Decoding the Issue Resolution Process In Practice via Issue Report Analysis: A Case Study of Firefox

Antu Saha Oscar Chaparro













WILLIAM & MARY

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Software Evolution and Analysis Lab

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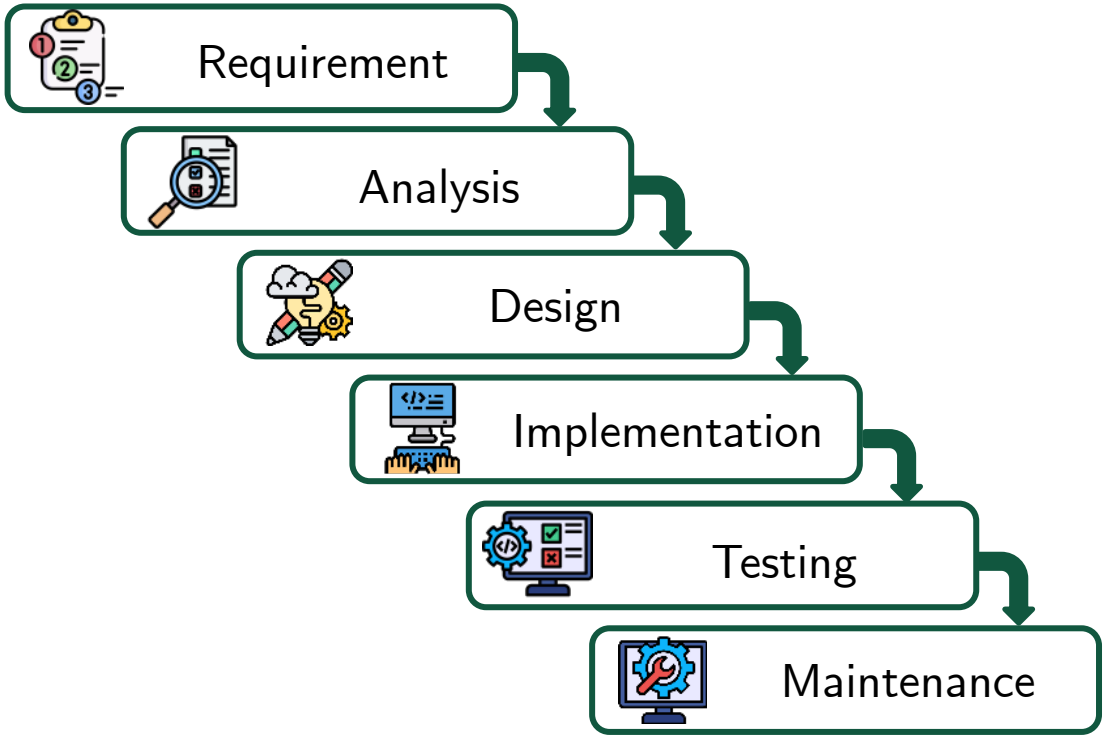
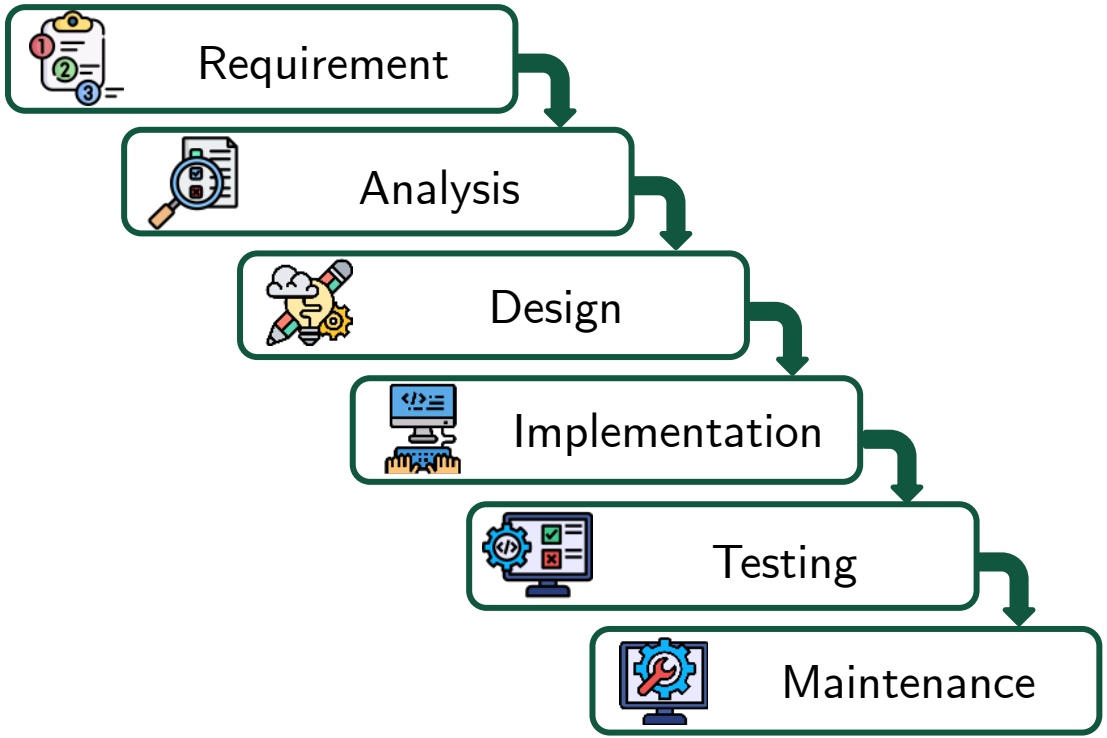
Software Development Process



Software Development Process



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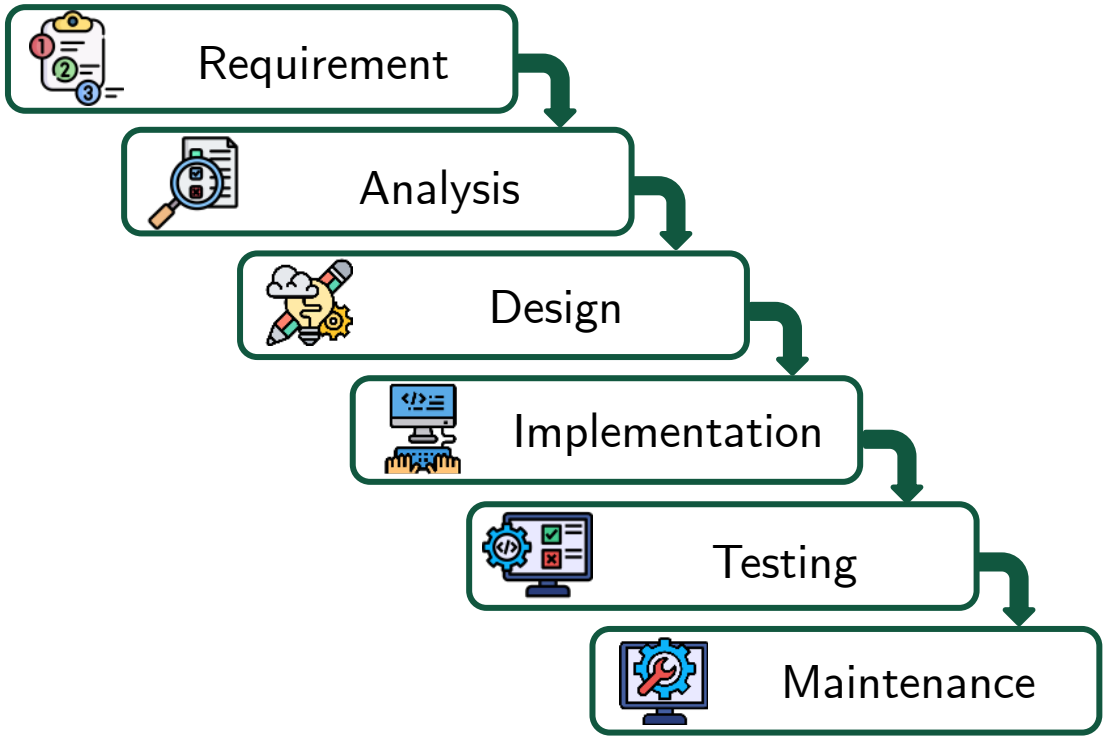


Rajlich's Software Change Model[1]

- Initiation
- Concept Location
- Impact Analysis
- Actualization
- Refactoring
- Verification
- Conclusion

1 Rajlich, Vaclav. Software engineering: The current practice. Crc Press, 2011.

Is this process really linear in practice?

Rajlich's Software Change Model[1]



1 Rajlich, Vaclav. Software engineering: The current practice. Crc Press, 2011.

Is this process really linear in practice?

To what extent does the practical process deviate from the linear process?

Rajlich's Software Change Model[1]



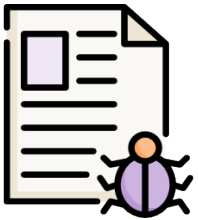
1 Rajlich, Vaclav. Software engineering: The current practice. Crc Press, 2011.

Addressing a Software Issue



Software Change

Captured in



Issue Report

Addressing a Software Issue



Software Change

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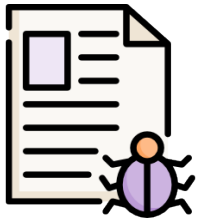

Issue Report



Understand Issue Priority & Severity



Identify Duplicate Issues

Addressing a Software Issue



Software Change

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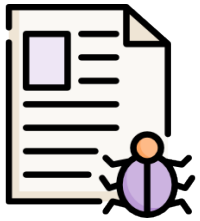


Issue Report



Understand Issue Priority & Severity



Identify Duplicate Issues



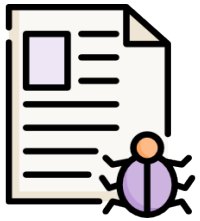
Assign Appropriate Developer

Addressing a Software Issue



Software Change

Captured in



Issue Report



Understand Issue Priority & Severity



Identify Duplicate Issues



Assign Appropriate Developer



Resolve Issue

Addressing a Software Issue



Software Change

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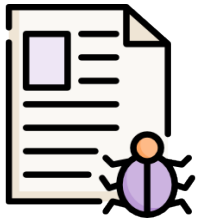


Issue Report

Understand Issue Priority & Severity

Identify Duplicate Issues

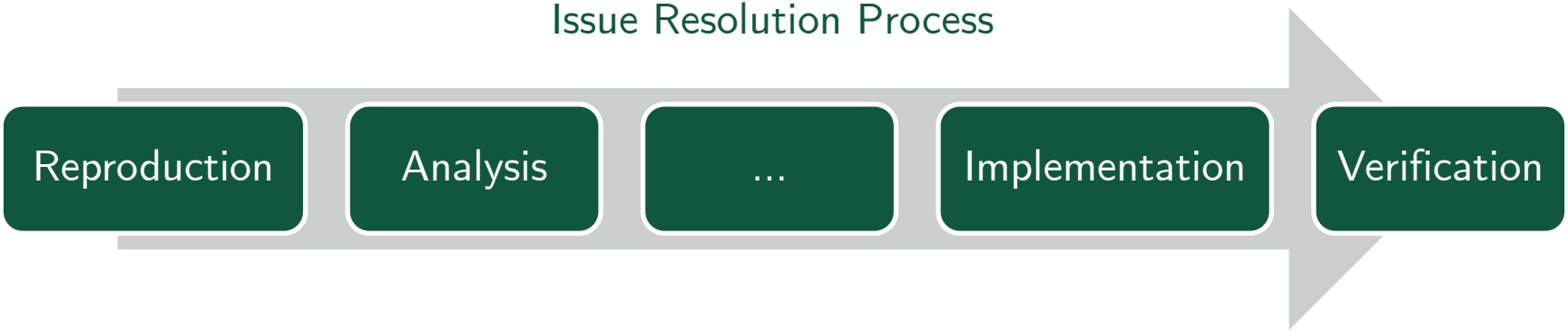
Assign Appropriate Developer



Resolve Issue

Addressing a Software Issue

Issue Resolution Process



Understand Issue Priority & Severity

Identify Duplicate Issues

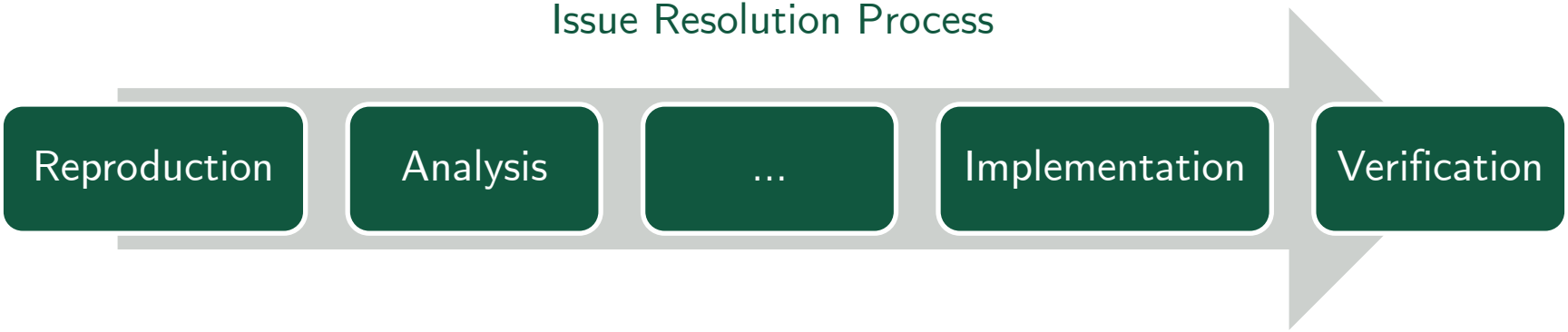
Assign Appropriate Developer



Resolve Issue

Research Goals

Issue Resolution Process



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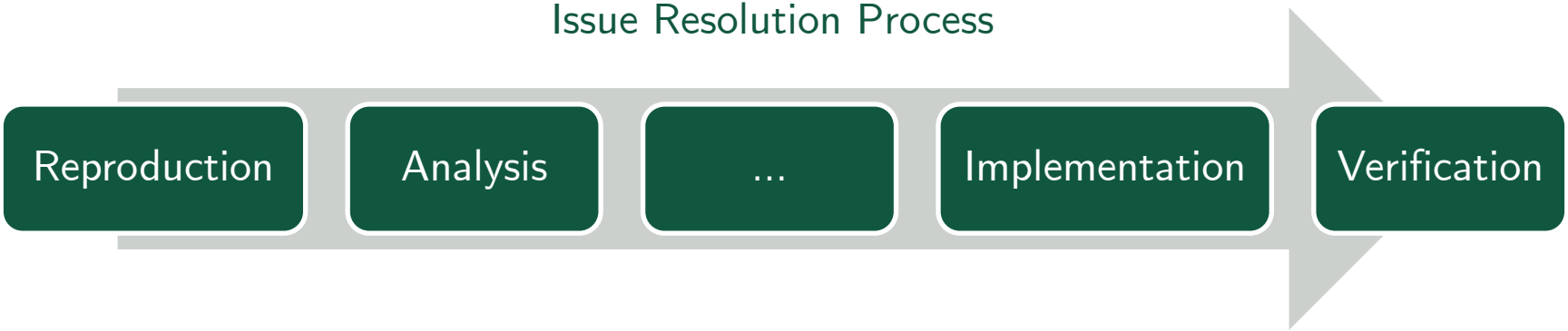
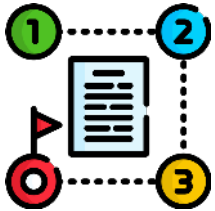
Issue Resolution Process



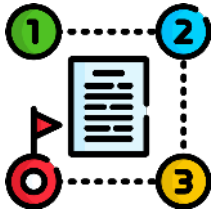


Identify the issue resolution stages

Research Goals

Issue Resolution Process

Reproduction → Analysis → ... → Implementation → Verification



Identify the issue resolution stages

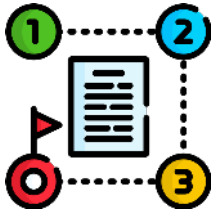


Understand the resolution process in practice

Research Goals

Issue Resolution Process

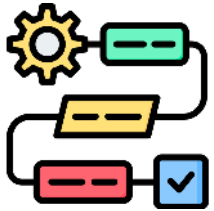
Reproduction → Analysis → ... → Implementation → Verification



Identify the issue resolution stages



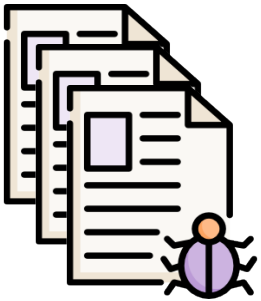
Understand the resolution process in practice



Derive the recurrent ways of issue resolution (i.e., patterns)

Identifying the Resolution Process

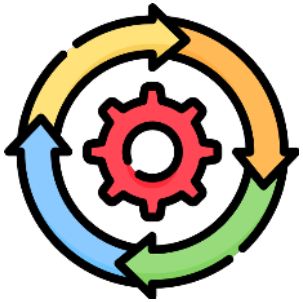
Issue Report Discussions



Human Annotators



Issue Resolution Process



Issues = Bugs, new features, enhancements, ...

Annotation Method and Process Inference

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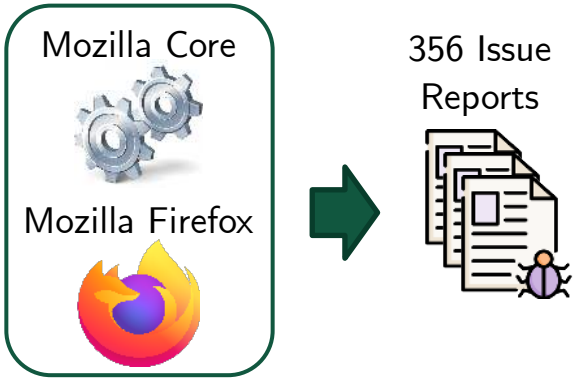
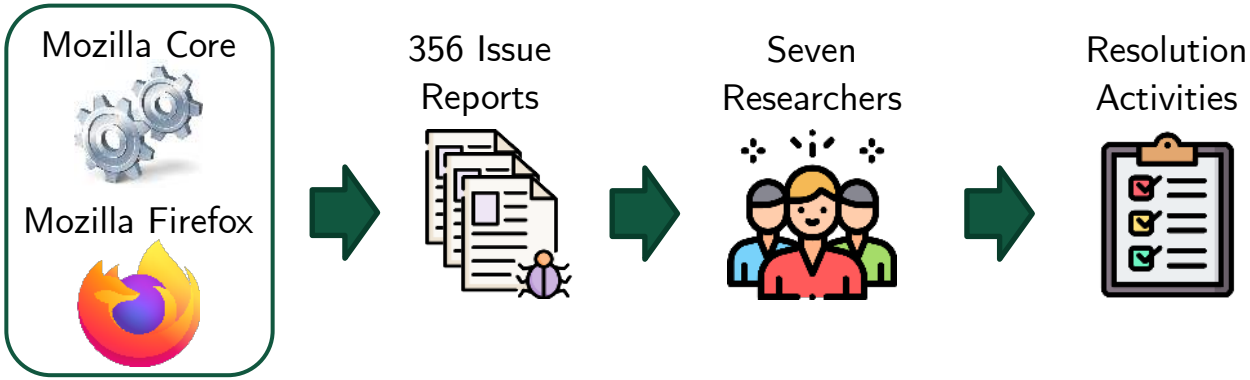


356 Issue Reports

Annotation Method and Process Inference



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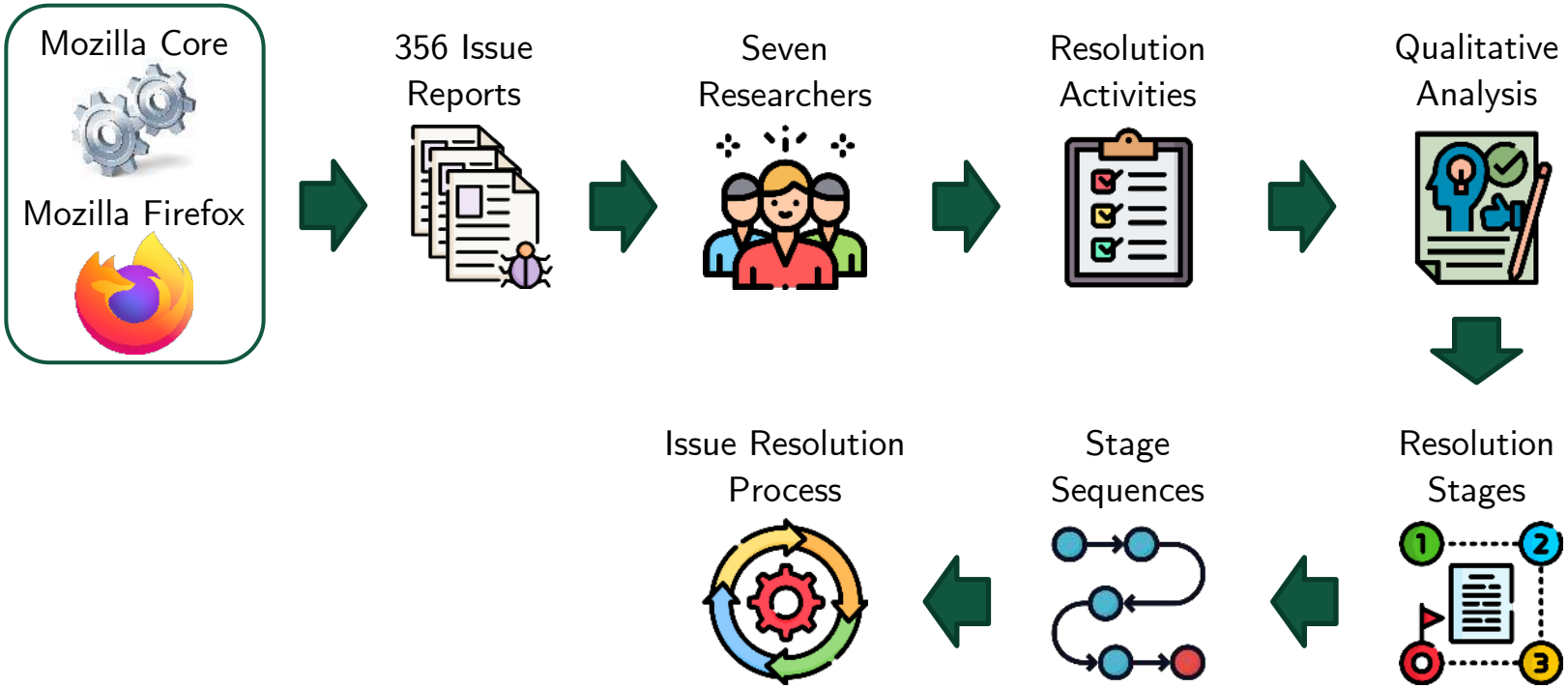
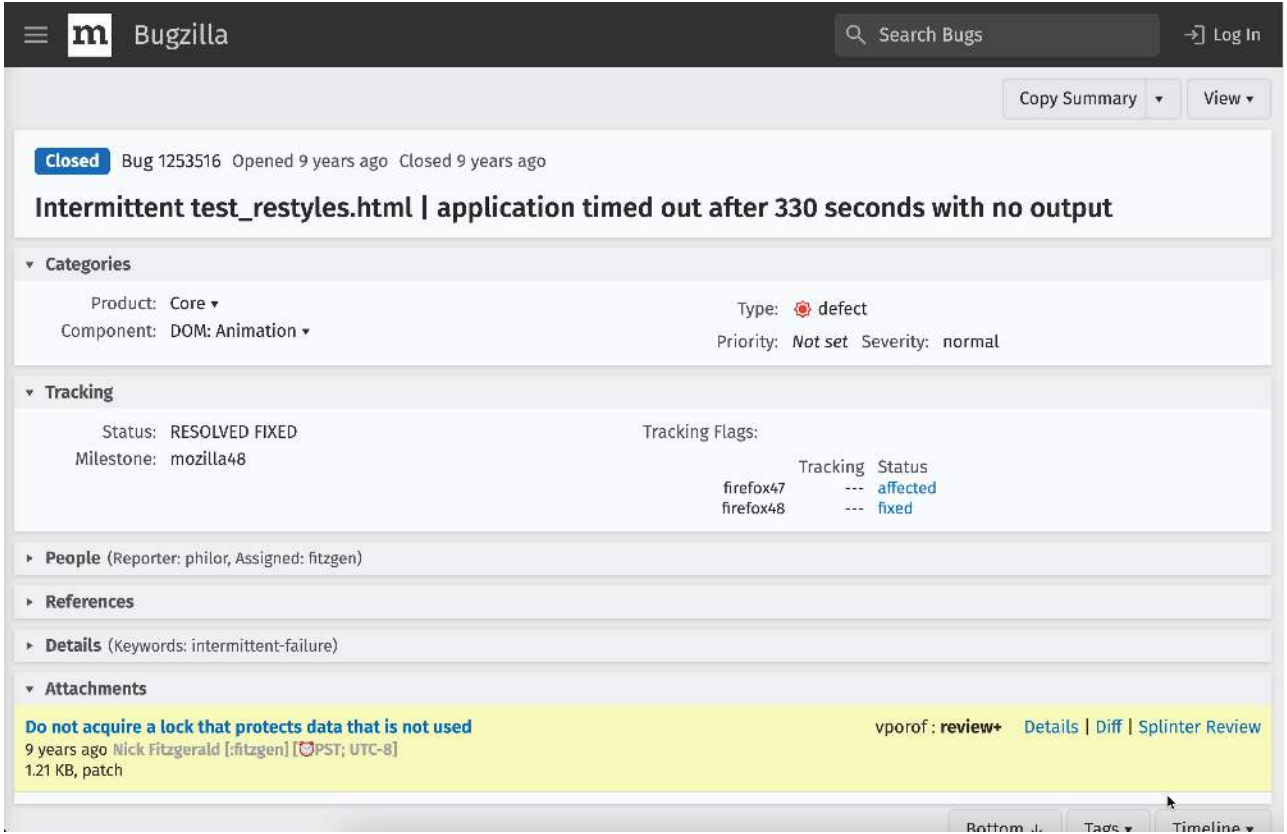


Issue Discussion Thread



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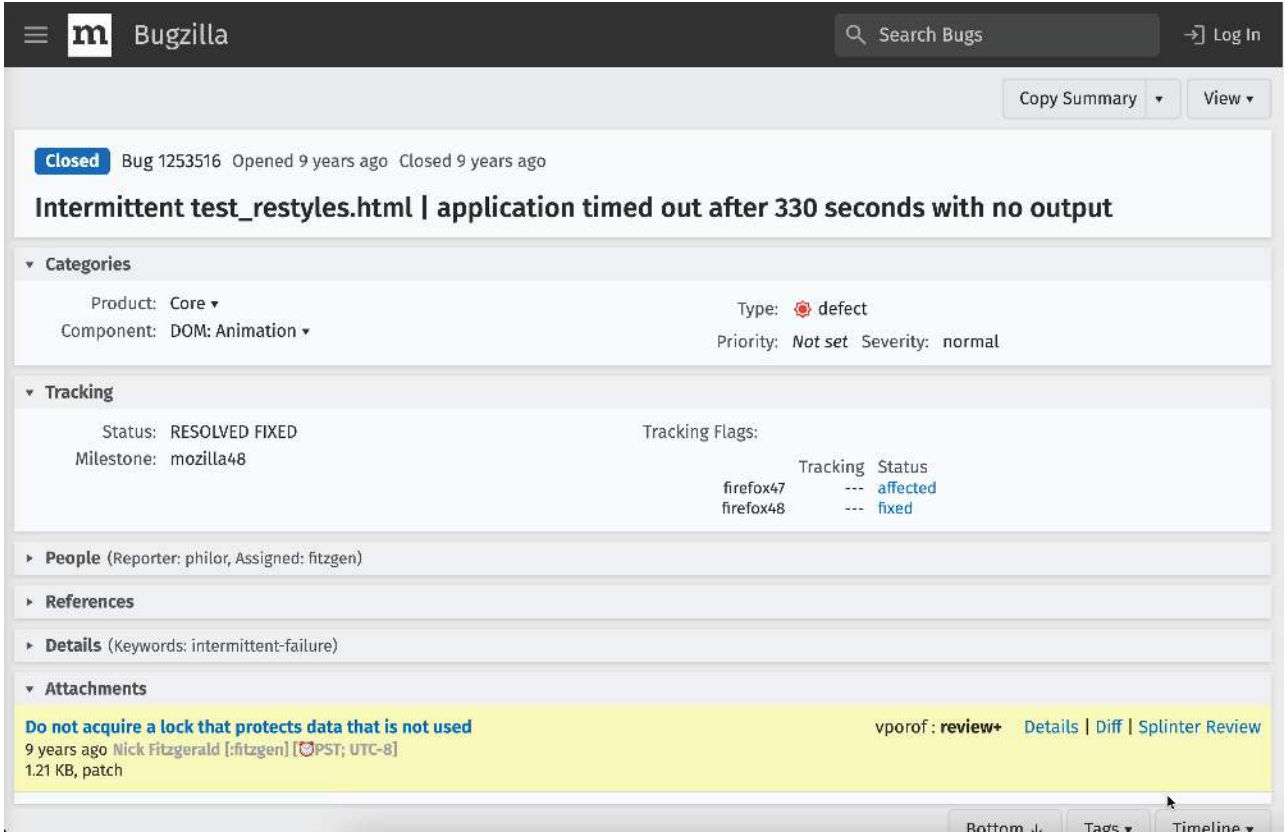


Identifying Resolution Stages



Identifying Resolution Stages



Issue Resolution Activities

- REPRODUCTION_ATTEMPT
- PROBLEM_CAUSE
- PROBLEM_REVIEW
- PROBLEM_CAUSE
- POTENTIAL_SOLUTION
- POTENTIAL_SOLUTION
- CODE_IMPLEMENTATION

Identifying Resolution Stages



Issue Resolution Activities

Issue Resolution Steps/Stages

REPRODUCTION_ATTEMPT

PROBLEM_CAUSE

PROBLEM_REVIEW

PROBLEM_CAUSE

POTENTIAL_SOLUTION

POTENTIAL_SOLUTION

CODE_IMPLEMENTATION

REPRODUCTION

Identifying Resolution Stages



Issue Resolution Activities

Issue Resolution Steps/Stages

REPRODUCTION_ATTEMPT → REPRODUCTION

PROBLEM_CAUSE → ANALYSIS

PROBLEM_REVIEW → ANALYSIS

PROBLEM_CAUSE → ANALYSIS

POTENTIAL_SOLUTION

POTENTIAL_SOLUTION

CODE_IMPLEMENTATION

Identifying Resolution Stages



Issue Resolution Activities

Issue Resolution Steps/Stages

REPRODUCTION_ATTEMPT → REPRODUCTION

PROBLEM_CAUSE

PROBLEM_REVIEW → ANALYSIS

PROBLEM_CAUSE

POTENTIAL_SOLUTION

POTENTIAL_SOLUTION → SOLUTION DESIGN

CODE_IMPLEMENTATION → IMPLEMENTATION

Identifying Resolution Stages



Issue Resolution Activities

Stage Sequence

REPRODUCTION_ATTEMPT

PROBLEM_CAUSE

PROBLEM_REVIEW

PROBLEM_CAUSE

POTENTIAL_SOLUTION

POTENTIAL_SOLUTION

CODE_IMPLEMENTATION

REPRODUCTION

ANALYSIS

SOLUTION DESIGN

IMPLEMENTATION

Issue Resolution Stages

Issue Resolution Stages



Reproduction

47 Issues (13.2%)

Issue Resolution Stages



Reproduction

47 Issues (13.2%)



Analysis

134 Issues (37.6%)

Issue Resolution Stages



Reproduction

47 Issues (13.2%)



Analysis

134 Issues (37.6%)



Solution Design

150 Issues (42.1%)

Issue Resolution Stages



Reproduction

47 Issues (13.2%)



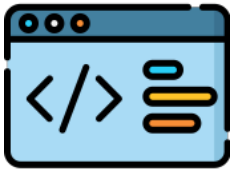
Analysis

134 Issues (37.6%)



Solution Design

150 Issues (42.1%)



Implementation

328 Issues (92.1%)

Issue Resolution Stages



Reproduction

47 Issues (13.2%)



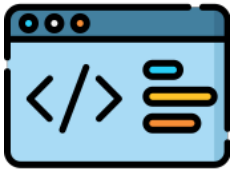
Analysis

134 Issues (37.6%)



Solution Design

150 Issues (42.1%)



Implementation

328 Issues (92.1%)



Code Review

264 Issues (74.2%)

Issue Resolution Stages



Reproduction

47 Issues (13.2%)



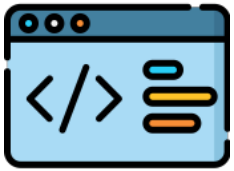
Analysis

134 Issues (37.6%)



Solution Design

150 Issues (42.1%)



Implementation

328 Issues (92.1%)



Code Review

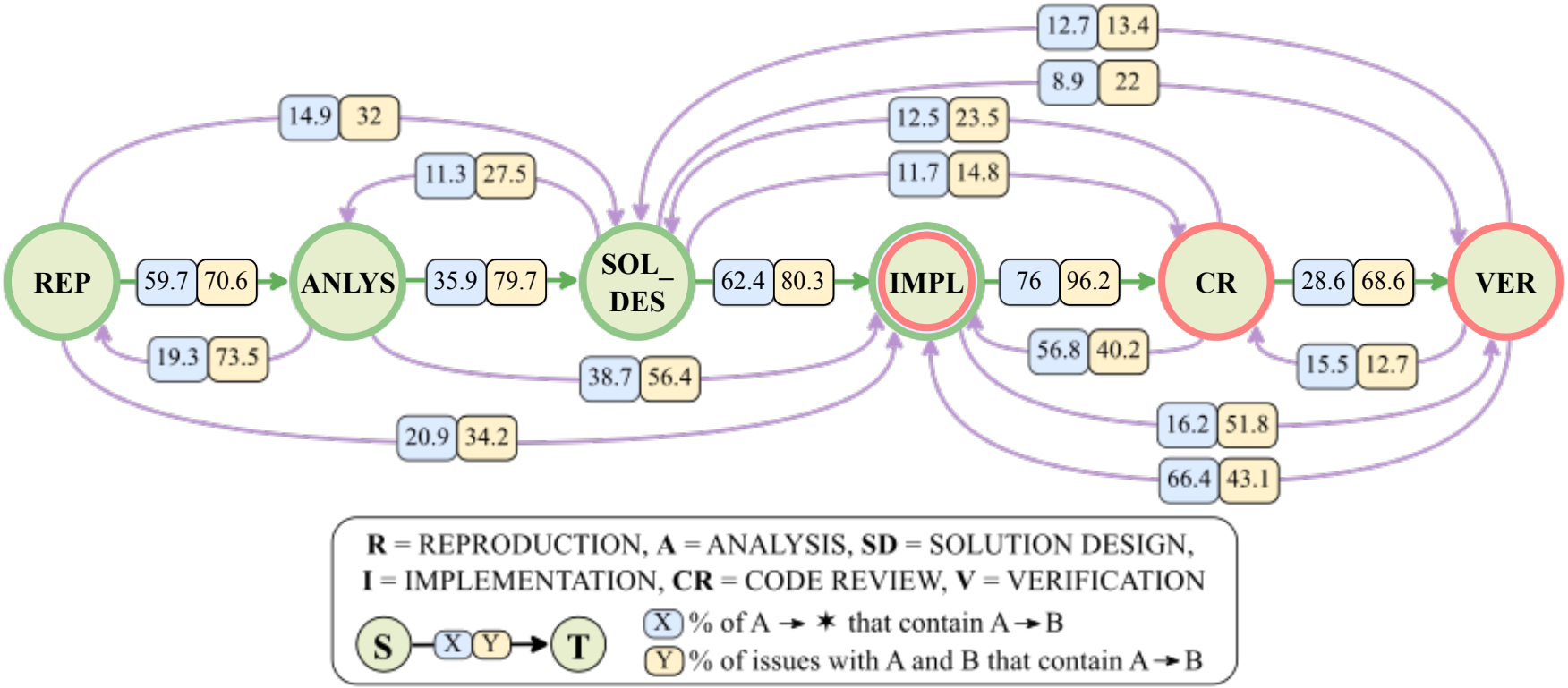
264 Issues (74.2%)



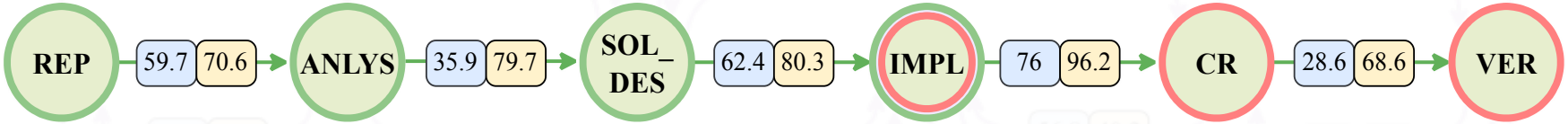
Verification

146 Issues (41%)

Overall Issue Resolution Process



Overall Issue Resolution Process



R = REPRODUCTION, **A** = ANALYSIS, **SD** = SOLUTION DESIGN,
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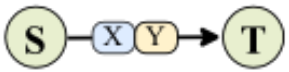
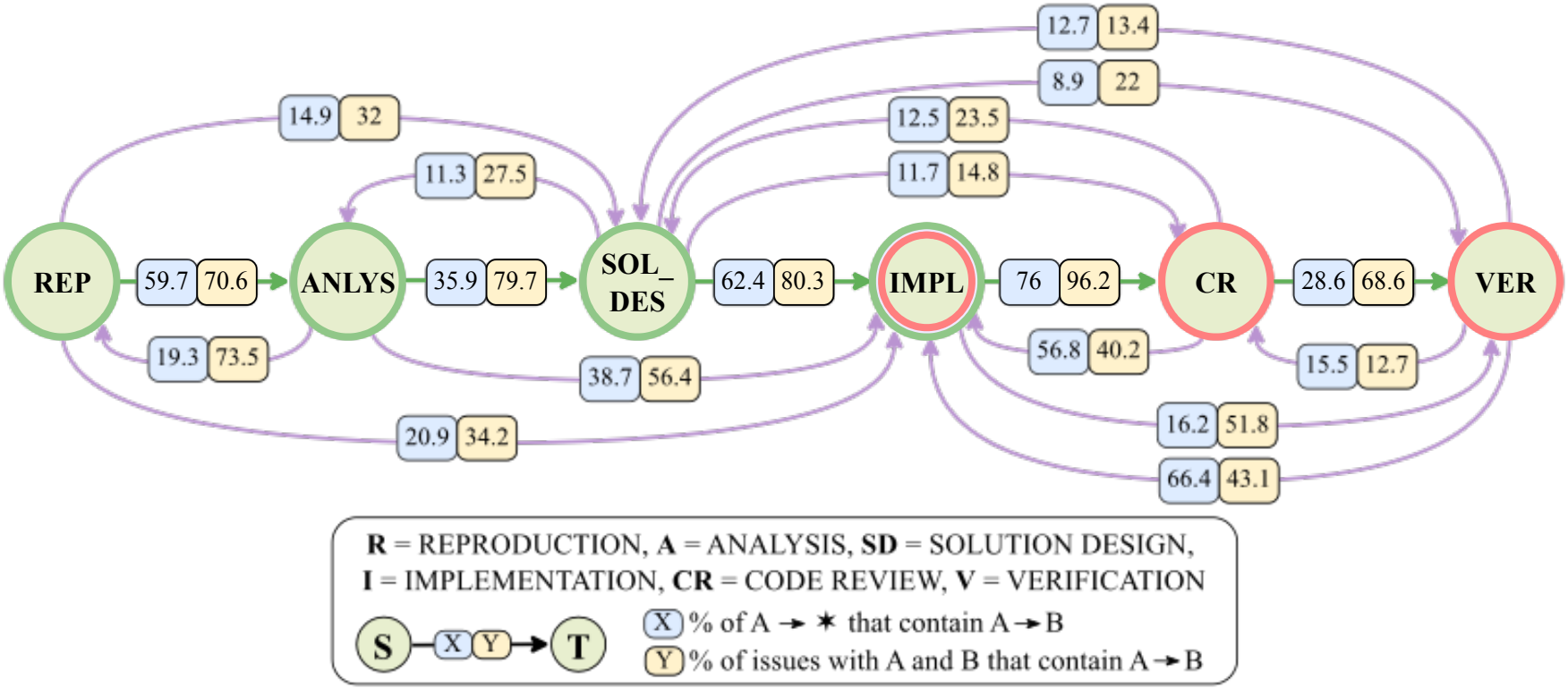


X % of A → ✶ that contain A → B

Y % of issues with A and B that contain A → B

Overall Issue Resolution Process



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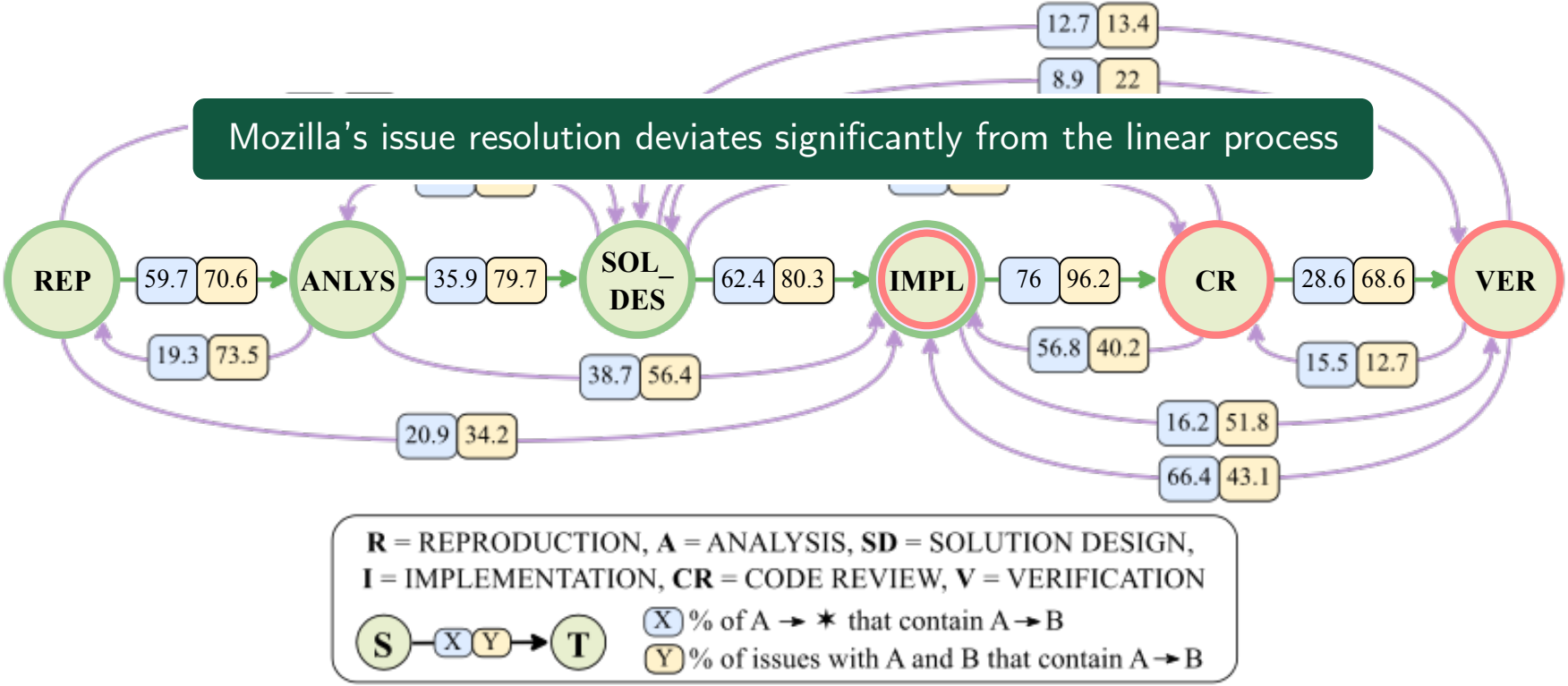

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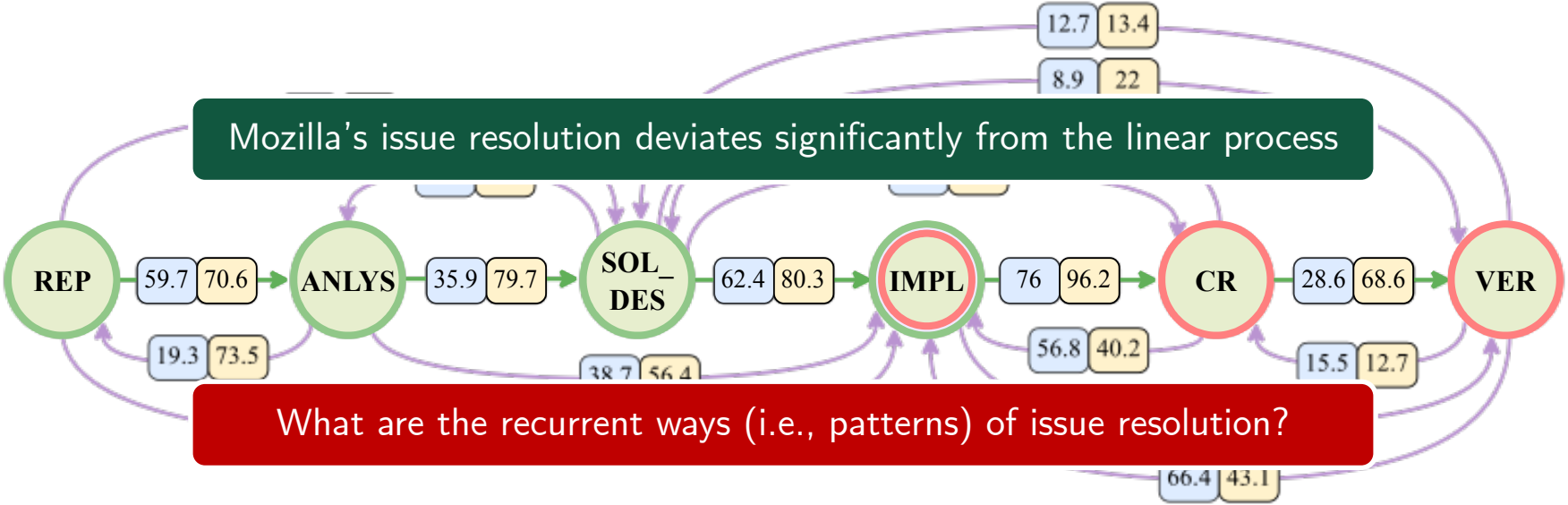

Mozilla's issue resolution deviates significantly from the linear process

What are the recurrent ways (i.e., patterns) of issue resolution?

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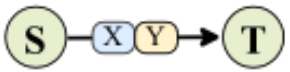

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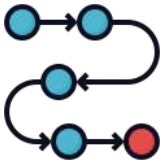
Inferring Issue Resolution Patterns

Stage Sequences



Qualitative Analysis



Grouping Sequences



Pattern Notations



Issue Resolution Patterns



Notation	Meaning
A?	A is optional
(A|B)	Either A/B/both stages
(A,B,...,Z)+	Repetitive A, B, ..., and Z

Pattern Derivation

Stages Sequence

Issue #585832 => REP → ANLYS → SOL_DES → IMPL

Pattern Derivation

Stages Sequence

Issue #585832	=>	REP → ANLYS → SOL_DES → IMPL
Issue #1253516	=>	REP → ANLYS → SOL_DES → IMPL
Issue #916390	=>	REP → ANLYS → SOL_DES → IMPL → CR
Issue #687929	=>	ANLYS → SOL_DES → REP → IMPL → CR → VER
Issue #1519164	=>	ANLYS → SOL_DES → REP → IMPL → CR → VER
Issue #833964	=>	REP → ANLYS → SOL_DES → IMPL → CR → IMPL → VER

Pattern Derivation

Stages Sequence

Issue #585832 => REP → ANLYS → SOL_DES → IMPL
Issue #1253516 => REP → ANLYS → SOL_DES → IMPL
Issue #916390 => REP → ANLYS → SOL_DES → IMPL → CR
Issue #687929 => ANLYS → SOL_DES → REP → IMPL → CR → VER
Issue #1519164 => ANLYS → SOL_DES → REP → IMPL → CR → VER
Issue #833964 => REP → ANLYS → SOL_DES → IMPL → CR → IMPL → VER

Issue Resolution Pattern

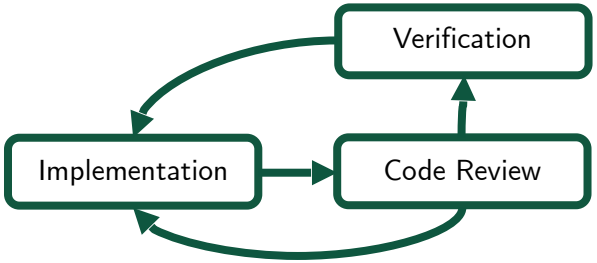
REP,ANLYS,SOL_DES,IMPL,(IMPL|CR|VER)?



More Pattern Examples

More Pattern Examples

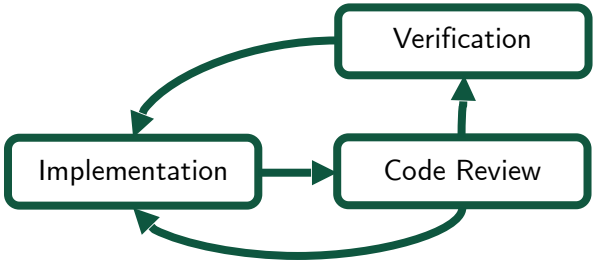
(IMPL,(CR|VER))+



28 Issues

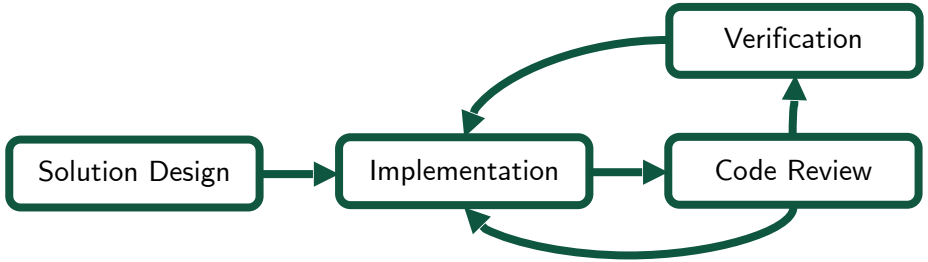
More Pattern Examples

(IMPL,(CR|VER))+



28 Issues

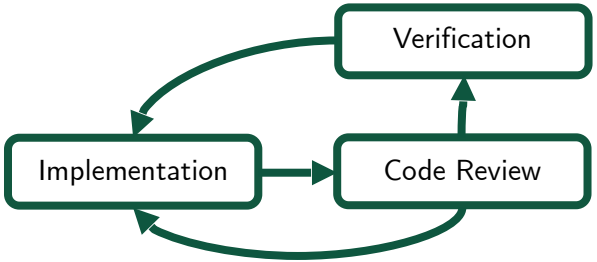
SOL_DES,(IMPL,(CR|VER))+



13 Issues

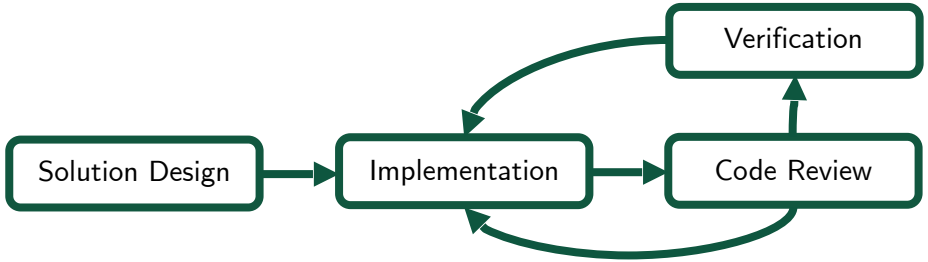
More Pattern Examples

(IMPL,(CR|VER))+



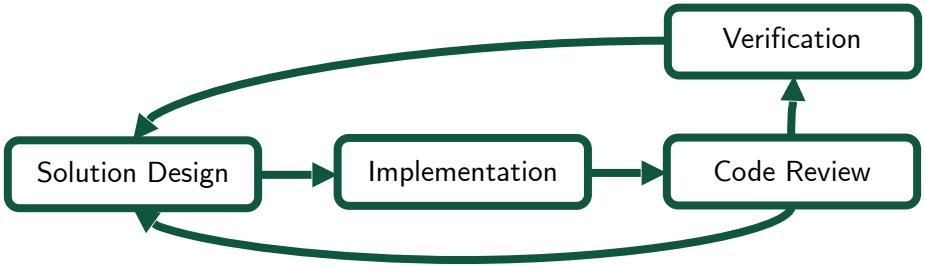
28 Issues

SOL_DES,(IMPL,(CR|VER))+



13 Issues

(SOL_DES,IMPL,(CR|VER))+

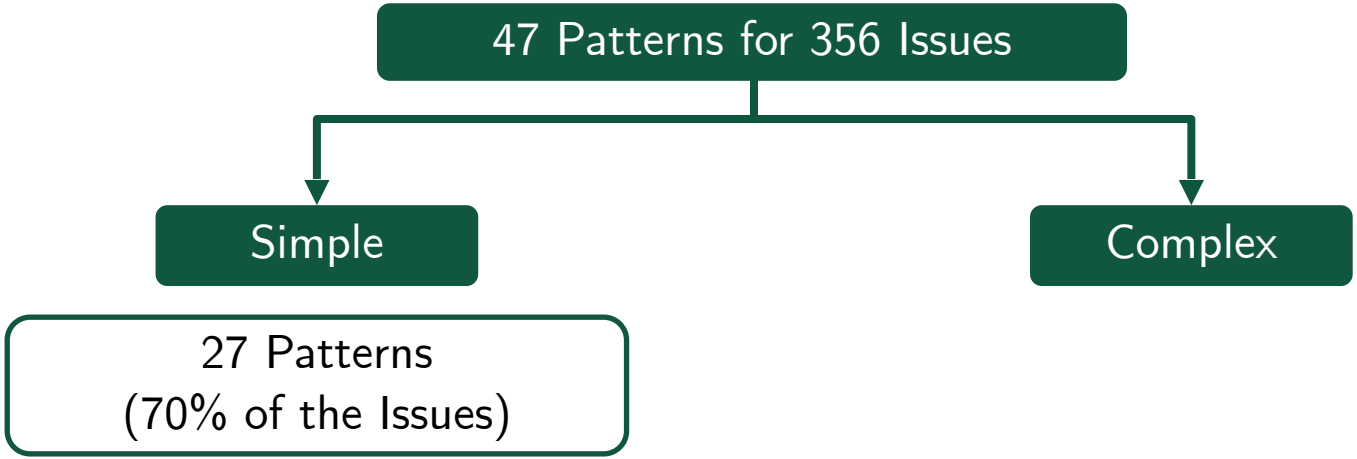


12 Issues

Overview of the Derived Patterns



Overview of the Derived Patterns



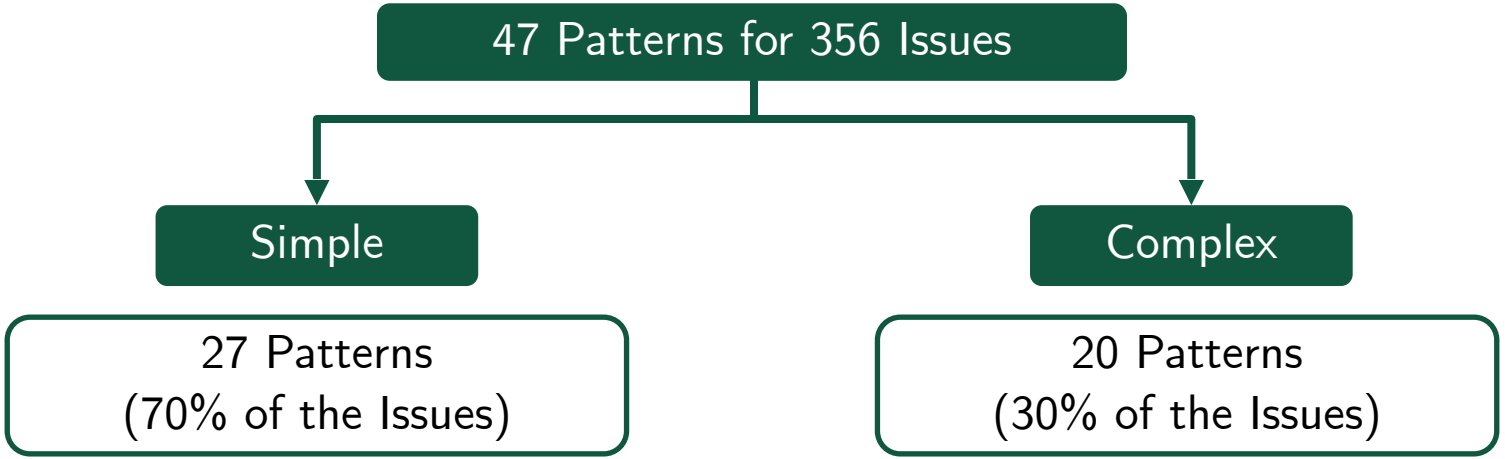
Do not contain repetitive stages

Examples

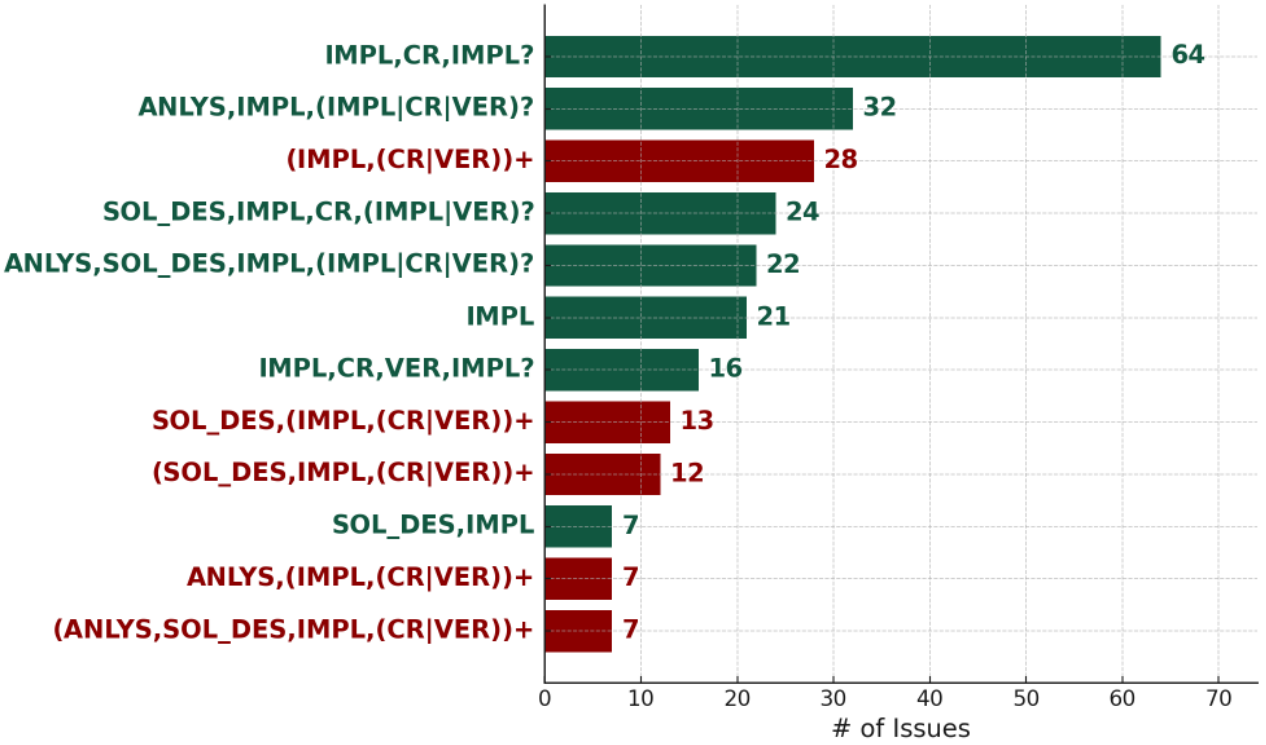
IMPL,CR,IMPL?

ANLYS,IMPL,(IMPL|CR|VER)?

Overview of the Derived Patterns



Issue Resolution Patterns



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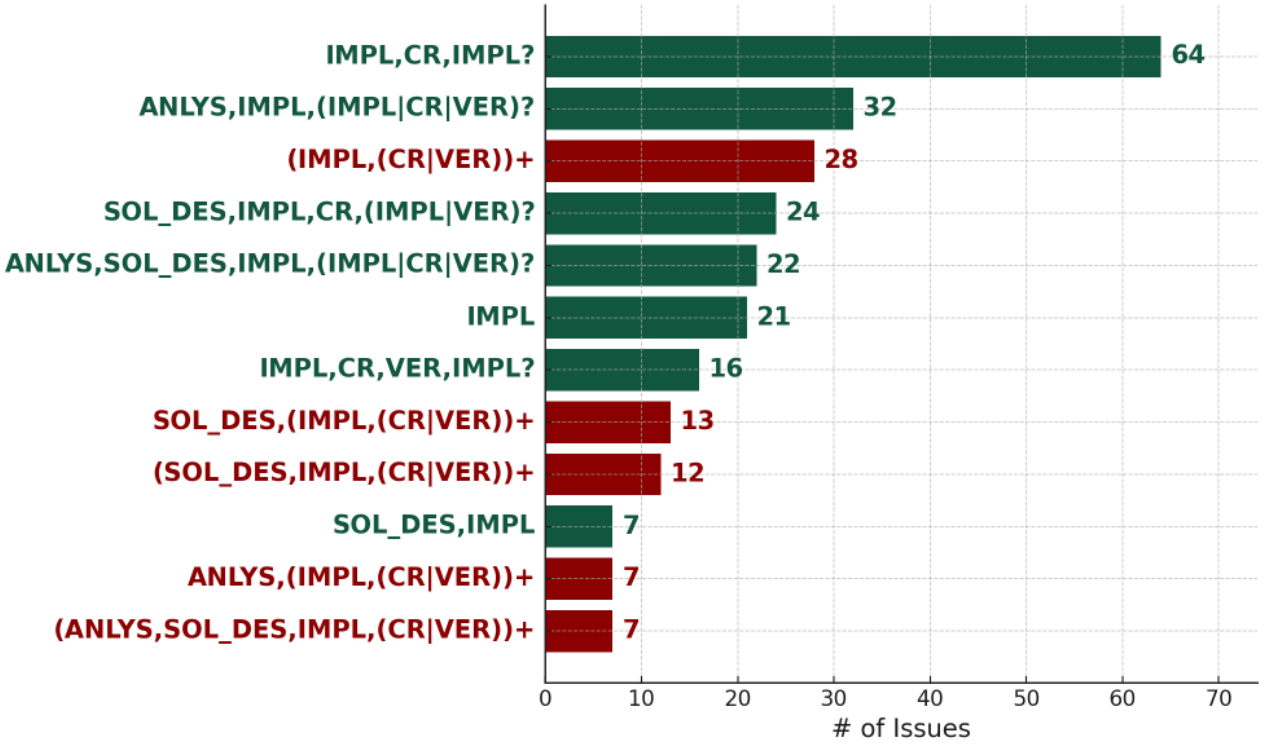
IMPL = Implementation, CR = Code Review, VER = Verification

Issue Resolution Patterns



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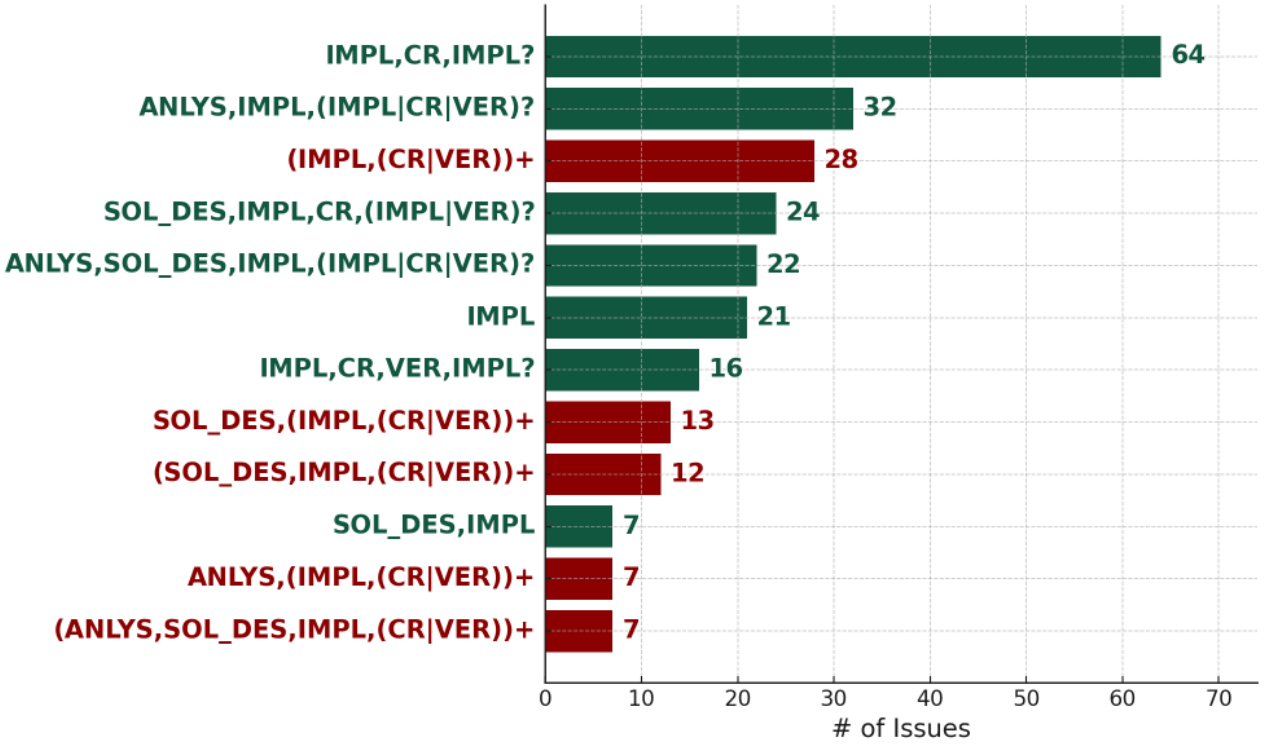
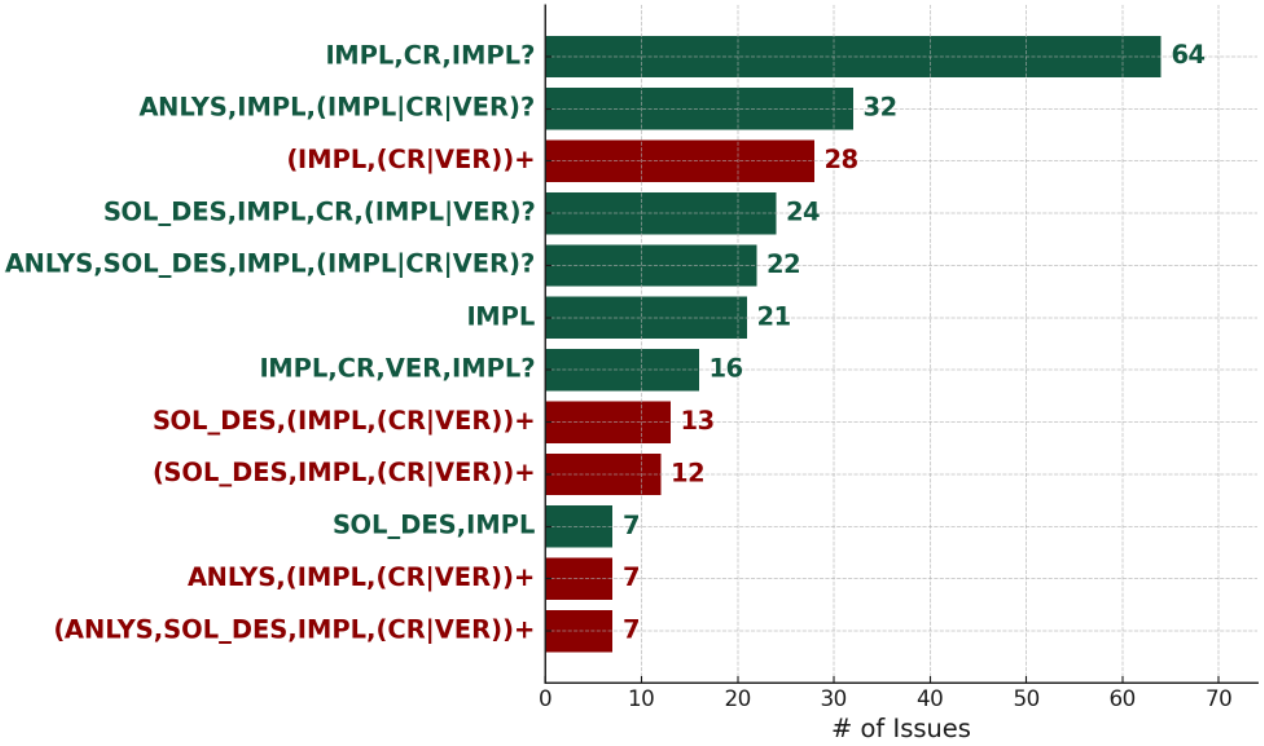


Mozilla developers follow diverse strategies during issue resolution

REP = Reproduction, ANLYS = Analysis, SOL_DES = Solution Design,
IMPL = Implementation, CR = Code Review, VER = Verification

Issue Resolution Patterns



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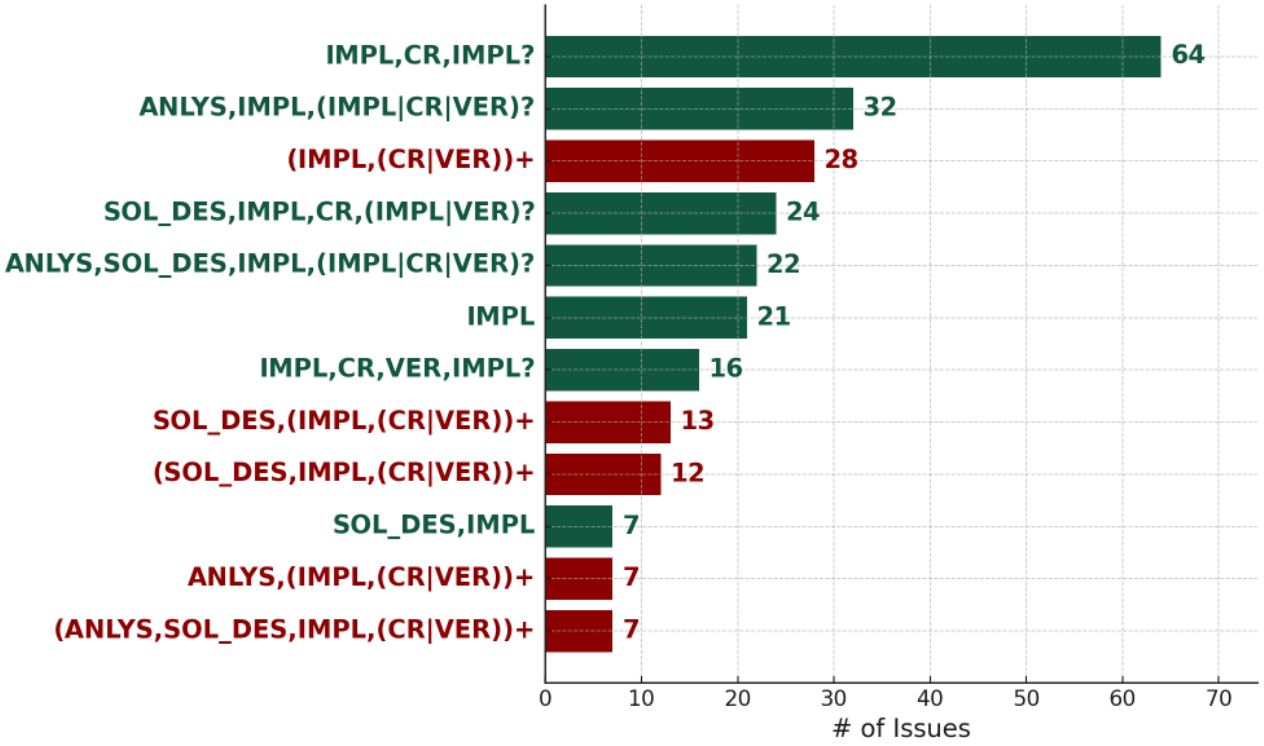

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Interview with Firefox Developers

2 Mozilla Devs



7 - 11 years of Mozilla experience
Contributed to ≈19K issues

Online Interview



Analyze Responses



Use Cases of Patterns

Use Cases of Patterns



Identifying Issues with a Complex Resolution

Use Cases of Patterns



Identifying Issues with a Complex Resolution



Identifying Issues Not Following the Expected Process

Use Cases of Patterns



Identifying Issues with a Complex Resolution



Identifying Issues Not Following the Expected Process



Identifying Potentially Complex Code Components

Use Cases of Patterns



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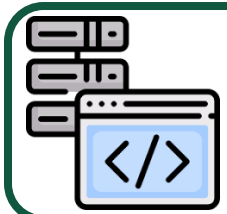

Identifying Potentially Complex Code Components



Improving Bots to Detect Unsolvable Issues

Use Cases of Patterns



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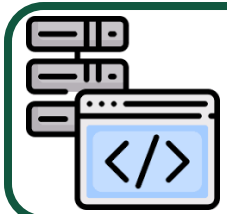

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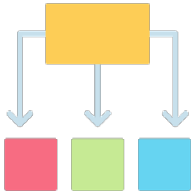

Suggesting and Decomposing Meta-Issues

Use Cases of Patterns



Identifying Issues with a Complex Resolution



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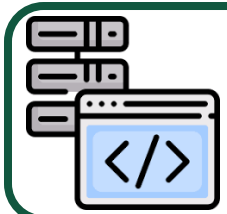

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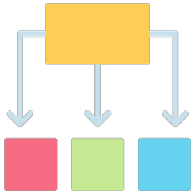

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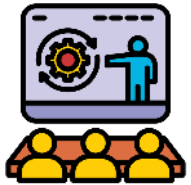


Training Junior Developers

Generalizability of Patterns

Generalizability of Patterns

Chromium

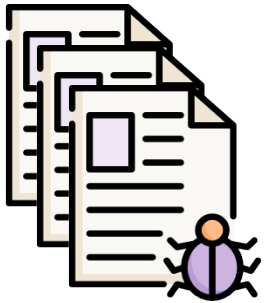


GnuCash



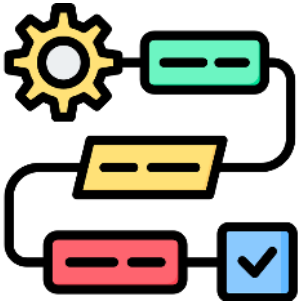


20 Issue Reports





Resolution Patterns



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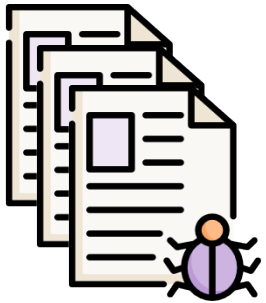



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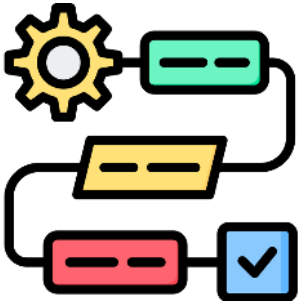
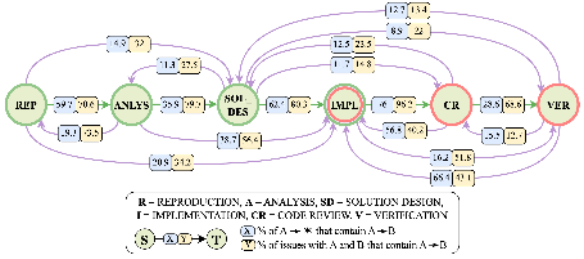


We found similar patterns to Mozilla

Overall Issue Resolution Process



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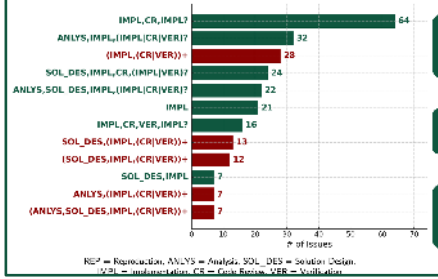

Mozilla developers follow diverse strategies during issue resolution

18 patterns are found in 80% of the issues

Pattern diversity is evident across Firefox's 14 years of evolution

Use Cases of Patterns

- Identifying Issues with a Complex Resolution
- Identifying Issues Not Following the Expected Process
- Identifying Potentially Complex Code Components
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- Suggesting and Decomposing Meta-Issues
- Training Junior Developers

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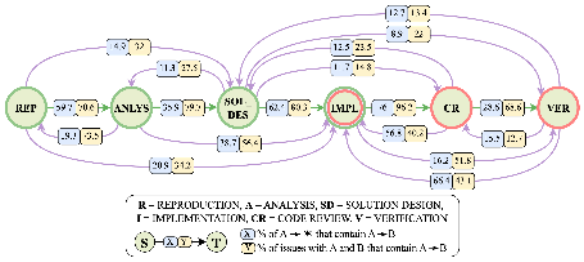

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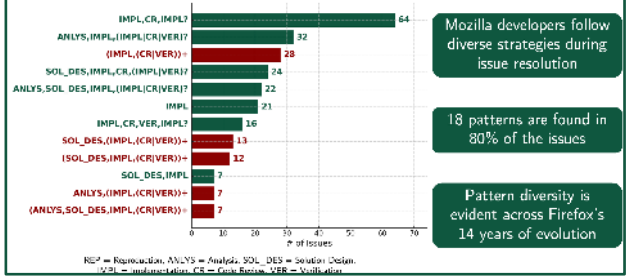

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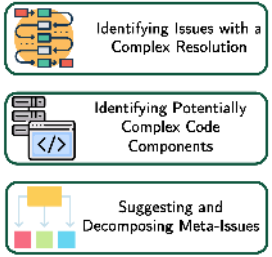

- Six Issue Resolution Stages
- Overall Issue Resolution Process
- 47 Issue Resolution Patterns

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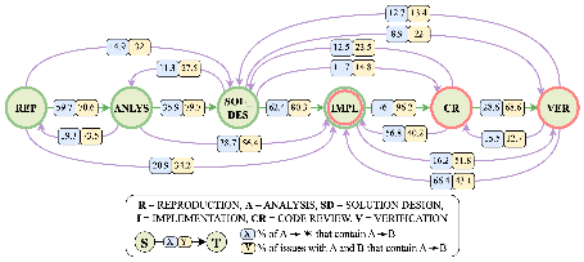

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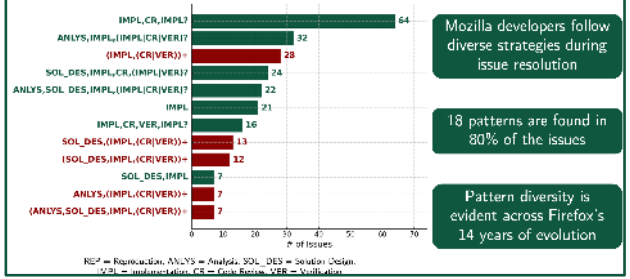

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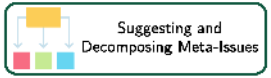
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Training Junior Developers

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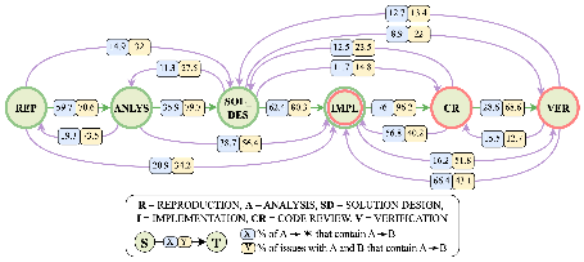
Issue resolution in practice deviates significantly from the linear process

Developers follow a variety of strategies (i.e., patterns) for issue resolution

Overall Issue Resolution Process



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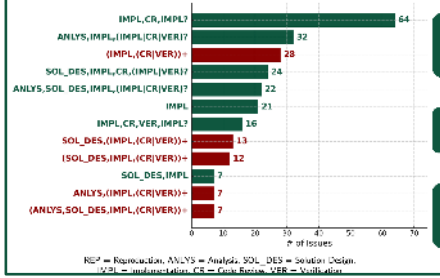

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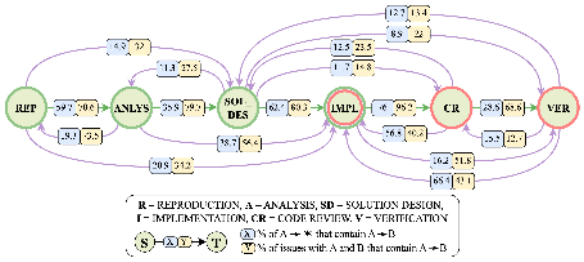
Identify the issue resolution process problem and improve the process

Train Mozilla developers and educate the new software engineers

Overall Issue Resolution Process



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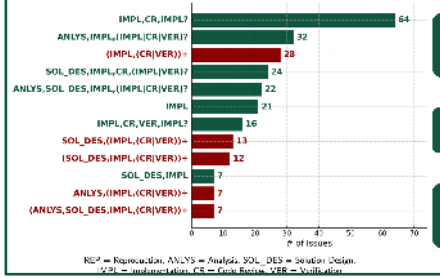

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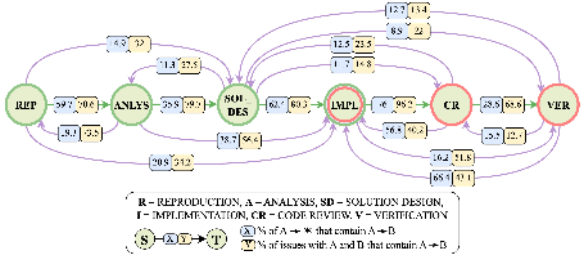

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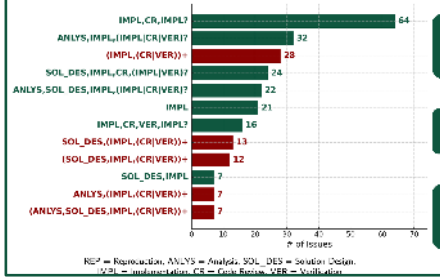

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Artifacts Available V1.1 · Artifacts Evaluated Functional V1.1 · Artifacts Evaluated Reusable V1.1

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SCAN ME

Antu Saha
asaha02@wm.edu