Em Busca de Maior Simplicidade e Confiabilidade no Processo de Integração de Código

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In Search of Greater Simplicity and Reliability for the Code Integration Process

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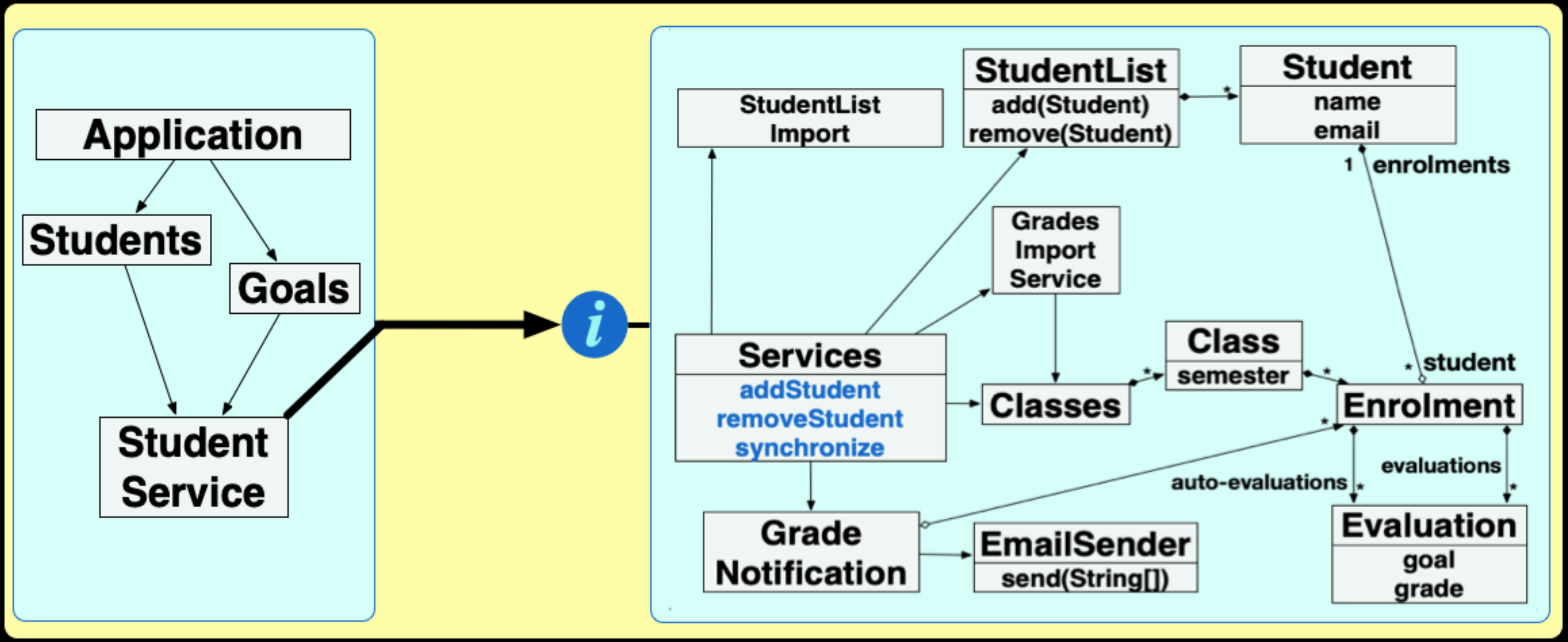
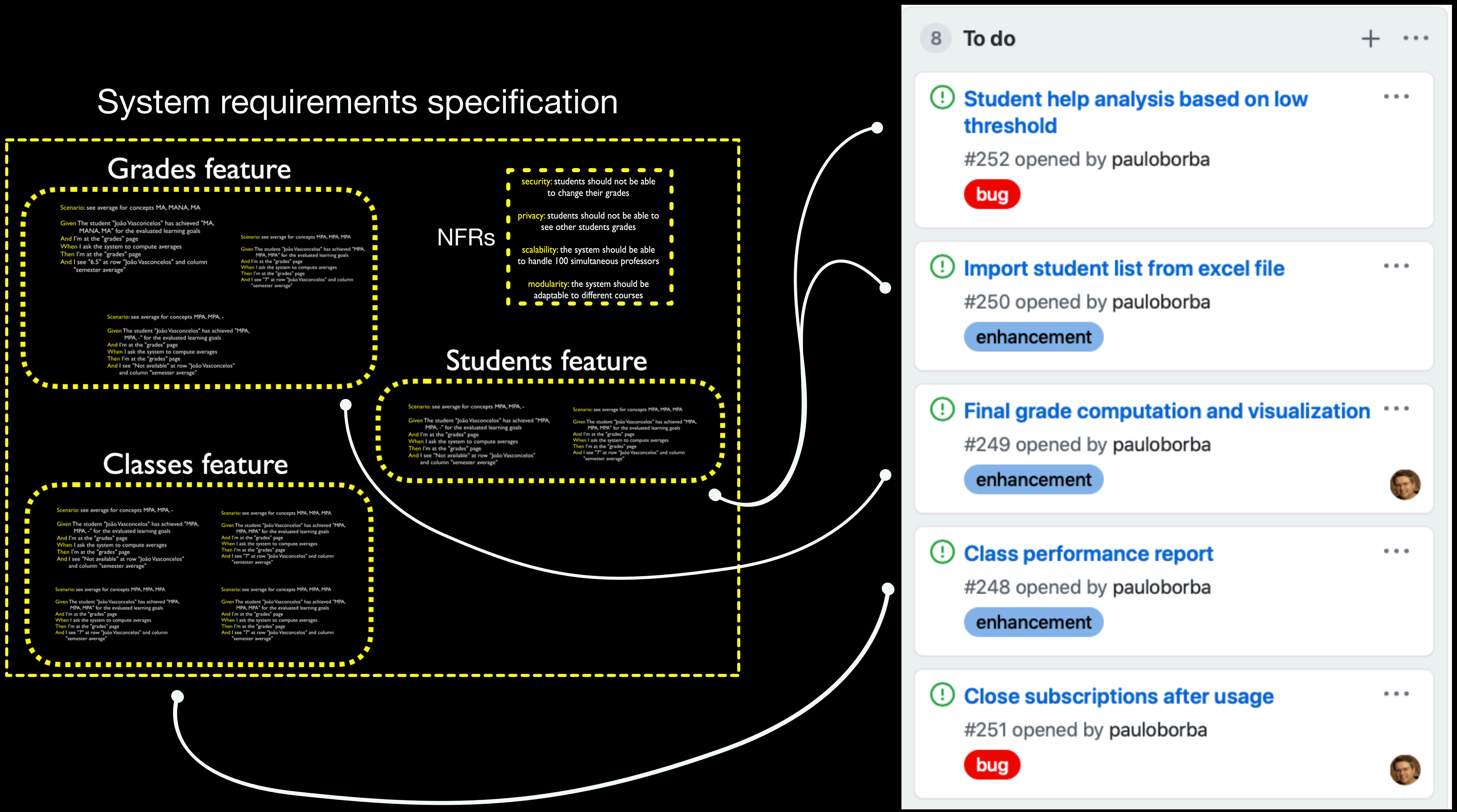
Collaborative software development



Task structure is often derived from requirements structure



Grades feature

```
Scenario: see average for concepts MA, MANA, MA

Given The student "João Vasconcelos" has achieved "MA,
      MANA, MA" for the evaluated learning goals
And I'm at the "grades" page
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And I see "6.5" at row "João Vasconcelos" and column
     "semester average"
```

```
Scenario: see average for concepts MPA, MPA, MPA

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```
Scenario: see average for concepts MPA, MPA, -

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Then I'm at the "grades" page
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```

NFRs

security: students should not be able to change their grades

privacy: students should not be able to see other students grades

scalability: the system should be able to handle 100 simultaneous professors

modularity: the system should be adaptable to different courses

Students feature

```
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Classes feature

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8 To do

Student help analysis based on low threshold
#252 opened by pauloborba
bug

Import student list from excel file
#250 opened by pauloborba
enhancement

Final grade computation and visualization
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Class performance report
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Close subscriptions after usage
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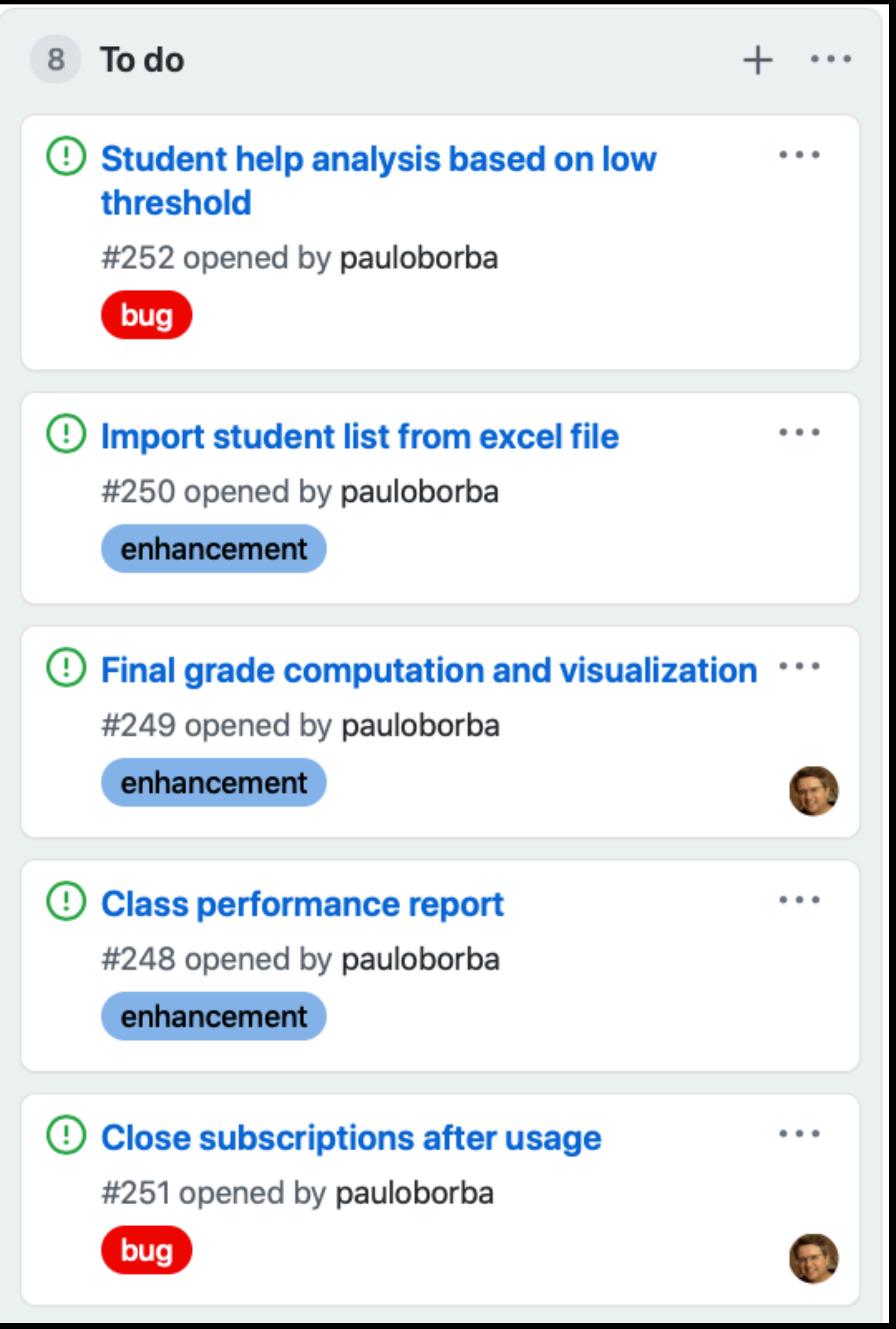
Tasks are often crosscutting



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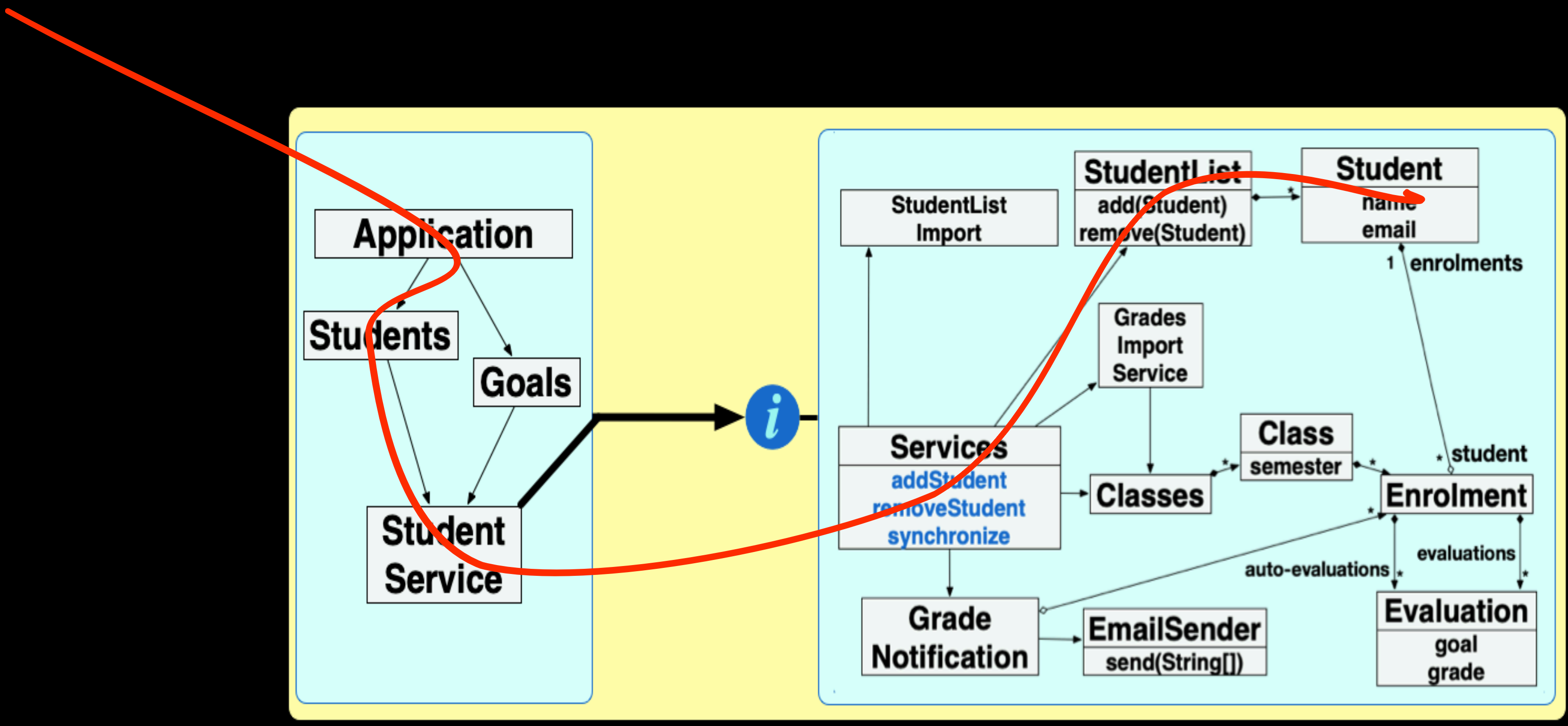
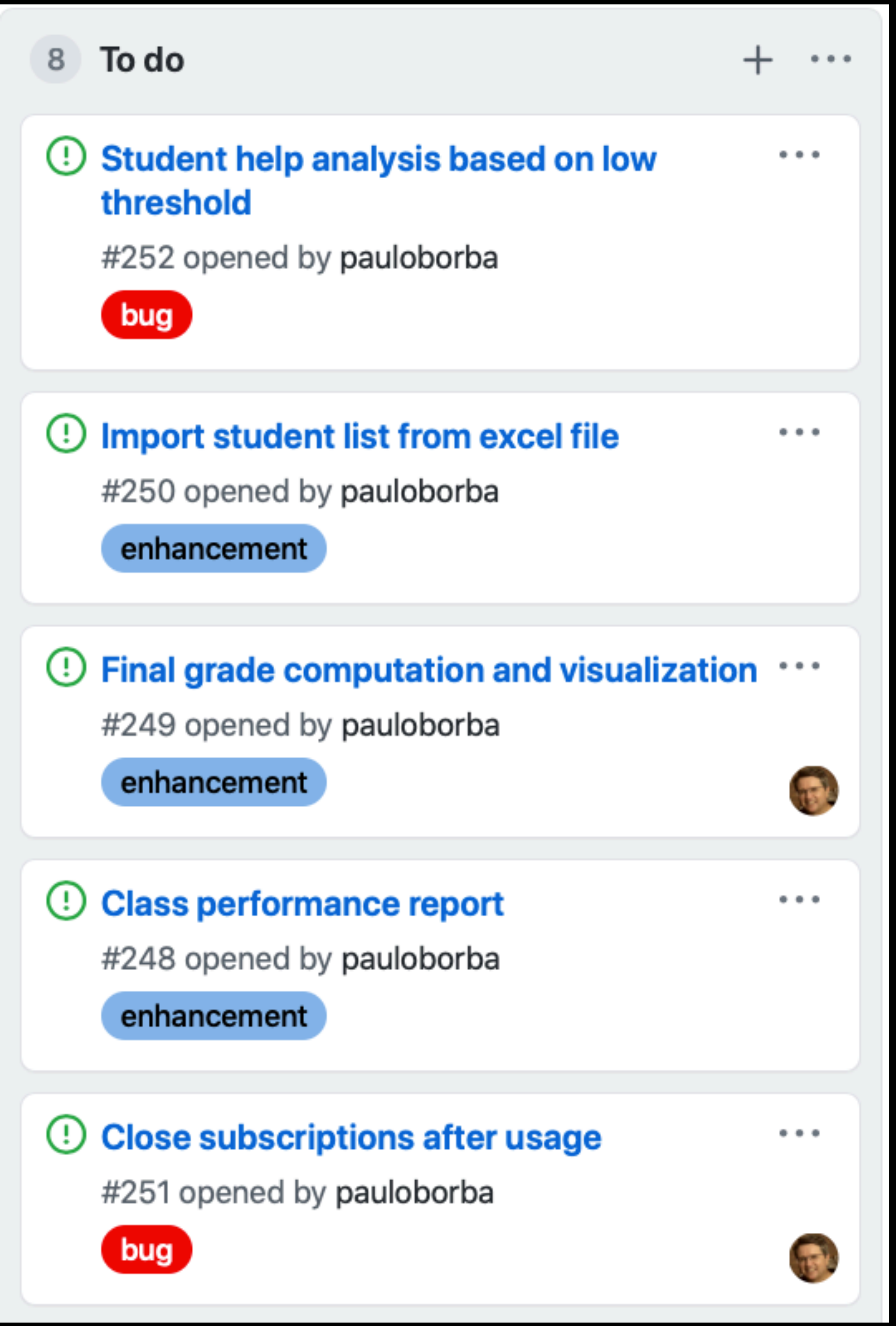


Tasks might involve changing classes in common



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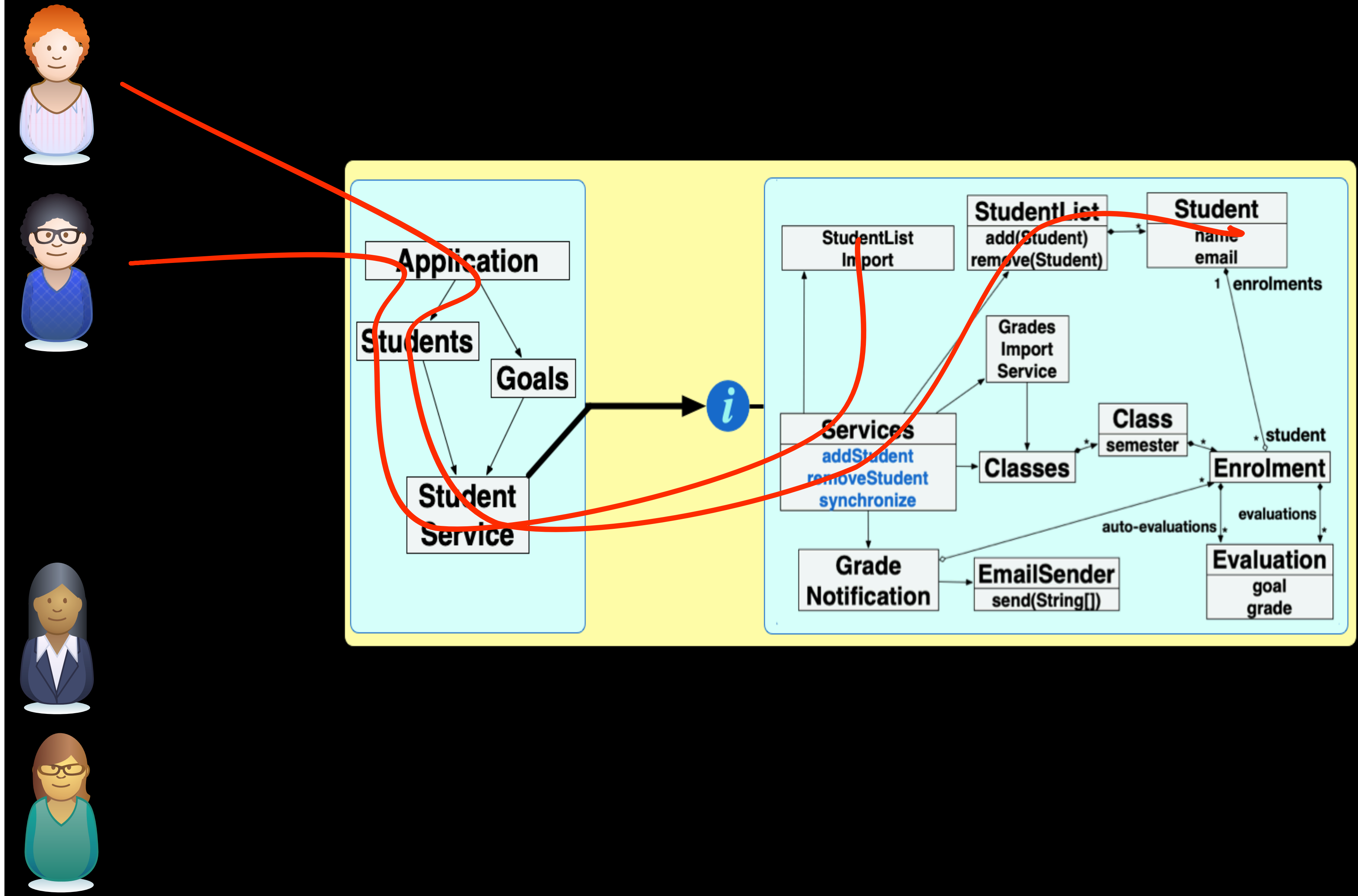
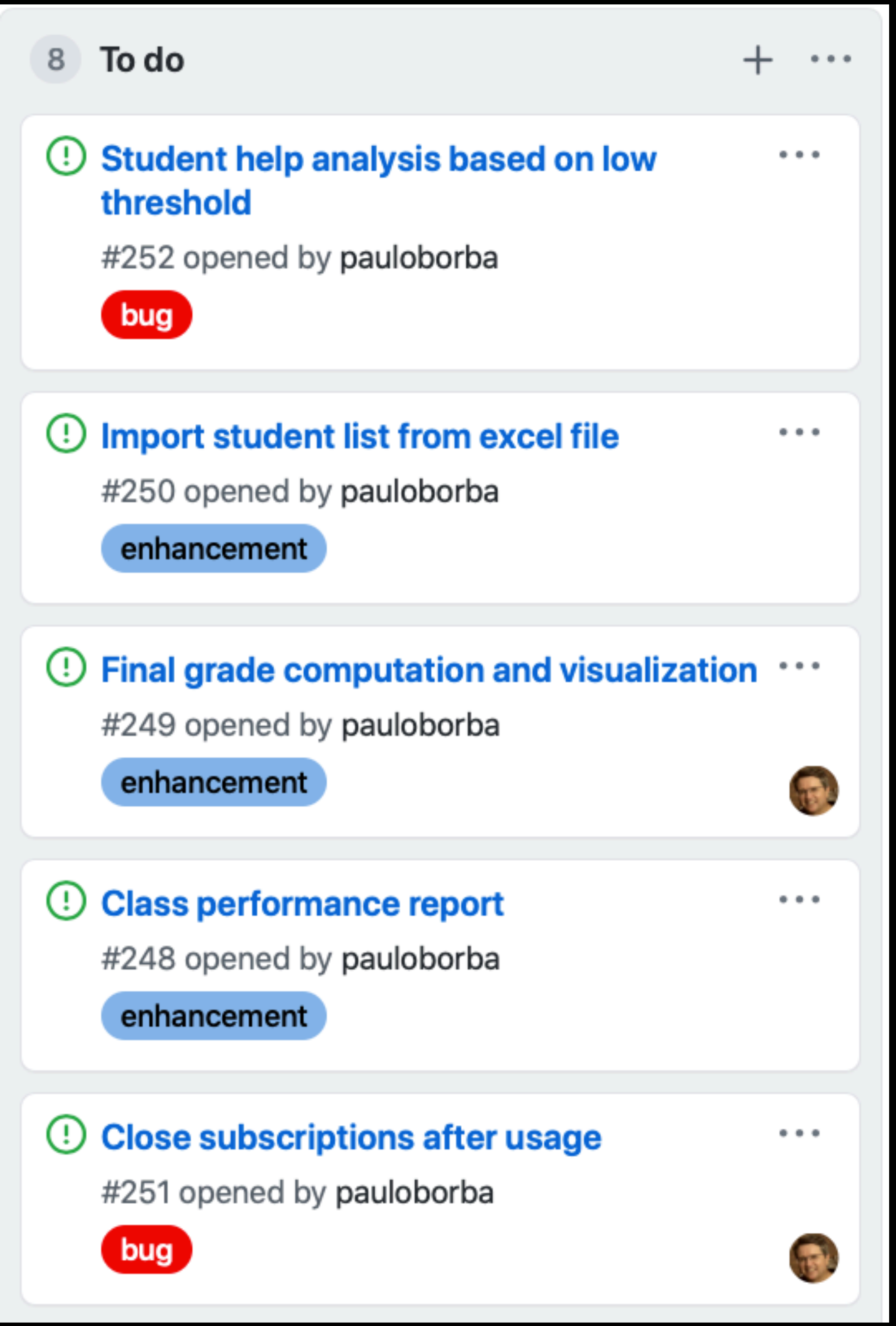


Task structure often does not match code structure



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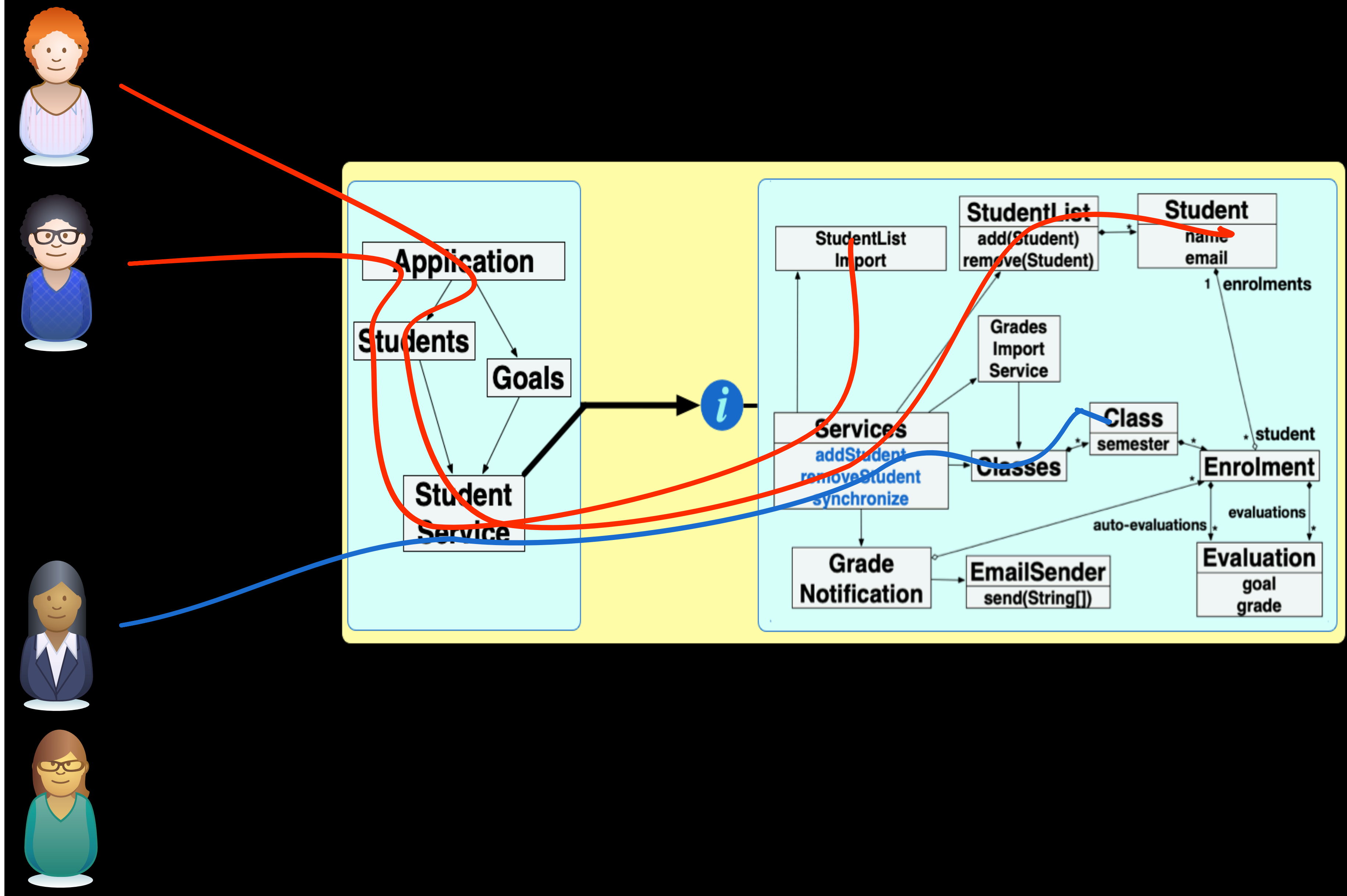
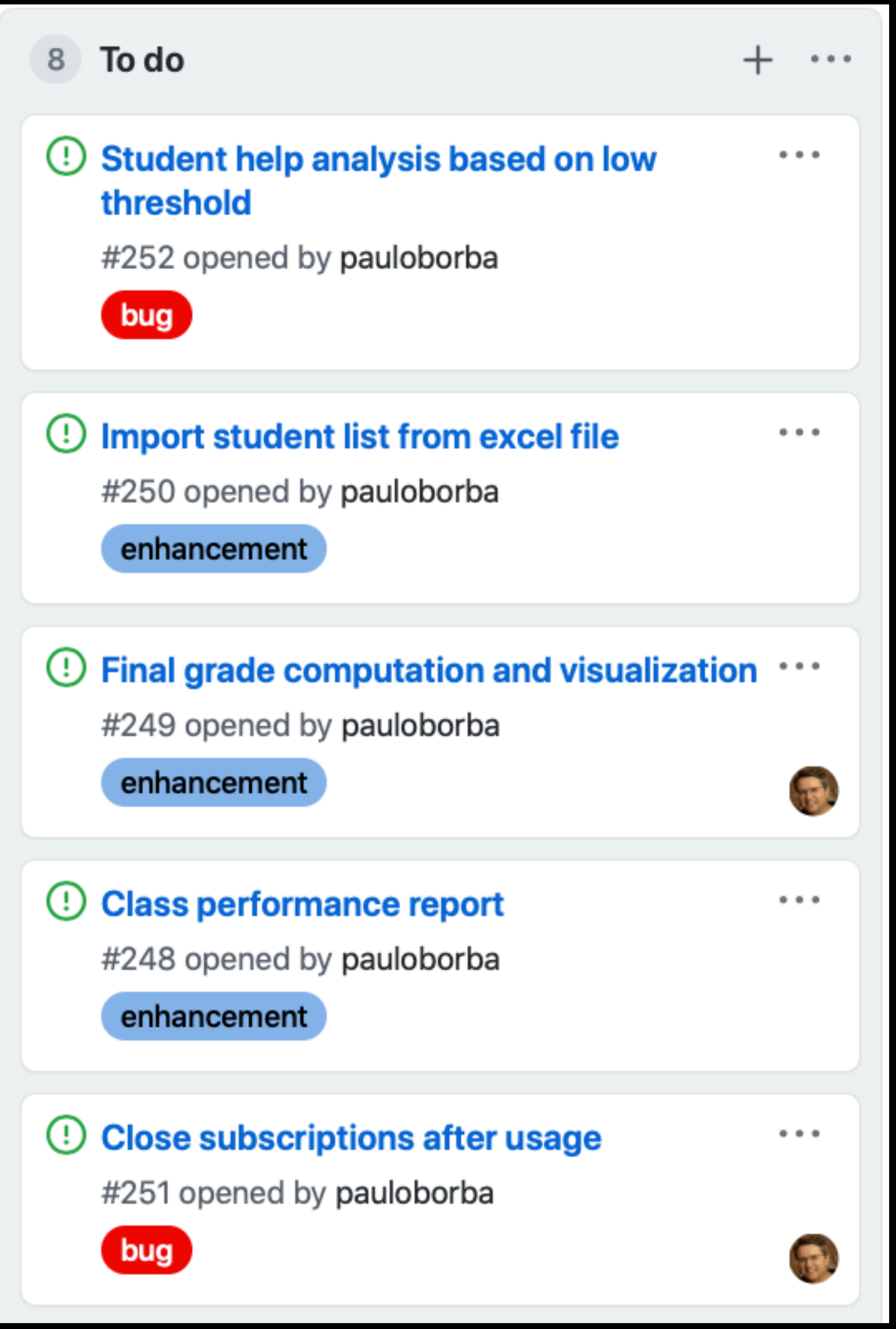


Modular development is not always possible, no matter the investment in modularity



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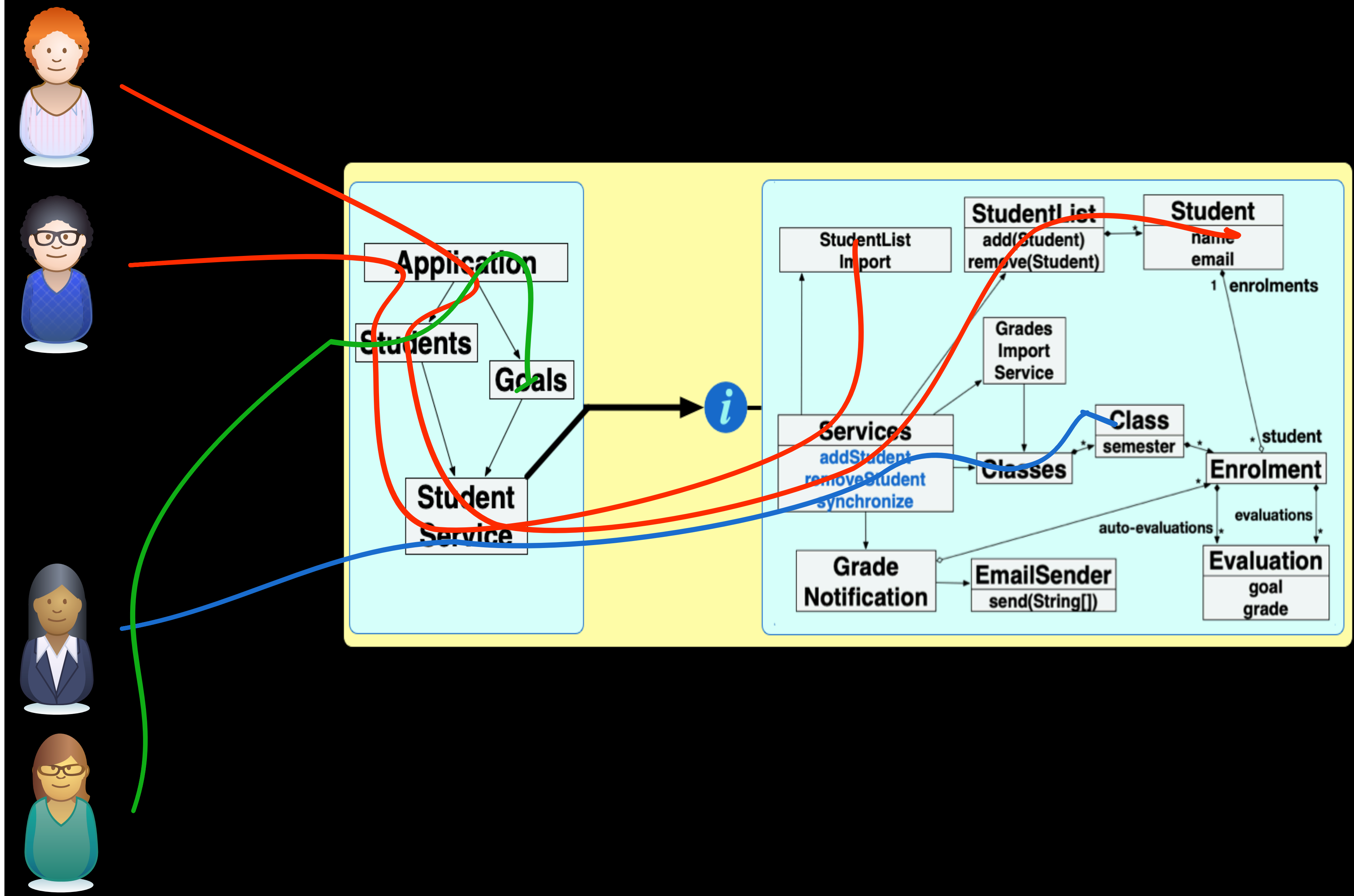
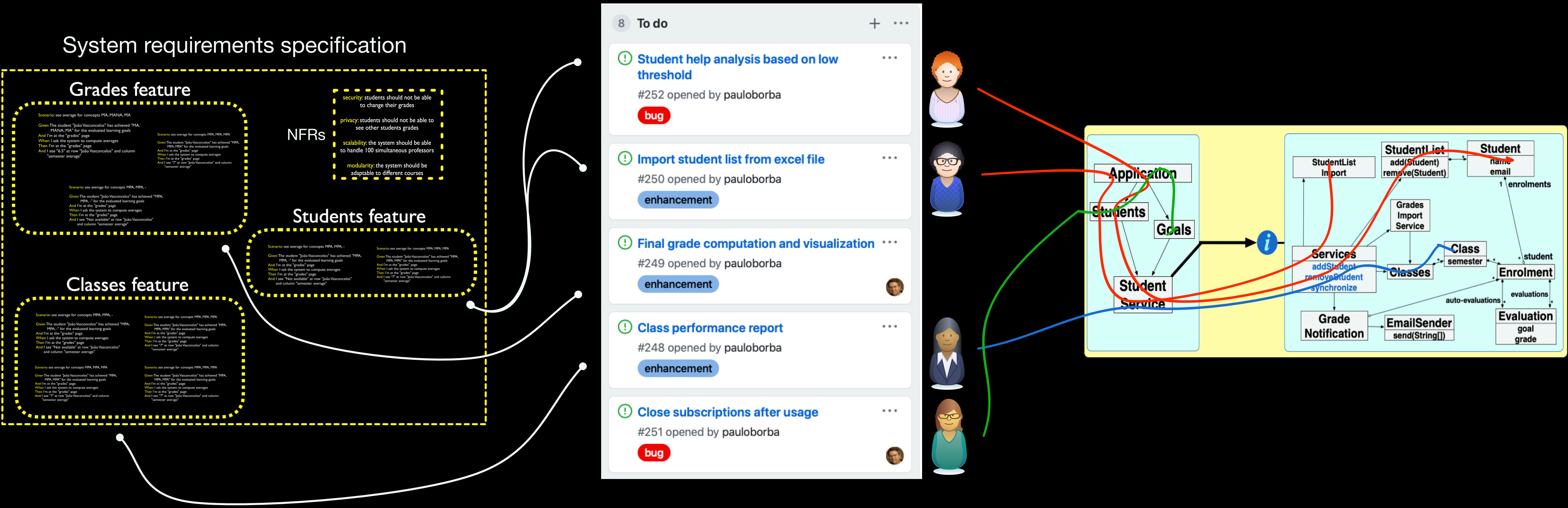


Different modular structures for different artifacts



System requirements specification

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How to reconcile different modular structures with collaborative parallel development?

Improved code integration and merging

Modular development when interfaces are difficult to define

Modular feature development in Software Product Lines (feature interaction)

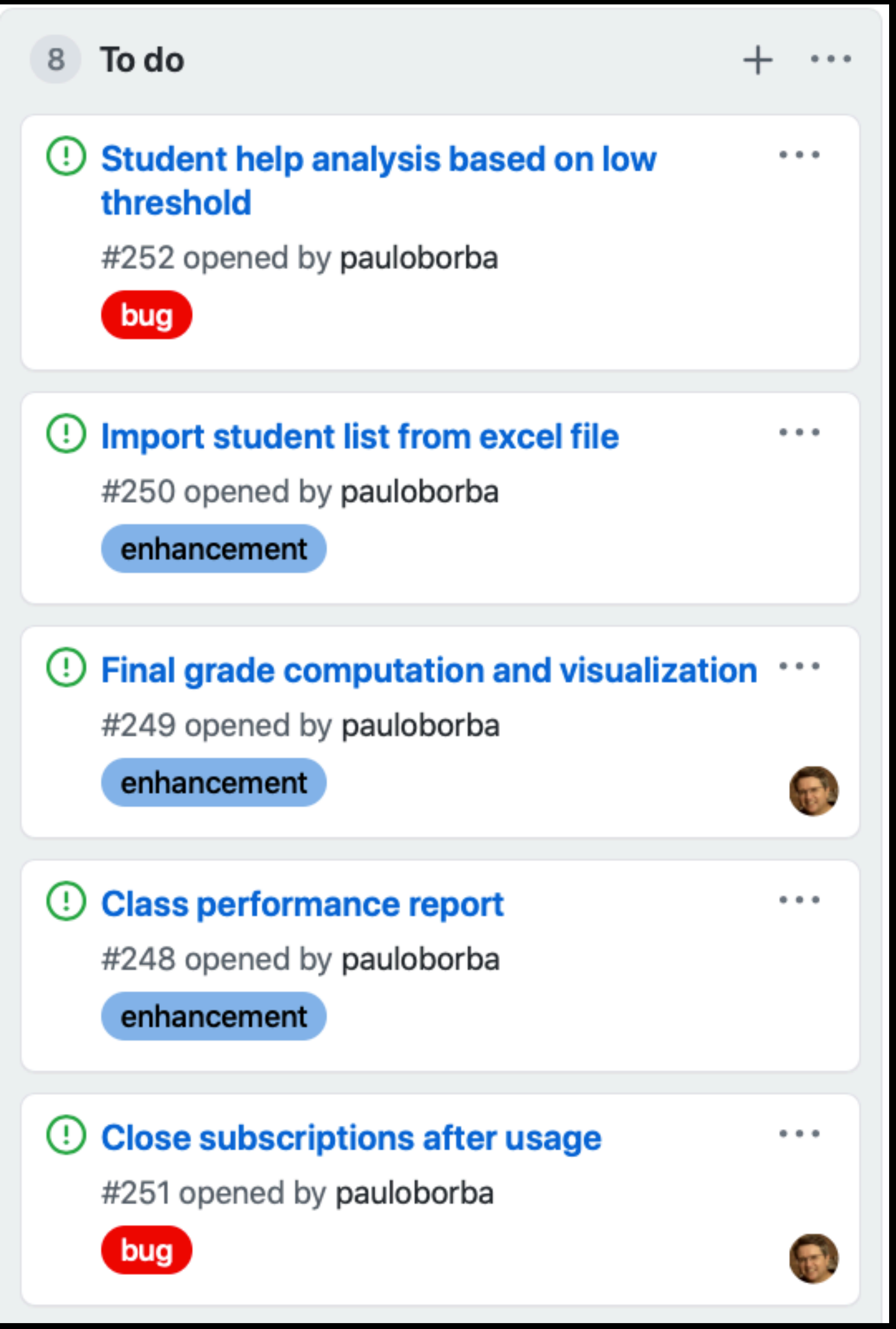
being exposed to software development pains

seeking feedback from excellent reviewers

talking to people with different background and views

What could go wrong during code integration?

(assuming branching and merging is available)



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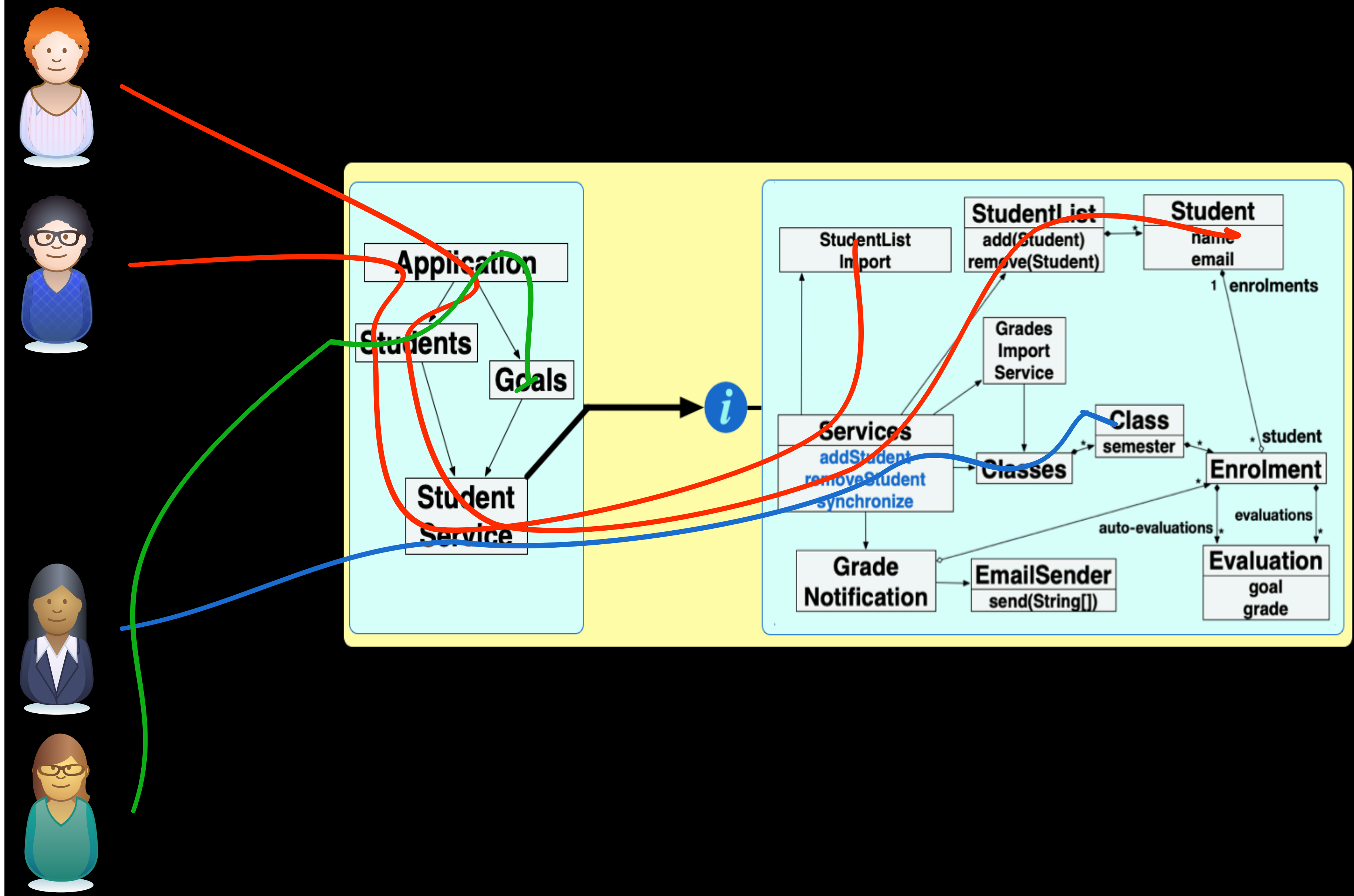
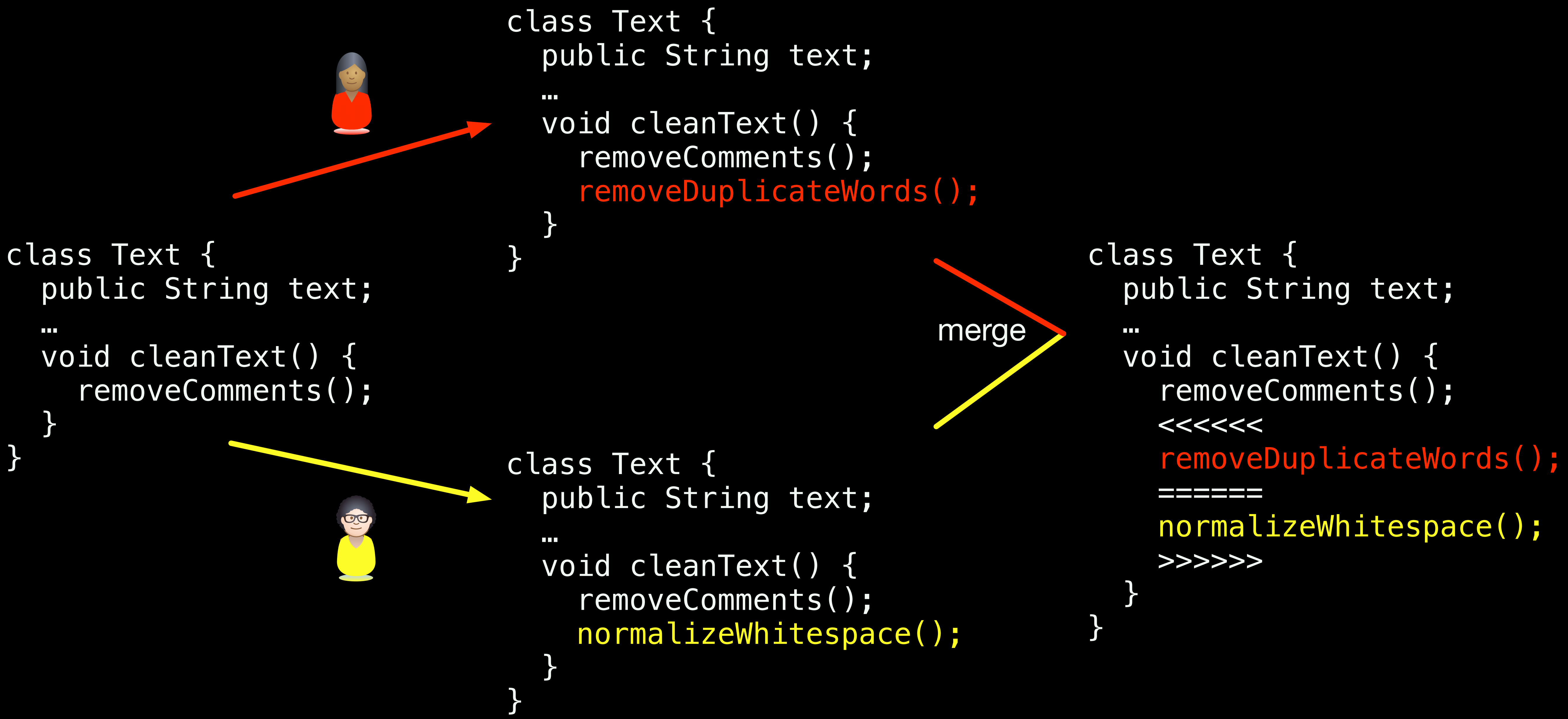


Merge conflicts

(textual conflicts)



```
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  public String text;
  …
  void cleanText() {
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
    removeDuplicateWords();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
    normalizeWhitespace();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
    <<<<<<
    removeDuplicateWords();
    ======
    normalizeWhitespace();
    >>>>>>
  }
}
```

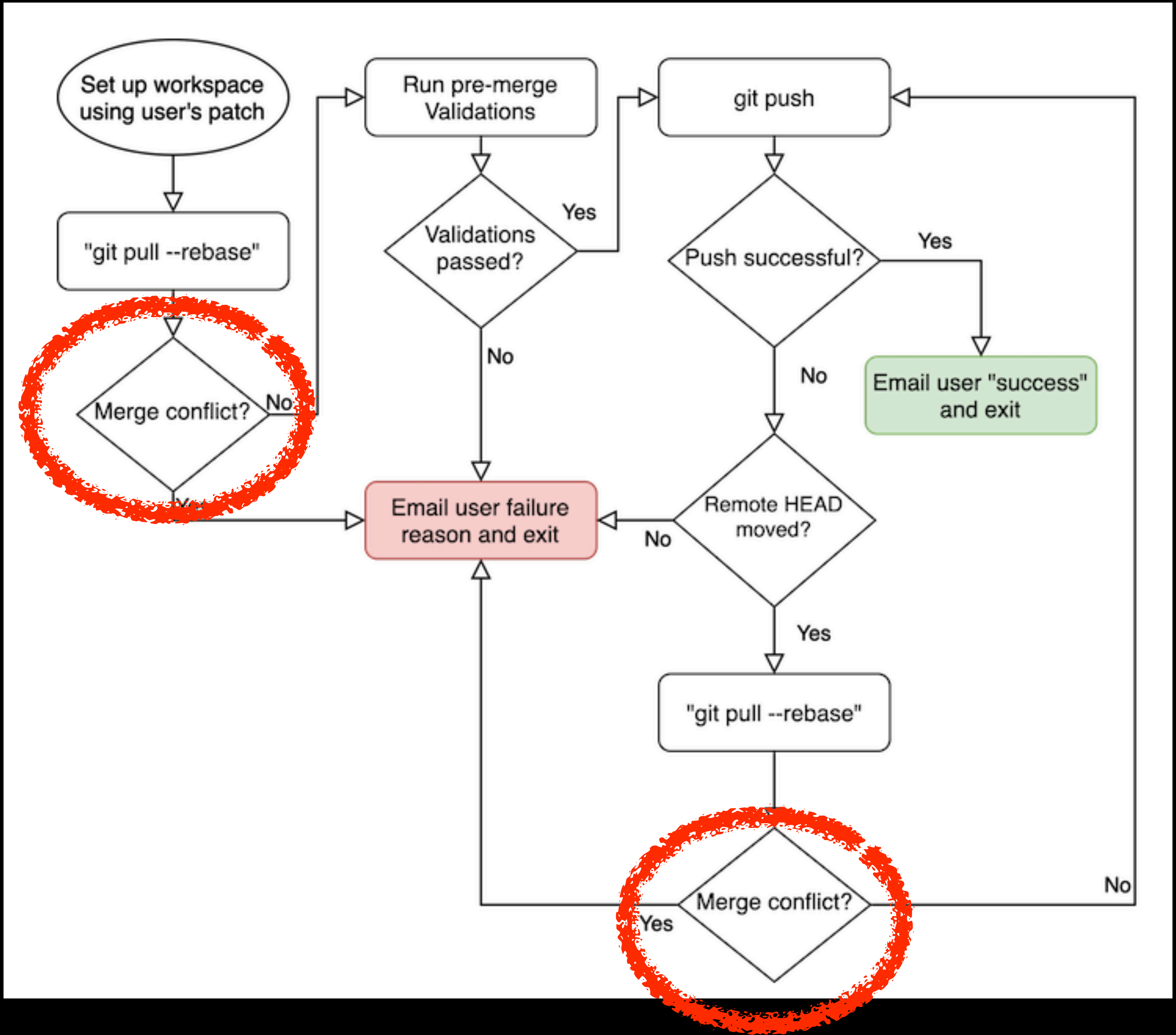
occur in many merge scenarios [Kasi&Sarma, Brun et al, Zimmermann]

affect productivity and quality [Meyer et al]

Avoiding merge conflicts at any cost...

- rushing to finish changes first
- partial check-ins
- continuous integration
- trunk-based development
- feature toggles

only partially motivated by the need to avoid merge conflicts, but with drawbacks anyway

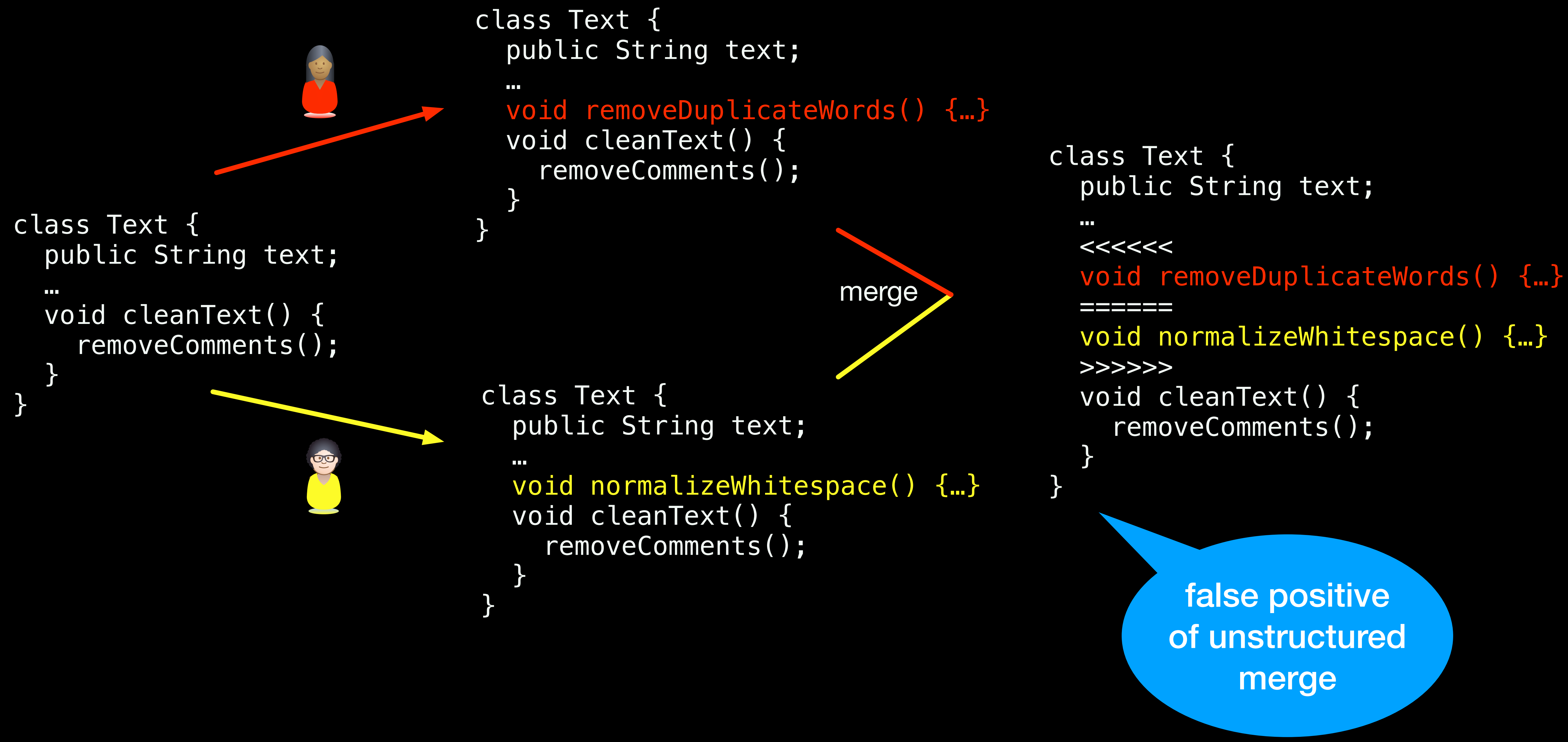


Niket Parikh. How LinkedIn handles merging code in high-velocity repositories. April 2020.

https://engineering.linkedin.com/blog/2020/continuous-integration

The code integration process should be simpler and more reliable

Developers waste time by manually resolving conflicts that could be automatically solved



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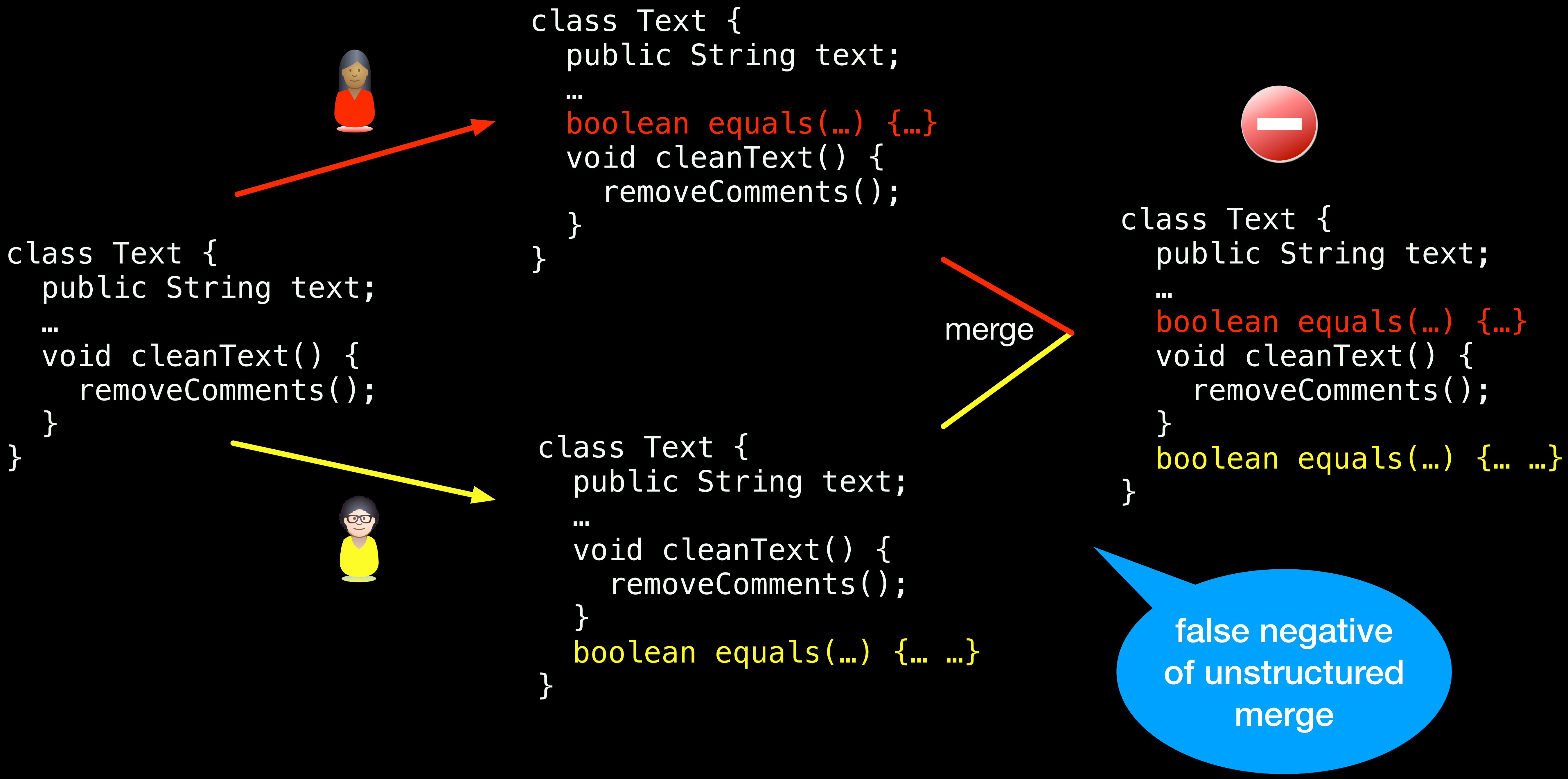
}
```

false positive of unstructured merge

Current merge tools might integrate conflicting changes without warning developers



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  public String text;
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  void cleanText() {
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  }
}
```

```
class Text {
  public String text;
  …
  boolean equals(…) {…}
  void cleanText() {
    removeComments();
  }
}
```

```
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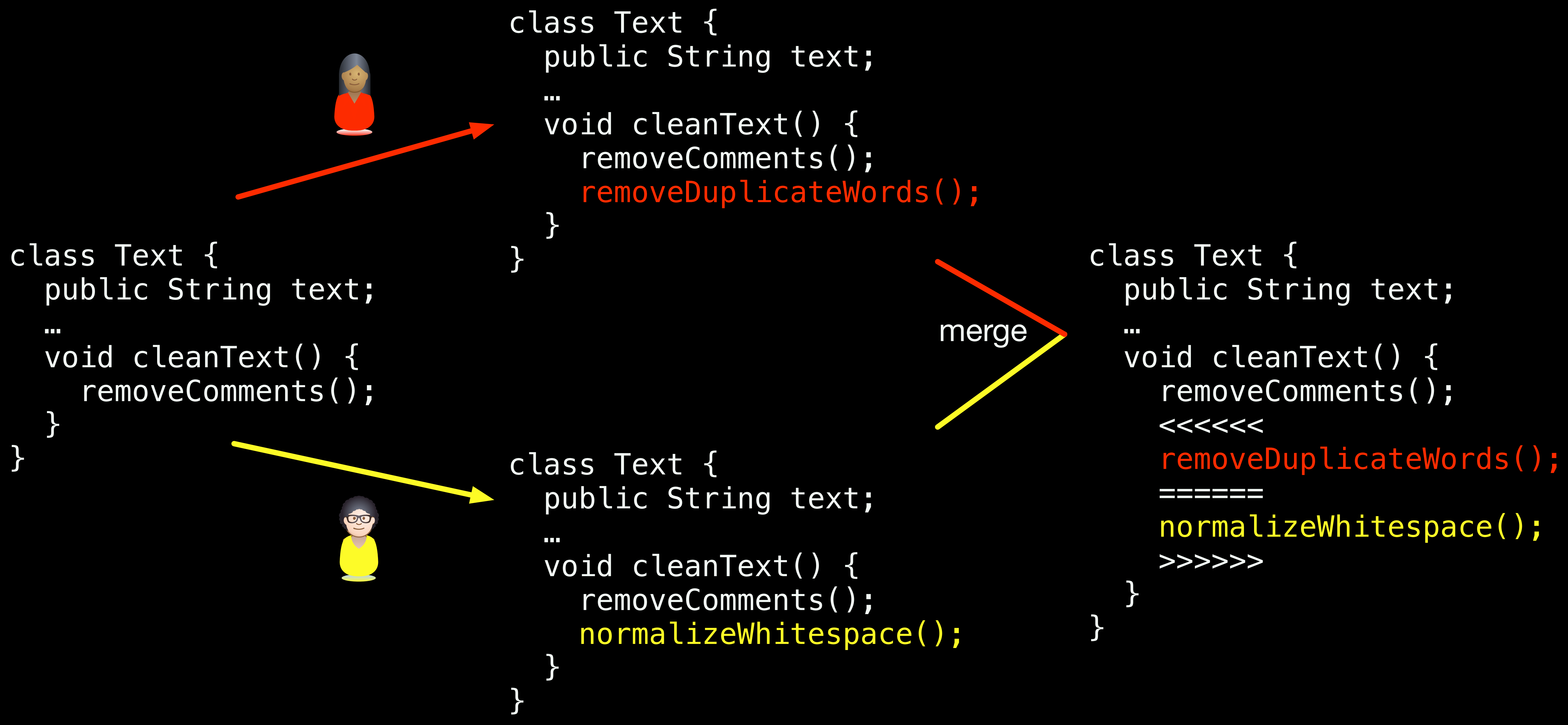
```

Structured
and
semistructured
merge tools to the rescue

Not clear for unstructured merge how to put together the textual changes



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  }
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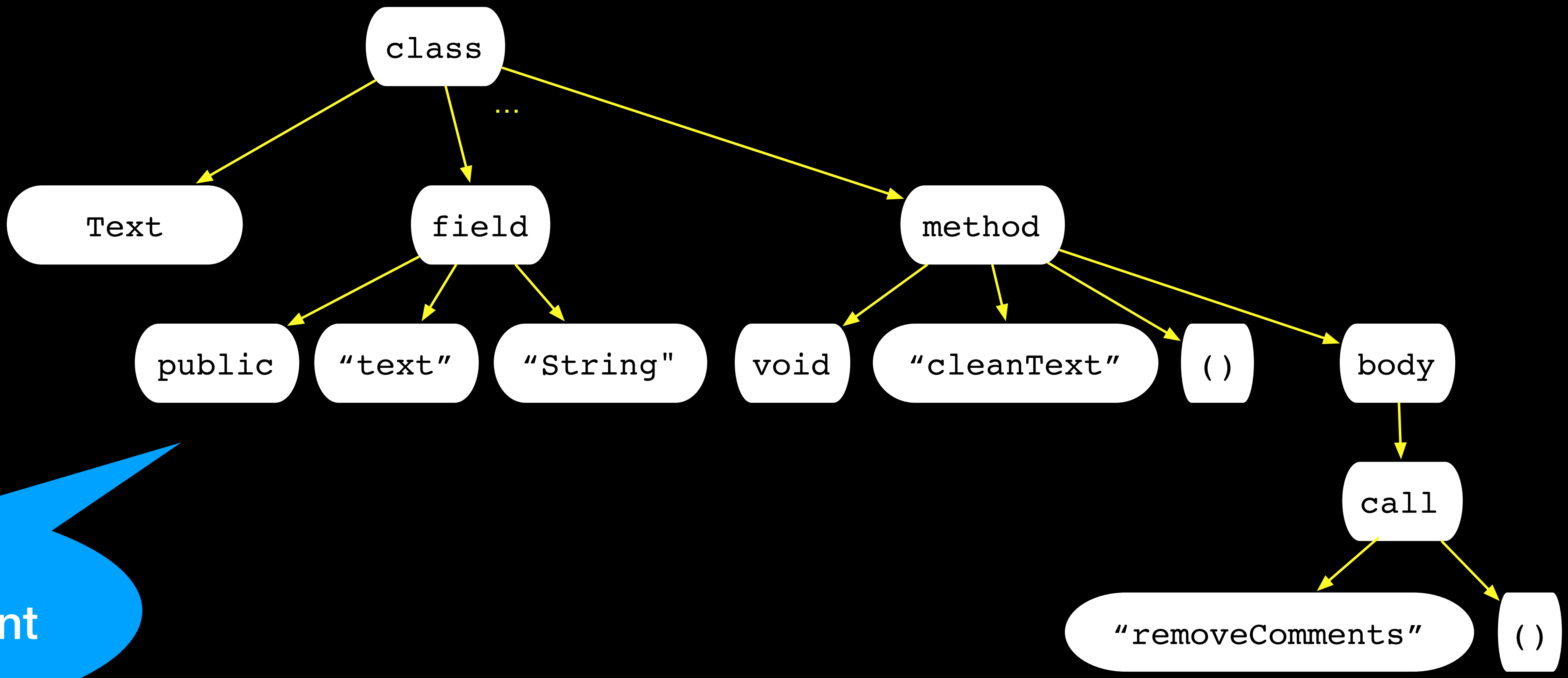
```

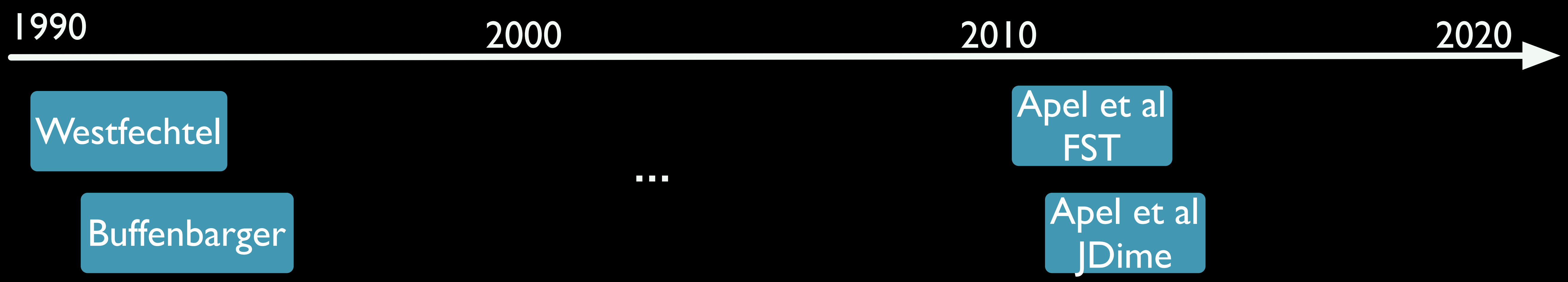
Structured merge works with ASTs, not a sequence of lines

```
class Text {                \n
  public String text;       \n
  …                         \n
  void cleanText() {        \n
    removeComments();       \n
  }                         \n
}                           \n
```



no conflicts for changes in different nodes

Structured merge tools timeline



Computationally expensive

Language dependent

No evaluation

Much less expensive

Much less dependent

Evaluation

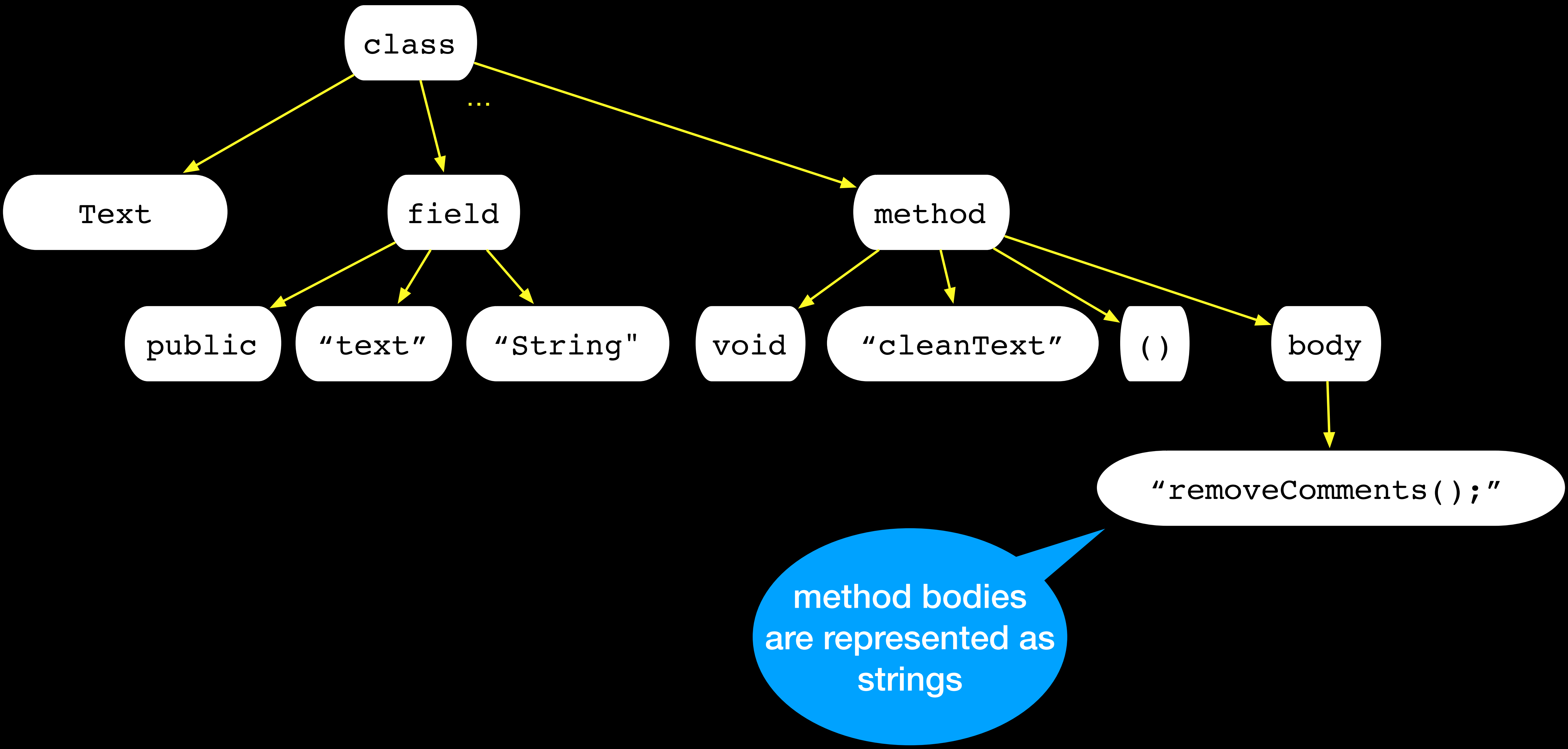
B. Westfechtel. Structure-Oriented Merging of Revisions of Software Documents. SCM 1991.

J. Buffenbarger. Syntactic Software Merging. SCM 1995.

S. Apel, J. Liebig, B. Brandl, C. Lengauer, and C. Kästner. Semistructured Merge: Rethinking Merge in Revision Control Systems. ESEC/FSE 2011.

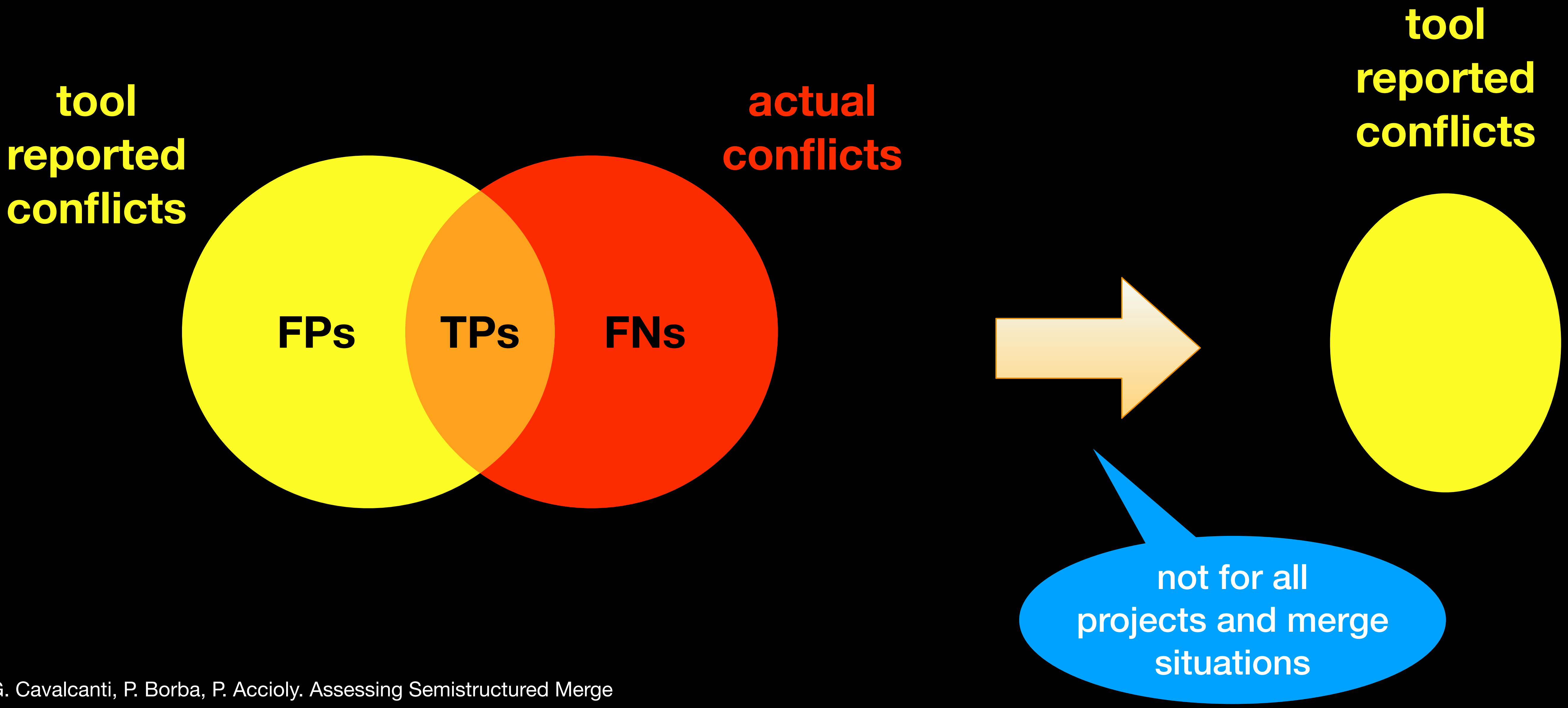
S. Apel, O. Leßenich, and C. Lengauer. Structured Merge with Auto-Tuning: Balancing Precision and Performance. ASE 2012.

Semistructured merge works with partial ASTs



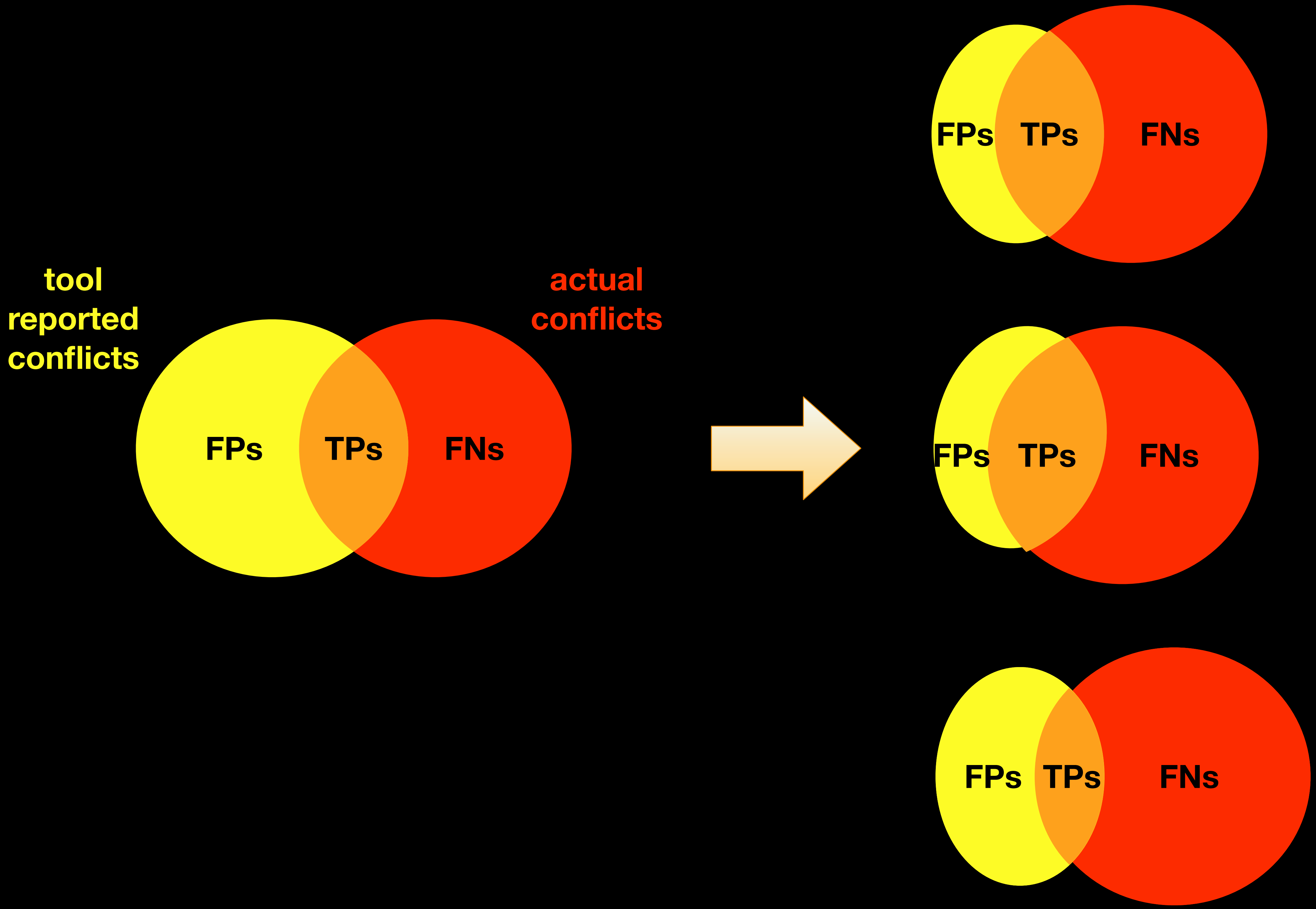
Evidence only about the reduction of reported conflicts

(34% ± 21%, 39%) (62% ± 24%, 71% ± 30%)



G. Cavalcanti, P. Borba, P. Accioly. Assessing Semistructured Merge in Version Control Systems: A Replicated Experiment. ESEM 2015.

Integration effort reduction?
Integration correctness impact?



A more comprehensive evaluation is not fully favourable for semistructured merge

(34,030 merges from 50 open source projects)

FSTMerge reports less false positives (34%) than unstructured merge tools.

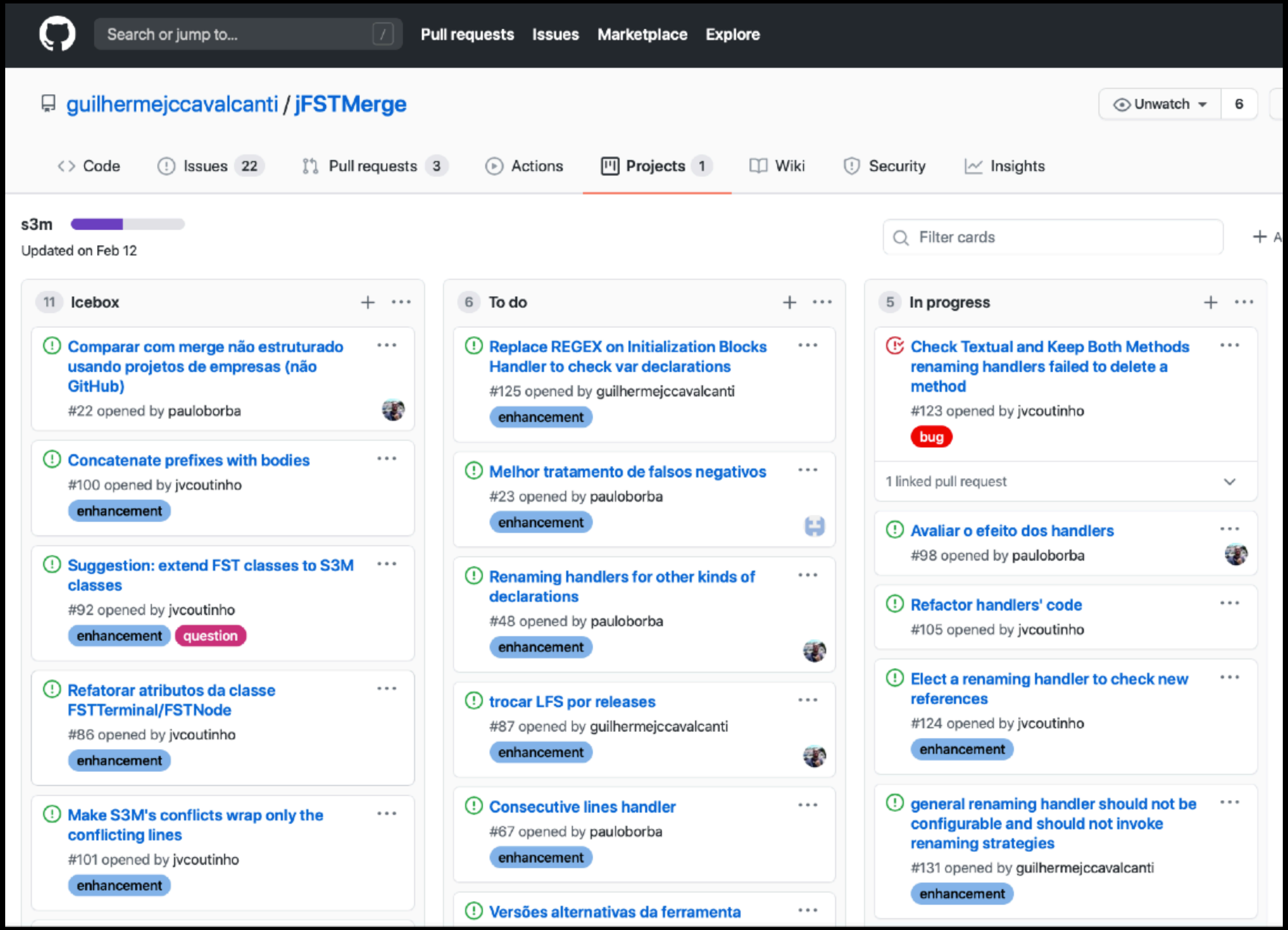
Easier to analyze and resolve.

No evidence that FSTMerge leads to fewer false negatives.

Harder to detect and resolve.

not uniformly across projects

S3M



Search or jump to... Pull requests Issues Marketplace Explore

guilhermejccavalcanti / jFSTMerge

Unwatch 6

Code | Issues 22 | Pull requests 3 | Actions | Projects 1 | Wiki | Security | Insights

s3m
Updated on Feb 12

Filter cards

11 Icebox

- Comparar com merge não estruturado usando projetos de empresas (não GitHub) — #22 opened by pauloborba
- Concatenate prefixes with bodies — #100 opened by jvcoutinho — enhancement
- Suggestion: extend FST classes to S3M classes — #92 opened by jvcoutinho — enhancement, question
- Refatorar atributos da classe FSTTerminal/FSTNode — #86 opened by jvcoutinho — enhancement
- Make S3M's conflicts wrap only the conflicting lines — #101 opened by jvcoutinho — enhancement

6 To do

- Replace REGEX on Initialization Blocks Handler to check var declarations — #125 opened by guilhermejccavalcanti — enhancement
- Melhor tratamento de falsos negativos — #23 opened by pauloborba — enhancement
- Renaming handlers for other kinds of declarations — #48 opened by pauloborba — enhancement
- trocar LFS por releases — #87 opened by guilhermejccavalcanti — enhancement
- Consecutive lines handler — #67 opened by pauloborba — enhancement
- Versões alternativas da ferramenta

5 In progress

- Check Textual and Keep Both Methods renaming handlers failed to delete a method — #123 opened by jvcoutinho — bug — 1 linked pull request
- Avaliar o efeito dos handlers — #98 opened by pauloborba
- Refactor handlers' code — #105 opened by jvcoutinho
- Elect a renaming handler to check new references — #124 opened by jvcoutinho — enhancement
- general renaming handler should not be configurable and should not invoke renaming strategies — #131 opened by guilhermejccavalcanti — enhancement

s3m: an improved semistructured merge tool for Java

s3m reports less conflicts (51%)

no additional false positives

at least 8% fewer false negatives

not prohibitively slower

(32x, < 1s in 80% of the scenarios, > 5s in only 2%)

But the benefits do not generalize, as strongly, to Javascript

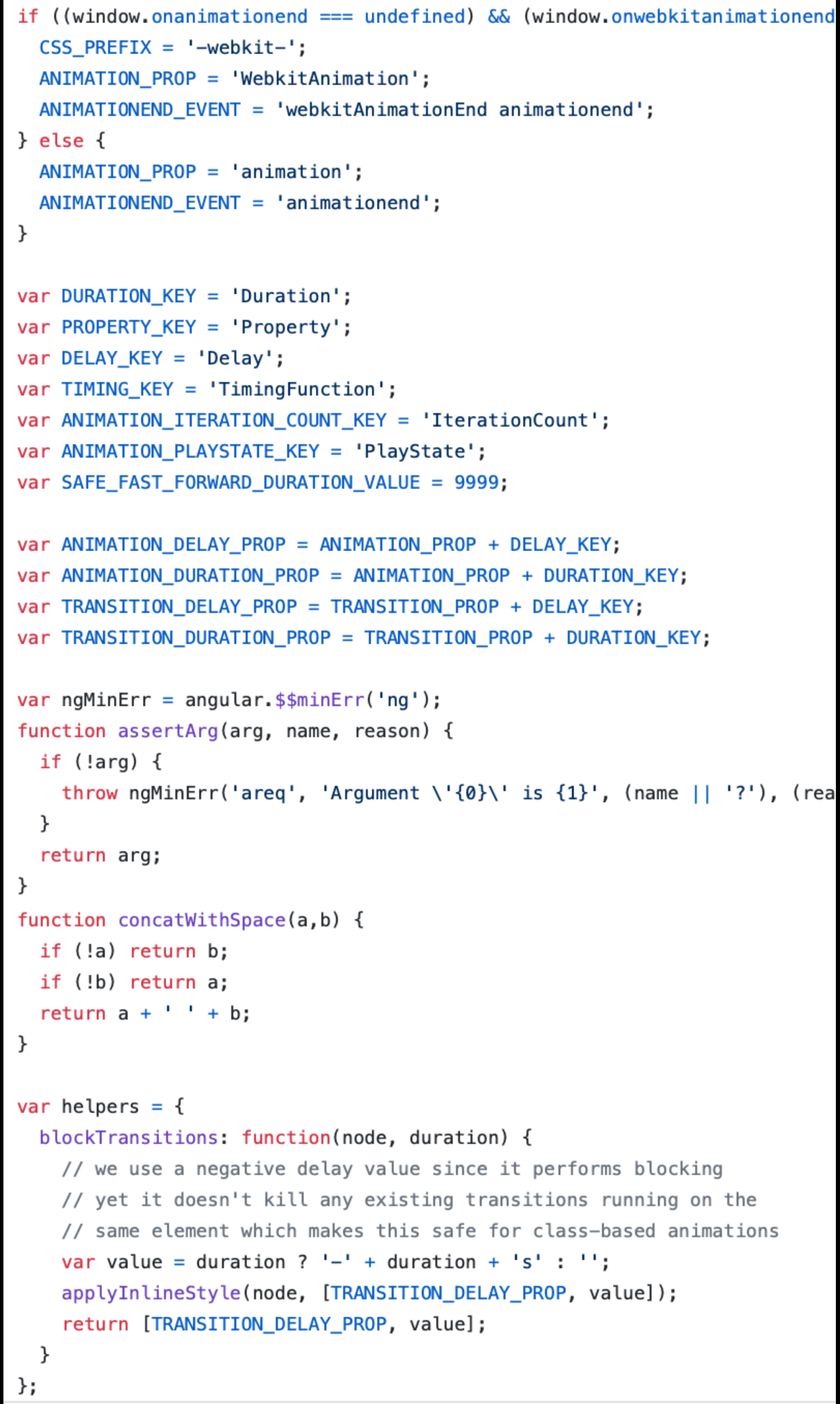
(10,345 merges from 50 projects)

s3m reports less conflicts (6%)

fewer false positives (87%) without compromising correctness (1 FN)

commutative and non-commutative elements at the same syntactic level

A. Tavares, P. Borba, G. Cavalcanti, S. Soares. Semistructured Merge in JavaScript Systems. ASE 2019.



```
if ((window.onanimationend === undefined) && (window.onwebkitanimationend
  CSS_PREFIX = '-webkit-';
  ANIMATION_PROP = 'WebkitAnimation';
  ANIMATIONEND_EVENT = 'webkitAnimationEnd animationend';
} else {
  ANIMATION_PROP = 'animation';
  ANIMATIONEND_EVENT = 'animationend';
}

var DURATION_KEY = 'Duration';
var PROPERTY_KEY = 'Property';
var DELAY_KEY = 'Delay';
var TIMING_KEY = 'TimingFunction';
var ANIMATION_ITERATION_COUNT_KEY = 'IterationCount';
var ANIMATION_PLAYSTATE_KEY = 'PlayState';
var SAFE_FAST_FORWARD_DURATION_VALUE = 9999;

var ANIMATION_DELAY_PROP = ANIMATION_PROP + DELAY_KEY;
var ANIMATION_DURATION_PROP = ANIMATION_PROP + DURATION_KEY;
var TRANSITION_DELAY_PROP = TRANSITION_PROP + DELAY_KEY;
var TRANSITION_DURATION_PROP = TRANSITION_PROP + DURATION_KEY;

var ngMinErr = angular.$$minErr('ng');
function assertArg(arg, name, reason) {
  if (!arg) {
    throw ngMinErr('areq', 'Argument \'{0}\' is {1}', (name || '?'), (rea
  }
  return arg;
}
function concatWithSpace(a,b) {
  if (!a) return b;
  if (!b) return a;
  return a + ' ' + b;
}

var helpers = {
  blockTransitions: function(node, duration) {
    // we use a negative delay value since it performs blocking
    // yet it doesn't kill any existing transitions running on the
    // same element which makes this safe for class-based animations
    var value = duration ? '-' + duration + 's' : '';
    applyInlineStyle(node, [TRANSITION_DELAY_PROP, value]);
    return [TRANSITION_DELAY_PROP, value];
  }
};
```

statement

statement

statement

declaration

declaration

statement

More structure does not always improve merge accuracy

(43,509 merges from more than 500 projects)

tools do not often differ

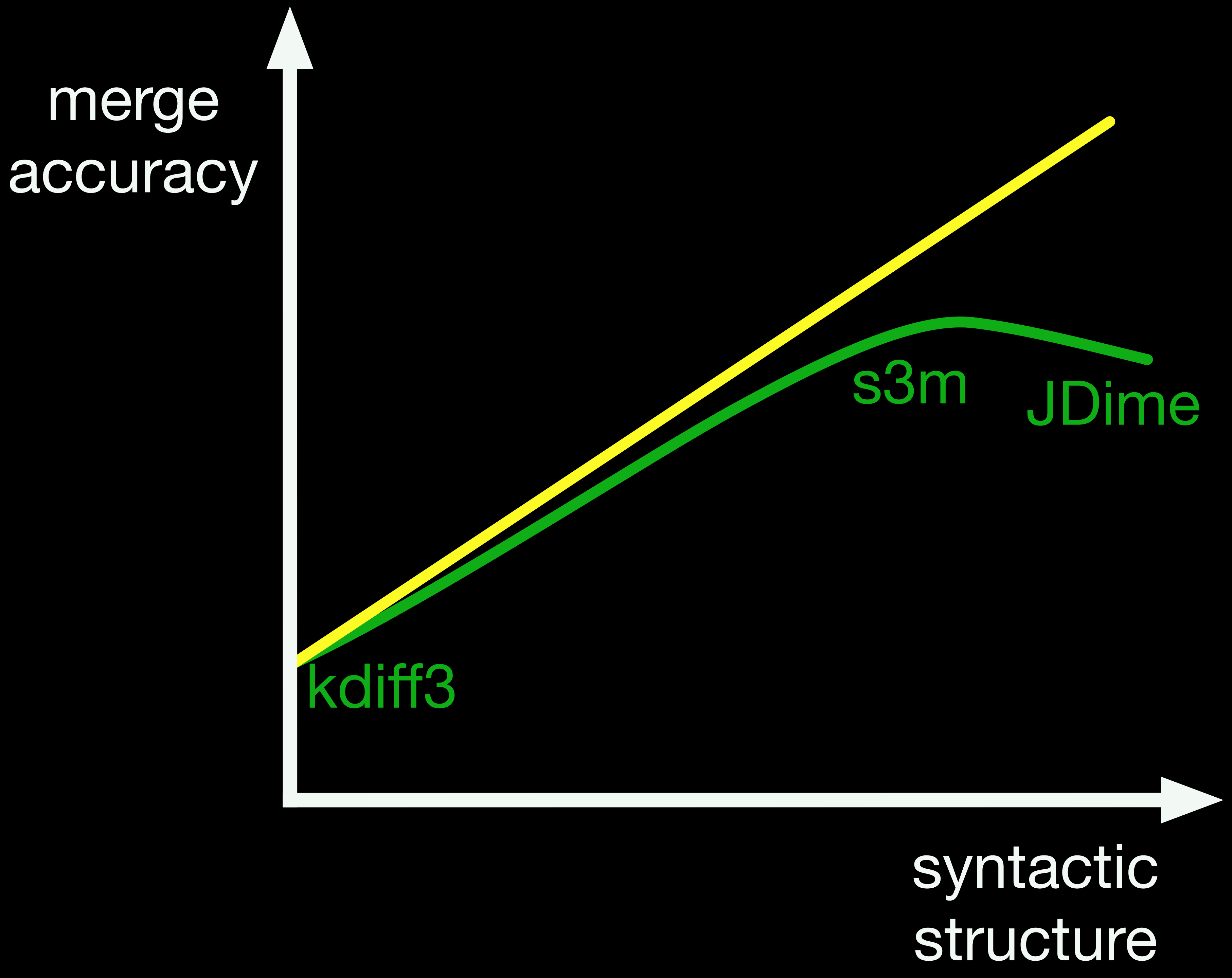
(24% of the ~1K scenarios with conflicts)

semistructured merge reports more false positives (9x, 36)

structured merge has more false negatives (8x, 39)

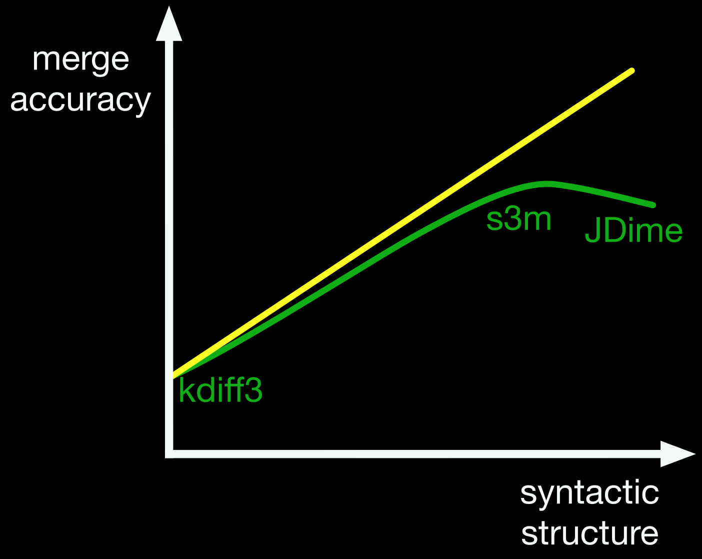
G. Cavalcanti, P. Borba, G. Seibt, S. Apel. The Impact of Structure on Software Merging: Semistructured versus Structured Merge. ASE 2019.

Literature versus New results suggestions



Combining merge strategies and avoiding consecutive line conflicts show promising results

G. Seibt, F. Heck, G. Cavalcanti, P. Borba, S. Apel. Leveraging Structure in Software Merge: An Empirical Study. Submitted for publication, 2020.



S3M

?

Replication data and materials

Solid available implementations

The right collaborations (excellent researchers)

understanding the community you should be involved in

Helping people focus on the merge conflicts that really matter!

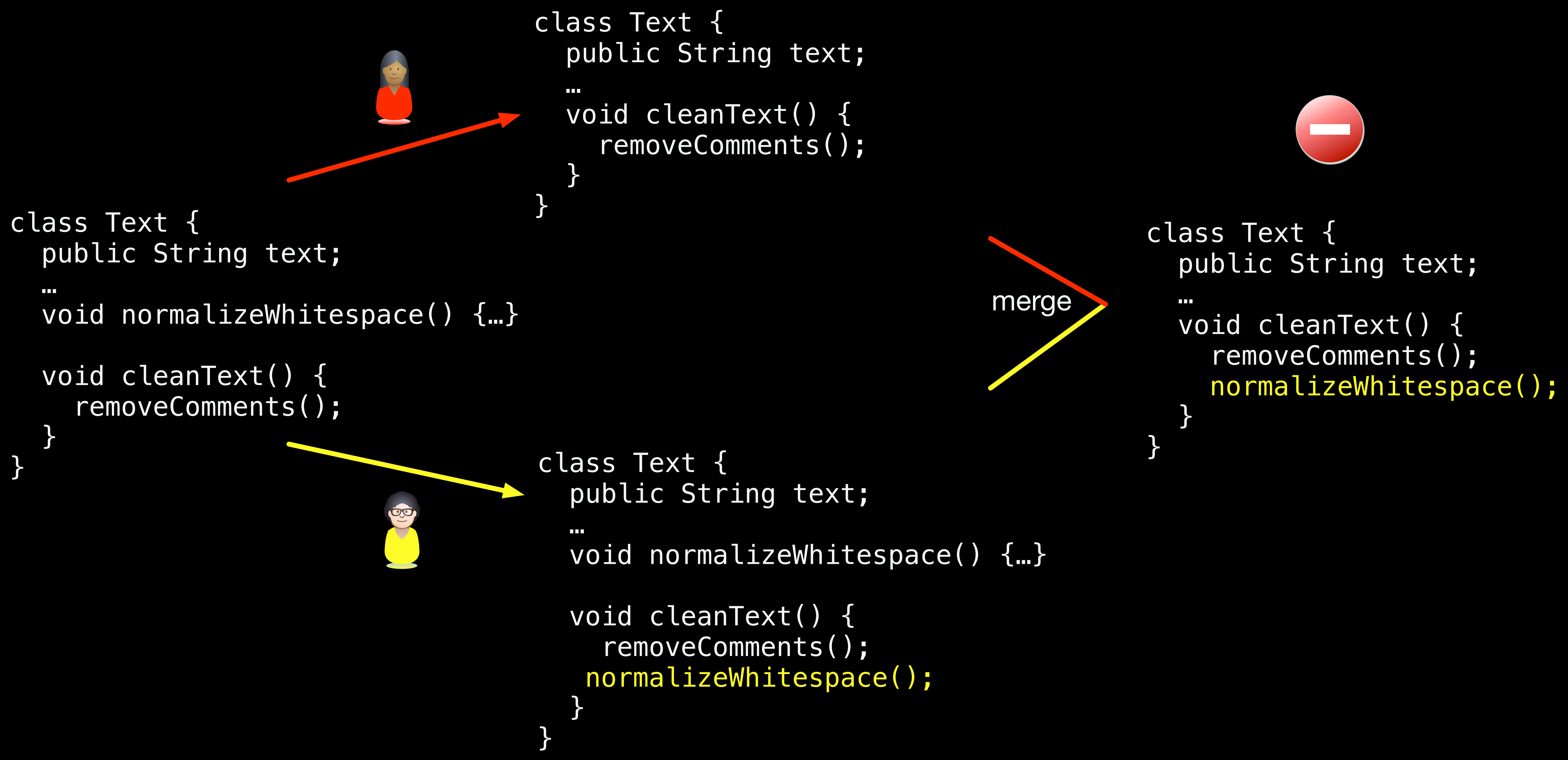
help needed and wanted!

http://is.gd/ISOeN7

But there are code integration problems beyond unnecessary merge conflicts…

Build conflicts

(static semantics/syntactic conflicts)



```
class Text {
  public String text;
  …
  void normalizeWhitespace() {…}

  void cleanText() {
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void normalizeWhitespace() {…}

  void cleanText() {
    removeComments();
   normalizeWhitespace();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
    normalizeWhitespace();
  }
}
```

Understanding and automatically resolving build conflicts

(57,065 merges from 451 Java projects with Travis CI)

6 conflict patterns

unavailable symbol is the most common (65%)

17 resolutions patterns

build conflict repair tool

covering 3 patterns

https://is.gd/TJnNcc

L. Da Silva. Detecting, Understanding and Resolving Build and Test Conflicts. ICSE Poster 2019.

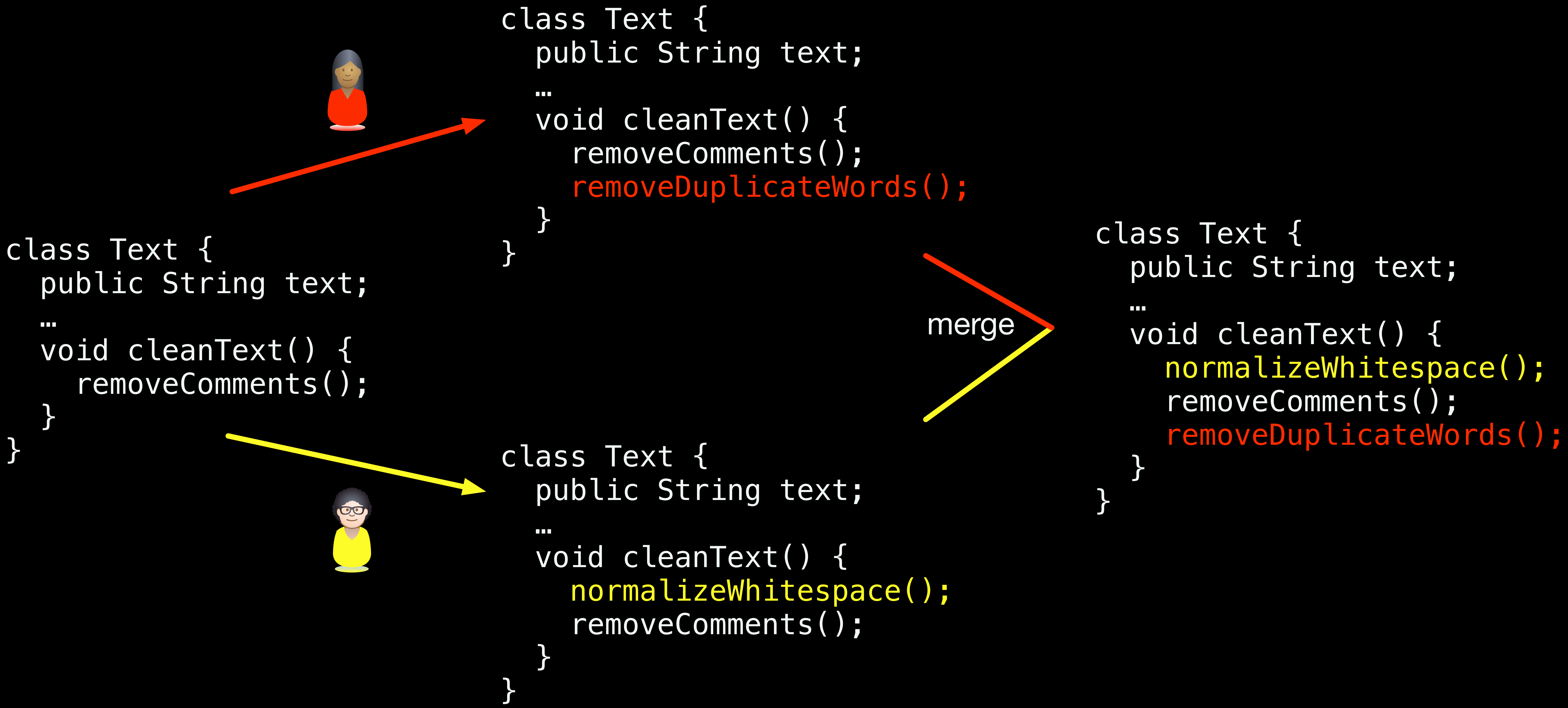
L. Da Silva, P. Borba , A. Pires. Build Conflicts in The Wild. Submitted for publication, 2020.

These are caused by syntactic or static semantics incompatibilities

But not as bad as dynamic semantic incompatibilities (test or production conflicts)

Test or production conflicts

(dynamic semantics conflicts)



```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
    removeDuplicateWords();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    normalizeWhitespace();
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    normalizeWhitespace();
    removeComments();
    removeDuplicateWords();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    normalizeWhitespace();
    removeComments();
    removeDuplicateWords();
  }
}
```

~~resulting text has no duplicate whitespace~~

resulting text has no duplicate words

```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertTrue(t.noDuplicateWhiteSpace());
```

FAILS!

Current merge tools are oblivious to the semantics of the code changes that they integrate

Missed conflicts are hardly detected by project tests or code reviews, and end up escaping to system users

hard to understand the underlying causes and fix the code

We need smart semantic merge tools to detect and resolve dynamic semantic conflicts

But what exactly is a dynamic semantics conflict?

Unintended
interference
between integrated
developers changes

But what exactly is interference?

Behavior of the integrated changes does not preserve the intended behavior of the individual changes

S. Horwitz, J. Prins, and T. Reps. Integrating Noninterfering Versions of Programs. TOPLAS 1989 (POPL 1988).

J. Goguen and J. Meseguer. Security Policies and Security Models. IEEE SSP 1982.

```
{true}

normalizeWhitespace();
removeComments();

{no duplicate whitespace}
```

```
{true}

removeComments();
removeDuplicateWords();

{no duplicate words}
```

$$\not\Downarrow$$

```
{true && true}

normalizeWhitespace();
removeComments();
removeDuplicateWords();

{no duplicate whitespace && no duplicate words}
```

```
{preA}                                                    {preB}

  A                                                         B

{postA}                                                   {postB}
```

$$\not\Downarrow$$

```
{preA && preB}

  merge(A,B)

{postA && postB}
```

Approximations for automatically detecting interference (and semantic conflicts)?

Detecting semantic conflicts with testing

Tests as partial specifications of changes

```
{true}

normalizeWhitespace();
removeComments();

{no duplicate whitespace}
```

```
Text t = new Text();
t.text = "the␣the␣␣dog";

t.cleanText();

assertTrue(t.noDuplicateWhiteSpace());
```

L. Da Silva, P. Borba, W. Mahmood, T. Berger, J. Moisakis. Detecting Semantic Conflicts via Automated Behavior Change Detection. ICSME 2020.

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
    removeDuplicateWords();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    normalizeWhitespace();
    removeComments();
  }
}
```

merge

```
class Text {
  public String text;
  …
  void cleanText() {
    normalizeWhitespace();
    removeComments();
    removeDuplicateWords();
  }
}
```

✗

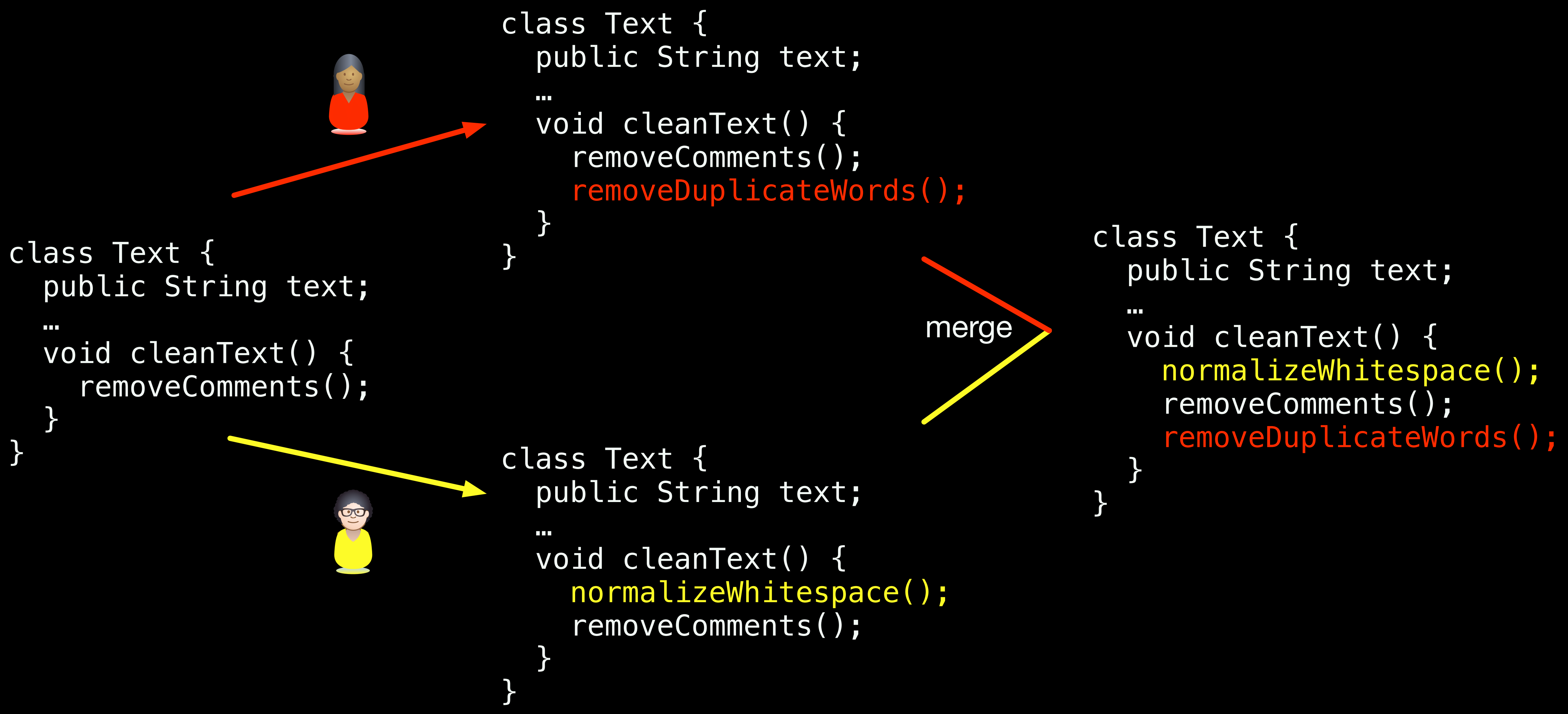
```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertTrue(t.noDuplicateWhiteSpace());
```

✓

```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertTrue(t.noDuplicateWhiteSpace());
```

✗

```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertTrue(t.noDuplicateWhiteSpace());
```



```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
    removeDuplicateWords();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    normalizeWhitespace();
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    normalizeWhitespace();
    removeComments();
    removeDuplicateWords();
  }
}
```

✓

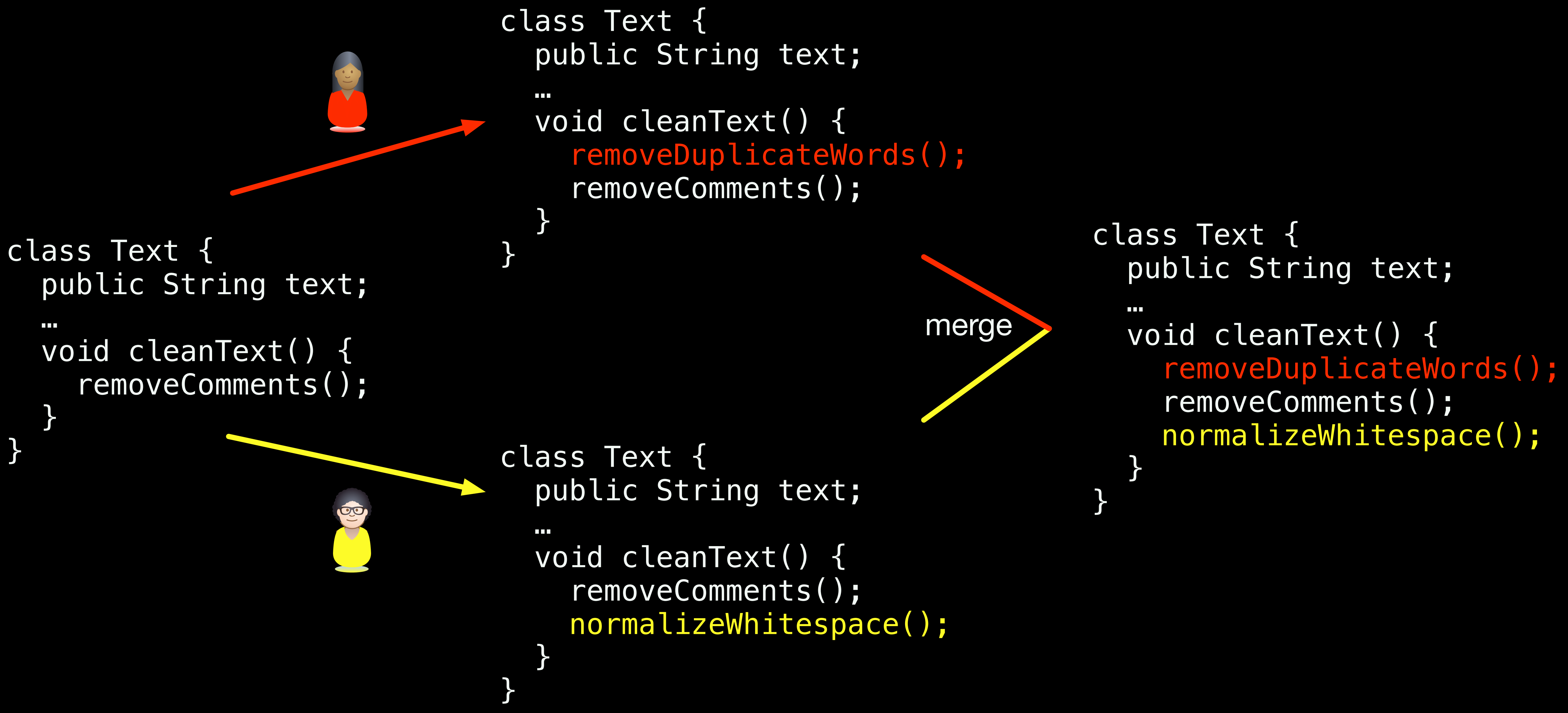
```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertFalse(t.noDuplicateWhiteSpace());
```

✗

```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertFalse(t.noDuplicateWhiteSpace());
```

✓

```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertFalse(t.noDuplicateWhiteSpace());
```



```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeDuplicateWords();
    removeComments();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeComments();
    normalizeWhitespace();
  }
}
```

```
class Text {
  public String text;
  …
  void cleanText() {
    removeDuplicateWords();
    removeComments();
    normalizeWhitespace();
  }
}
```

✗

```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertTrue(t.noDuplicateWhiteSpace());
```

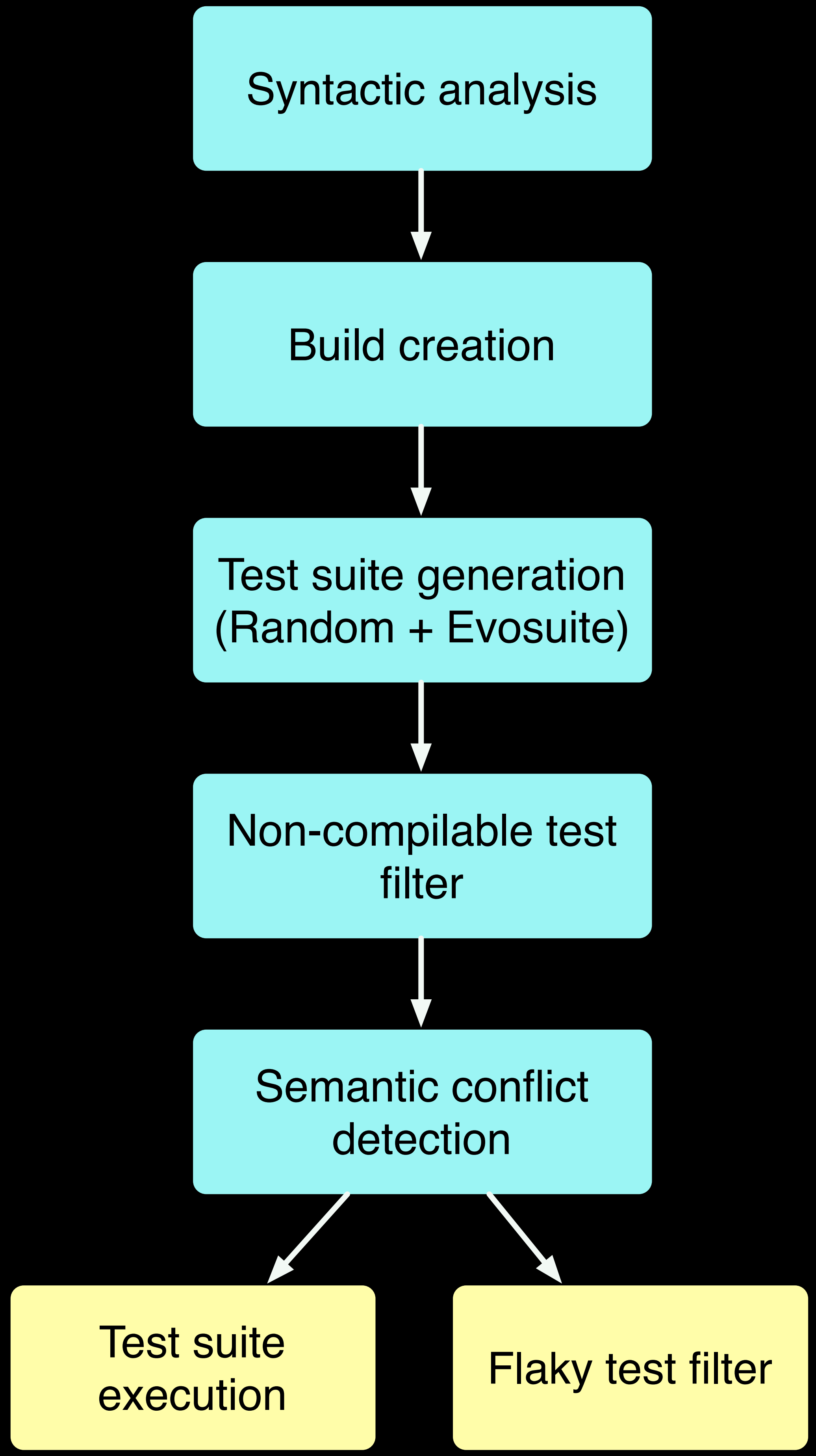
✓

```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertTrue(t.noDuplicateWhiteSpace());
```

✓

```
Text t = new Text();
t.text = "the␣the␣␣dog";
t.cleanText();
assertTrue(t.noDuplicateWhiteSpace());
```

Test based semantic merge tool


Syntactic analysis
Build creation
Test suite generation (Random + Evosuite)
Non-compilable test filter
Semantic conflict detection
Test suite execution
Flaky test filter

Challenges

- Useful if project tests do not often detect interference
- Differential testing can play the role of specifications only if changes do not affect interfaces
- Test generation tools are often too limited for industry strength projects (impact on FNs)
- FPs could be a problem too in our context

Detecting semantic conflicts with static analysis

Building and comparing 4 SDGS

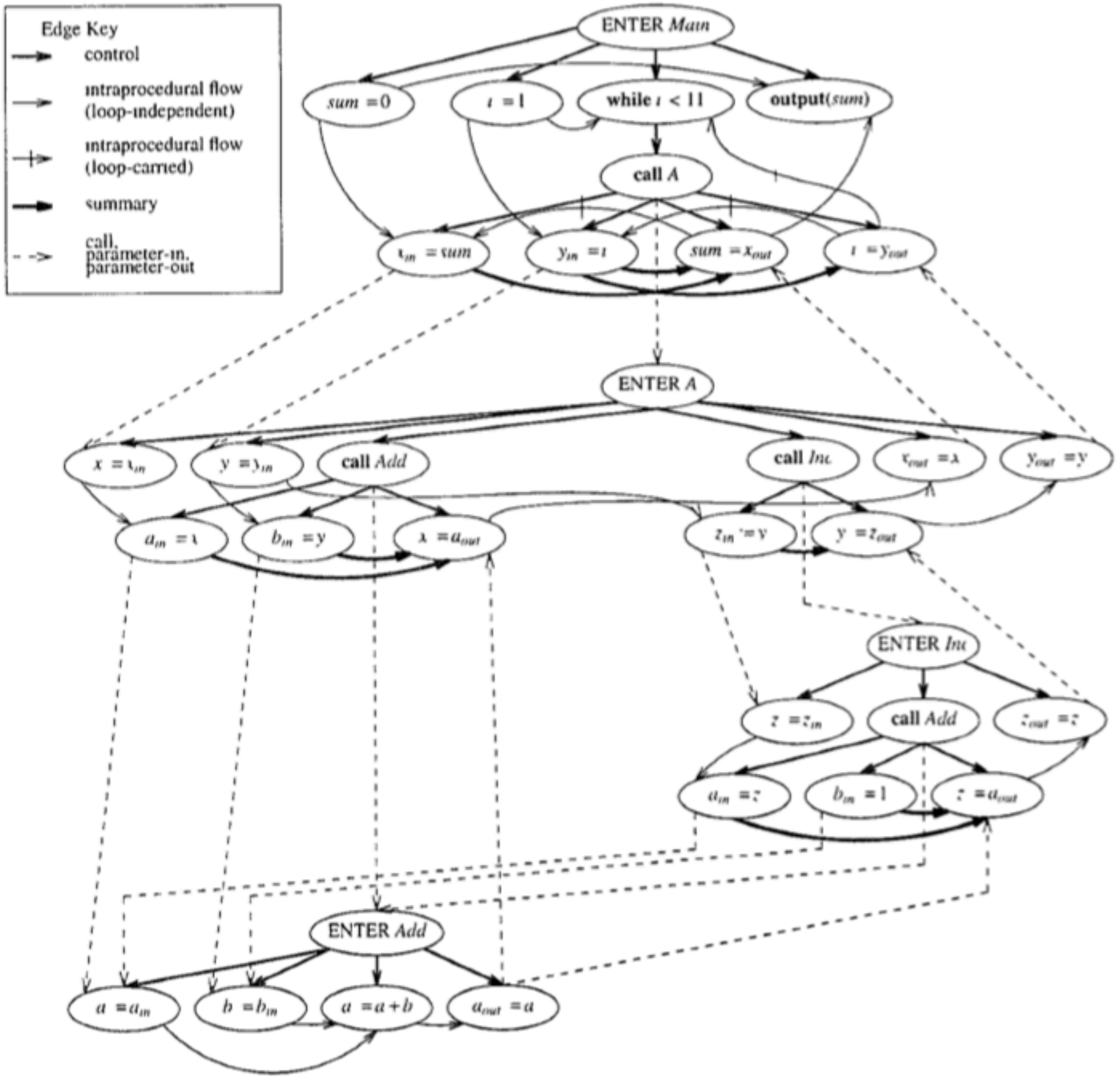
D. Binkley, S. Horwitz, T. Reps. Program Integration for Languages with Procedural Calls. TOSEM 1995.

```
procedure Main
   sum = 0
   i = 1
   while i < 11 do
        call A (sum, i)
   od
   output(sum)
end

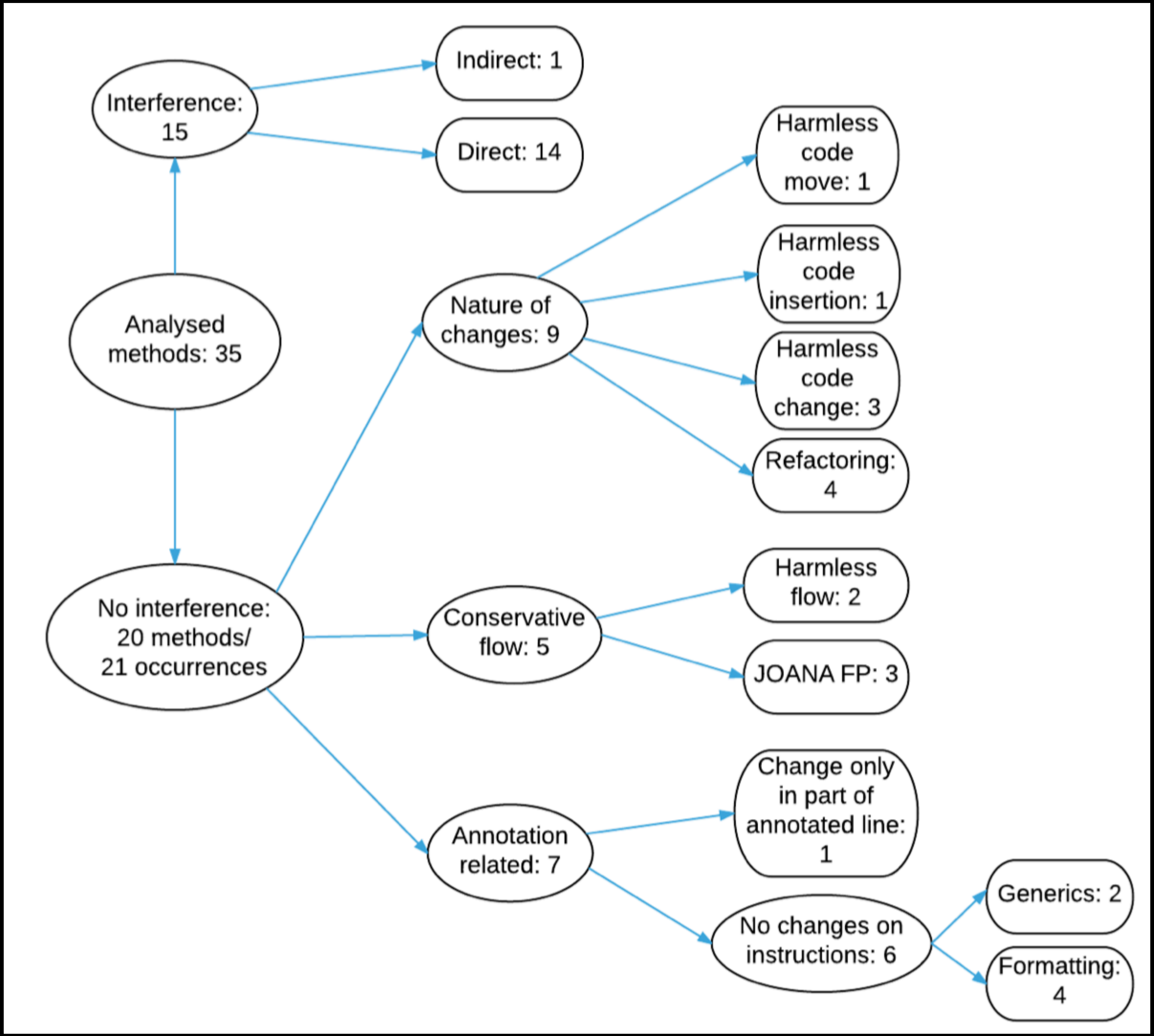
procedure A (x, y)
   call Add (x, y)
   call Increment (y)
return

procedure Add (a, b)
   a = a + b
return

procedure Increment (z)
   call Add (z, 1)
return
```



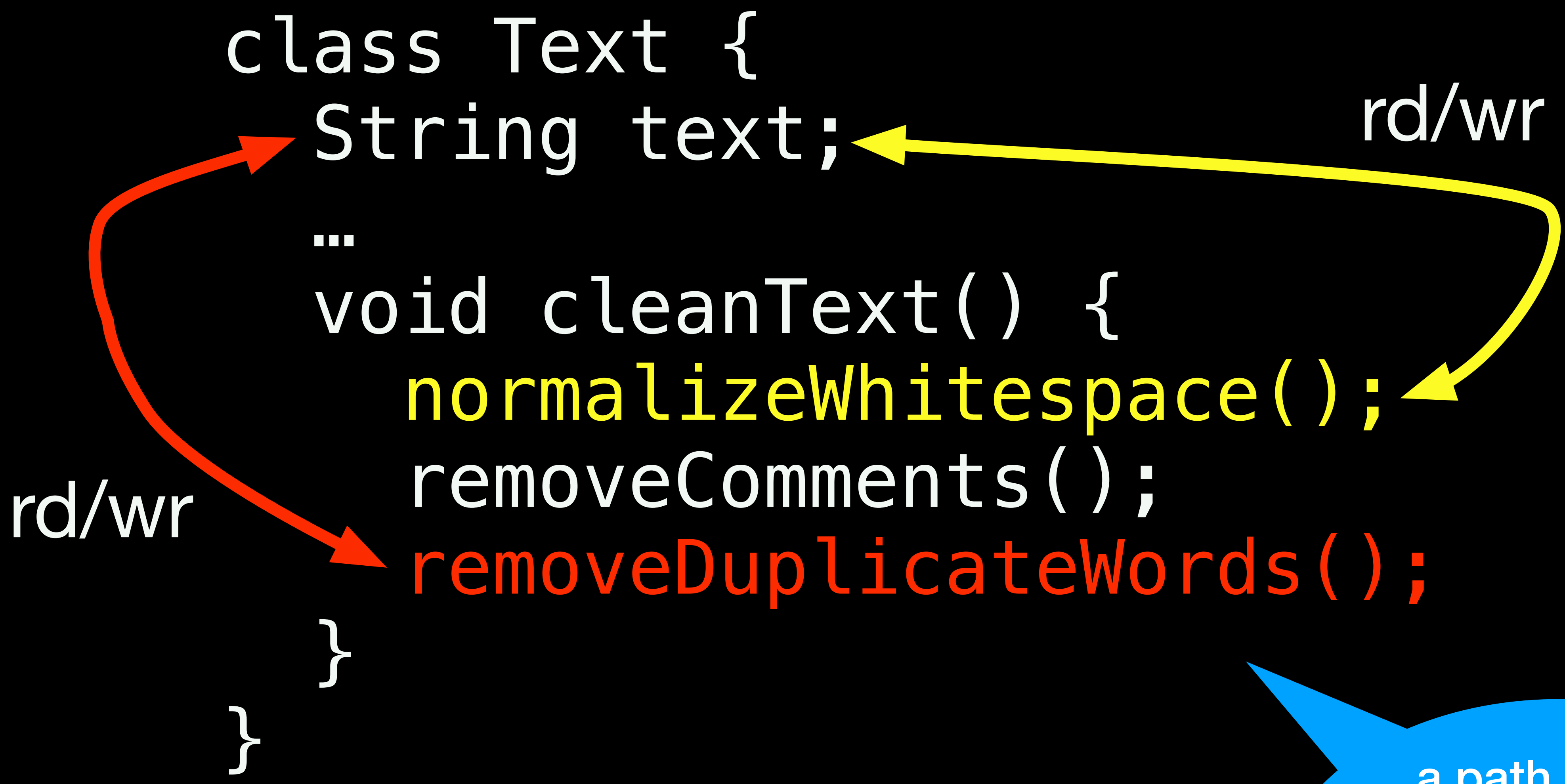
Information flow (between developers changes) analysis implementation, for a single SDG, is very slow



R. Barros Filho, P. Borba. Semantic conflict detection with information flow analysis. 2020.

Is there a reasonably accurate and lightweight approximation?

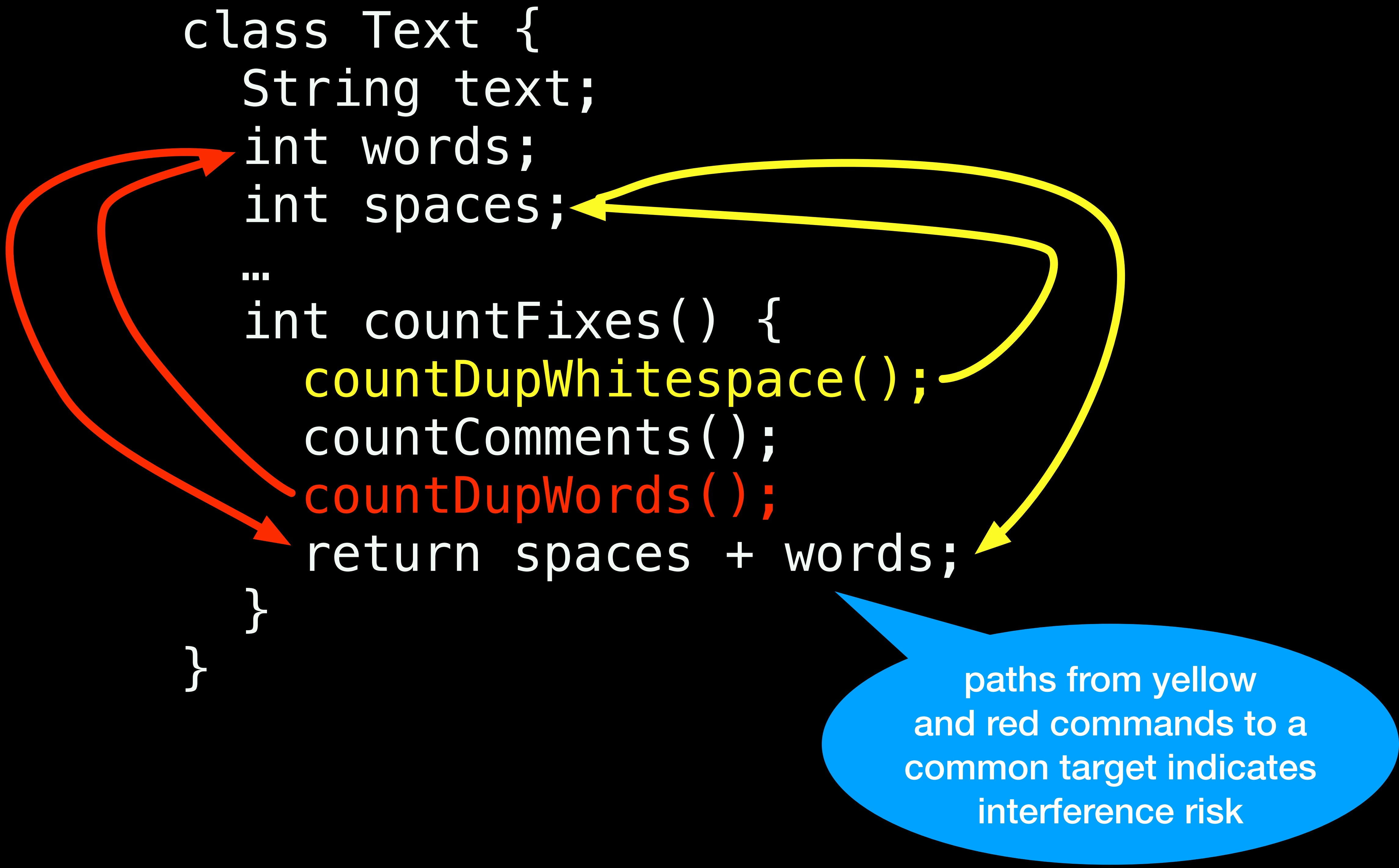
Detecting data flow between developers changes



```
class Text {
  String text;
  …
  void cleanText() {
    normalizeWhitespace();
    removeComments();
    removeDuplicateWords();
  }
}
```

a path from a yellow to a red command, or vice-versa, indicates interference risk

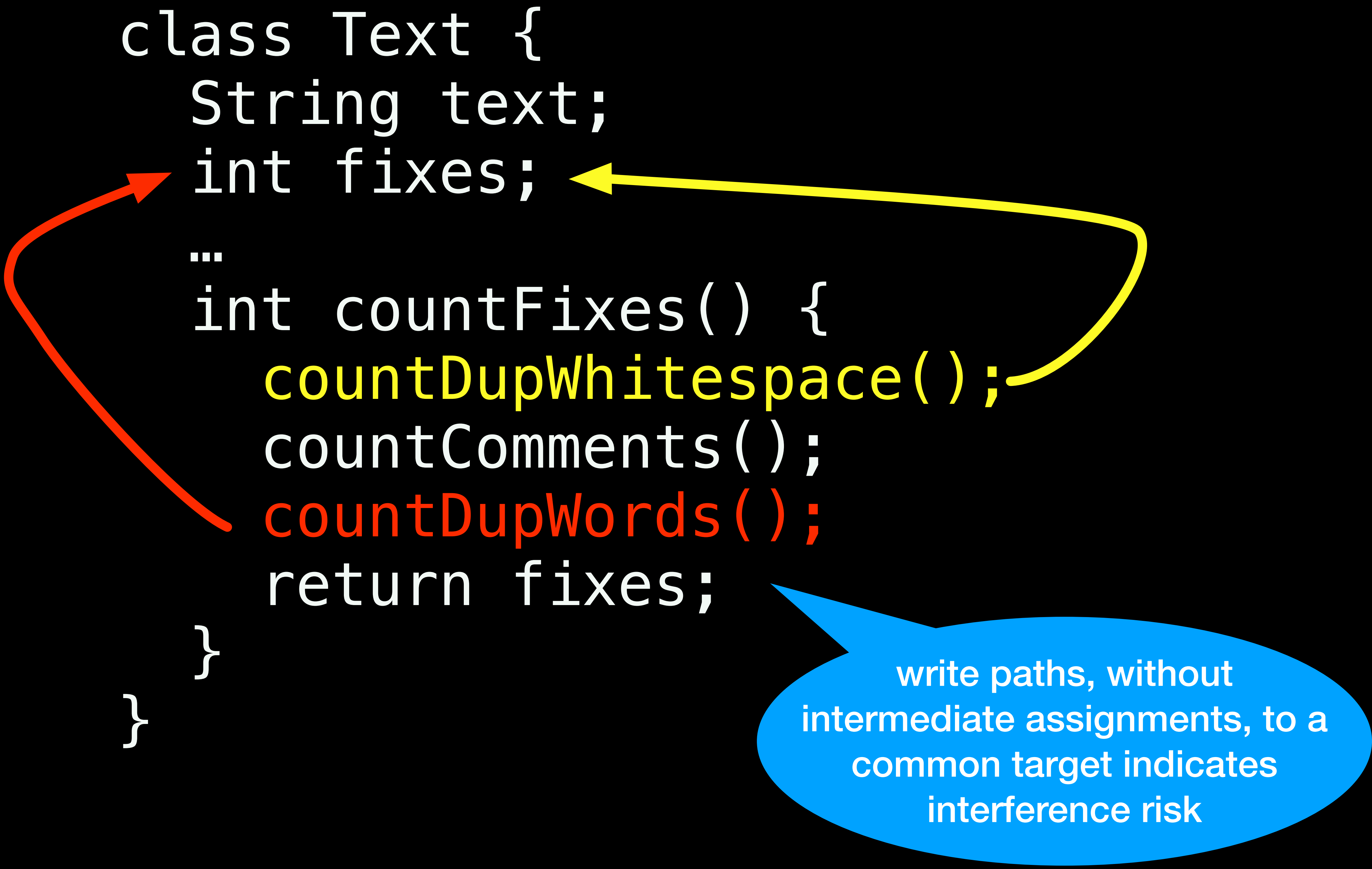
Detecting data flow confluence from developers changes



```
class Text {
  String text;
  int words;
  int spaces;
  …
  int countFixes() {
    countDupWhitespace();
    countComments();
    countDupWords();
    return spaces + words;
  }
}
```

paths from yellow and red commands to a common target indicates interference risk

Detecting overriding assignments involving developers changes



```
class Text {
  String text;
  int fixes;
  …
  int countFixes() {
    countDupWhitespace();
    countComments();
    countDupWords();
    return fixes;
  }
}
```

write paths, without intermediate assignments, to a common target indicates interference risk

Improved code integration and merging

Semantic interference, static analysis

Formal notions of specifications and refinement (behavior preservation)

industry is a partner not an idol or oracle

work on what industry needs, not what it wants

be careful with proxies and the wrong incentives

learn different research tools along the way

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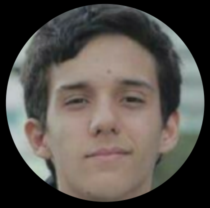
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