Oregon State University

Software Practitioner Perspectives on Merge Conflicts and Resolutions

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Why practitioner perspectives matter

“You cannot combine tens of conflicting commits… it’s not sane.”

“I have to jump around between tools and copy and paste version numbers… this is why integration matters.”

“I’m often dealing with code other people wrote. Nobody can review every pull request... Code is much easier to write than read.”

Merge Conflicts and Resolutions

- Collaborative development requires periodic synchronization of divergent changes.

- 19% of all merges result in merge conflicts. [Kasi & Sarma 2013, Brun et al. 2011]
- Resolutions can cause delays, integration errors, workflow disruptions. [Bird et al. 2012, Estler et al. 2014]

- Resolving merge conflicts is non-trivial.
- We have focused on techniques, predictions, and automated resolutions.
- However, practitioner perspectives have largely been ignored.

Research Goal & Questions

To empirically understand the perspective of practitioners when they approach and perform merge conflict resolutions.

RQ1 How do software practitioners approach merge conflicts?

RQ2 What unmet needs impact the difficulty of a merge conflict resolution?

RQ3 How well do tools meet practitioner needs for merge conflicts?

Study Design - Interviews and Surveys

Interviews

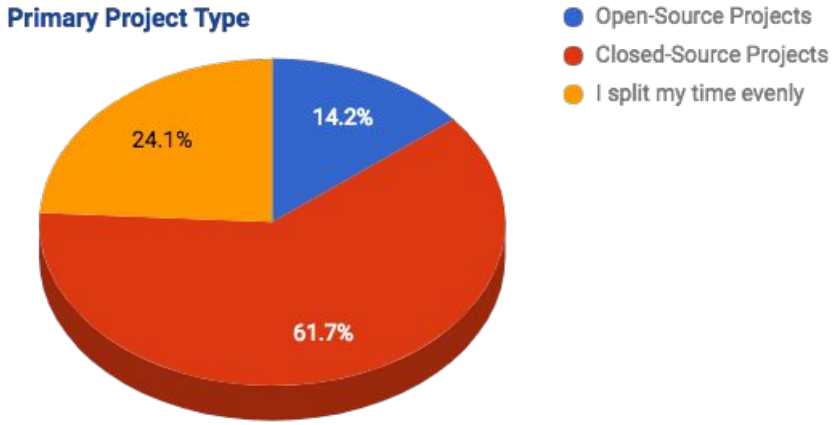
- Provided insight into how practitioners approach merge conflicts, and their unmet needs.
- 10 software practitioners from 7 organizations.
- Median of 5 years of software development experience.

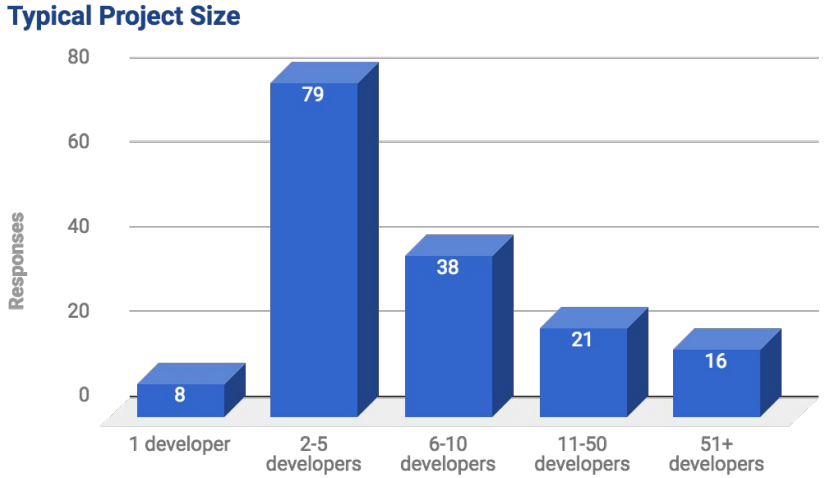
Part.	Exp.	Role	Project Source	Project Size
P1	18 yrs.	Sr. Software Developer	Open	1700
P2	6 yrs.	Software Engineer	Open	1700
P3	3 yrs.	Software Engineer	Open	1700
P4	10 yrs.	Software Developer	Open	<10
P5	3 yrs.	Infrastructure Engineer	Closed	<10
P6	5 yrs.	Software Developer	Closed	<10
P7	5 yrs.	Software Engineer	Open	200
P8	25 yrs.	Director	Open	600
P9	8 yrs.	Software Developer	Open	600
P10	2 yrs.	Software Developer	Open	<5

Study Design - Interviews and Surveys

Survey

- Validate our results and provided a broader perspective.
- 162 participants from the software development industry.
- 74.2% had 6 or more years of software development experience.

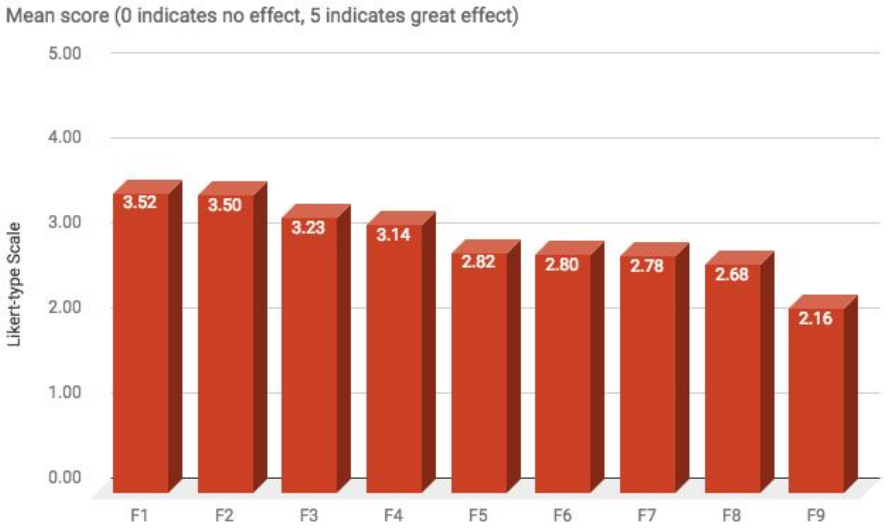




Results

RQ1: How do practitioners approach merge conflicts?

F1	Complexity of conflicting lines of code
F2	Your knowledge/expertise in area of conflicting code
F3	Complexity of the files with conflicts
F4	Number of conflicting lines of code
F5	Time to resolve a conflict
F6	Atomicity of changesets in the conflict
F7	Dependencies of conflicting code on other components
F8	Number of files in the conflict
F9	Non-functional changes (whitespace, renaming, etc.)



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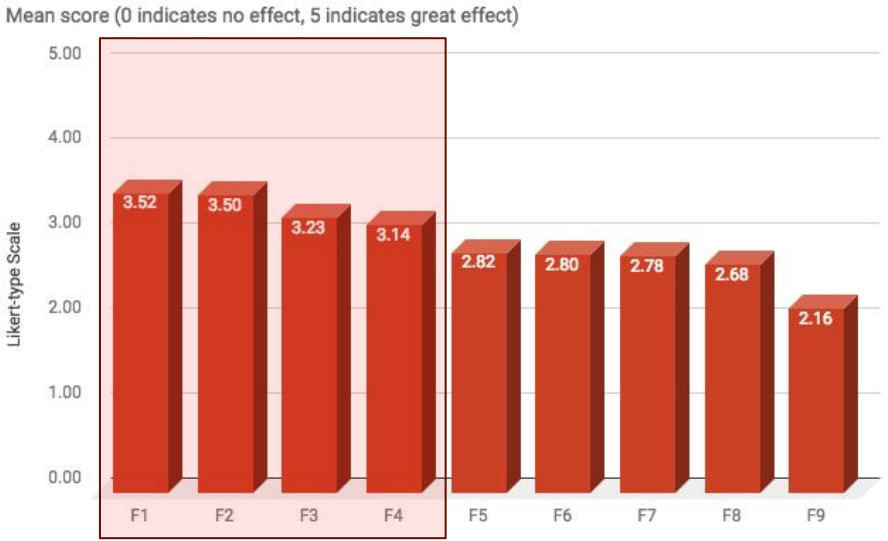
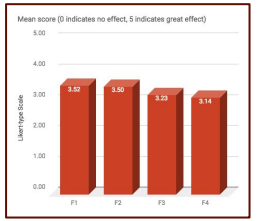


RQ1: How do practitioners approach merge conflicts?

Top-4 Factors for Difficulty

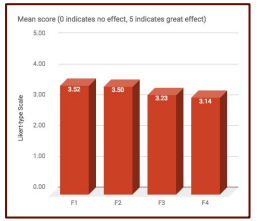


- Technical Aspects
  - Complexity of the code (F1, F3)
  - Size of the conflicting changes (F4)
- Social Aspects
  - Expertise in area of conflicting code (F2)

"Small is always easy. A 1-line merge conflict is always easier than a 400-line merge conflict, and can be done now."

RQ1: How do practitioners approach merge conflicts?

Top-4 Factors for Difficulty



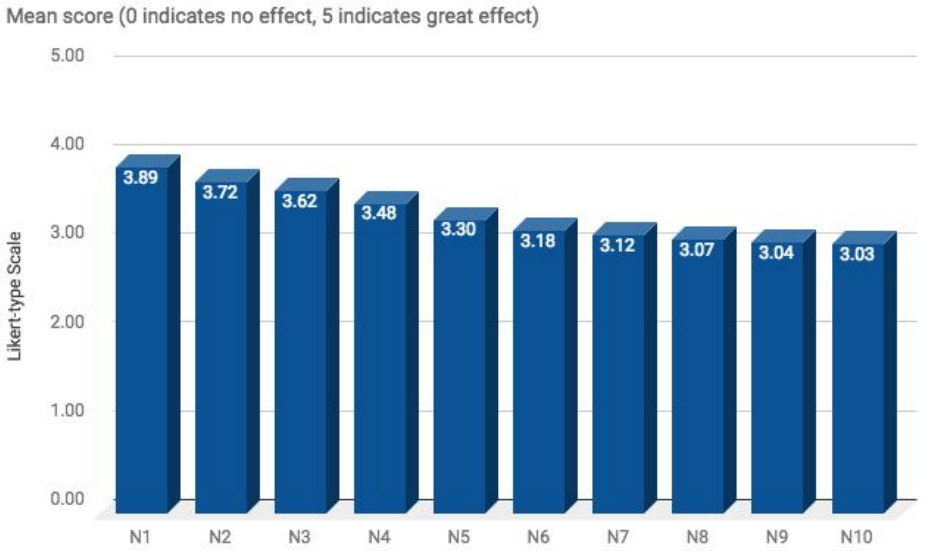
- Technical Aspects
  - Complexity of the code (F1, F3)
  - Size of the conflicting changes (F4)

- Social Aspects
  - Expertise in area of conflicting code (F2)

"A lot of what I work on is in my own little area… I know what to do… But in [unfamiliar parts of code], then I'll get someone else to resolve the merge conflict for me."

RQ2: What unmet needs impact the difficulty of a merge conflict resolution?

N1	How easy is it to understand the code involved in the merge conflict
N2	Your expertise in the area of code with the merge conflict
N3	The amount of information you have about the conflicting code
N4	How well tools present information in an understandable way
N5	Changing assumptions within the code
N6	Complexity of the project structure
N7	Trustworthiness of tools
N8	Informativeness of commit messages
N9	Project culture
N10	Tool support for examining development history



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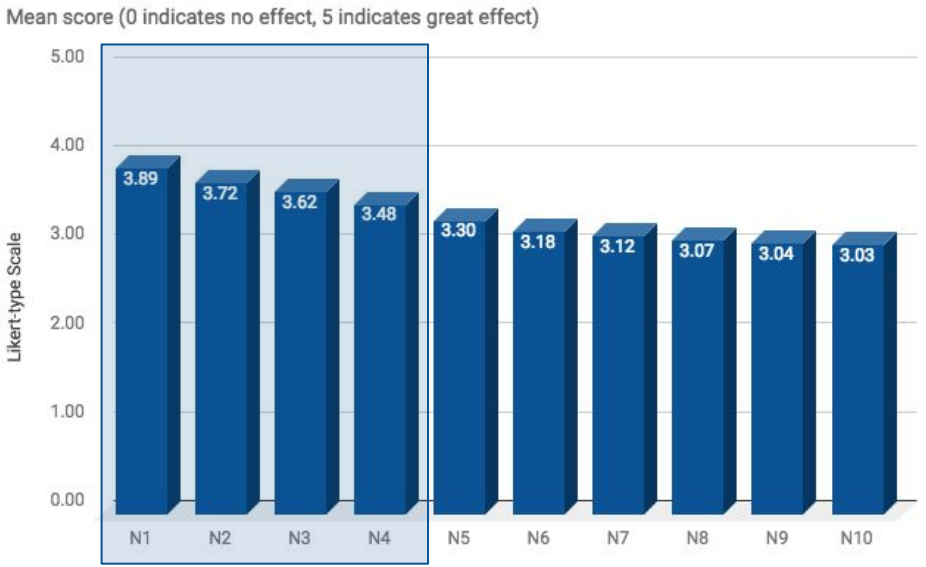

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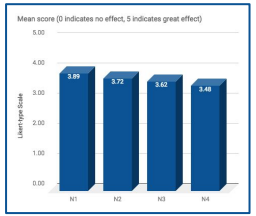
Top-4 Unmet Needs

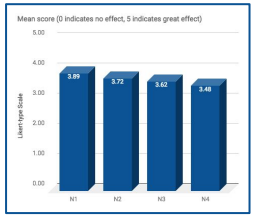


- Social Needs
  - Expertise in area of conflicting code (N2)
- Technical Needs
  - Understandability of code (N1)
  - Contextual information about the conflict (N3)
  - Tool presentation of relevant info (N4)

"I'm often dealing with code other people wrote… So now I have to go back and do some archaeology to find out what's going on. Code is much easier to write than read."

RQ2: What unmet needs impact the difficulty of a merge conflict resolution?

Top-4 Unmet Needs



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"You focus on understanding the small change, not the big one. It's easier to understand… get the small change to go with the flow of the bigger change."

RQ2: What unmet needs impact the difficulty of a merge conflict resolution?

Closed-Source Practitioners

N1	How easy is it to understand the code involved in the merge conflict
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Open-Source Practitioners

N1	How easy is it to understand the code involved in the merge conflict
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N3	Tool support for examining development history
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Open-Source Practitioners

N1	How easy is it to understand the code involved in the merge conflict
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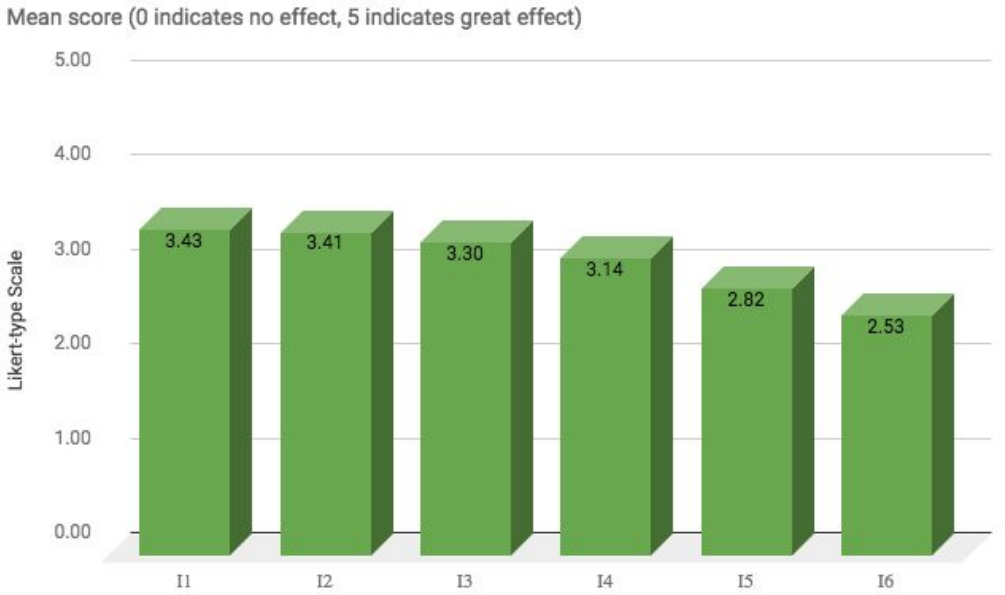
OSS projects have frequent changes, in goals and personnel, which requires additional support for history exploration. This “pain point” has not been addressed by current merge toolsets.

RQ3: How well do tools meet practitioner needs for merge conflicts?

I1	Better usability
I2	Better ways of filtering out less relevant information
I3	Better ways of exploring project history
I4	Better graphical presentation of information
I5	Better transparency in tool functionality/operations
I6	Better terminology that is more consistent with my other tools



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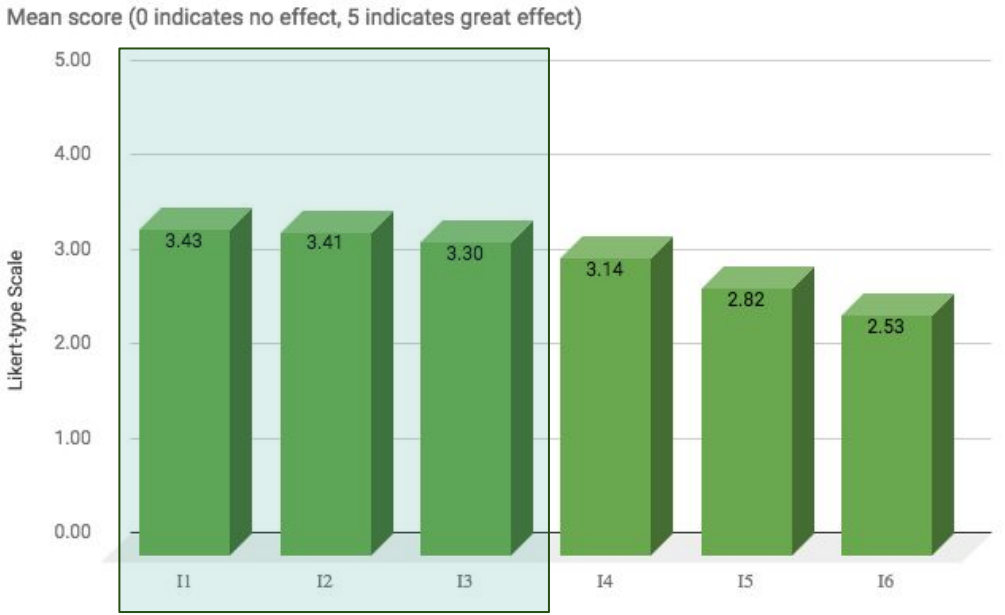
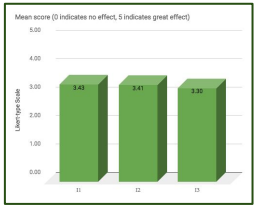


RQ3: How well do tools meet practitioner needs for merge conflicts?

Top-3 Tool Improvements



- Better Usability (I1)
  - Average of 2.5 tools for merge conflicts
- Better Filtering of Less-Relevant Information (I2)
  - Larger projects, larger scalability concerns
- Better Project History Exploration (I3)
  - Practitioners use workaround, but seamless support is needed

"I have to jump around between tools and copy and paste version numbers… this is why integration matters."

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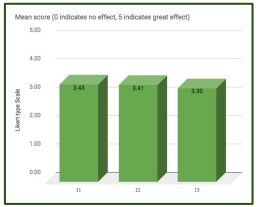

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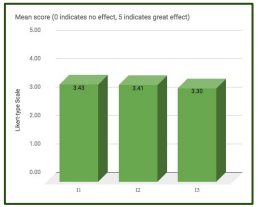
"You want to extract the relevant commits. The ones that actually clash… you want to zoom in on them and understand just enough and don't waste time."

RQ3: How well do tools meet practitioner needs for merge conflicts?

Top-3 Tool Improvements



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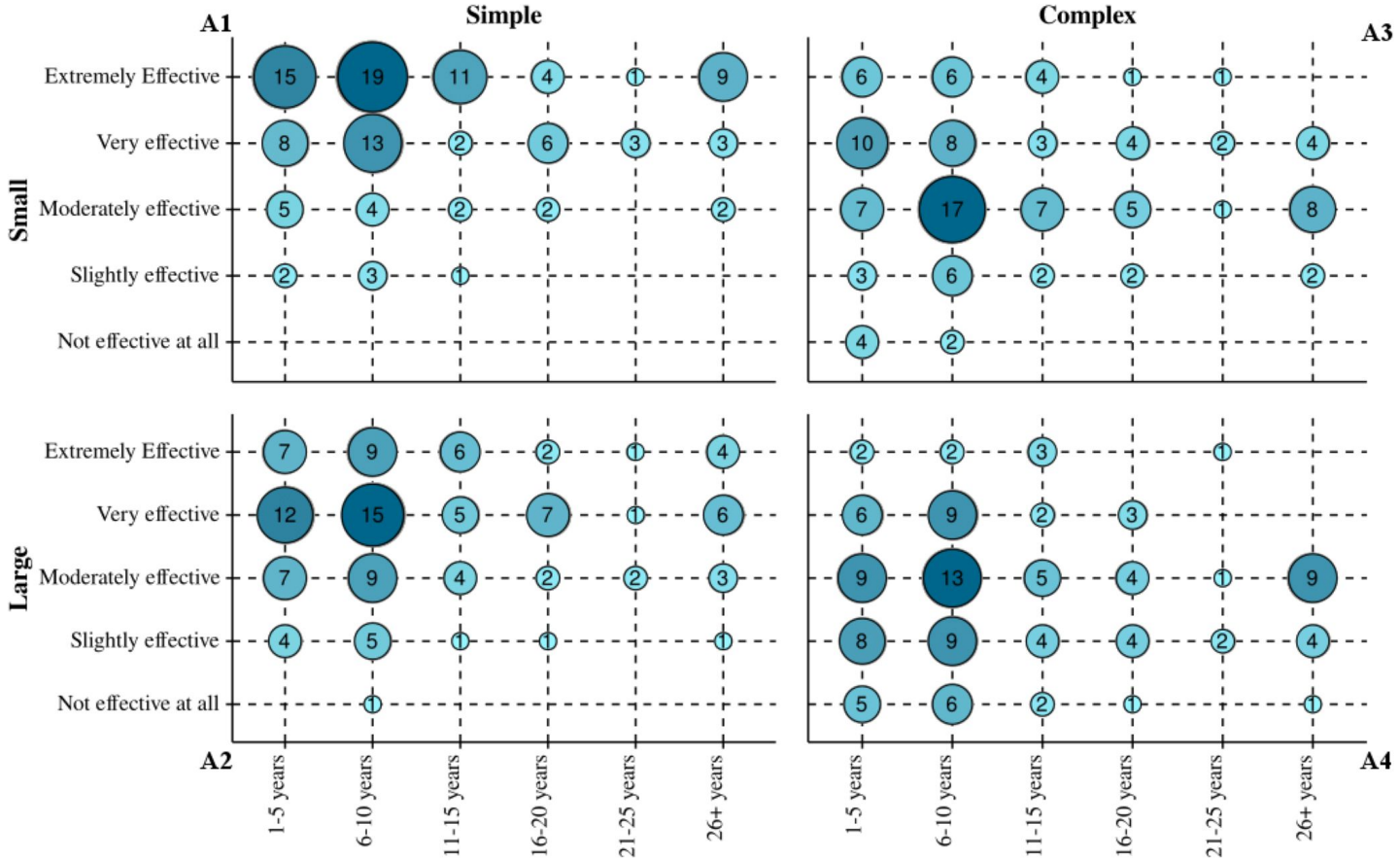
"Give me a way to explore the history. To drill down, to go back up, you know? To resurface and understand what happened."

Effectiveness of practitioners' toolsets in supporting perceived size and complexity of merge conflicts, split along development experience.



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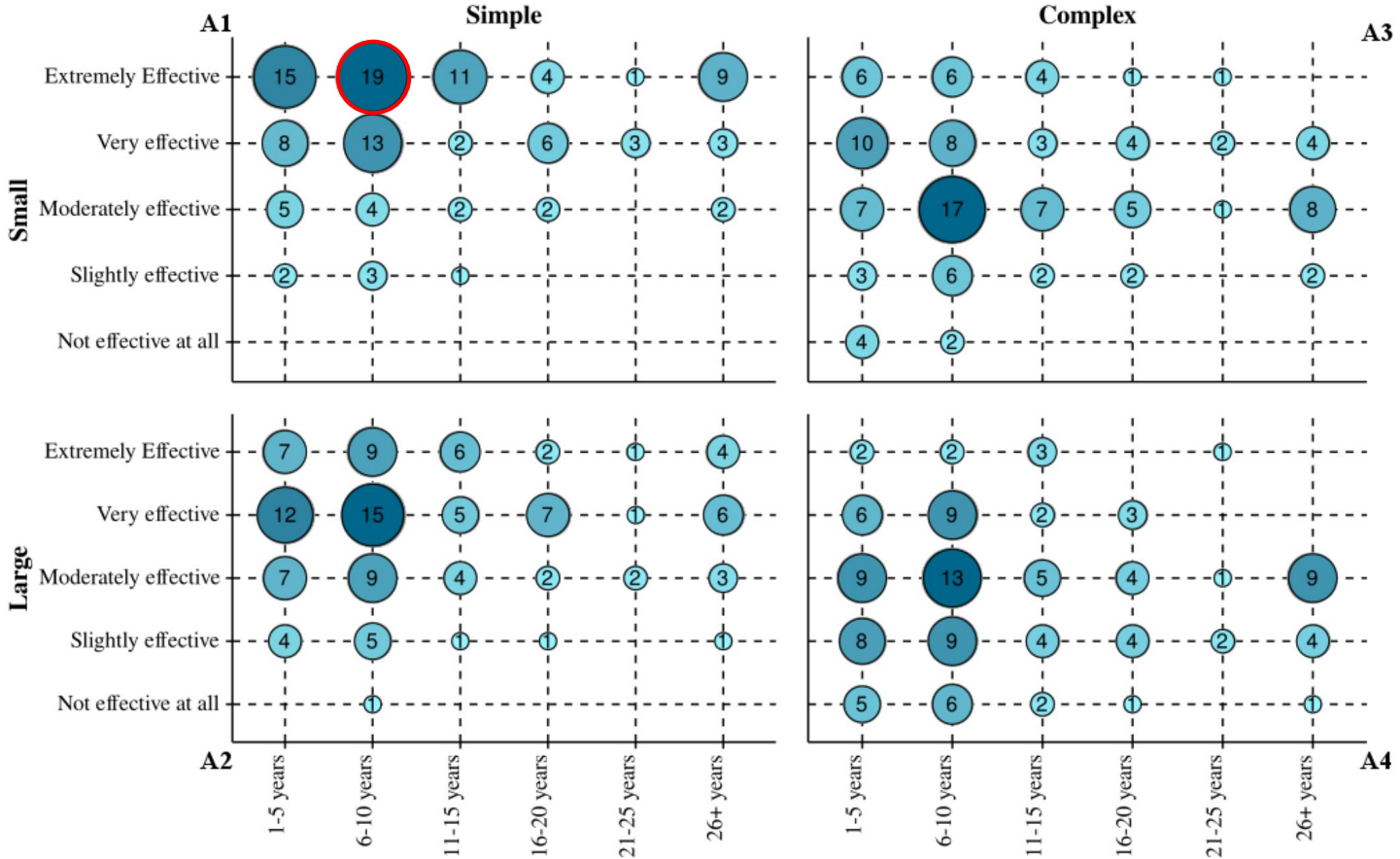

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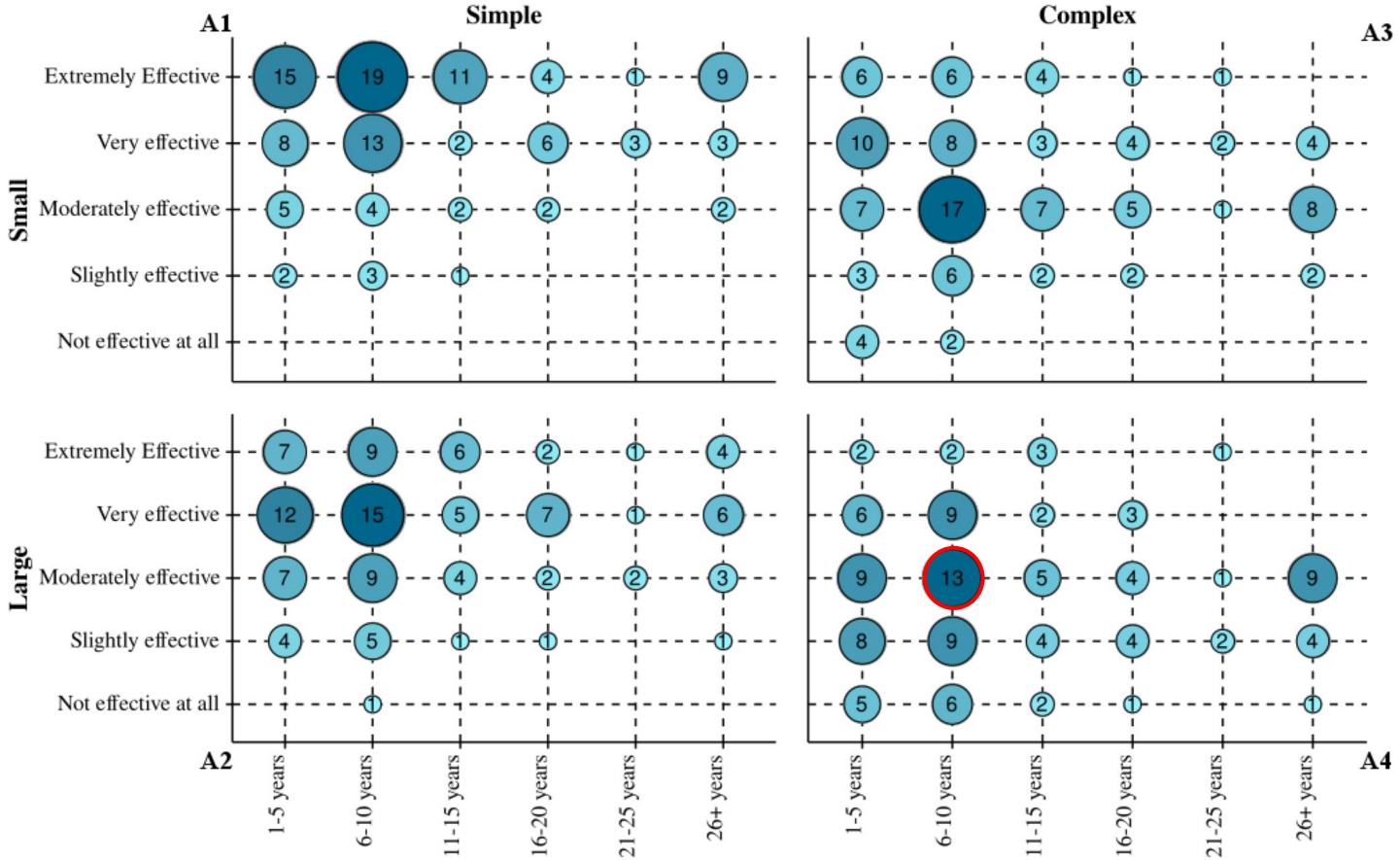

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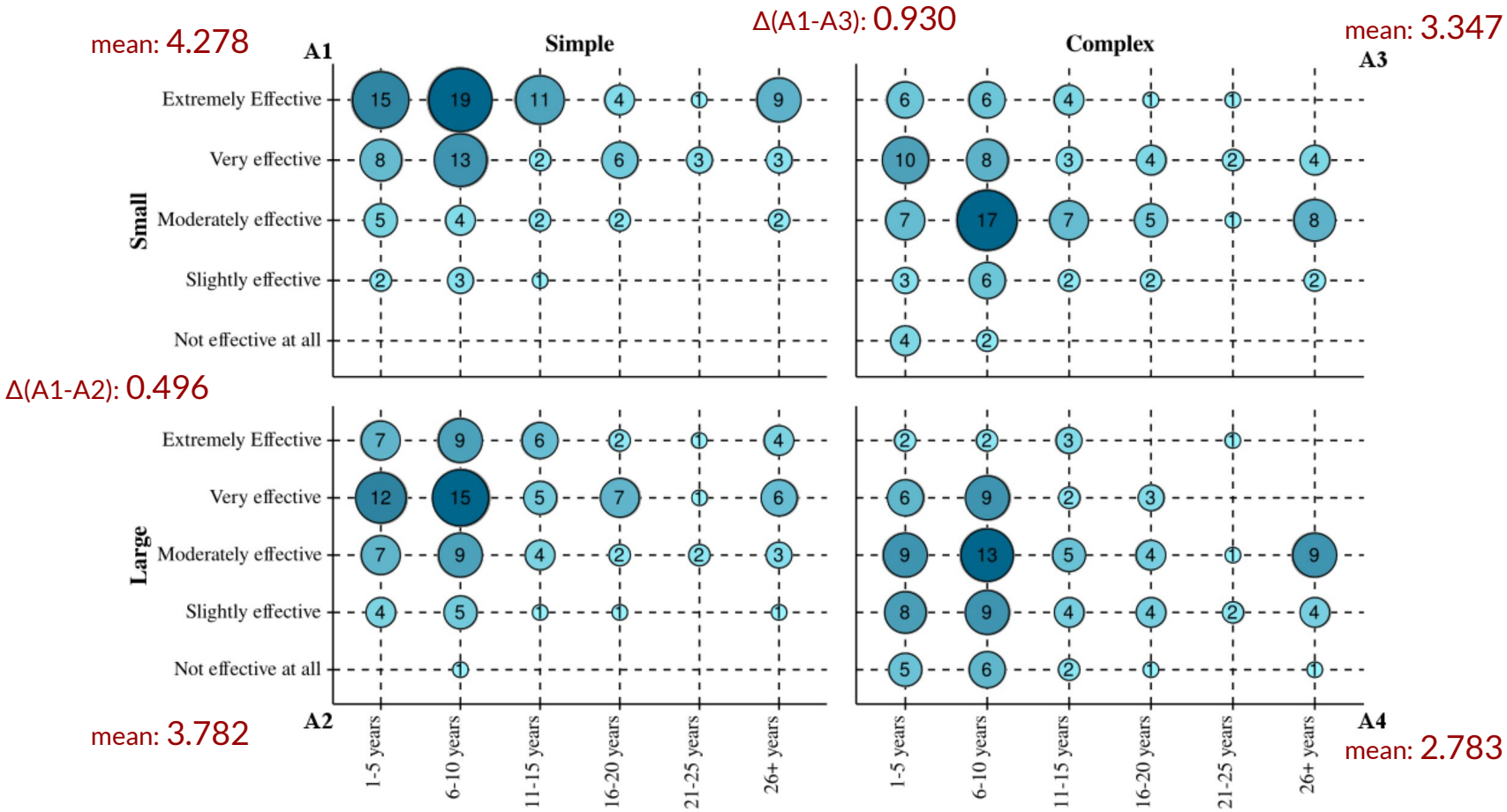

Conclusions

RQ1 How do software practitioners approach merge conflicts?

Practitioners **rely on their expertise** in the conflicting code to **understand and assess** the merge conflict.

Practitioners **rely on simple estimations**, rather than precise metrics calculated by tools.

Conclusions

RQ2 What unmet needs impact the difficulty of a merge conflict resolution?

Practitioners have unmet needs along dimensions of:

1. comprehending code snippets in isolation,
2. understanding the code context underlying multiple code snippets that are split across multiple files, and commits,
3. The ability to quickly comprehend the complexity of these code snippets.

Conclusions

RQ3 How well do tools meet practitioner needs for merge conflicts?

- Tools are lacking in **usability**, **information filtering**, and **history exploration** support.
- Practitioners are doing **workarounds** and using **multiple tools** to resolve merge conflicts.
- Tools do not scale to large, complex merge conflicts (especially along the complexity dimension).

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Questions?

RQ1: Difficulties in Assessing Merge Conflicts

- F1 Complexity of conflicting lines of code
- F2 Your knowledge/expertise in area of conflicting code
- F3 Complexity of the files with conflicts
- F4 Number of conflicting lines of code

RQ2: Unmet Needs in Resolving Merge Conflicts

- N1 How easy is it to understand the code involved in the merge conflict
- N2 Your expertise in the area of code with the merge conflict
- N3 The amount of information you have about the conflicting code
- N4 How well tools present information in an understandable way

RQ3: Merge Conflict Tool Improvements

- I1 Better usability
- I2 Better ways of filtering out less relevant information
- I3 Better ways of exploring project history

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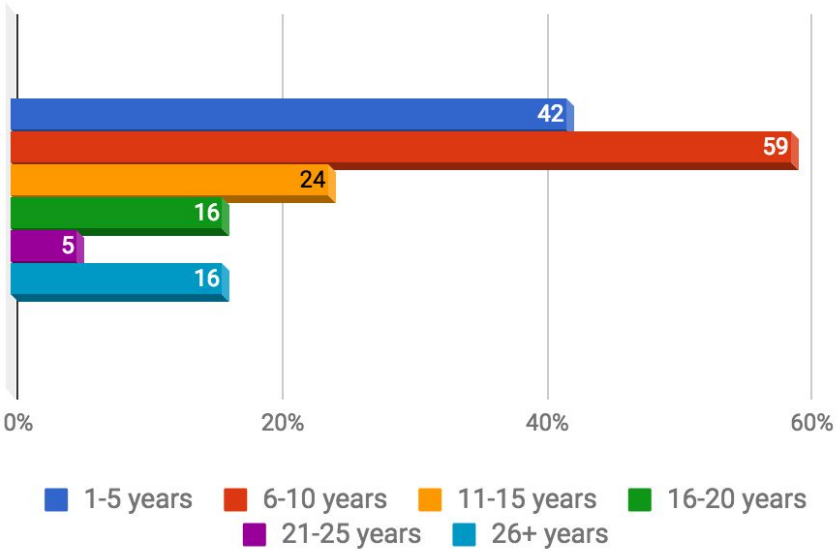
Survey Participants Merge Toolsets (Top 10)

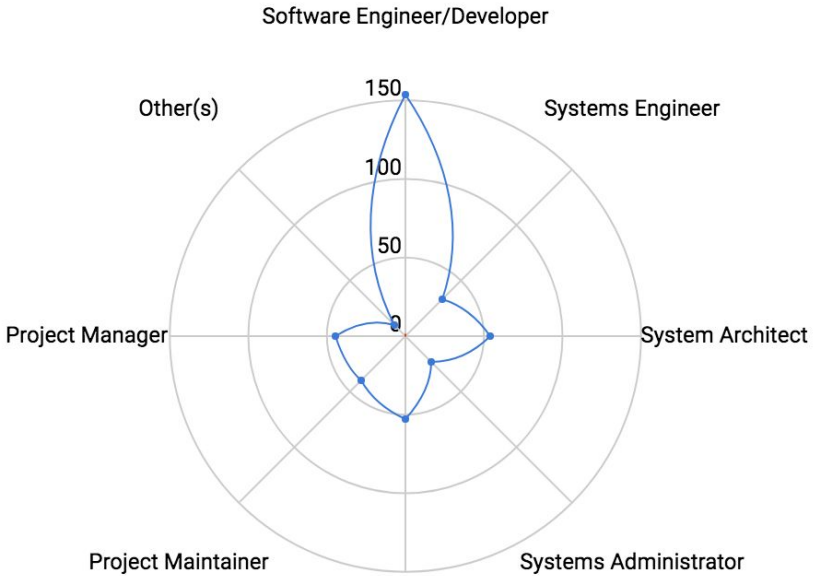
Tool	# of Participants	Description
Git	37	Version Control System
Vim/vi	17	Text Editor
Text Editor (unspecified)	14	Text Editor
Git Diff	11	Diffing Tool
GitHub	11	Website
Eclipse	10	IDE
KDiff3	9	Diff & Merge
Meld	8	Diff & Merge
SourceTree	8	Git/Hg Desktop Client
Sublime Text	7	Text Editor

Survey Participants

Professional Development Experience



Collaborative Software Project Roles



Merge Conflict

- Merge conflicts are a scenario in which two copies of the same codebase diverge and cannot be automatically merged, thus requiring human intervention to resolve.

- This definition excludes other types of conflicts that exist within software projects (i.e. social conflicts or semantic conflicts, such as build or test failures).