The Impact of Bug Management Patterns on Bug Fixing: A Case Study of Eclipse Projects

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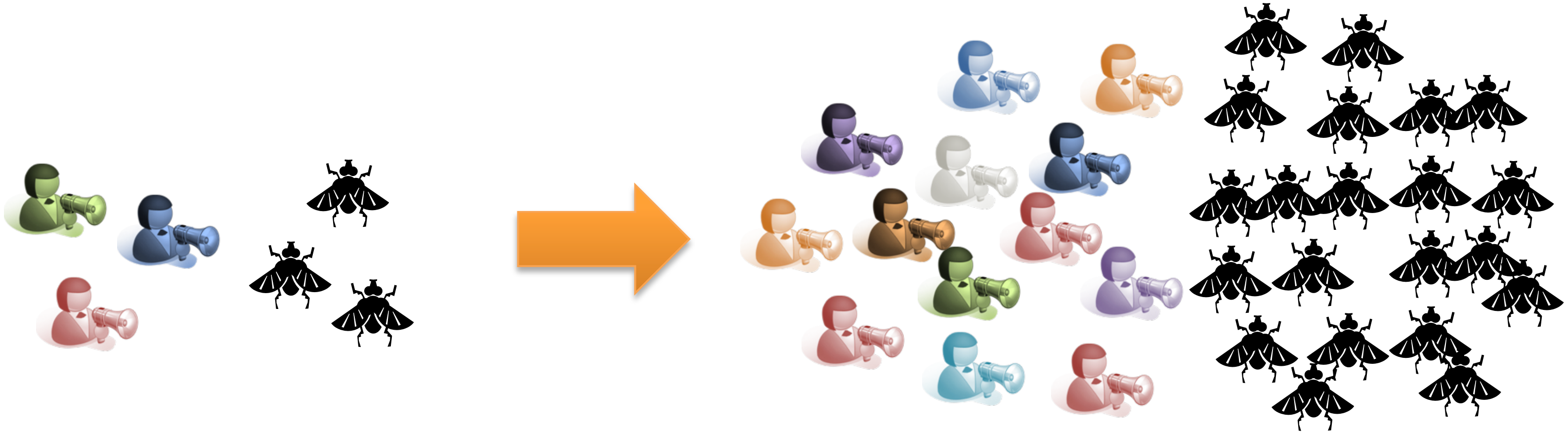
Background

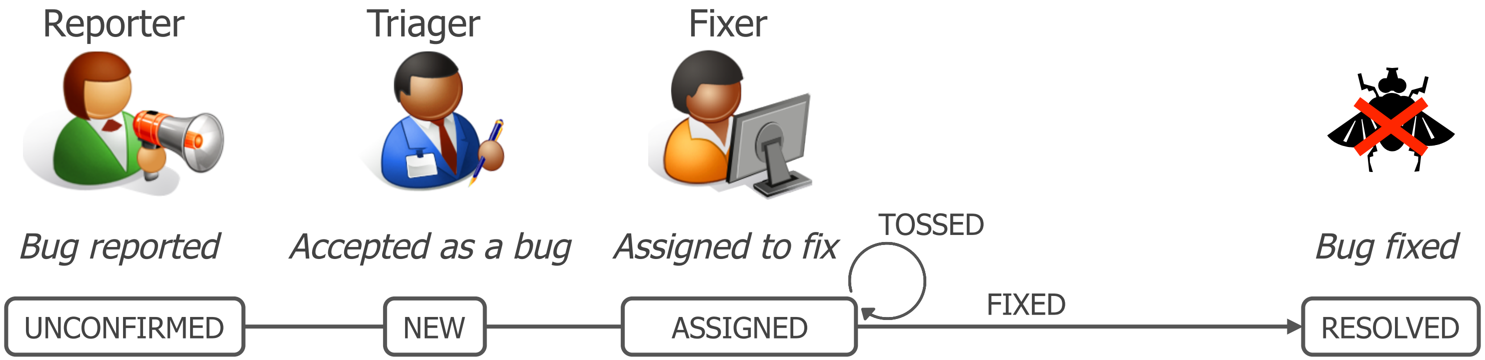
- An efficient bug management process (reports, assignment and fixing) is critical for the success of software projects.

- As the user base grows, some large open source projects receive a large number of bug reports.



Complex challenges
to the bug management process

- Bug management process



  - Understand a large amount of new bug reports
  - Figure out If they are real bugs and whether they were reported in the past (i.e., duplicate bugs)
  - Assign them to appropriate persons to fix the bugs quickly
    - 44% of bugs in the Eclipse project are reassigned to more than one developer [Jeong et al. 2009]

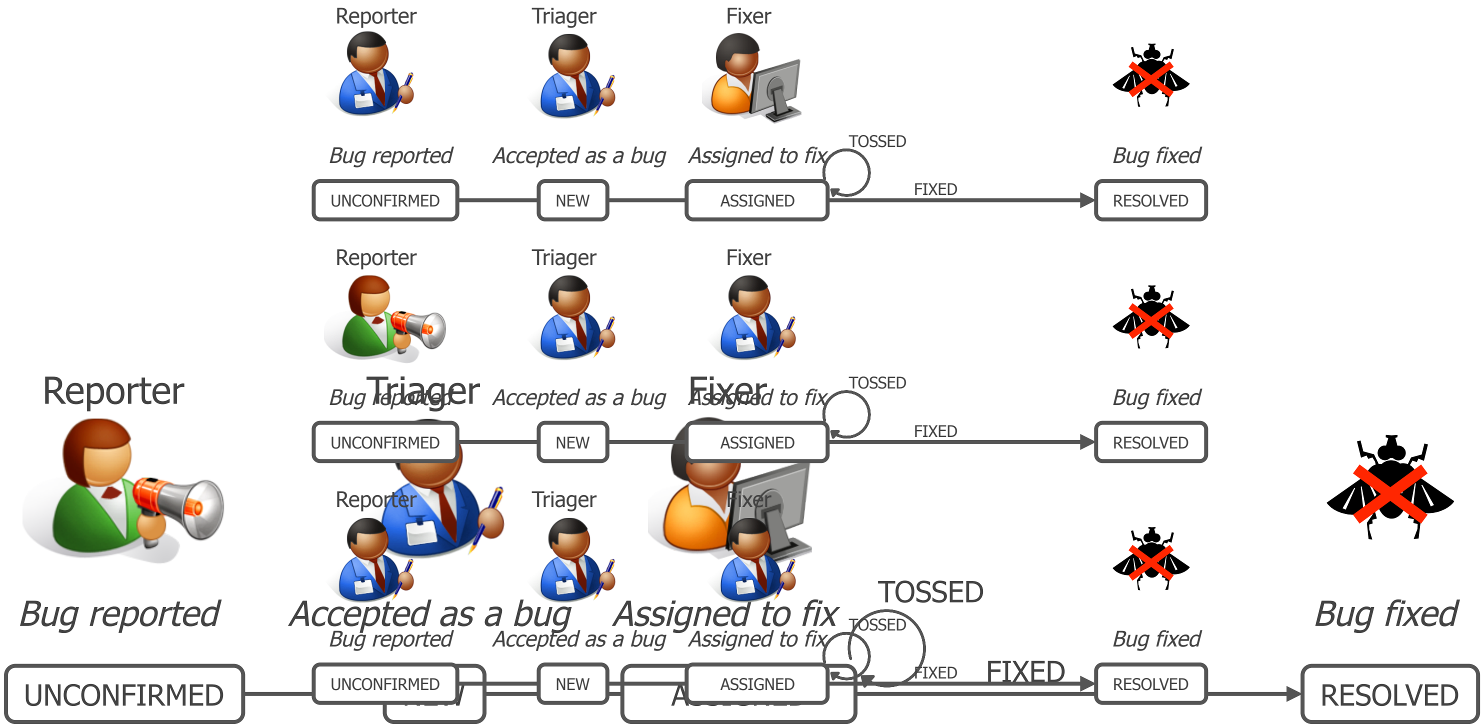
Related work

- Quality of bug reports
  - A good report helps developers to quickly find, replicate, and understand the bugs.
    [N. Bettenburg et al. 2008] [S. Breu et al. 2010] [T. Zimmermann et al 2010]
- Detection of duplicate bug reports
  - Users often report the same problems which were reported and fixed in the past.
    [X. Wang et al. 2008] [N. Bettenburg et al. 2008] [C. Sun et al. 2010]
- Re-opening and reassigning of bug reports
  - A bug sometimes is be reopen and reassigned when it was assigned to an inappropriate developer.
    [Anvik et al. 2007] [G.Jeong et al. 2009] [E. Shihab et al. 2010] [P. J. Guo et al. 2011]

Our focus:

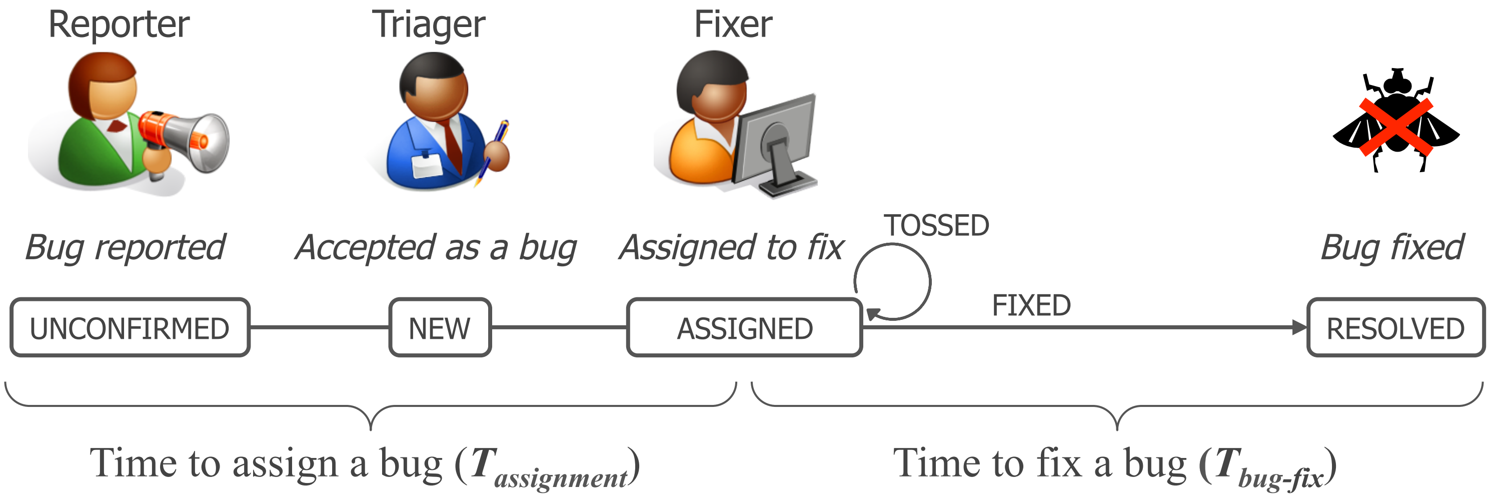
Relations between the individuals

- Relations between individuals involved in the bug management process
  - *Who reports? → Who triages it? → Who fixes it?*



Our goal

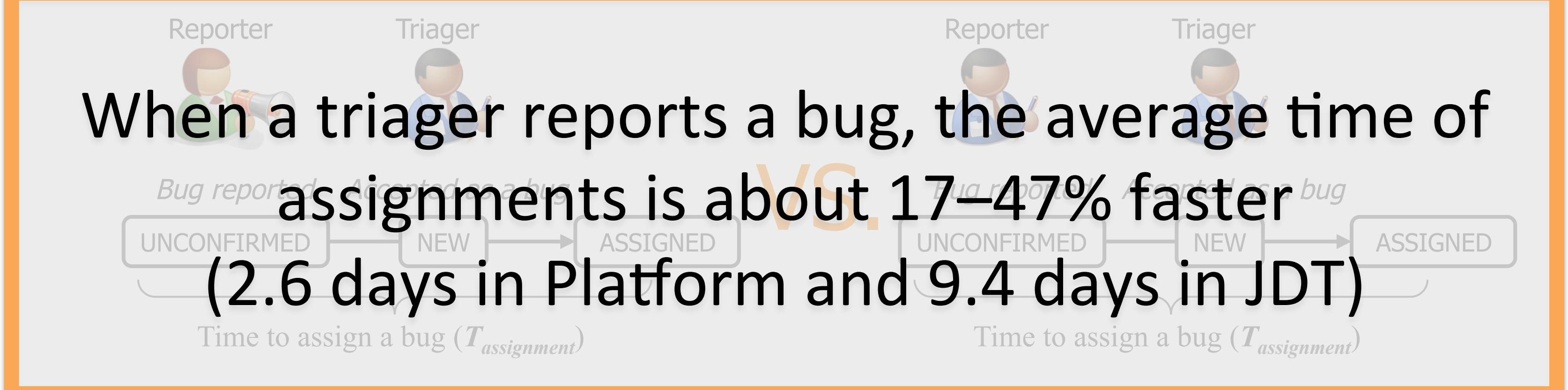
- To better understand the impact of the relations between the individuals on the efficiency of the bug management process
  - Impact of the **time to assign** bug fixing tasks
  - Impact on the **time to fix** bugs



Pilot study (1)

Eclipse Platform and JDT

- RQ1: *Does the time to assign a bug fixing task depend on the fact that the same developer reports a bug and triages it?*



When a triager reports a bug, the average time of assignments is about 17–47% faster (2.6 days in Platform and 9.4 days in JDT)

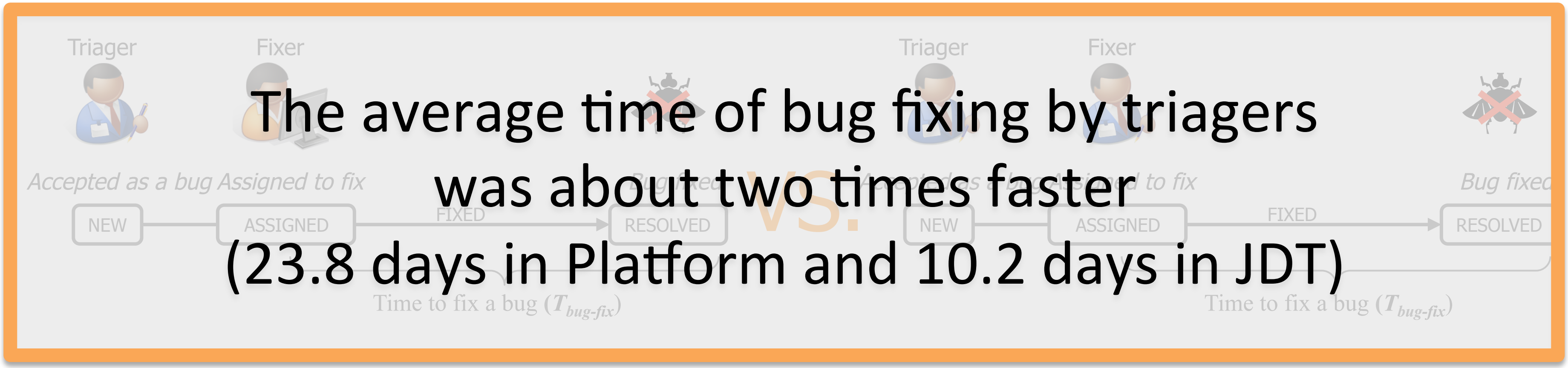
- Result

project	Reporter = Triager ?	# of reports	ratio	average days	median days	SD	max days	min days	P-value
Platform	yes	1,000	24.2%	12.6	0.0	66.8	812.1	0.0	$< 0.01 **$
	no	3,133	75.8%	15.2	0.5	68.9	842.9	0.0	
JDT	yes	452	27,3%	10.6	0.0	57.8	713.7	0.0	$< 0.01 **$
	no	1,205	72.7%	20.0	0.5	79.6	927.0	0.0	

Pilot study (2)

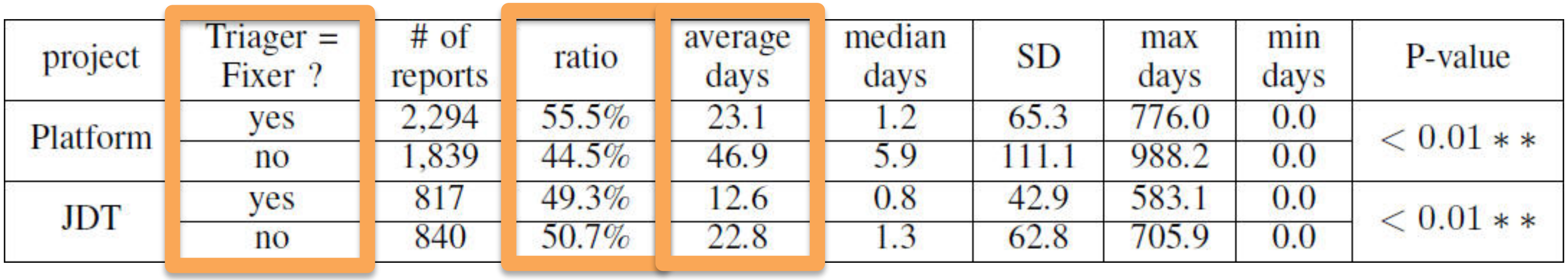
Eclipse Platform and JDT

- RQ2: *Does the time to fix a bug depend on the fact that the same developer triages a bug and fixes it?*



The average time of bug fixing by triagers was about two times faster (23.8 days in Platform and 10.2 days in JDT)

- Result

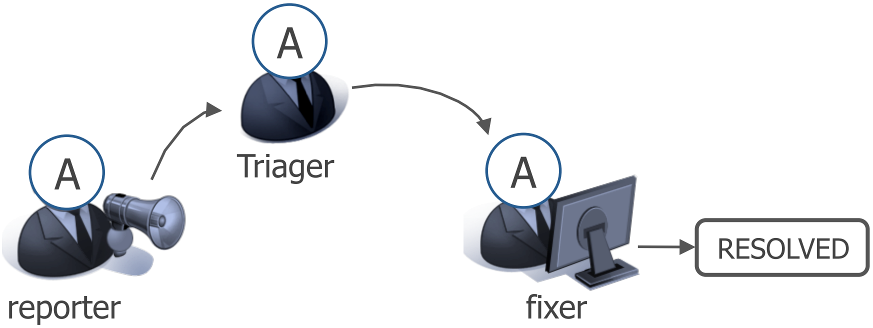


project	Triager = Fixer ?	# of reports	ratio	average days	median days	SD	max days	min days	P-value
Platform	yes	2,294	55.5%	23.1	1.2	65.3	776.0	0.0	$< 0.01 **$
	no	1,839	44.5%	46.9	5.9	111.1	988.2	0.0	
JDT	yes	817	49.3%	12.6	0.8	42.9	583.1	0.0	$< 0.01 **$
	no	840	50.7%	22.8	1.3	62.8	705.9	0.0	

Bug Management Patterns

Reporter=Triager=Fixer (R=T=F)

One contributor plays all of the roles.



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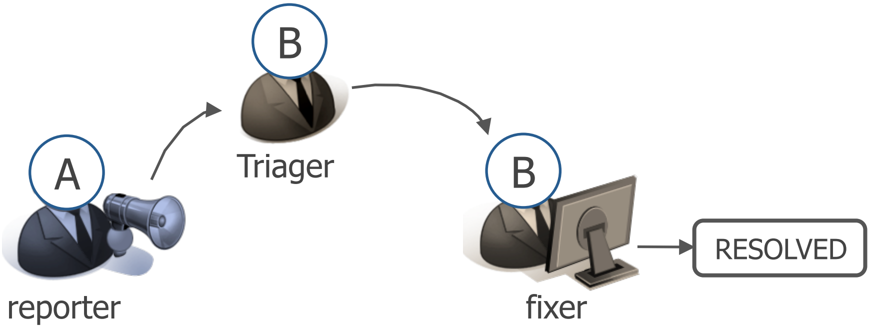

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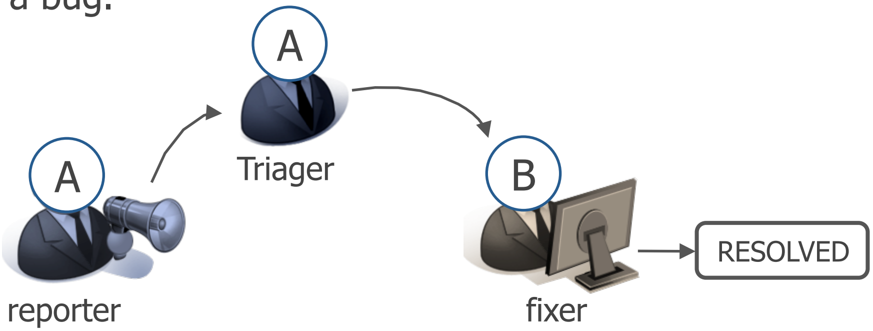

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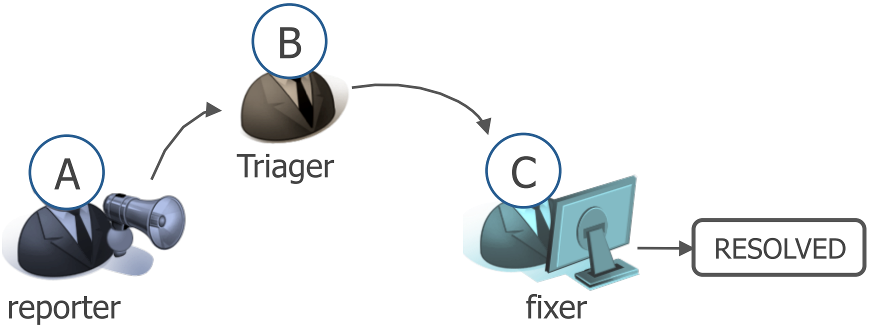

Pattern #1

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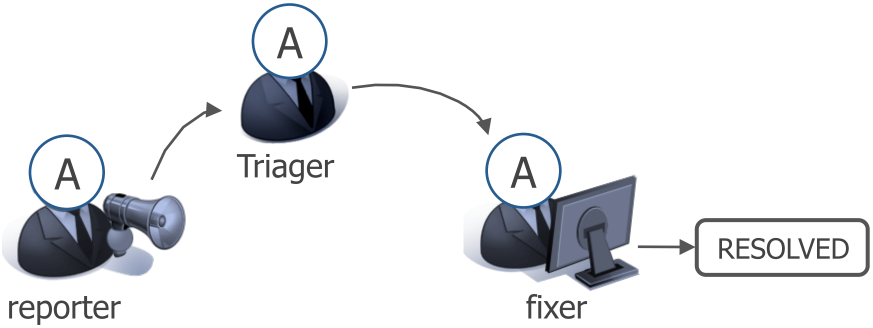

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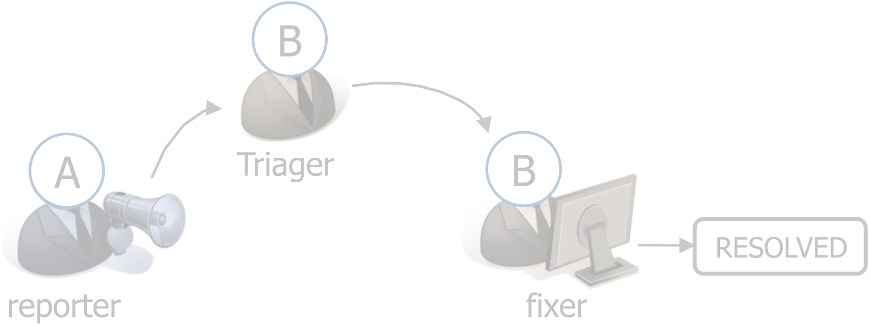

Reporter=Triager≠Fixer (R=T≠F)

Reporter≠Triager≠Fixer (R≠T≠F)

- Pattern #1 is assumed to make bug fixing faster.
  - He likely knows the bug source.
  - He likely has good confidence in his ability.

Pattern #2

Reporter=Triager=Fixer (R=T=F)

Reporter≠Triager=Fixer (R≠T=F)

- From our pilot study (RQ1), Pattern #2 can be assumed to make the bug assignment faster, but bug fix may be slower.

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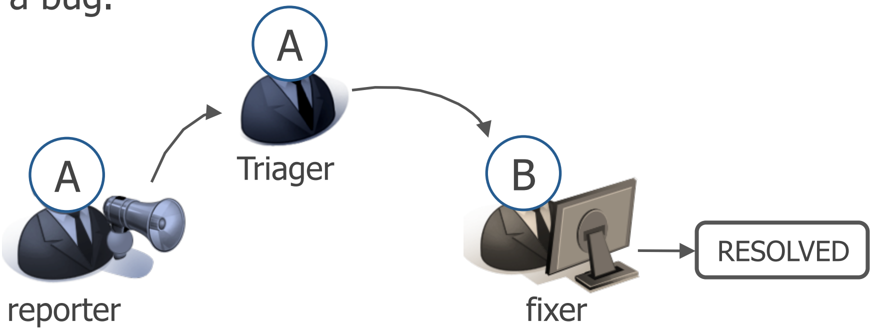

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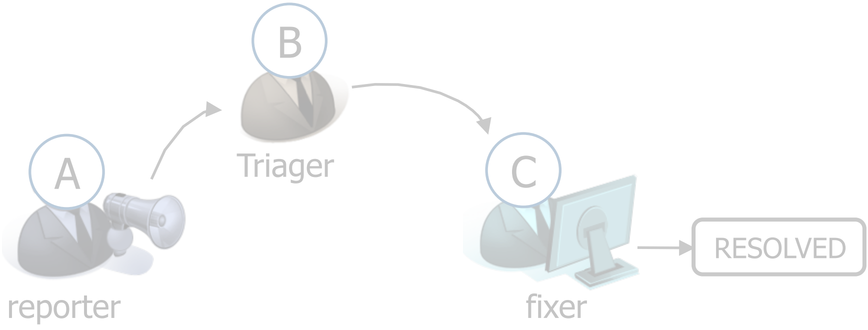

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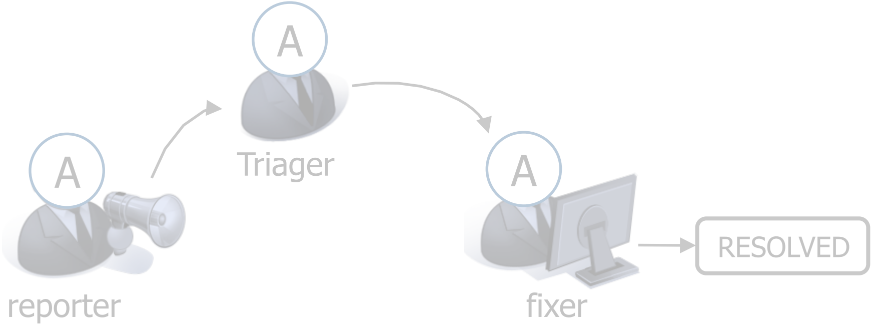

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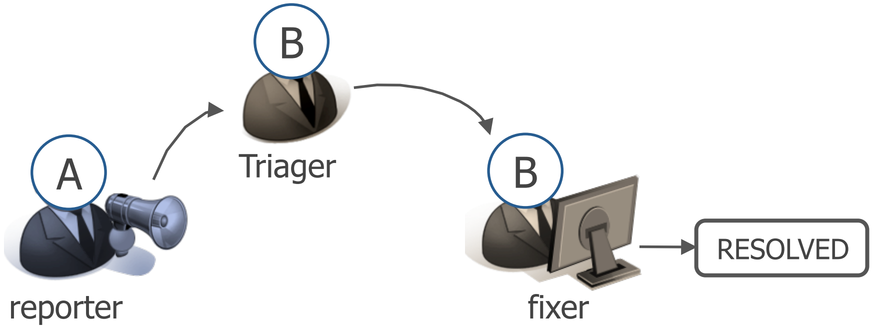

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- Pattern #3 would make bug fixing itself faster if (B) has a good understanding of the bug reported by (A).
- otherwise it would make bug fixing difficult, because (B) has to spend the time to investigate the bug.

Pattern #4

- This pattern is assumed to make both the bug assignment and bug fixing most difficult
- The mismatches of knowledge and skills between them would be larger than the other patterns.

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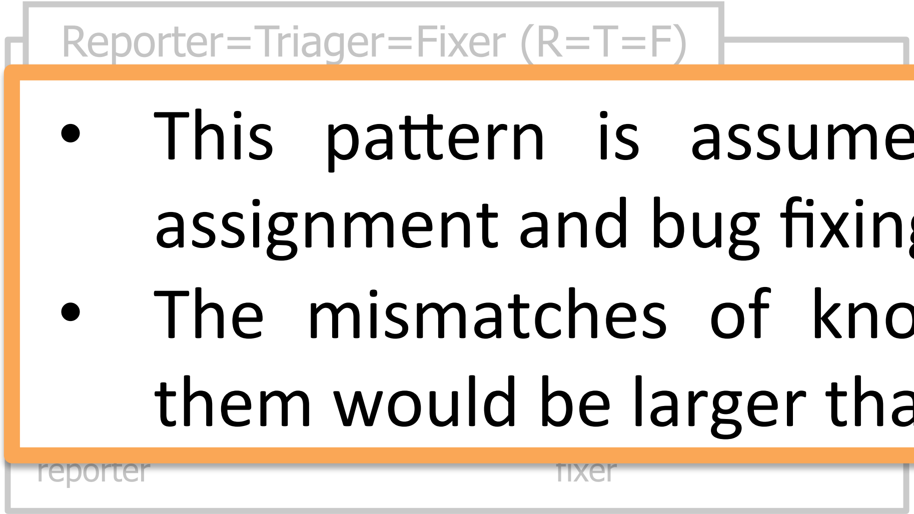

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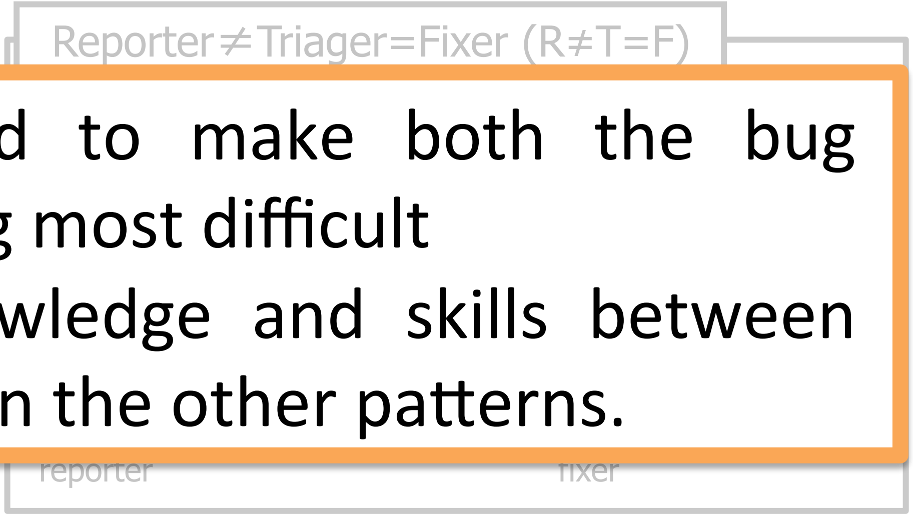

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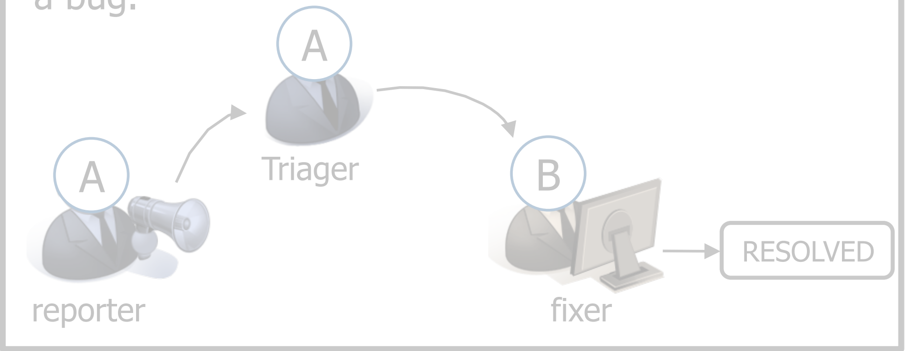

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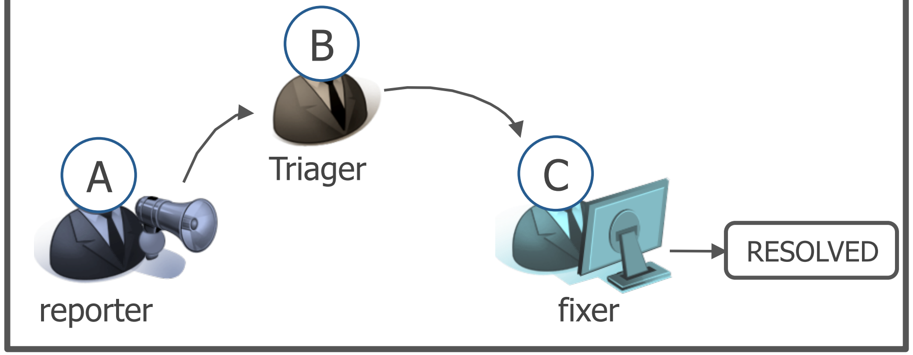
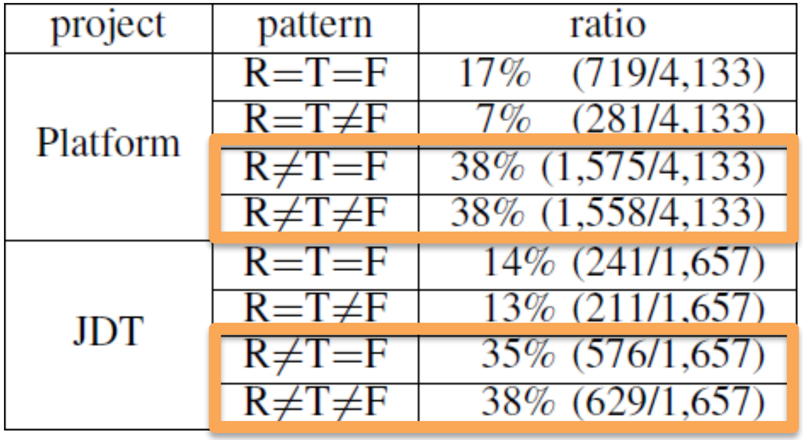


Case study on bug management patterns

Eclipse Platform and JDT

- Data sets (also used in the pilot study)
  - fixed bug reports from 2007 to 2009 (*)
    - Eclipse Platform: 4,133 reports
      - 811 reporters, 54 triagers and 85 fixers
    - Eclipse JDT: 1,657 reports
      - 369 reporters, 23 triagers and 33 fixers
    - The ratio of #3 and #4 are almost same and large (i.e., important patterns for the bug management process)

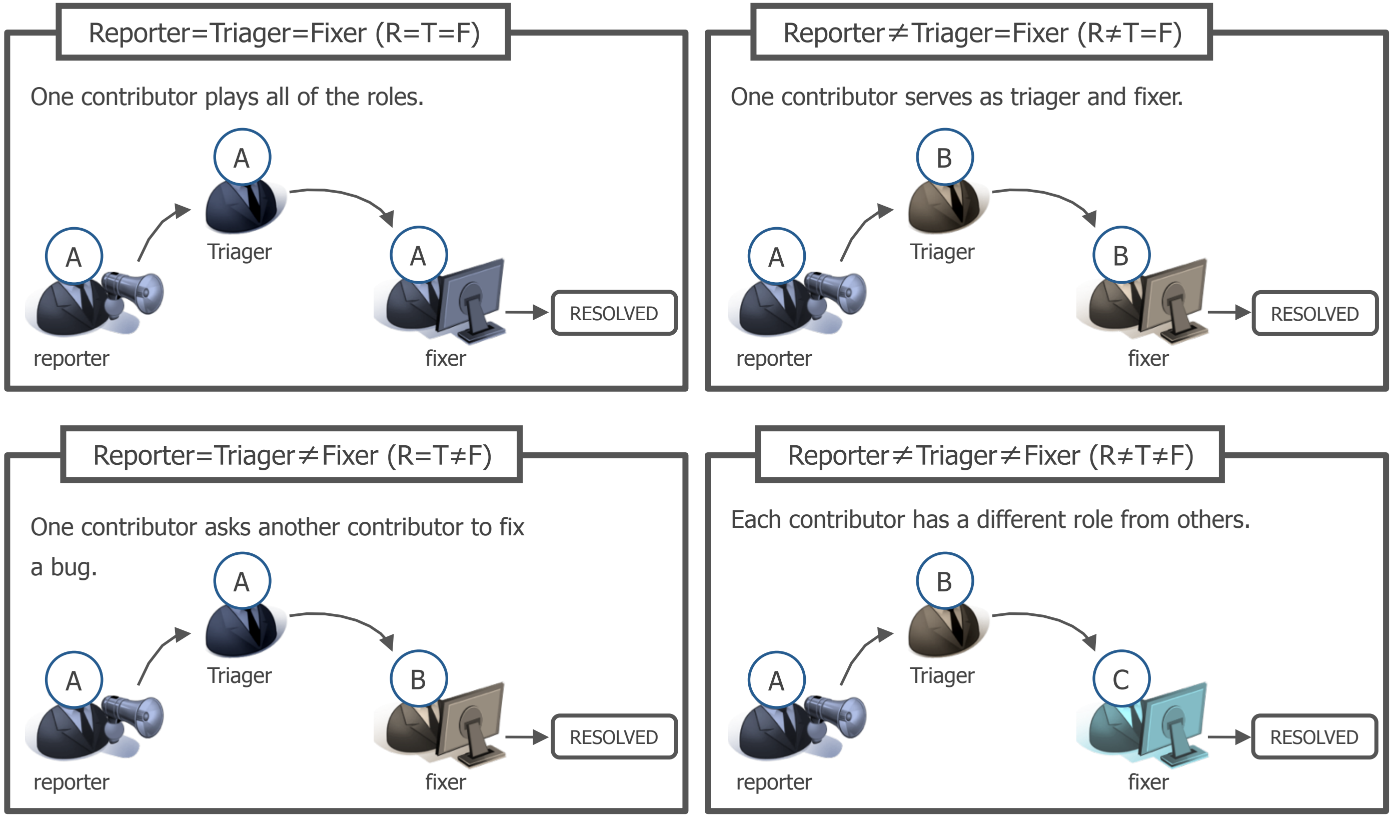


project	pattern	ratio
Platform	R=T=F	17% (719/4,133)
	R=T≠F	7% (281/4,133)
	R≠T=F	38% (1,575/4,133)
	R≠T≠F	38% (1,558/4,133)
JDT	R=T=F	14% (241/1,657)
	R=T≠F	13% (211/1,657)
	R≠T=F	35% (576/1,657)
	R≠T≠F	38% (629/1,657)

Case study (1)

Bug management patterns in Eclipse Platform and JDT

- RQ3: *How do the bug management patterns impact the time to complete bug assignments?*



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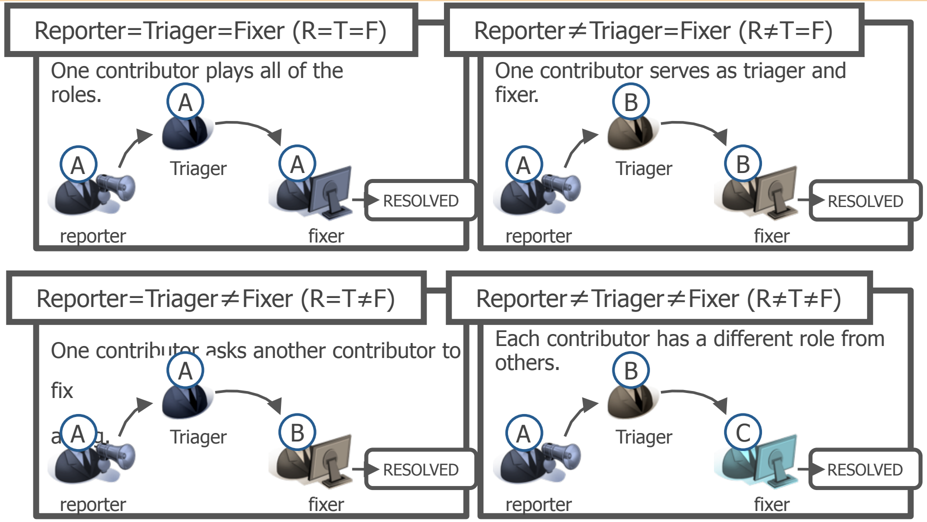

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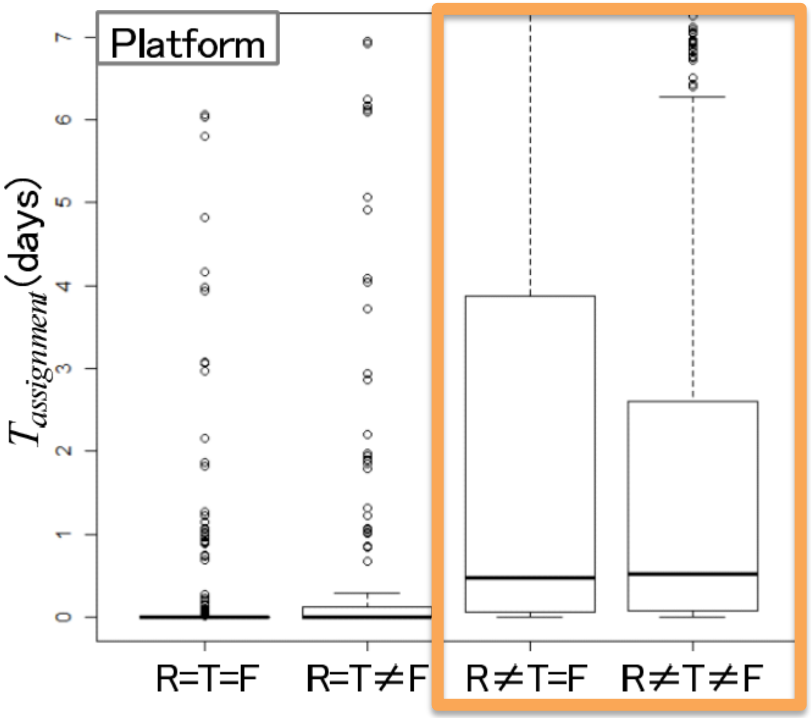
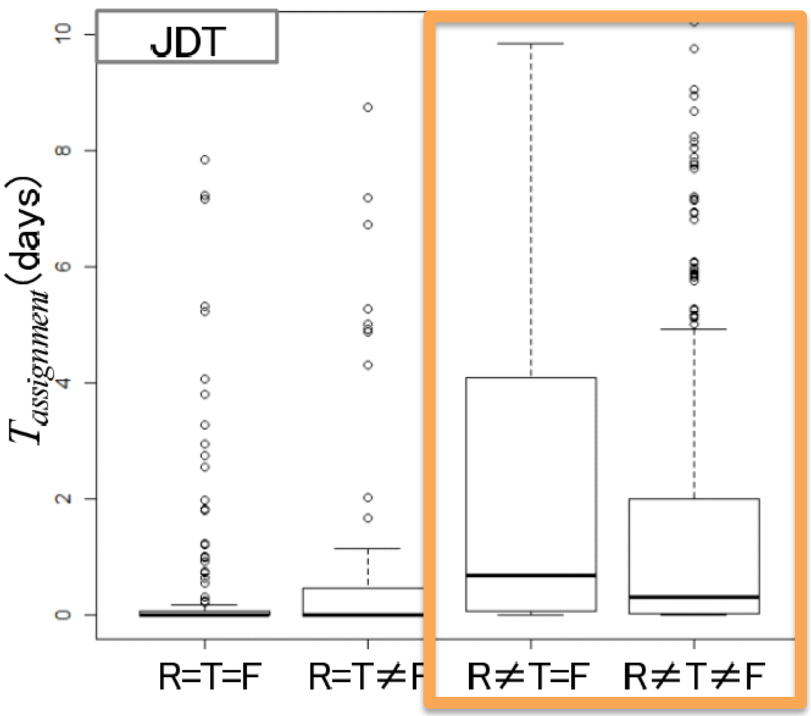
- Result





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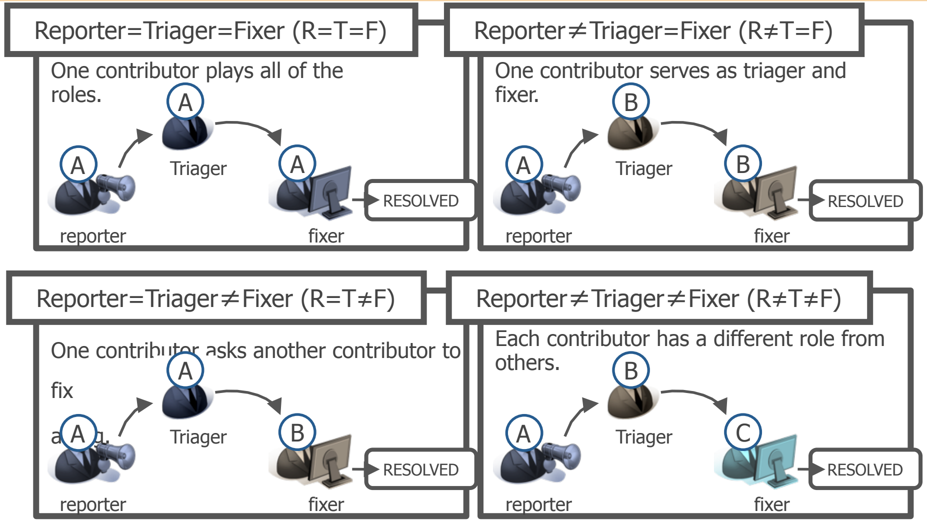

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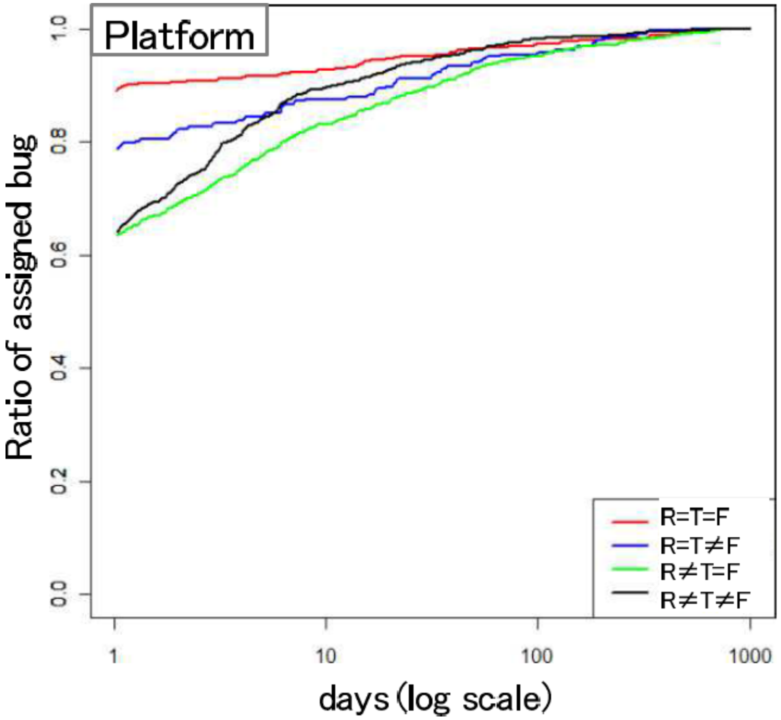
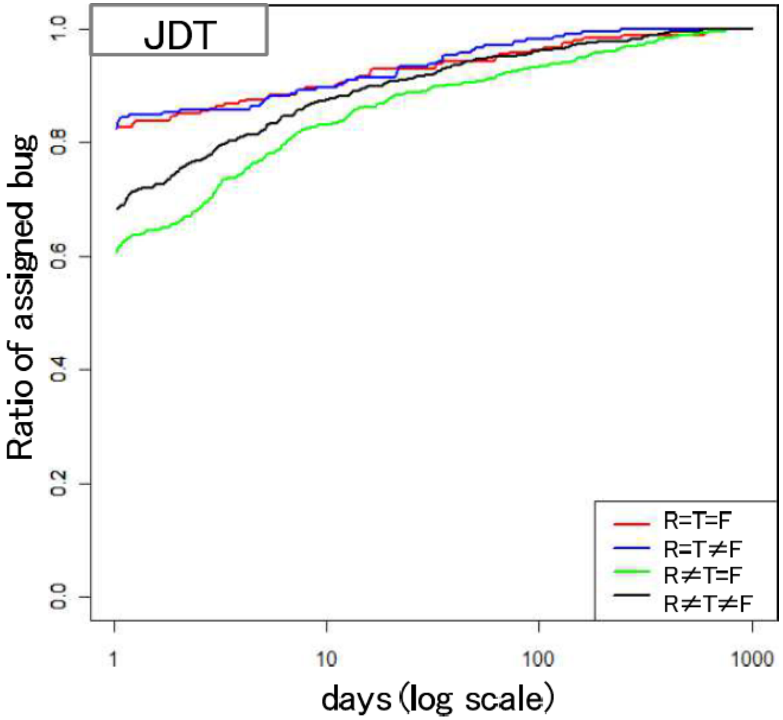
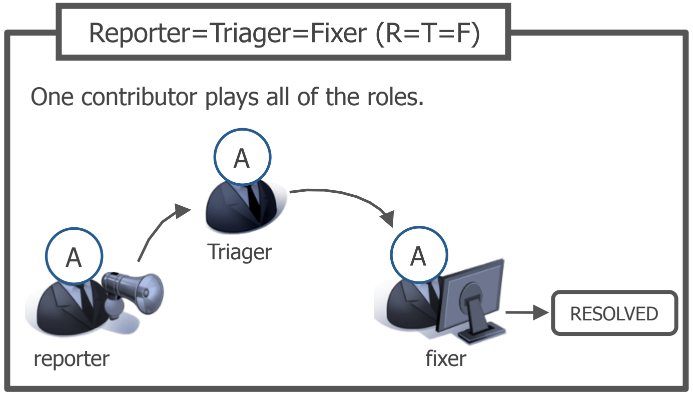




Case study (2)

Bug management patterns in Eclipse Platform and JDT

- RQ4: *How do the bug management patterns impact the time to fix bugs?*



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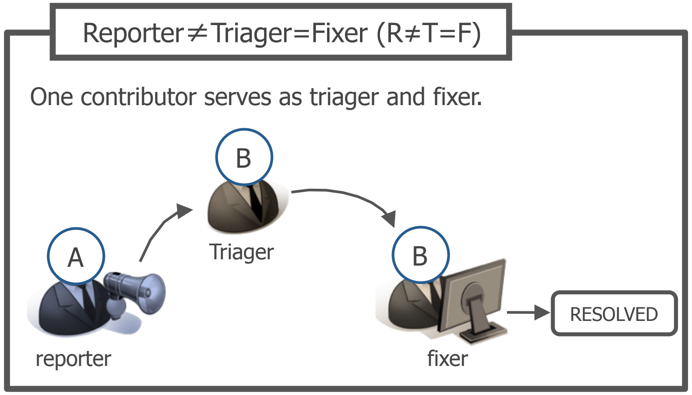

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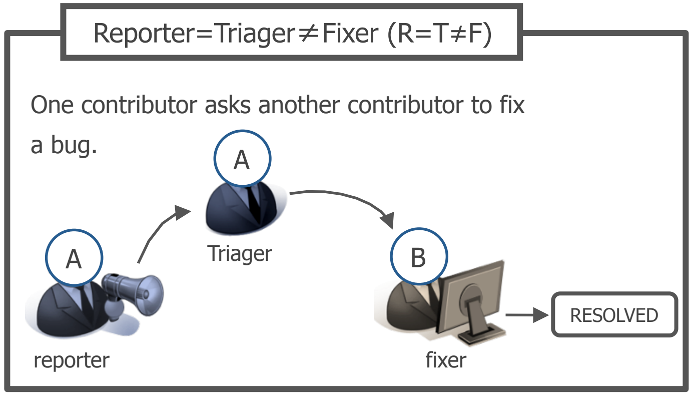

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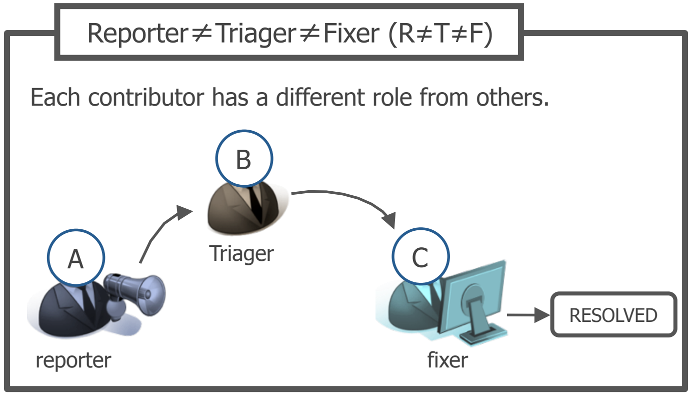

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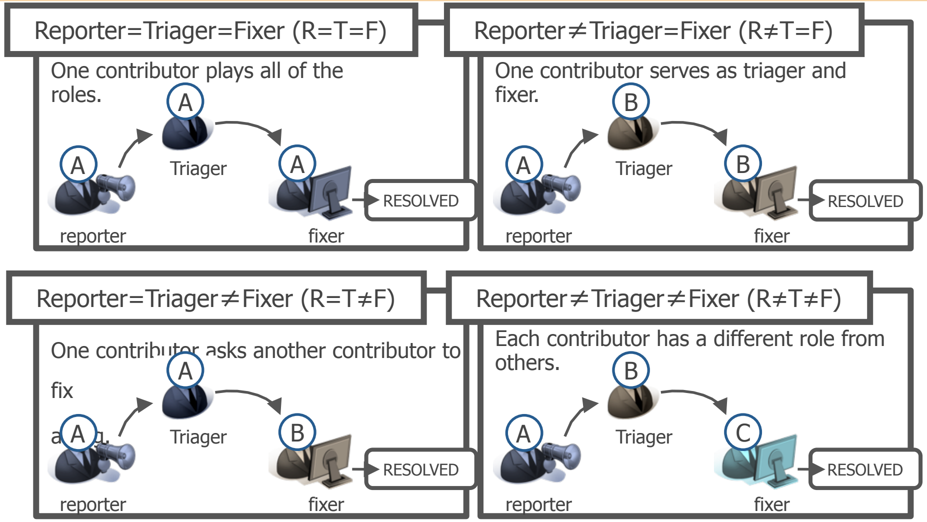

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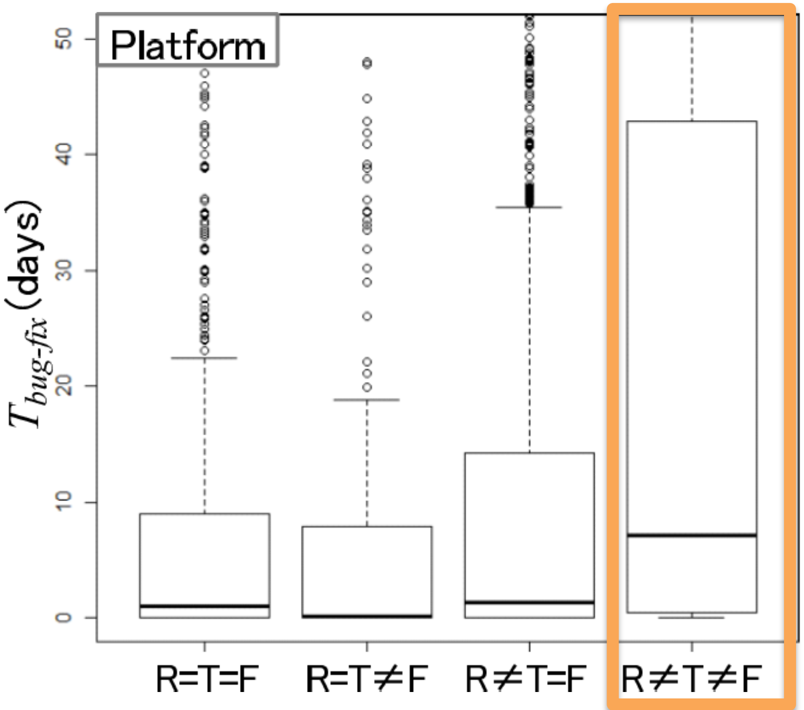

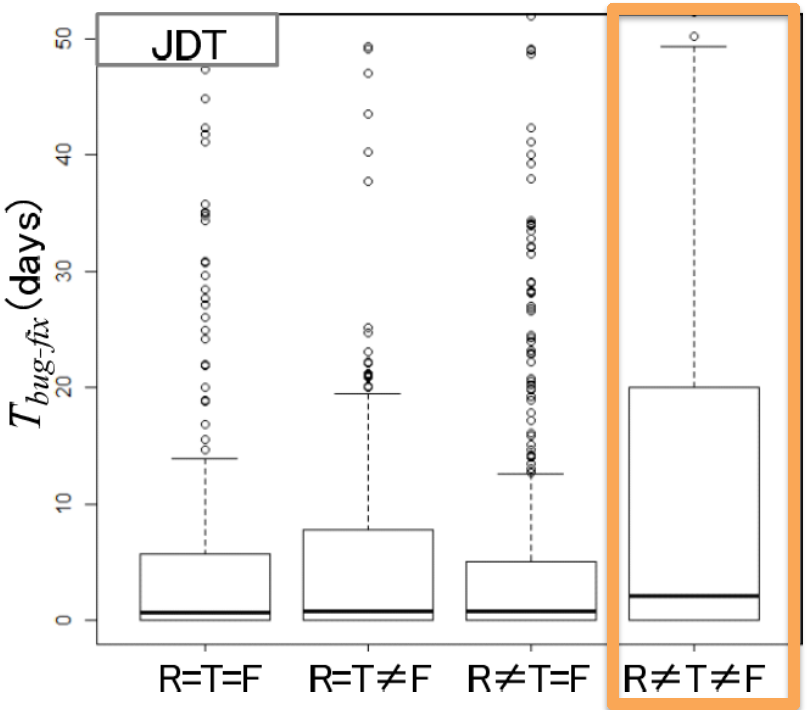

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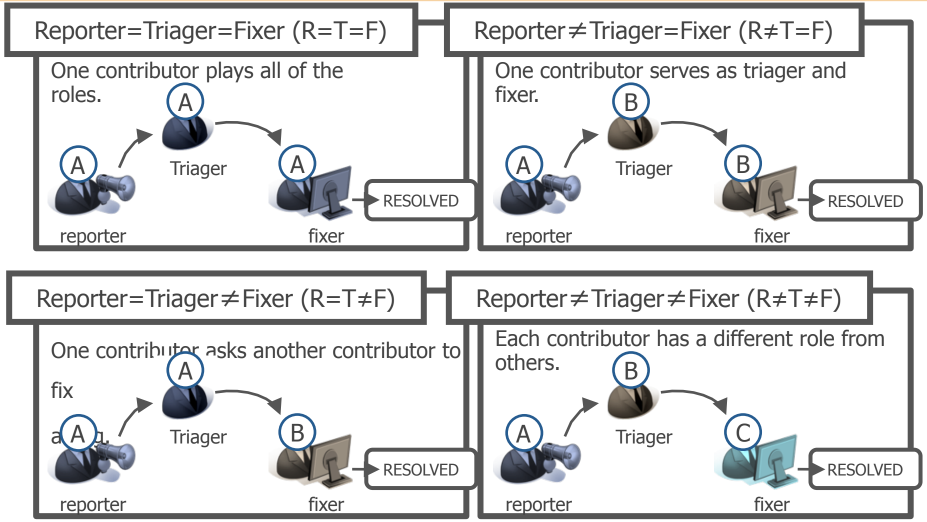

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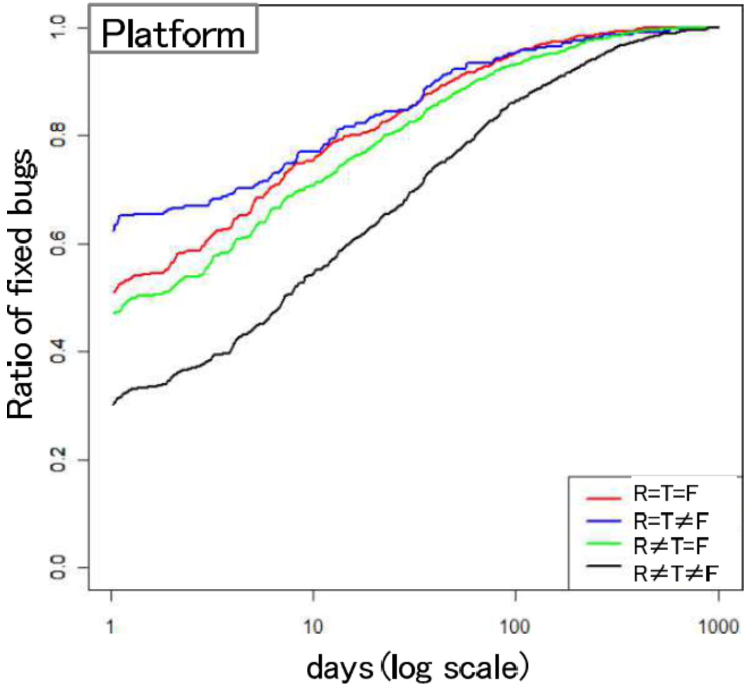
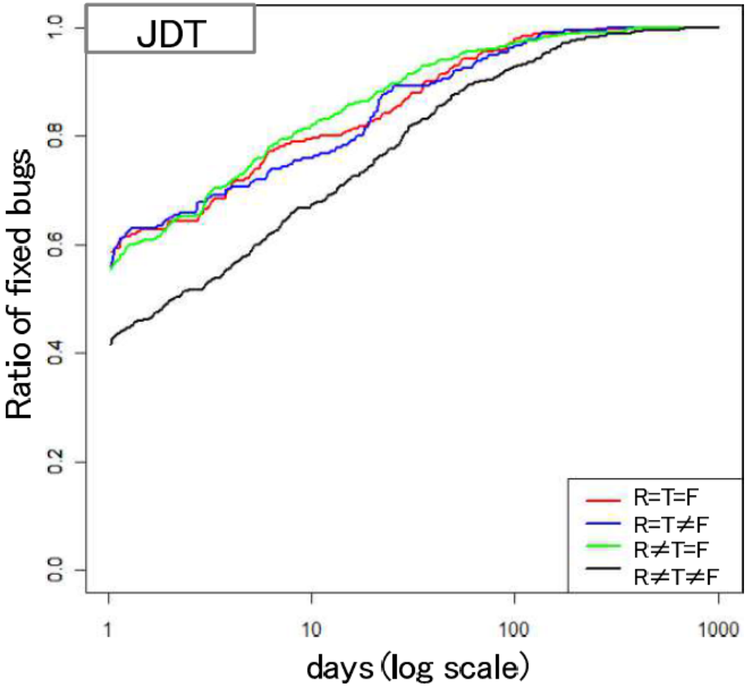




Discussions (1)

Summary of our findings

RQ1

When **a triager makes a bug report** as a reporter, the time to assign a bug fixing task is **17–47% faster** than a regular reporter.

Task Assignment

RQ3

Surprisingly when **the triager assigns a task to himself**, he needs **48%–58% longer time** for the assignment than when he assigns it to other developers.

RQ2

When **a triager assigns a bug fixing task to himself**, he can fix the bug around **two times faster** than other developers.

Bug Fix

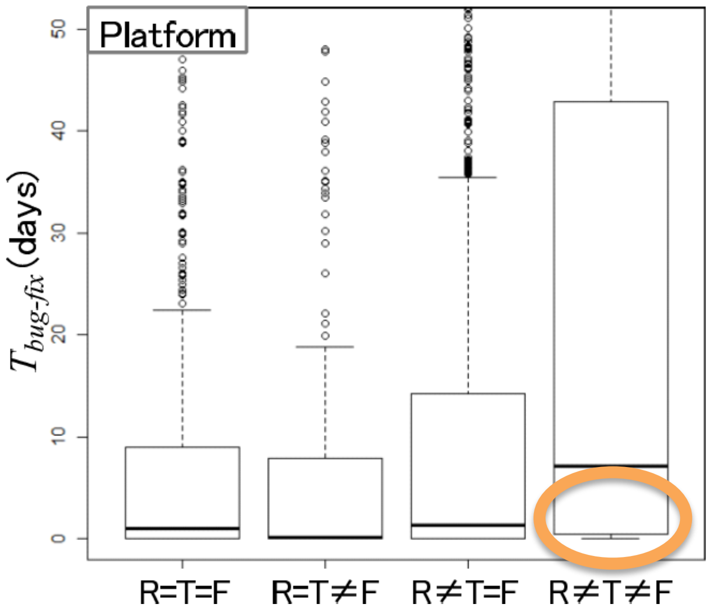
RQ4

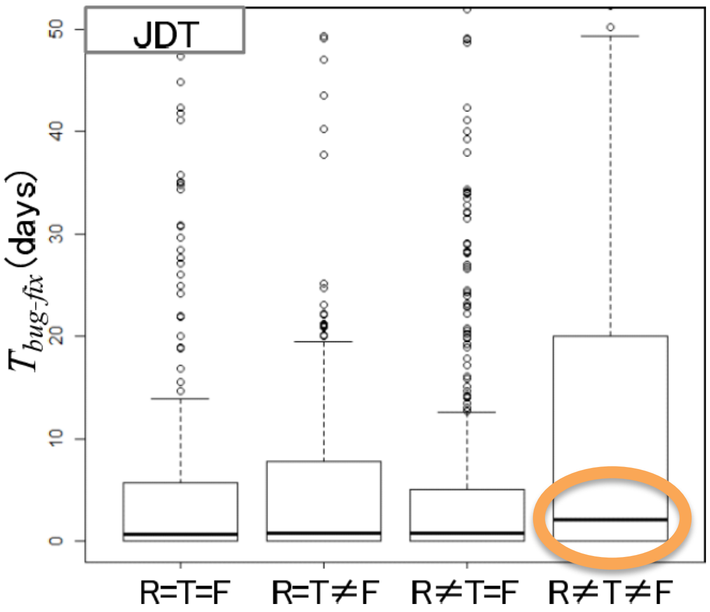
The pattern [R≠T≠F] exhibits the worst performance in bug fixing.

Discussions (2)

The impact of discussions among developers

- The boxplot of [R≠T≠F] had the widest distribution.
  - This implies that in some cases the pattern works better than other patterns.

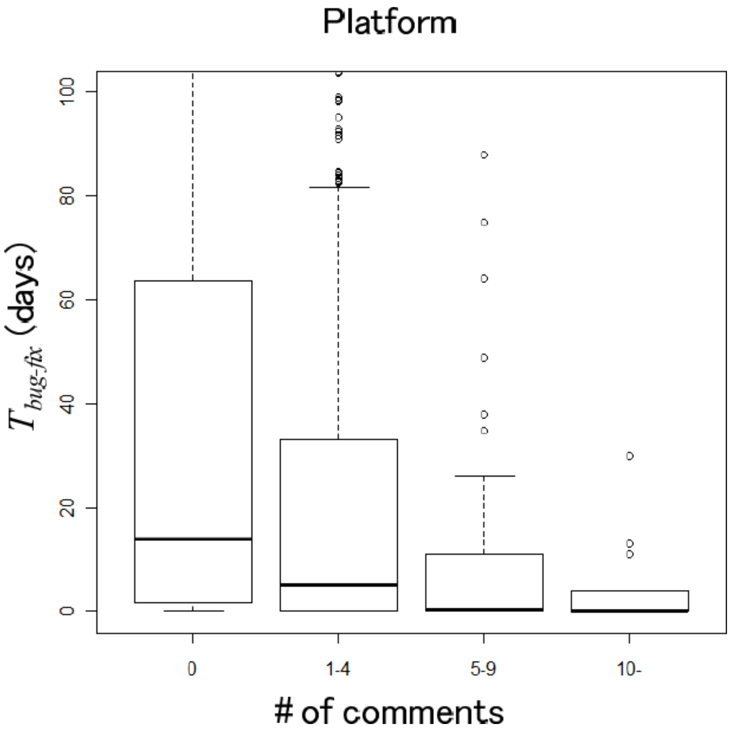




Discussions (2)

The impact of discussions among developers

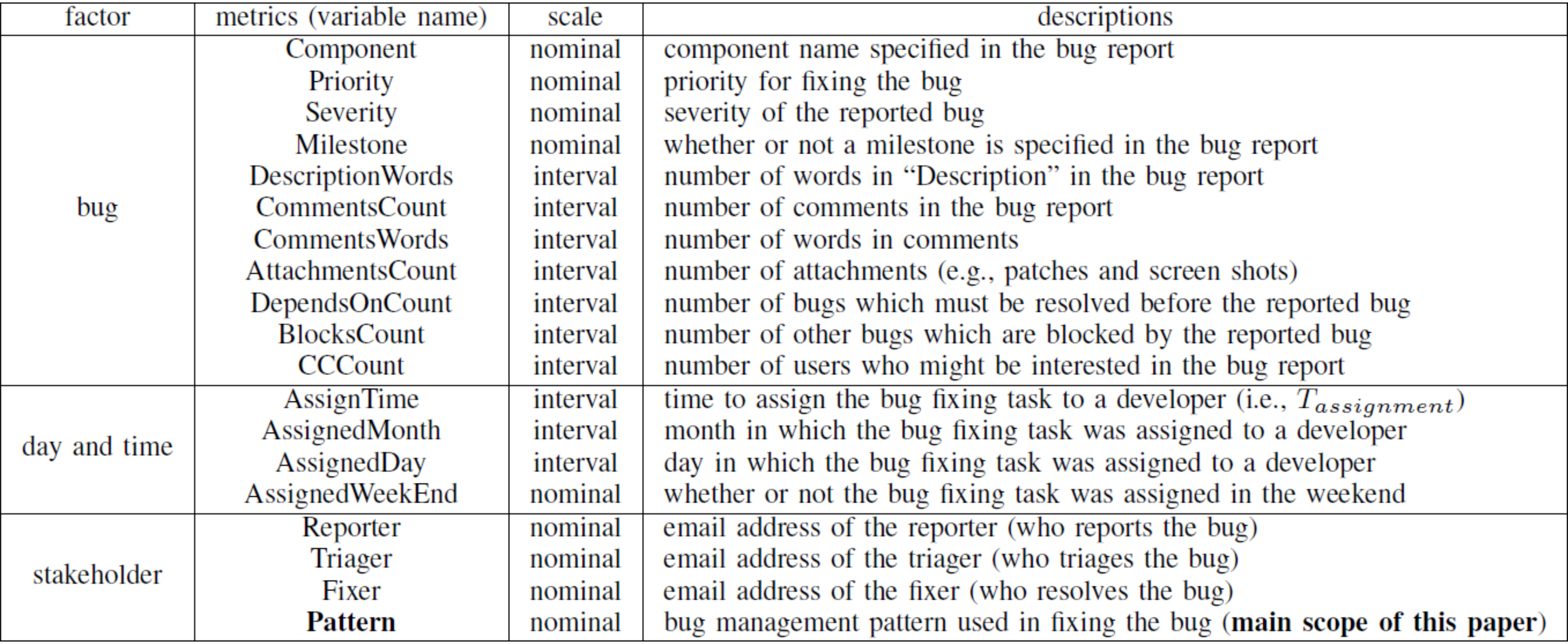
- Discussions about bugs before bug report assignment made a difference in the bug-fixing performance.



Discussions (3)

Other factors that would impact the time to fix

- There are many other factors that would impact the time to fix bugs.

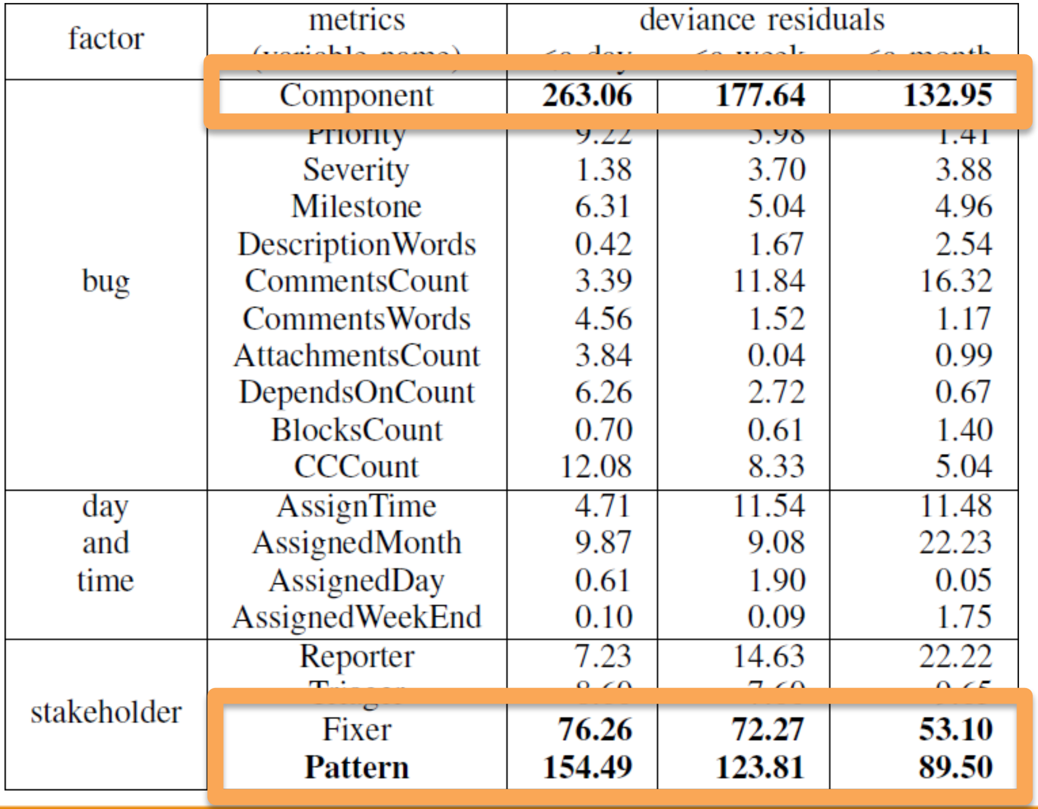


factor	metrics (variable name)	scale	descriptions
bug	Component	nominal	component name specified in the bug report
	Priority	nominal	priority for fixing the bug
	Severity	nominal	severity of the reported bug
	Milestone	nominal	whether or not a milestone is specified in the bug report
	DescriptionWords	interval	number of words in “Description” in the bug report
	CommentsCount	interval	number of comments in the bug report
	CommentsWords	interval	number of words in comments
	AttachmentsCount	interval	number of attachments (e.g., patches and screen shots)
	DependsOnCount	interval	number of bugs which must be resolved before the reported bug
	BlocksCount	interval	number of other bugs which are blocked by the reported bug
	CCCount	interval	number of users who might be interested in the bug report
day and time	AssignTime	interval	time to assign the bug fixing task to a developer (i.e., $T_{assignment}$)
	AssignedMonth	interval	month in which the bug fixing task was assigned to a developer
	AssignedDay	interval	day in which the bug fixing task was assigned to a developer
	AssignedWeekEnd	nominal	whether or not the bug fixing task was assigned in the weekend
stakeholder	Reporter	nominal	email address of the reporter (who reports the bug)
	Triager	nominal	email address of the triager (who triages the bug)
	Fixer	nominal	email address of the fixer (who resolves the bug)
	Pattern	nominal	bug management pattern used in fixing the bug (**main scope of this paper**)

Discussions (3)

Other factors that would impact the time to fix

- We analyzed which metrics contributed to our prediction (logistic regression) model.



factor	metrics (variable name)	deviance residuals ≤a day	 ≤a week	 ≤a month
bug	Component	**263.06**	**177.64**	**132.95**
	Priority	9.22	5.98	1.41
	Severity	1.38	3.70	3.88
	Milestone	6.31	5.04	4.96
	DescriptionWords	0.42	1.67	2.54
	CommentsCount	3.39	11.84	16.32
	CommentsWords	4.56	1.52	1.17
	AttachmentsCount	3.84	0.04	0.99
	DependsOnCount	6.26	2.72	0.67
	BlocksCount	0.70	0.61	1.40
	CCCount	12.08	8.33	5.04
day and time	AssignTime	4.71	11.54	11.48
	AssignedMonth	9.87	9.08	22.23
	AssignedDay	0.61	1.90	0.05
	AssignedWeekEnd	0.10	0.09	1.75
stakeholder	Reporter	7.23	14.63	22.22
	Triager	8.60	7.60	9.65
	Fixer	**76.26**	**72.27**	**53.10**
	Pattern	**154.49**	**123.81**	**89.50**

Discussions

Threats to Validity

- Only three years (from 2007 to 2009) bug report data without reassignments
  - Such data selection might bring bias against the complete picture of open source development

- Only the two open source projects
  - The Eclipse projects is large enough, but they have developers who are fully employed by IBM
  - The user base of the Eclipse products is different from that of other products such as Mozilla

Conclusion and future work

- A need for better ways to communicate and share knowledge between the different individuals.
  - In cases where all roles were played by different individuals, the efficiency of the bug fixing was negatively impacted.
  - Communication appears to have a positive impact on speeding up bug fixing time even when every role is played by different individuals.

- Our future work includes investigating other projects and other factors (e.g., complexity of bugs).

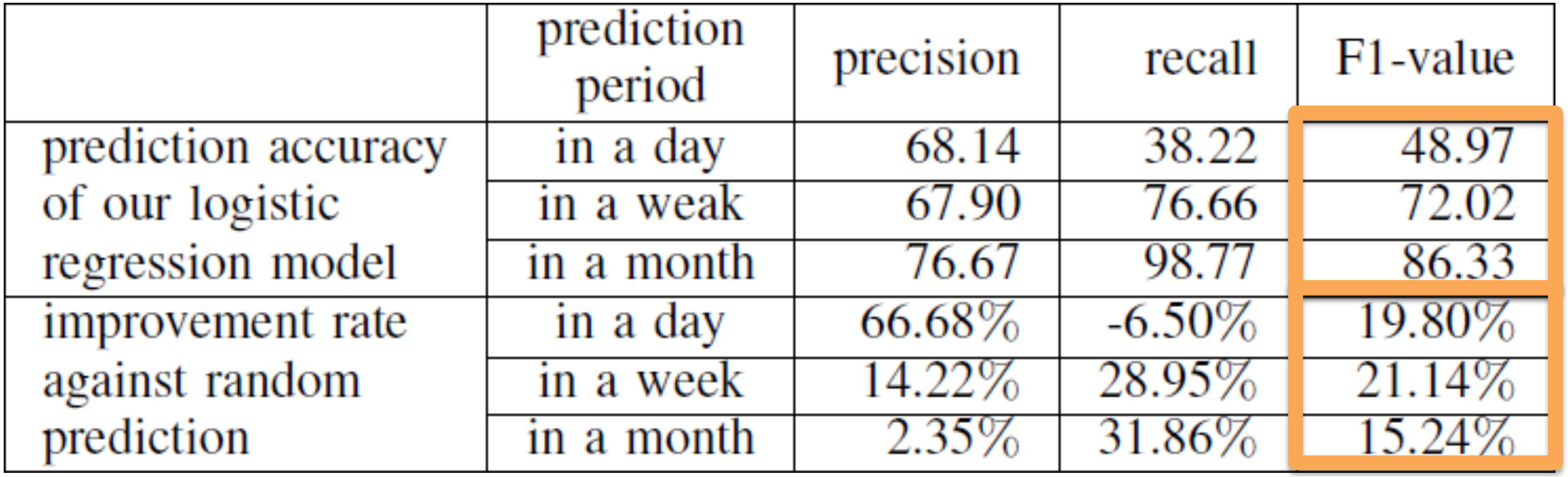
Questions?

- Email: masao@sys.wakayama-u.ac.jp
- HP: http://oss.sys.wakayama-u.ac.jp

Discussions

Other factors that would impact the time to fix

- We created a prediction model based on logistic regression to quantify the relationships between the factors.
  - All the F1-values of our results also perform the result which is predicted by using randomly selected independent variable.

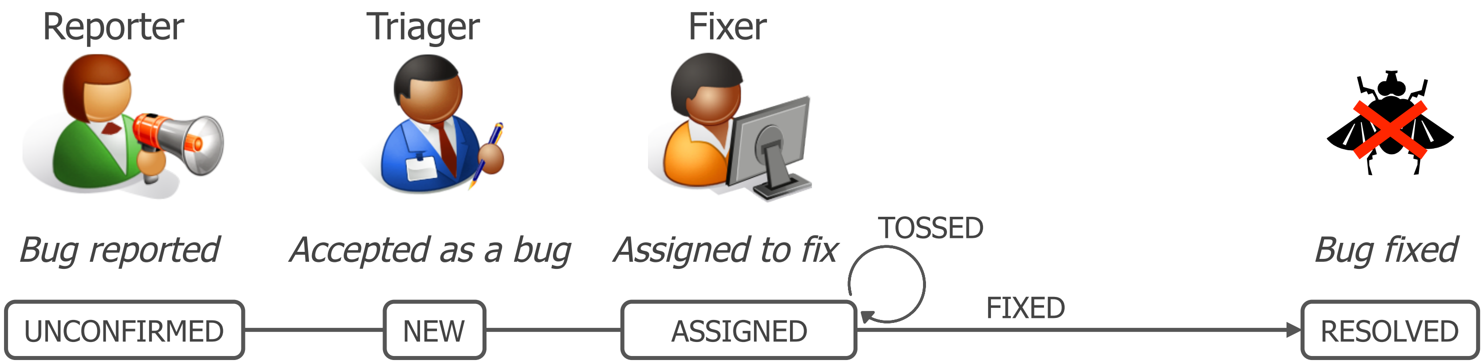


	prediction period	precision	recall	F1-value
prediction accuracy of our logistic regression model	in a day	68.14	38.22	48.97
	in a weak	67.90	76.66	72.02
	in a month	76.67	98.77	86.33
improvement rate against random prediction	in a day	66.68%	-6.50%	19.80%
	in a week	14.22%	28.95%	21.14%
	in a month	2.35%	31.86%	15.24%

Our focus:

Relations between the individuals

- The triager plays a very important role in the bug management process
- The triager needs to
  - have a good understanding of the bug report
  - assign the bug fixing task to the most appropriate developer who can fix the bug as quickly as possible


Reporter
Triager
Fixer
Bug reported
Accepted as a bug
Assigned to fix
TOSSED
Bug fixed
FIXED
UNCONFIRMED
NEW
ASSIGNED
RESOLVED