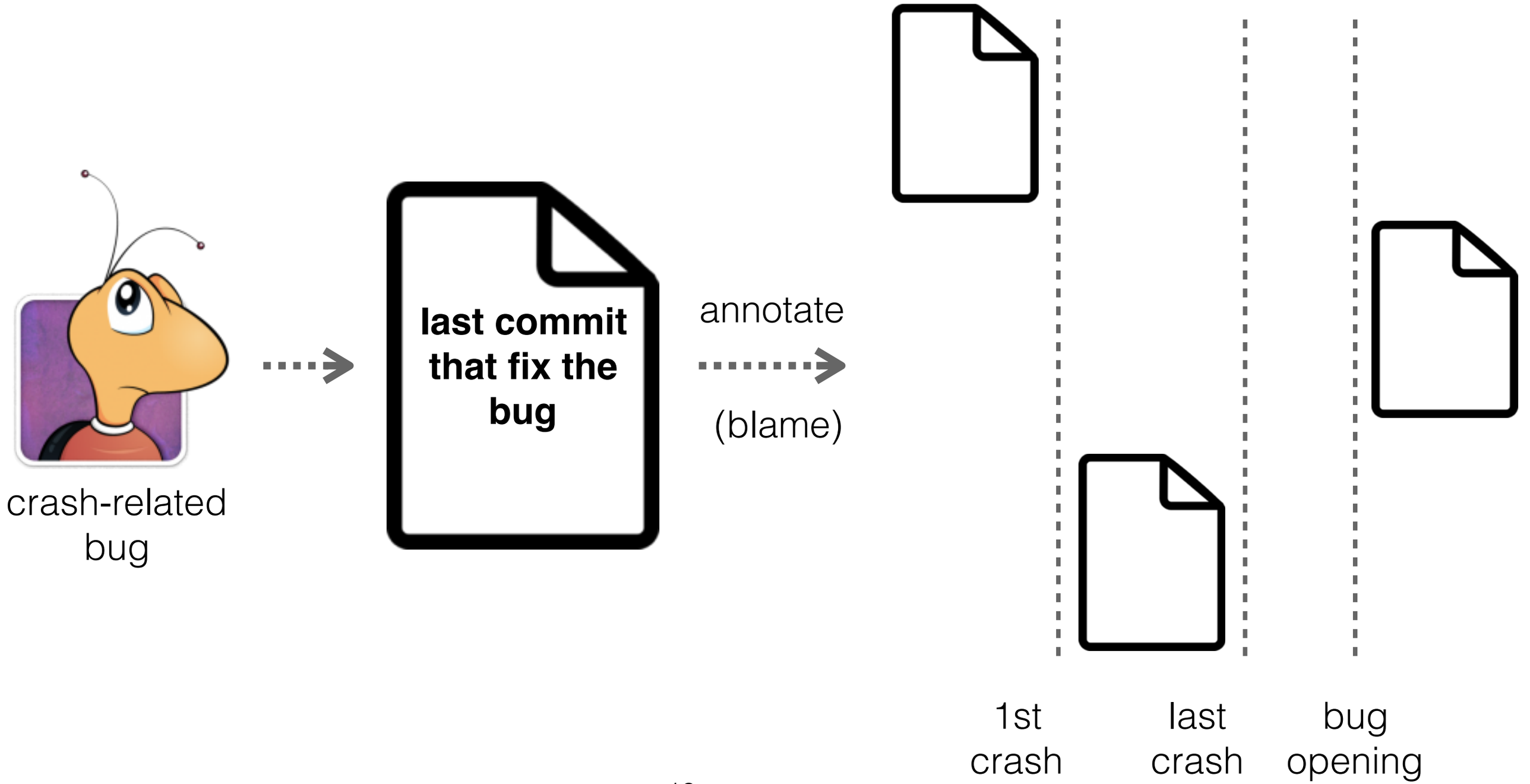
Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?**
In ACM sigsoft software engineering notes (SZZ algorithm)



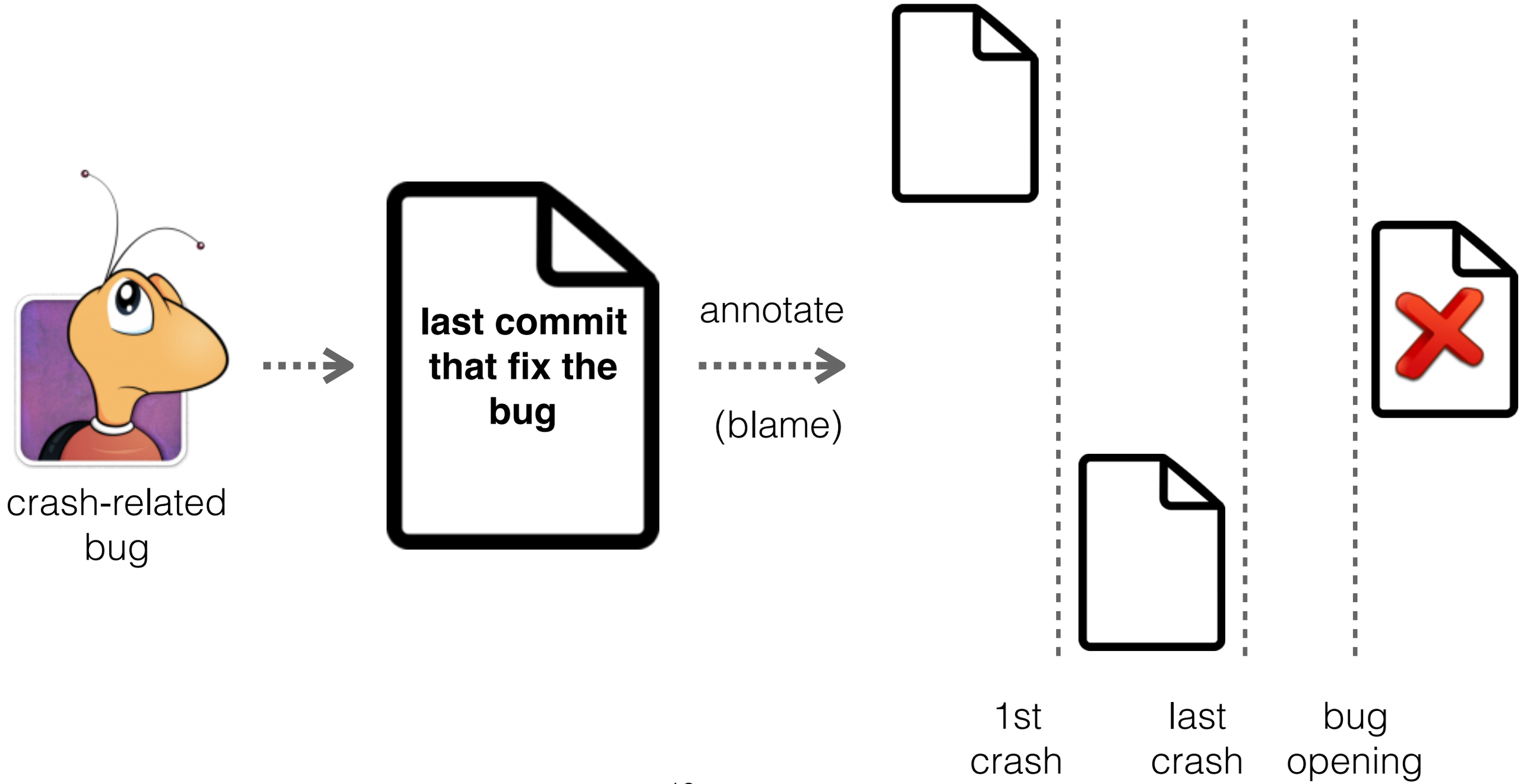
Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?**
In ACM sigsoft software engineering notes (SZZ algorithm)



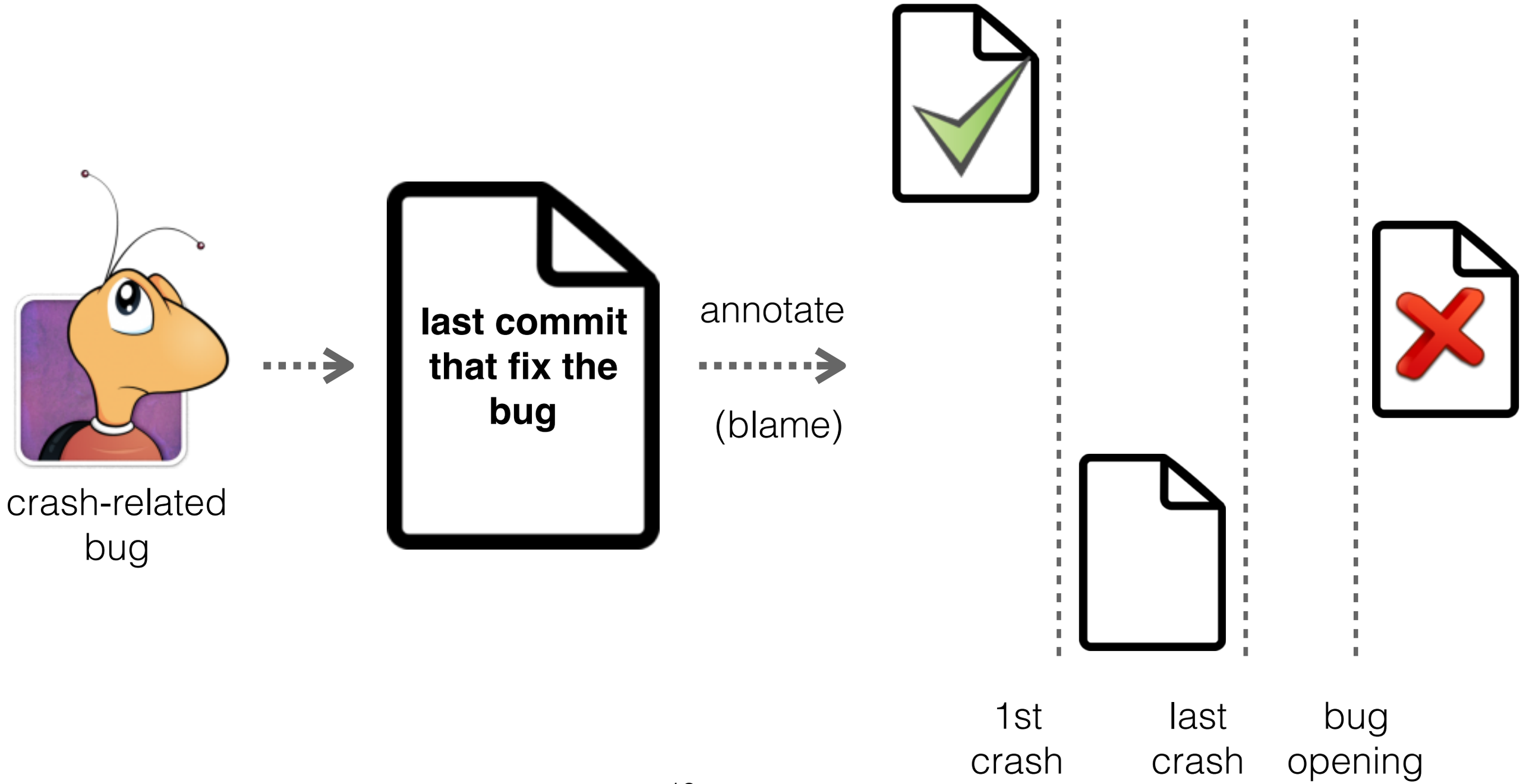
Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?**
In ACM sigsoft software engineering notes (SZZ algorithm)



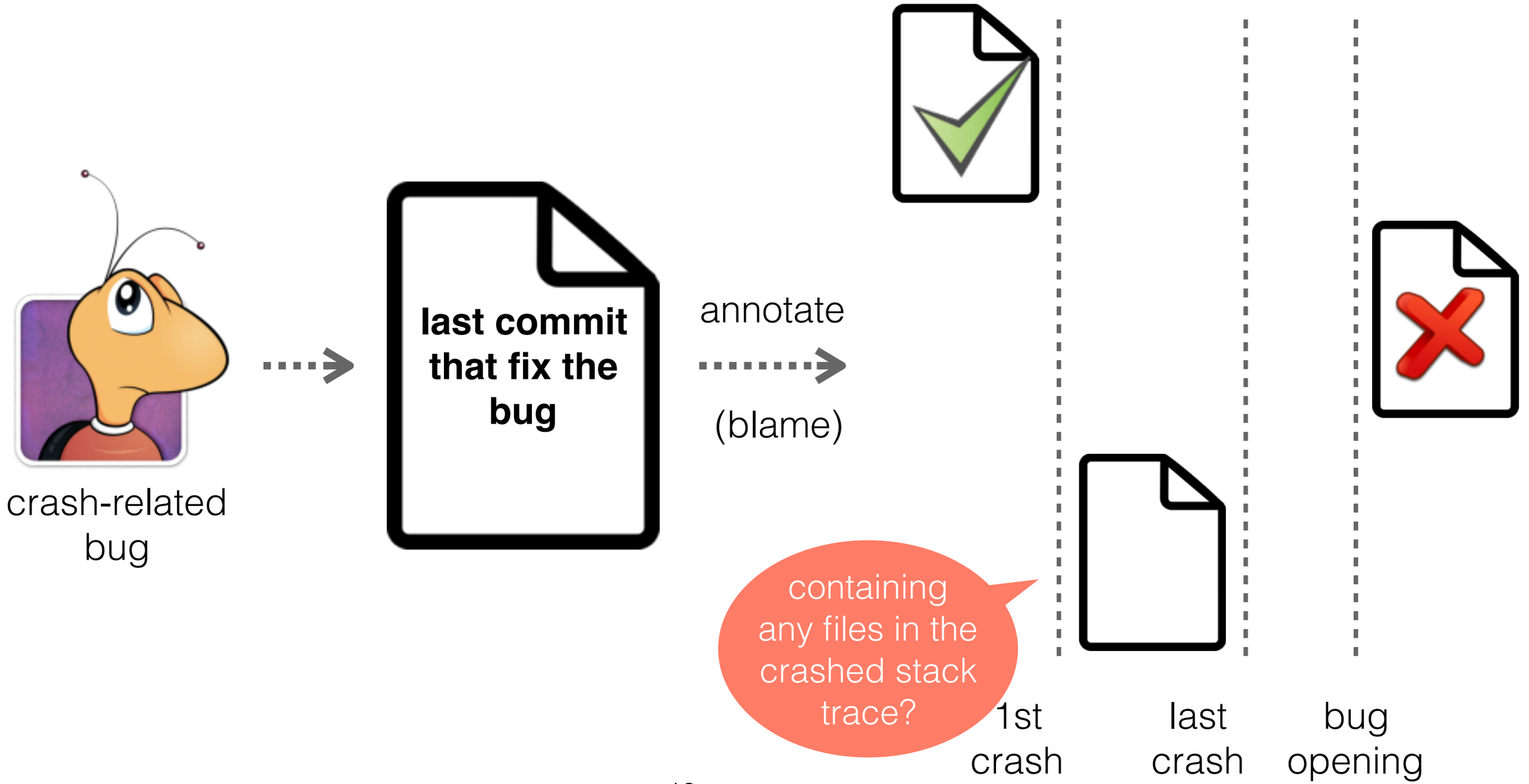
Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?**
In ACM sigsoft software engineering notes (SZZ algorithm)



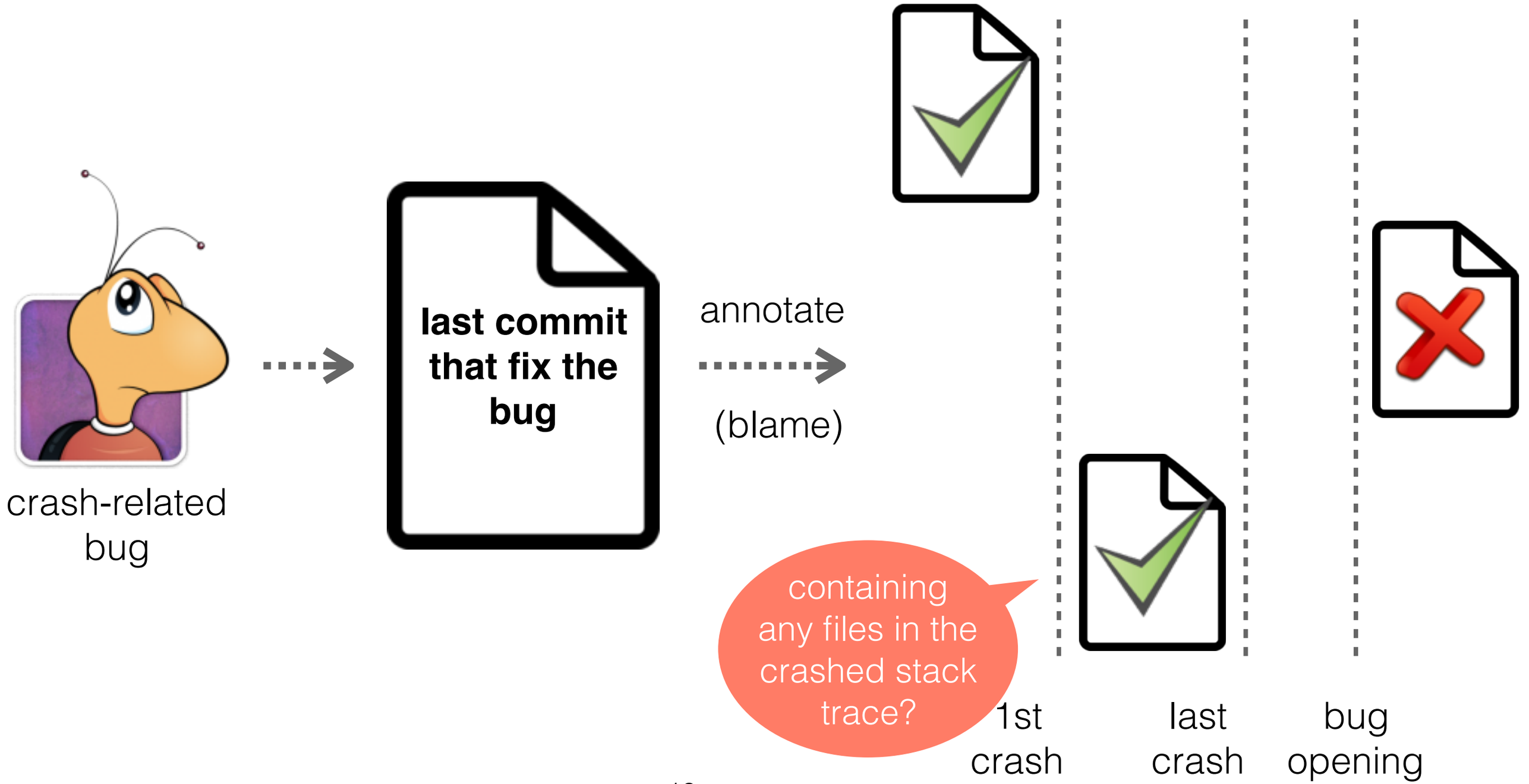
Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?**
In ACM sigsoft software engineering notes (SZZ algorithm)



Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?**
In ACM sigsoft software engineering notes (SZZ algorithm)



Computing Code Complexity Metrics

cyclomatic complexity

LOC

# of functions

comment lines / code lines

max nesting

Computing Code Complexity Metrics

cyclomatic complexity

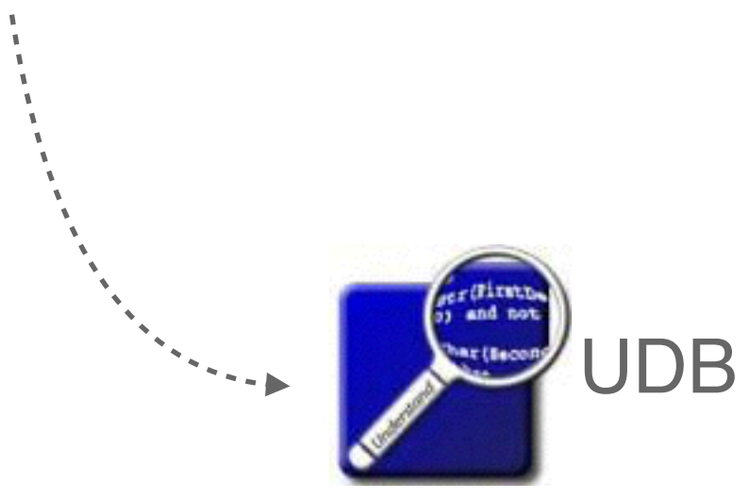
LOC

scitools Understand

# of functions

comment lines / code lines

max nesting



Computing Code Complexity Metrics

cyclomatic complexity

LOC

scitools Understand

# of functions

comment lines / code lines

max nesting

UDB

python™ API

Computing Social Network Analysis (SNA) Metrics

SNA can assess the extent of centrality of a specific class in a software system.

PageRank

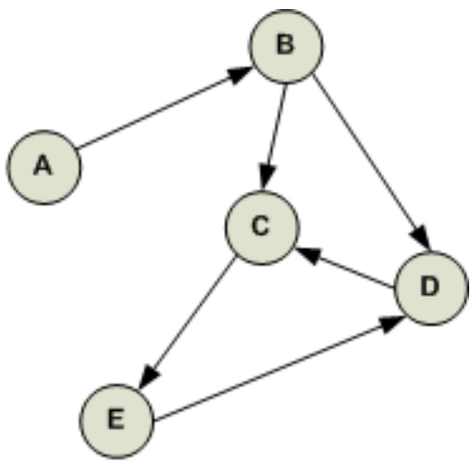
betweenness

closeness

indegree

outdegree

Computing Social Network Analysis (SNA) Metrics



dependency graph
among classes

SNA can assess the extent of centrality of a specific class in a software system.

PageRank

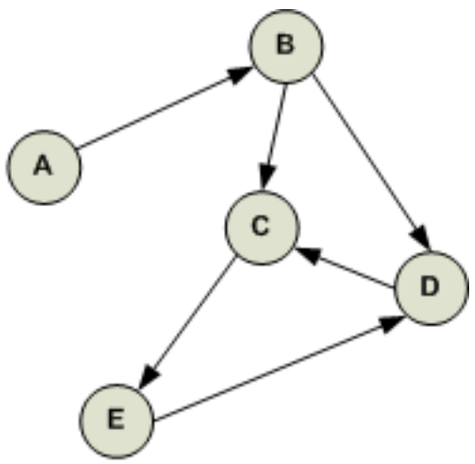
betweenness

closeness

indegree

outdegree

Computing Social Network Analysis (SNA) Metrics



dependency graph among classes

Understand

	a	b	c	d	e
a	0	1	0	0	0
b	0	0	1	1	0
c	0	0	0	0	1
d	0	0	1	0	0
e	0	0	0	1	0

adjacency matrix

SNA can assess the extent of centrality of a specific class in a software system.

PageRank

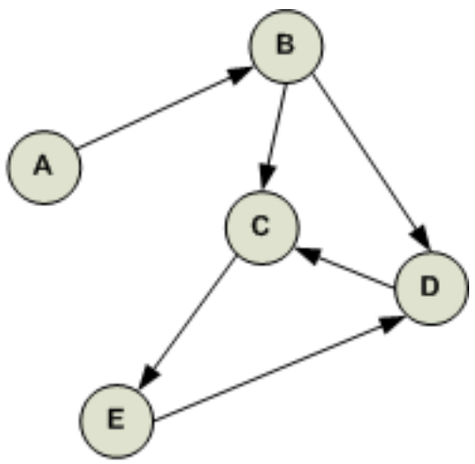
betweenness

closeness

indegree

outdegree

Computing Social Network Analysis (SNA) Metrics



dependency graph among classes

Understand

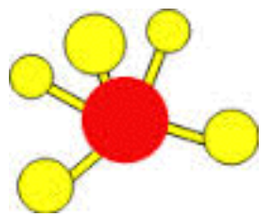
	a	b	c	d	e
a	0	1	0	0	0
b	0	0	1	1	0
c	0	0	0	0	1
d	0	0	1	0	0
e	0	0	0	1	0

adjacency matrix

SNA can assess the extent of centrality of a specific class in a software system.

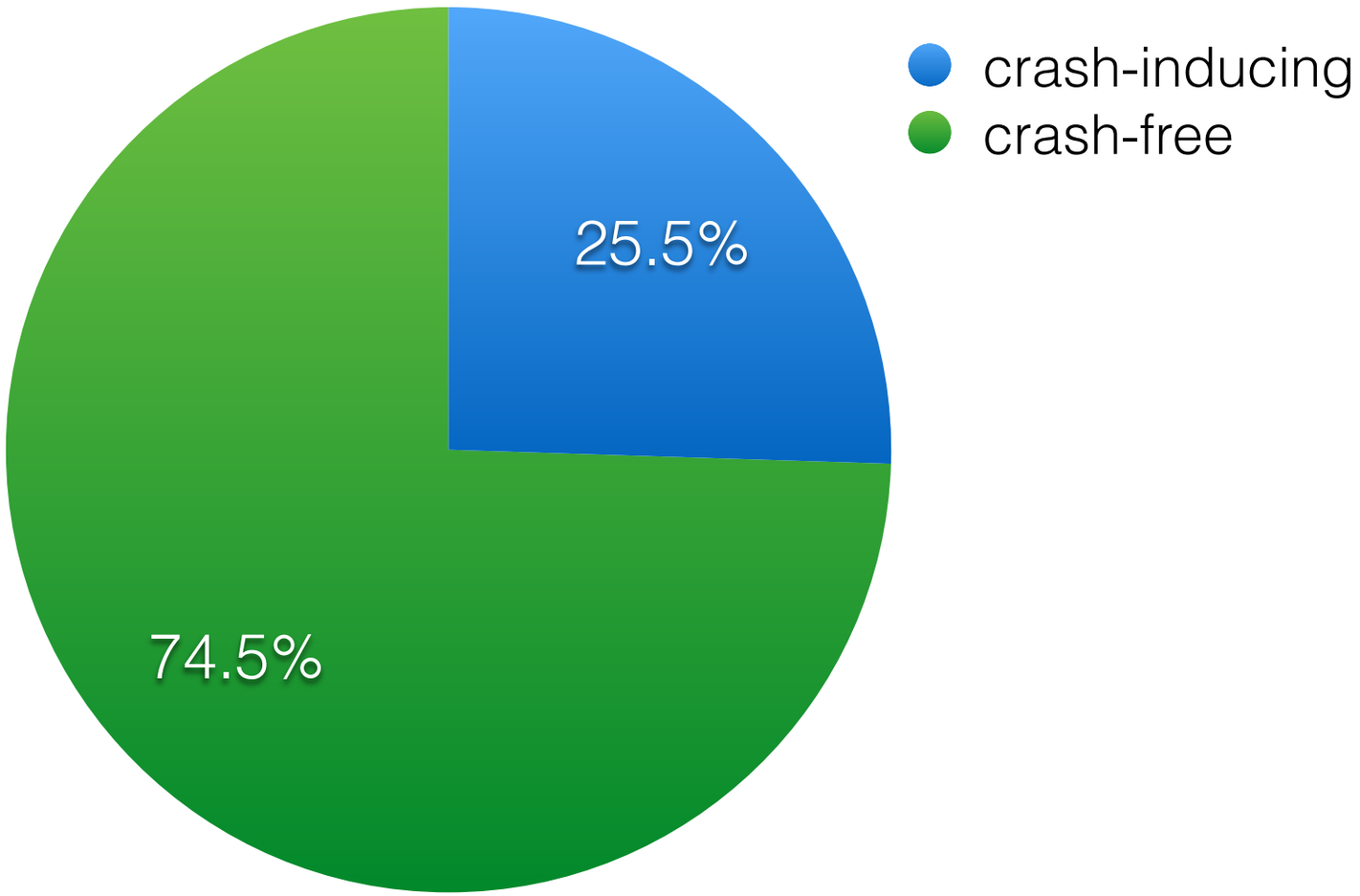
PageRank
betweenness
closeness
indegree
outdegree

igraph



Case Study Results

One Out of Four Commits in Firefox will Induce Future Crashes



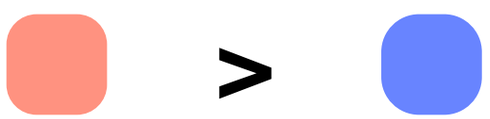
Significant Difference between Crash-inducing commits and crash-free commits

Crash-inducing commit

Crash-free commits

reporter experience

commit message



changed files & churn

Mozilla developers

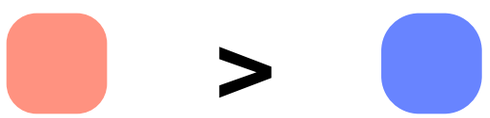
Significant Difference between Crash-inducing commits and crash-free commits

Crash-inducing commit

Crash-free commits

reporter experience

commit message

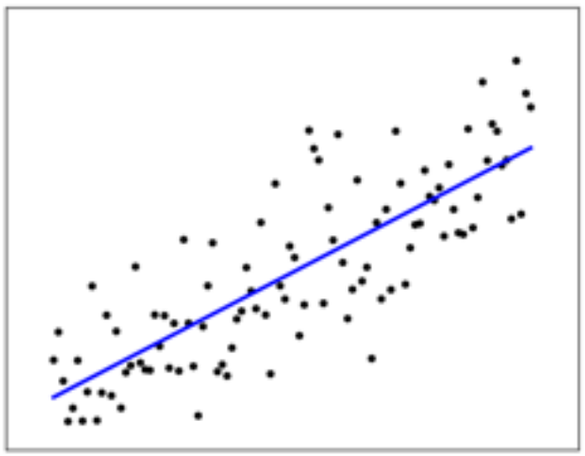


Outside contributors receive more scrutiny (through code review sessions) than those from Mozilla developers

changed files & churn

Mozilla developers

Prediction of Crash-inducing Commits

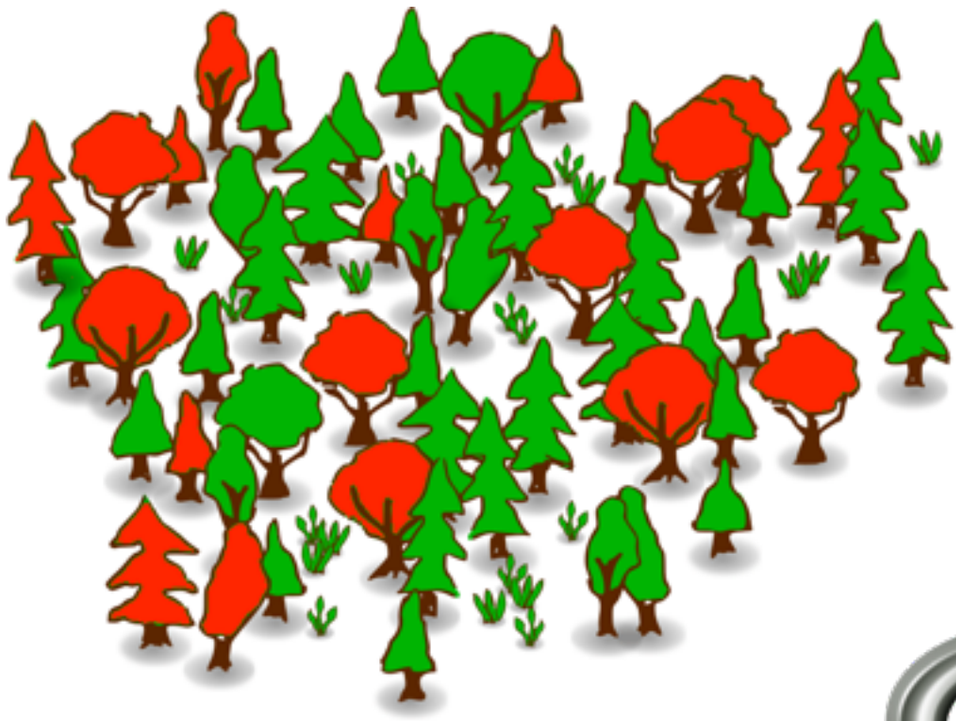


General Linear Model

$$P(X \mid C_i) = \prod_{k=1}^{n} P(x_k \mid C_i)$$

Naive Bayes

Decision tree

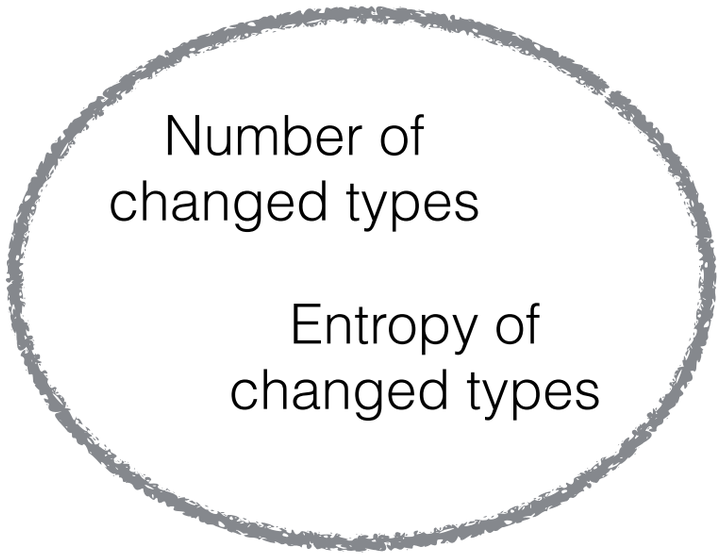


Random Forest

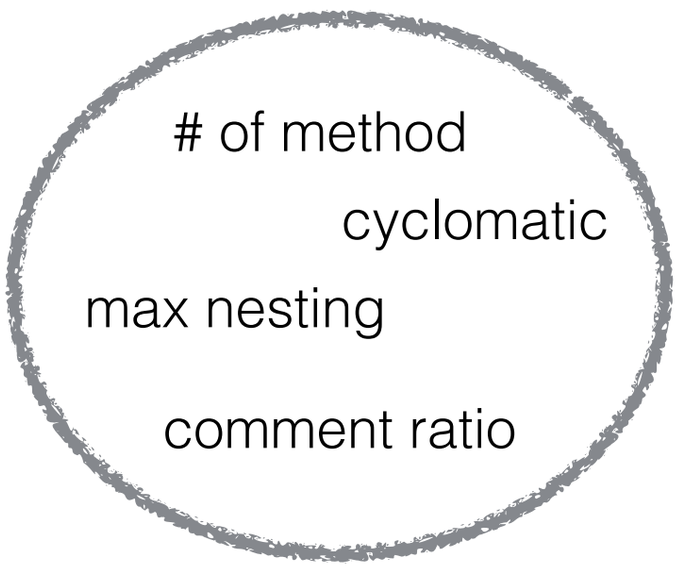
Predictive Metrics
(extracted at the level of commits)

Commit log

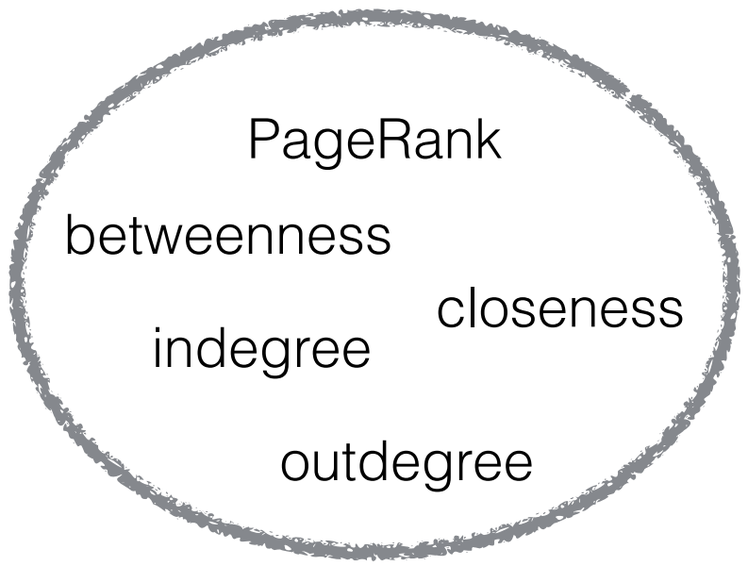
Changed type



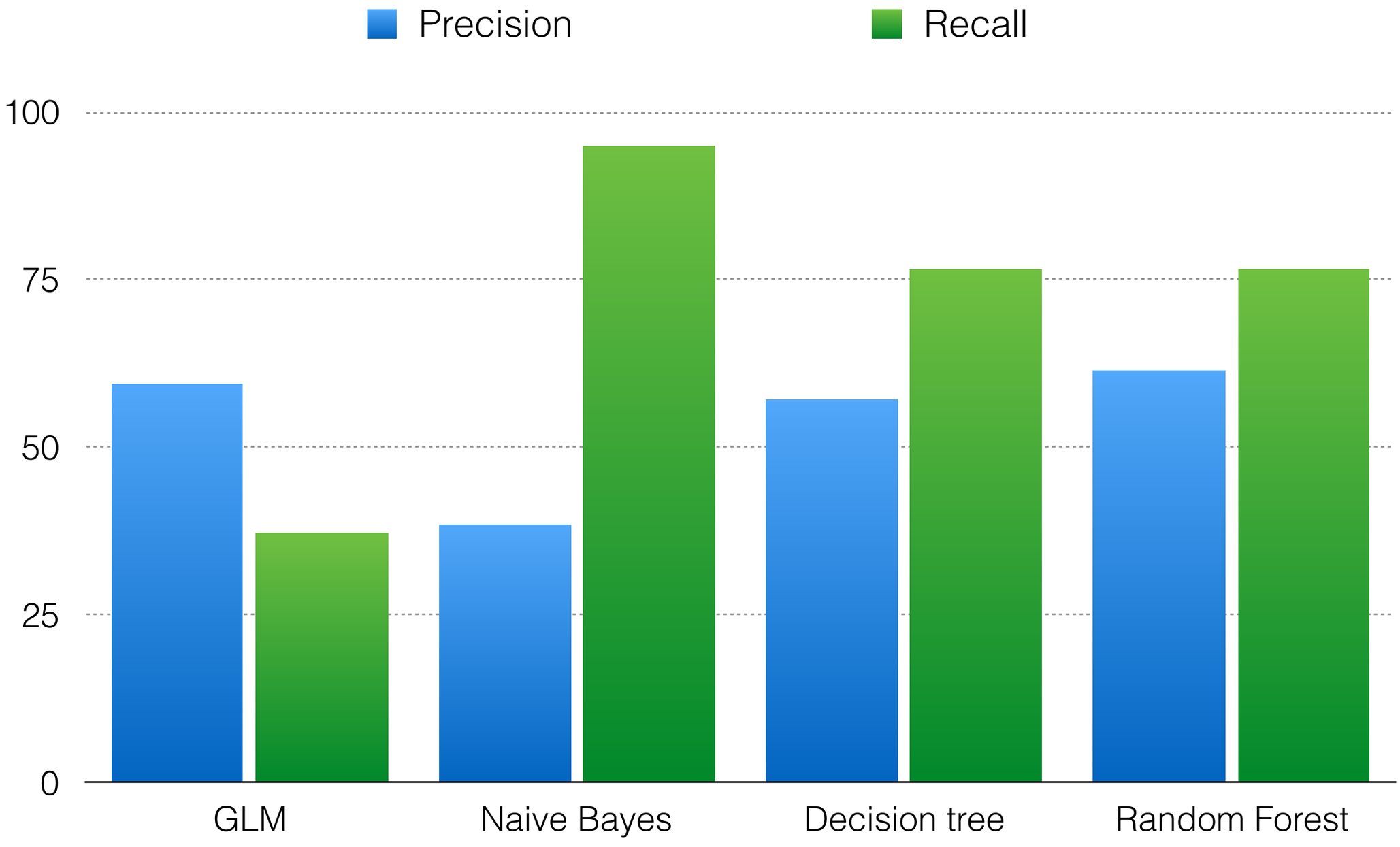
Code complexity



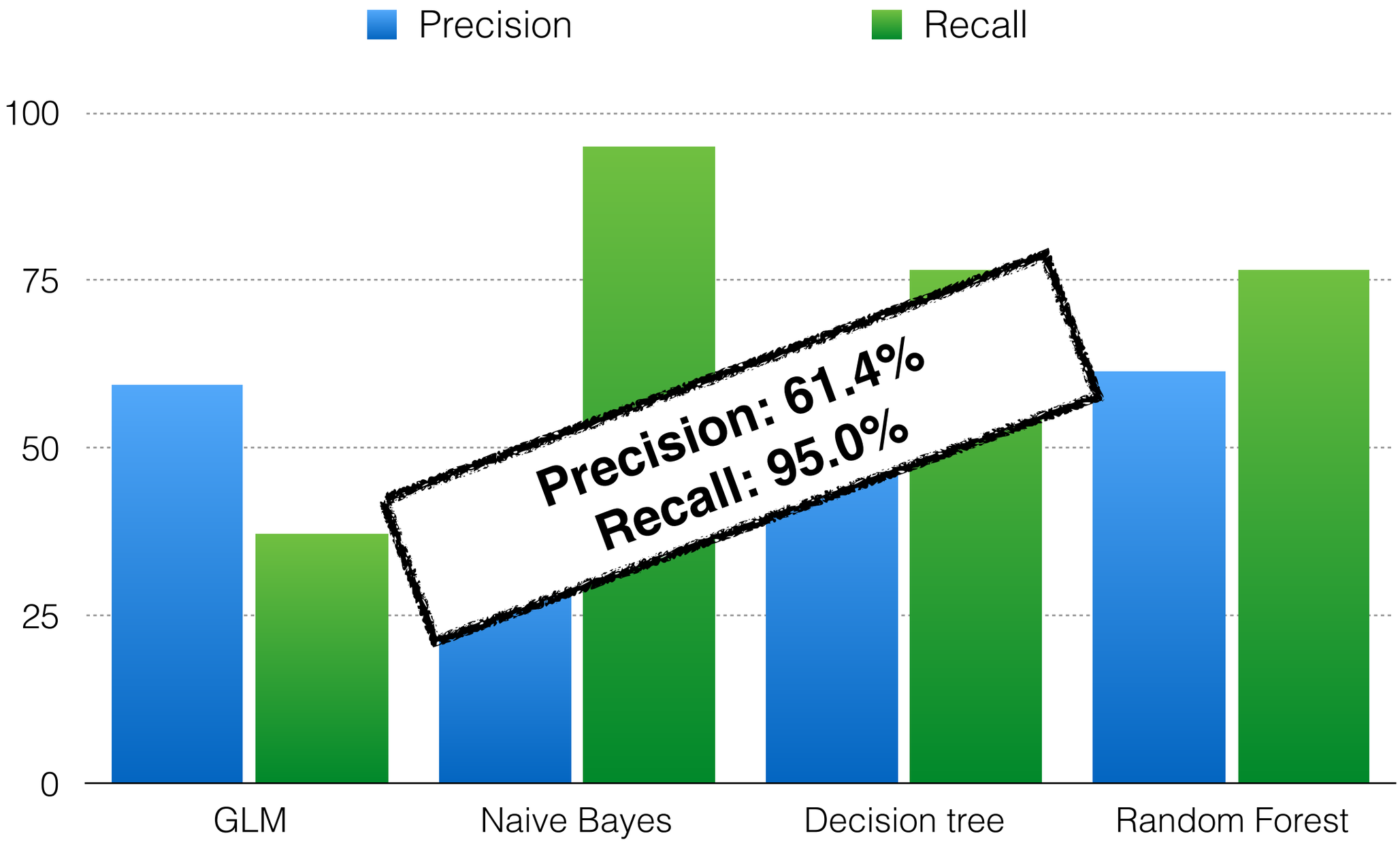
Social network analysis



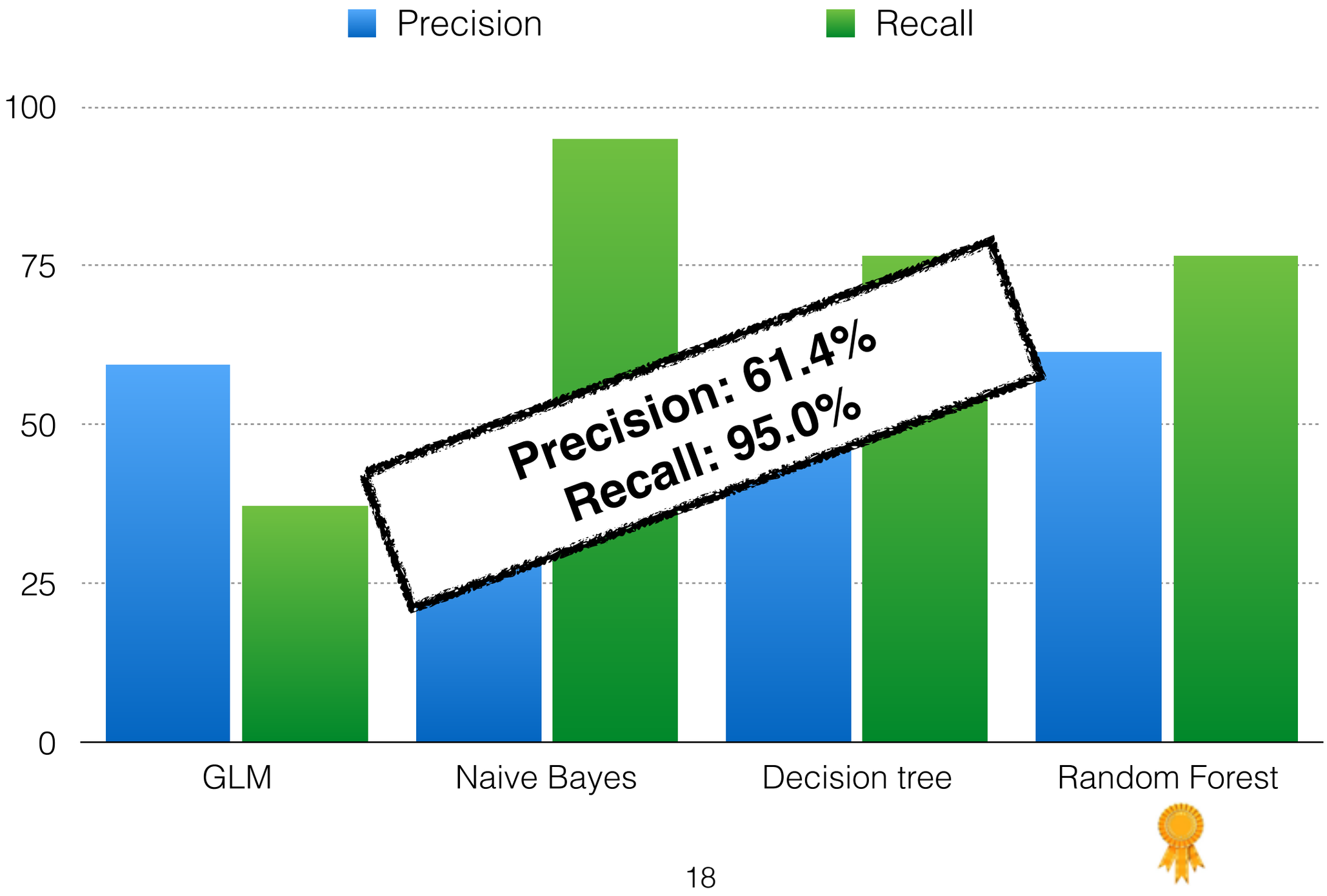
Prediction Result of Crash-inducing commits



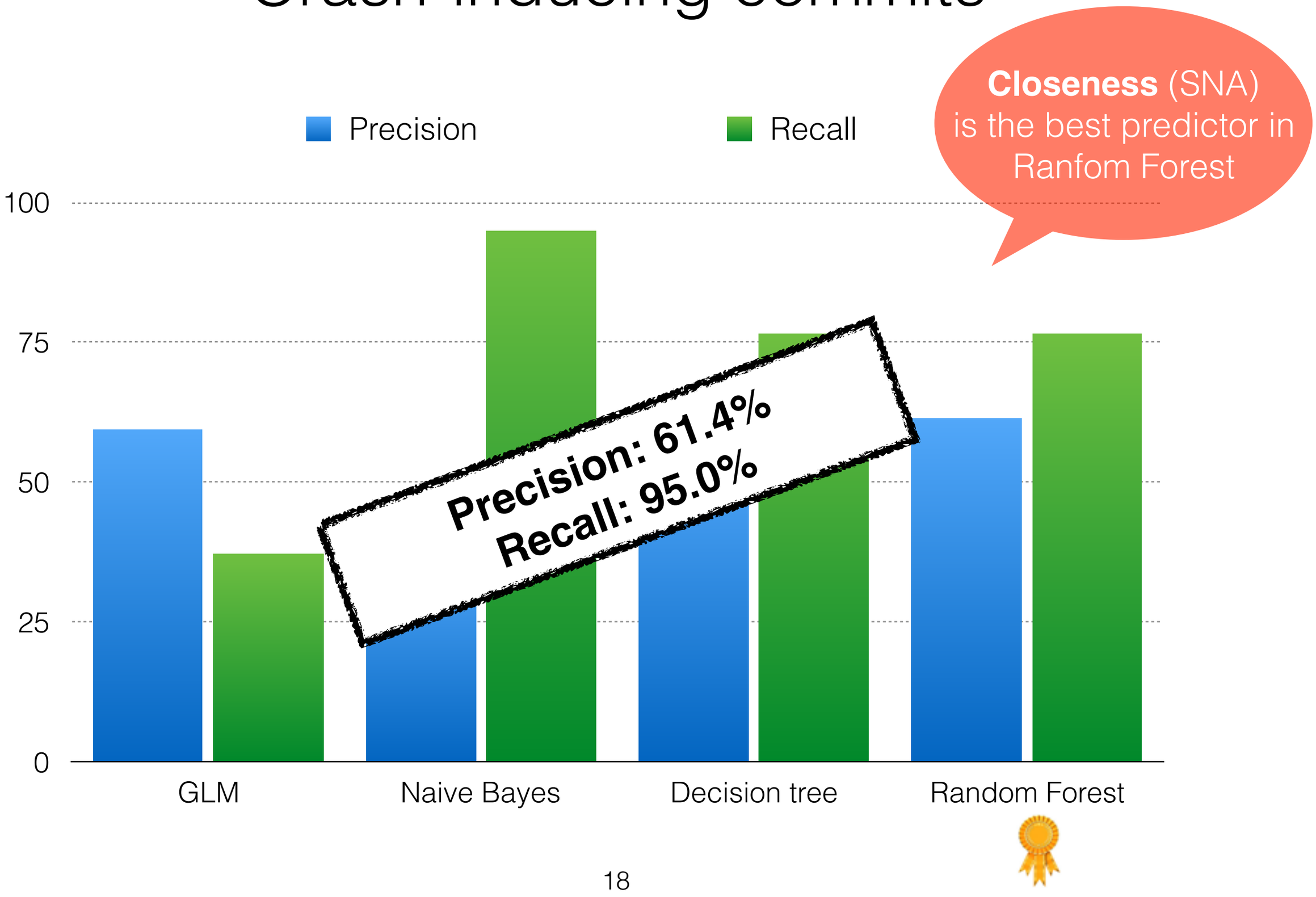
Prediction Result of Crash-inducing commits



Prediction Result of Crash-inducing commits



Prediction Result of Crash-inducing commits



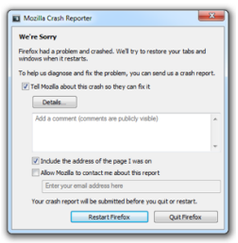
Closeness (SNA) is the best predictor in Ranfom Forest

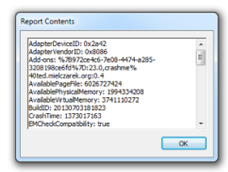
Future Work

- Generalisation of this approach to other software systems
- Study of crash-inducing code reviews
- Implementation of a crash detection tool suite

Conclusion

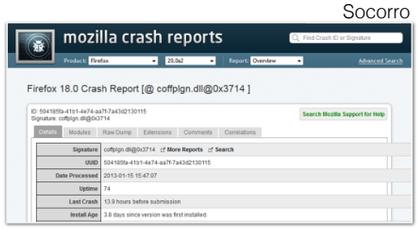
Crash Collecting System

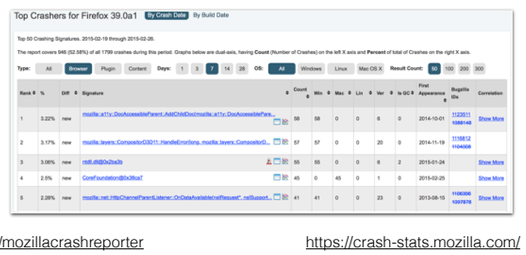




https://support.mozilla.org/en-US/kb/mozillacrashreporter

Socorro

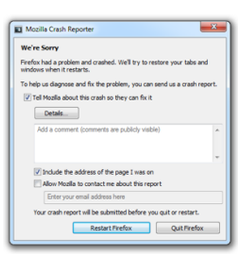


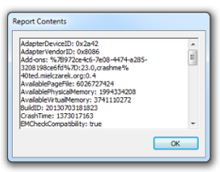


https://crash-stats.mozilla.com/

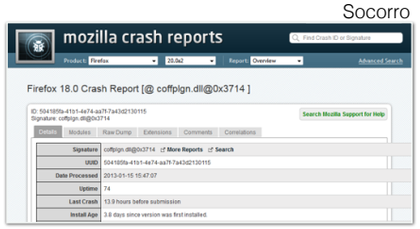
Conclusion

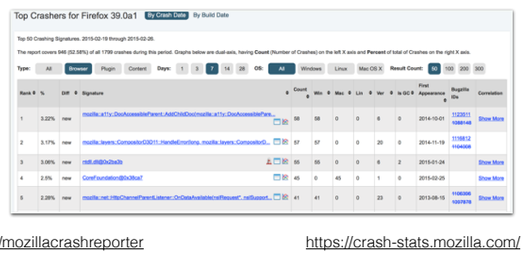
Crash Collecting System





Socorro

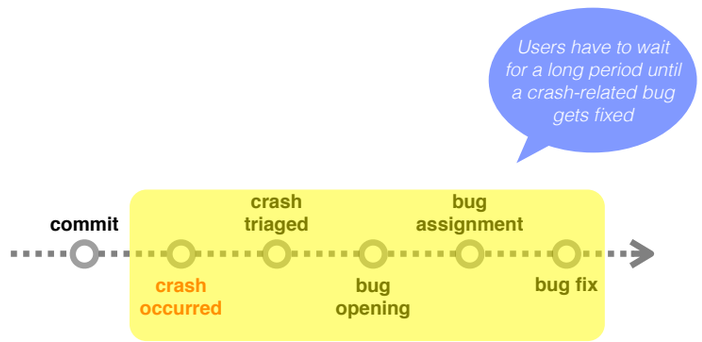




https://support.mozilla.org/en-US/kb/mozillacrashreporter

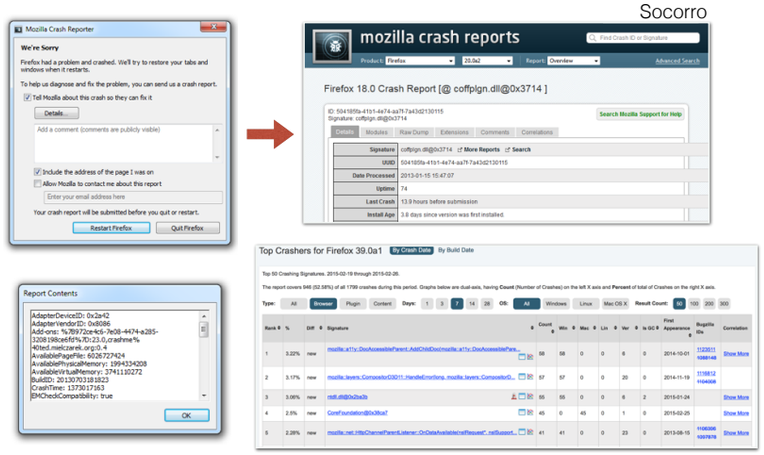
https://crash-stats.mozilla.com/

Challenge



Conclusion

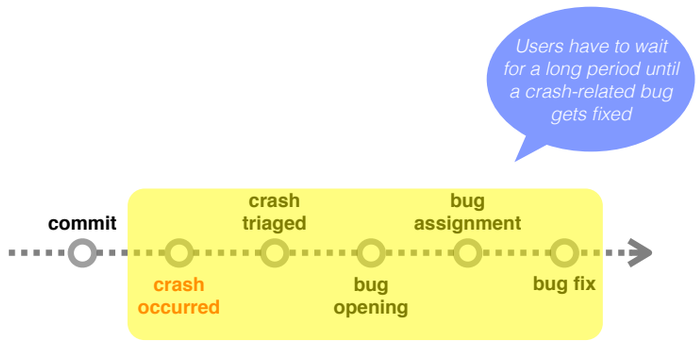
Crash Collecting System



https://support.mozilla.org/en-US/kb/mozillacrashreporter

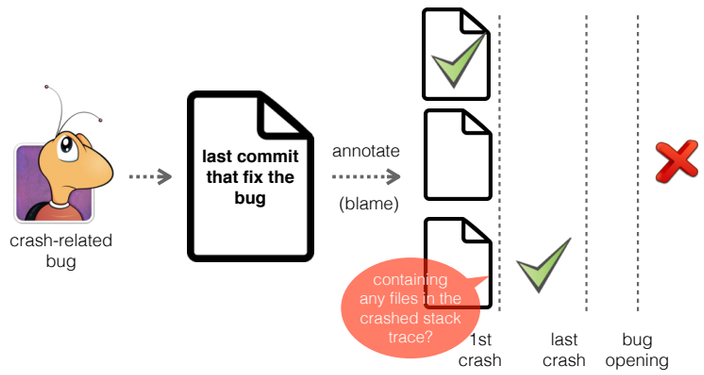
https://crash-stats.mozilla.com/

Challenge



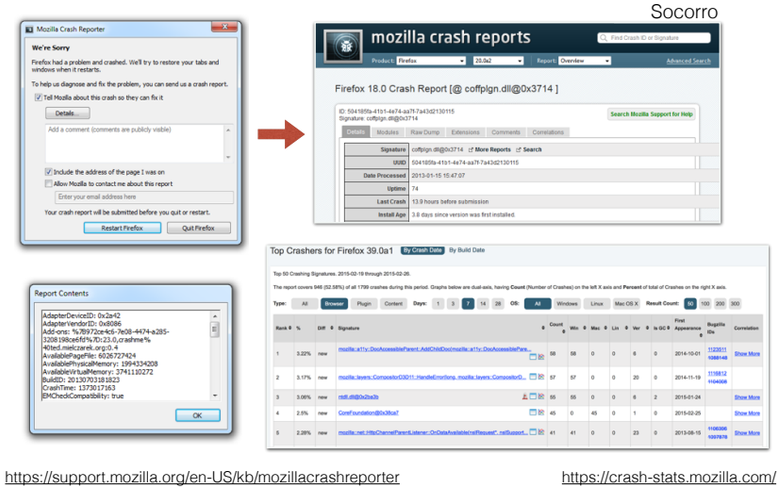
Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?** In ACM sigsoft software engineering notes (SZZ algorithm)



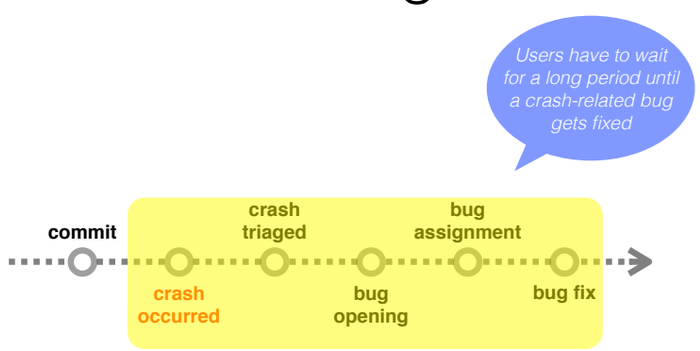
Conclusion

Crash Collecting System



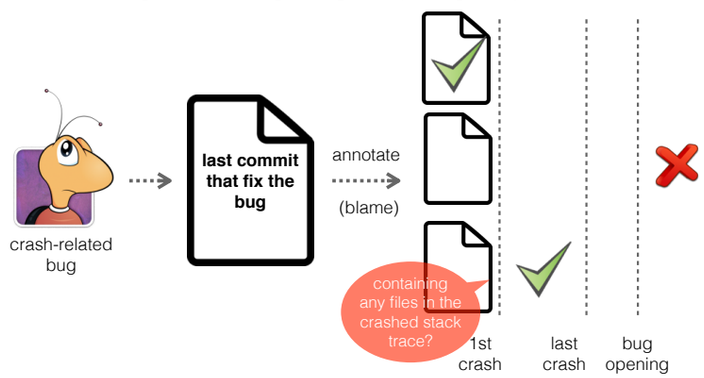
https://support.mozilla.org/en-US/kb/mozillacrashreporter https://crash-stats.mozilla.com/

Challenge

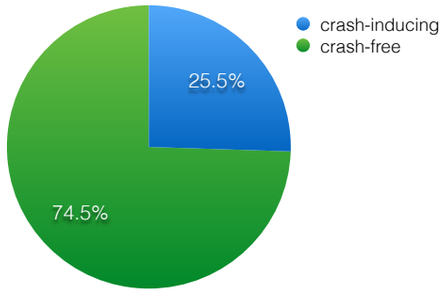


Identifying Crash-inducing Commits

J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?** In ACM sigsoft software engineering notes (SZZ algorithm)



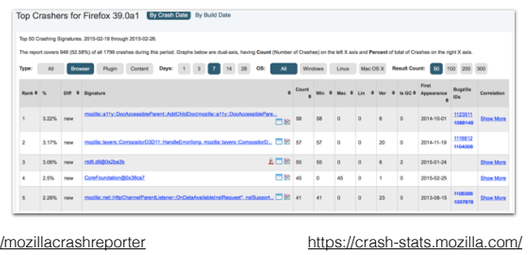
One Out of Four Commits in Firefox will Induce Future Crashes



Conclusion

Crash Collecting System

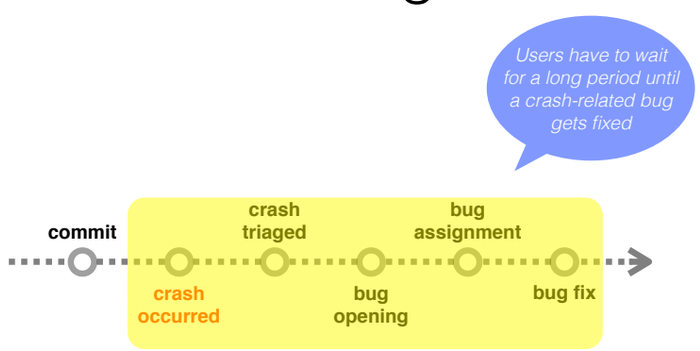
Socorro



https://support.mozilla.org/en-US/kb/mozillacrashreporter

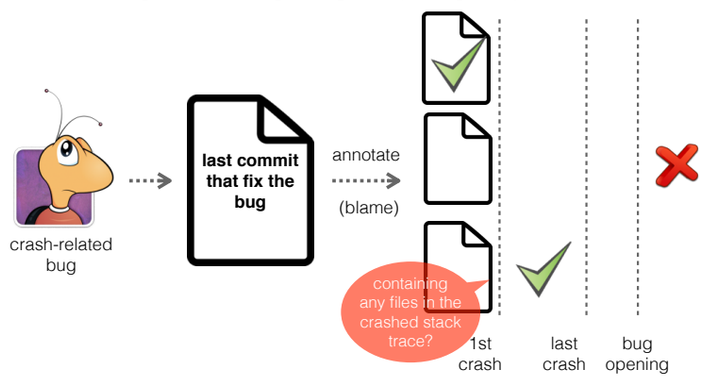
https://crash-stats.mozilla.com/

Challenge

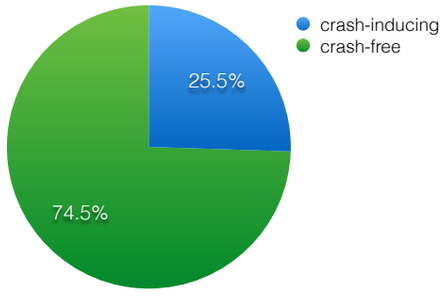


Identifying Crash-inducing Commits

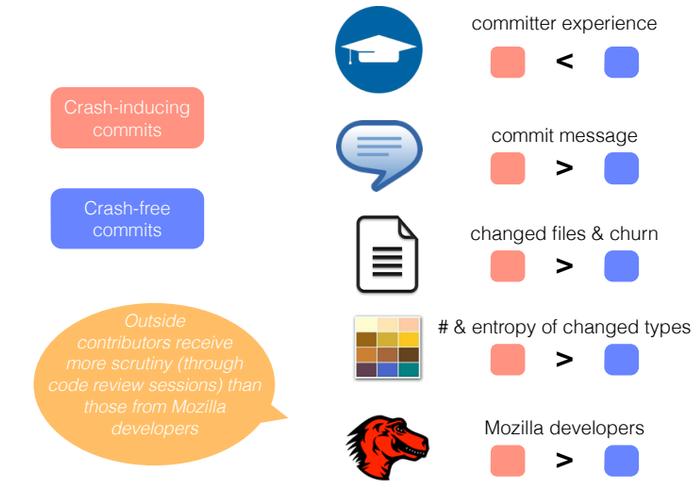
J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?** In ACM sigsoft software engineering notes (SZZ algorithm)



One Out of Four Commits in Firefox will Induce Future Crashes



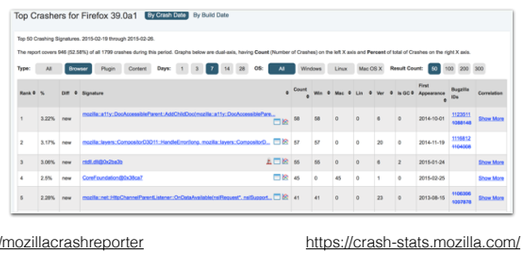
Significant Differences between Crash-inducing and Crash-free Commits



Conclusion

Crash Collecting System

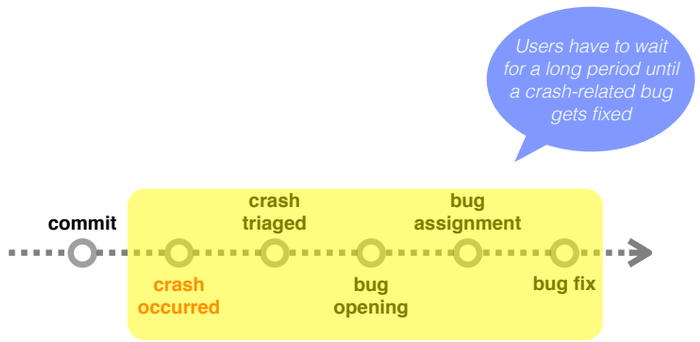
Socorro



https://support.mozilla.org/en-US/kb/mozillacrashreporter

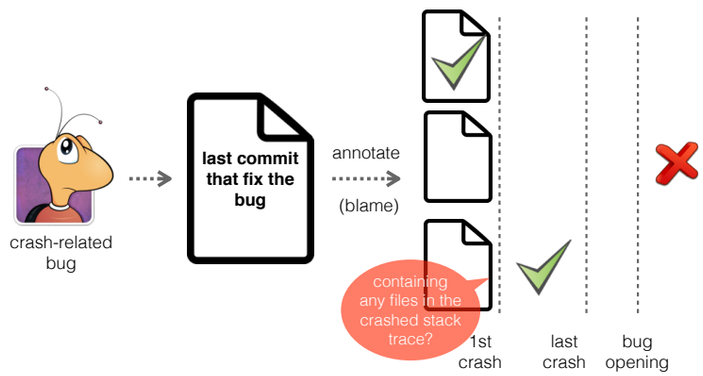
https://crash-stats.mozilla.com/

Challenge

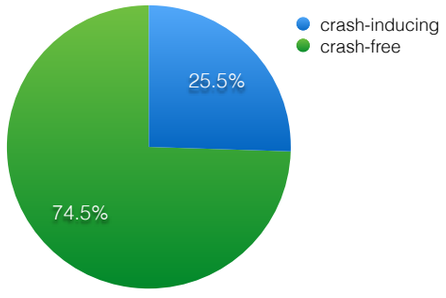


Identifying Crash-inducing Commits

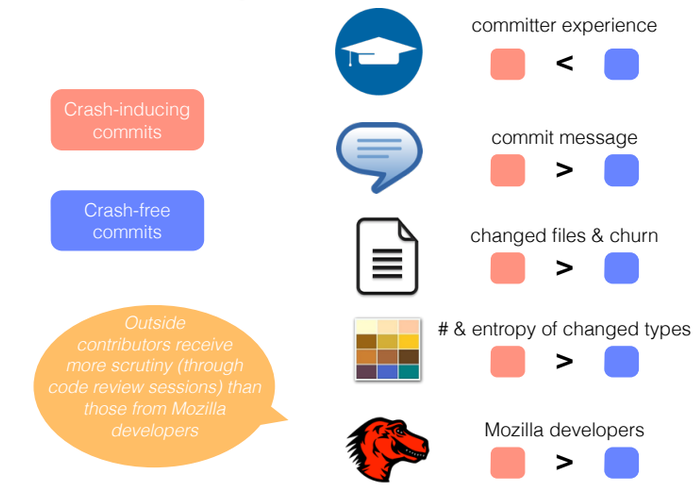
J. **S**liwerski, T. **Z**immermann, and A. **Z**eller. **When do changes induce fixes?** In ACM sigsoft software engineering notes (SZZ algorithm)



One Out of Four Commits in Firefox will Induce Future Crashes



Significant Differences between Crash-inducing and Crash-free Commits



Just-in-time Quality Assurance