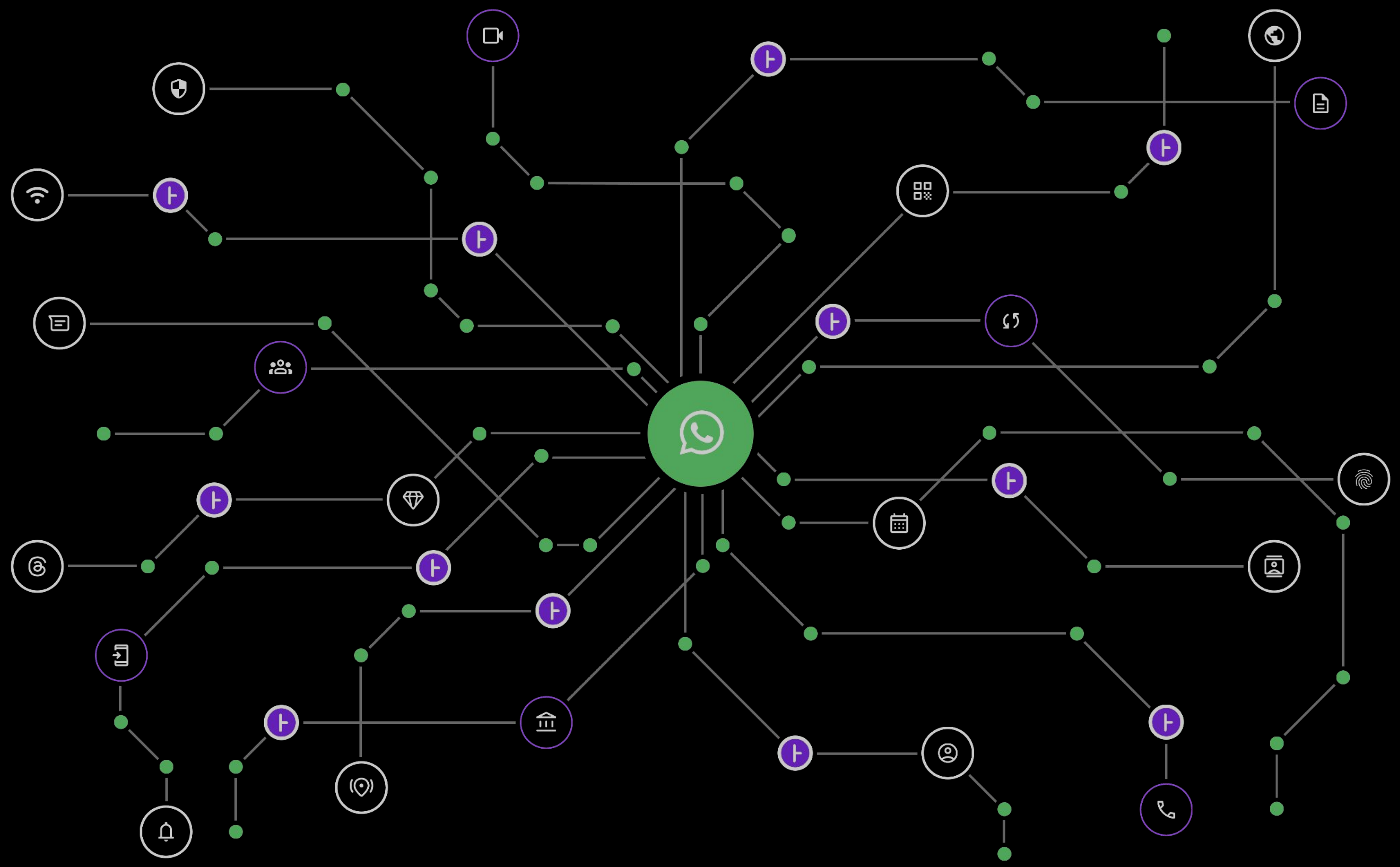
SOAP@PLDI 2025

Compositional Static Callgraph Reachability Analysis for WhatsApp Android App Health



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Motivation

Performance critical functions (transitively) calling computationally expensive ones?

```
void somethingOnTheUI() {
 checkSomething();
}

void checkSomething() {
 readFromDatabase();
}

void readFromDatabase() {
 /* Slow stuff */
}
```

Challenges

Specification

What’s performance critical and what’s computationally expensive?

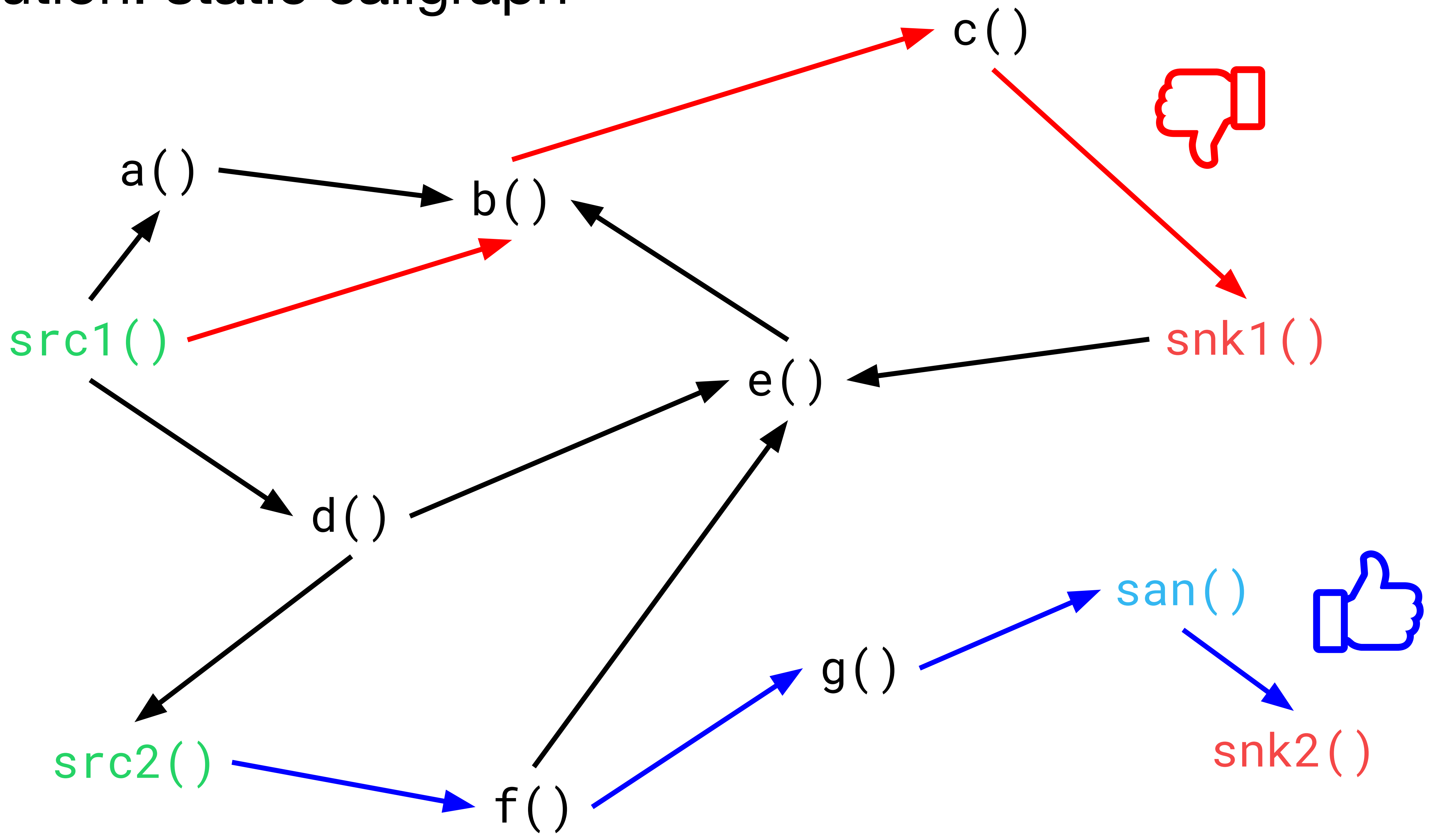
Analyzer

Automated and fast enough to give feedback on code changes

Reachability

Source to sink call chain without sanitizer

Approximate solution: static callgraph



Infer

Open-source static analysis platform

Developed at Meta - fbinfer.com

Language frontends

C, C++, Objective-C, Java/Kotlin, C#, Erlang

Checkers

Memory safety, data races, deadlocks, temporal properties, annotation reachability, …

Annotation reachability - Specification

Java annotations in code

```
@PerfCrit
void somethingOnTheUI() {
 checkSomething();
}

void checkSomething() {
 readFromDatabase();
}

@Expensive
void readFromDatabase() {
 /* Slow stuff */
}
```

Infer config

```
"annotation-reachability-custom-pairs":
[{
 "sources": ["PerfCrit"],
 "sinks": ["Expensive"]
}]
```

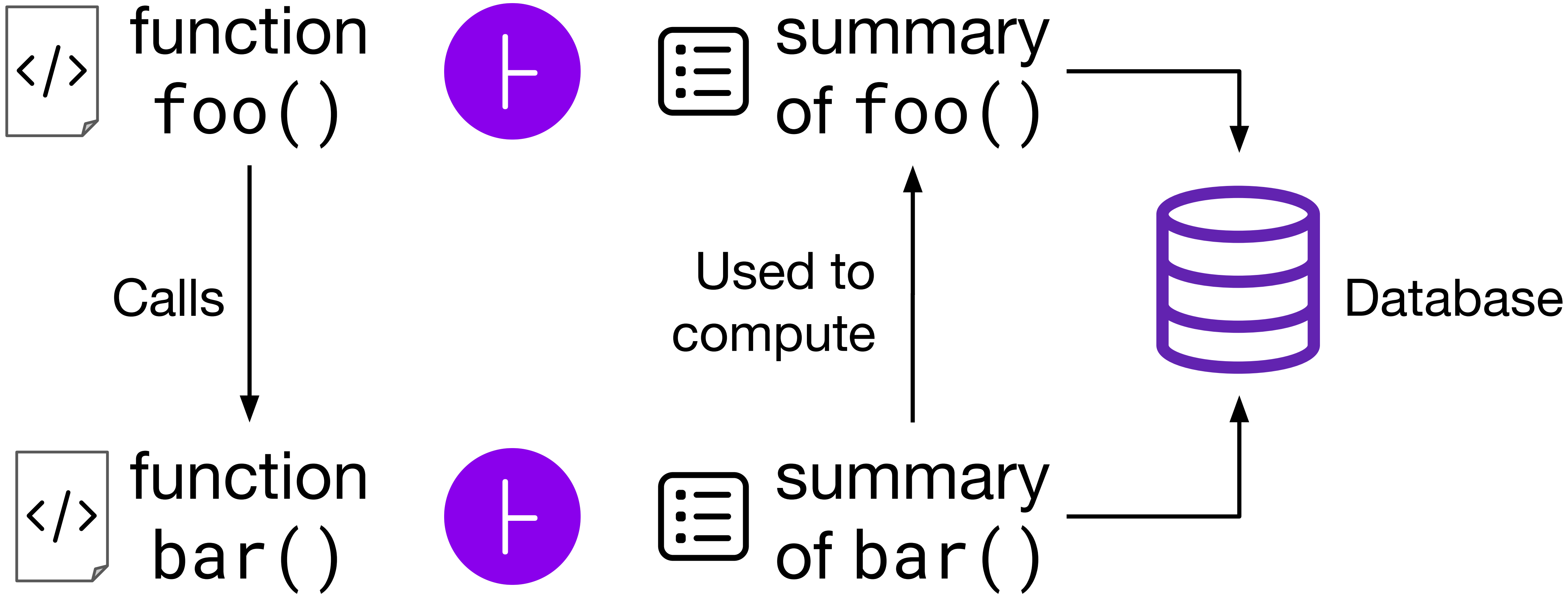
Infer checkers

Modular: analyze one procedure at a time

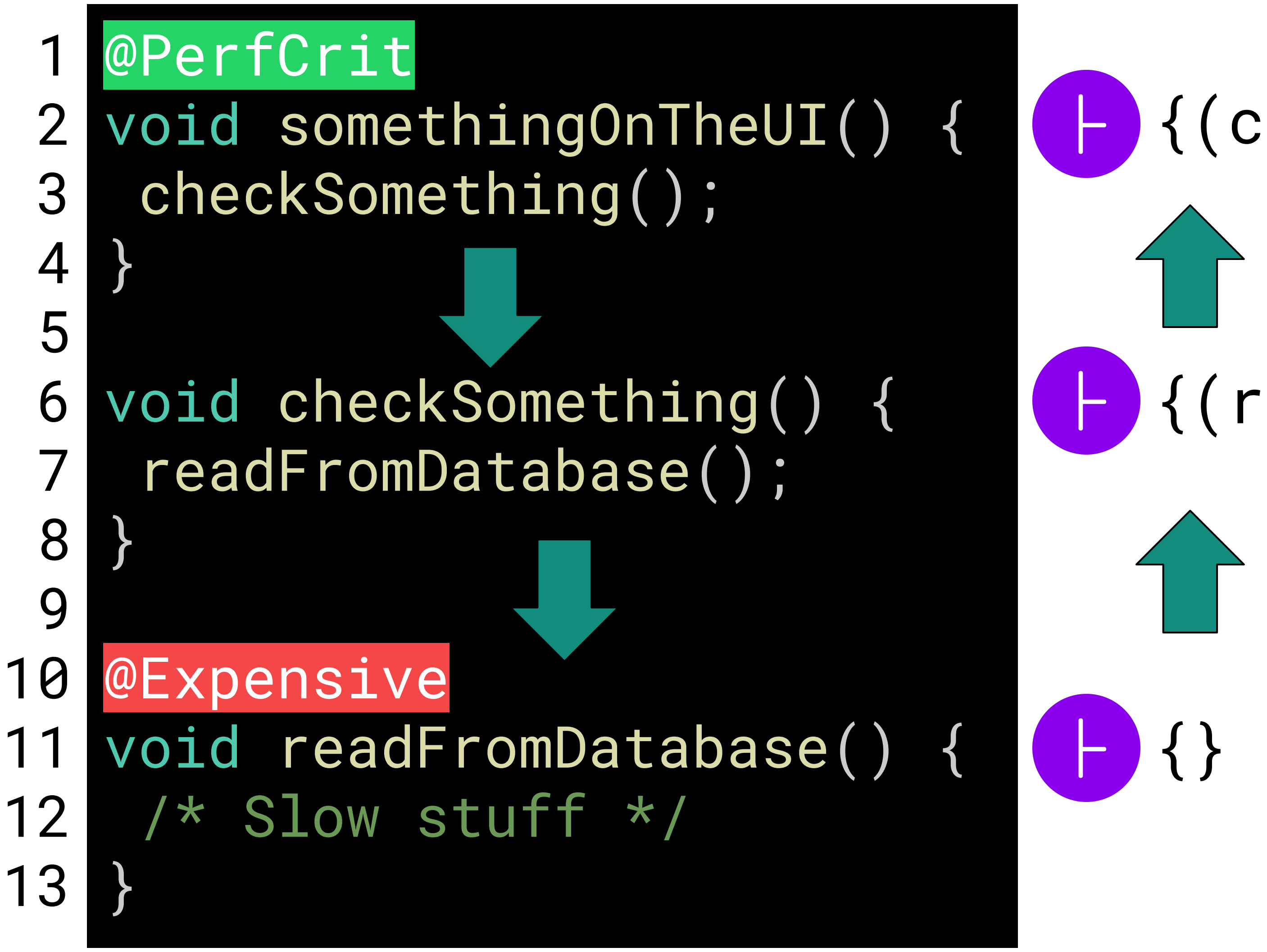
Abstract interpretation: propagate state, obtain summary

Compositional: summary can be used in all calling contexts

On-demand: analyze dependencies as needed



Annotation reachability - Analysis



```
 1 @PerfCrit
 2 void somethingOnTheUI() {
 3  checkSomething();
 4 }
 5
 6 void checkSomething() {
 7  readFromDatabase();
 8 }
 9
10 @Expensive
11 void readFromDatabase() {
12  /* Slow stuff */
13 }
```

⊢ {(checkSomething, 3, readFromDatabase, @Expensive)}

⊢ {(readFromDatabase, 7, readFromDatabase, @Expensive)}

⊢ {}

Report an issue: source function has sink in summary

`(somethingOnTheUI, @PerfCrit, readFromDatabase, @Expensive)`

Path: reconstruct from summary recursively

`somethingOnTheUI() → checkSomething() → readFromDatabase()`

Annotation reachability - Analysis

Abstract state in F: set of (G, N, H, A) tuples

- Just one step towards sink

Initial state: empty

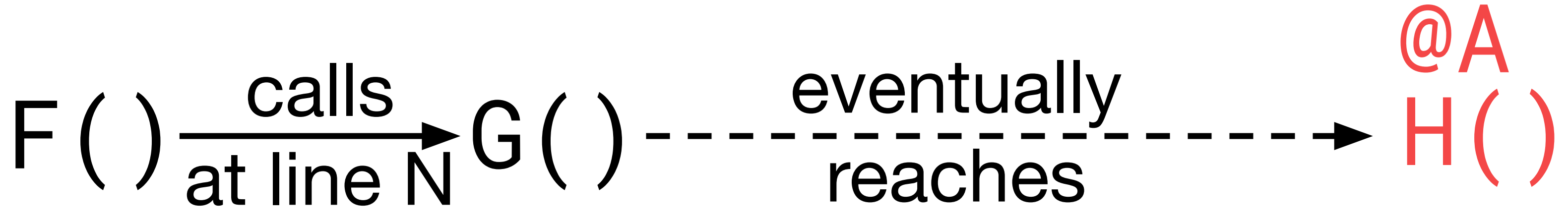
Traverse instructions in-order

Transfer function: call to some G

- If G is sink → add entry for G (via G)
- If G can reach H → add entry for H (via G)
- Check for sanitizer

Join: set join

Summary: state at exit



F() calls at line N G() eventually reaches @A H()

Flow- and path-insensitive

Overapproximate

- E.g. calls guarded by infeasible conditions

Underapproximate

- E.g. dynamic dispatch, lambdas

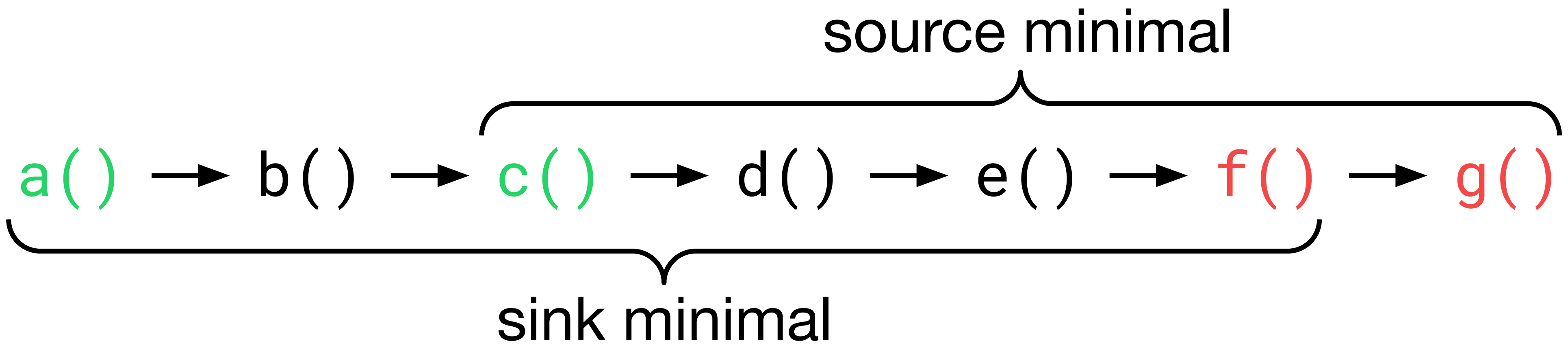
Annotation reachability - extensions

Regular expressions

- External code
- Compactness
- Other languages

```
"annotation-reachability-custom-models": {
  "Expensive": ["com\.library\.SomeClass\..*"]
}
```

Path minimization



Reachability analysis for WhatsApp Android

Specification

Collaborate with WhatsApp app health team: 2 properties, 8 annotations, 11 regexps

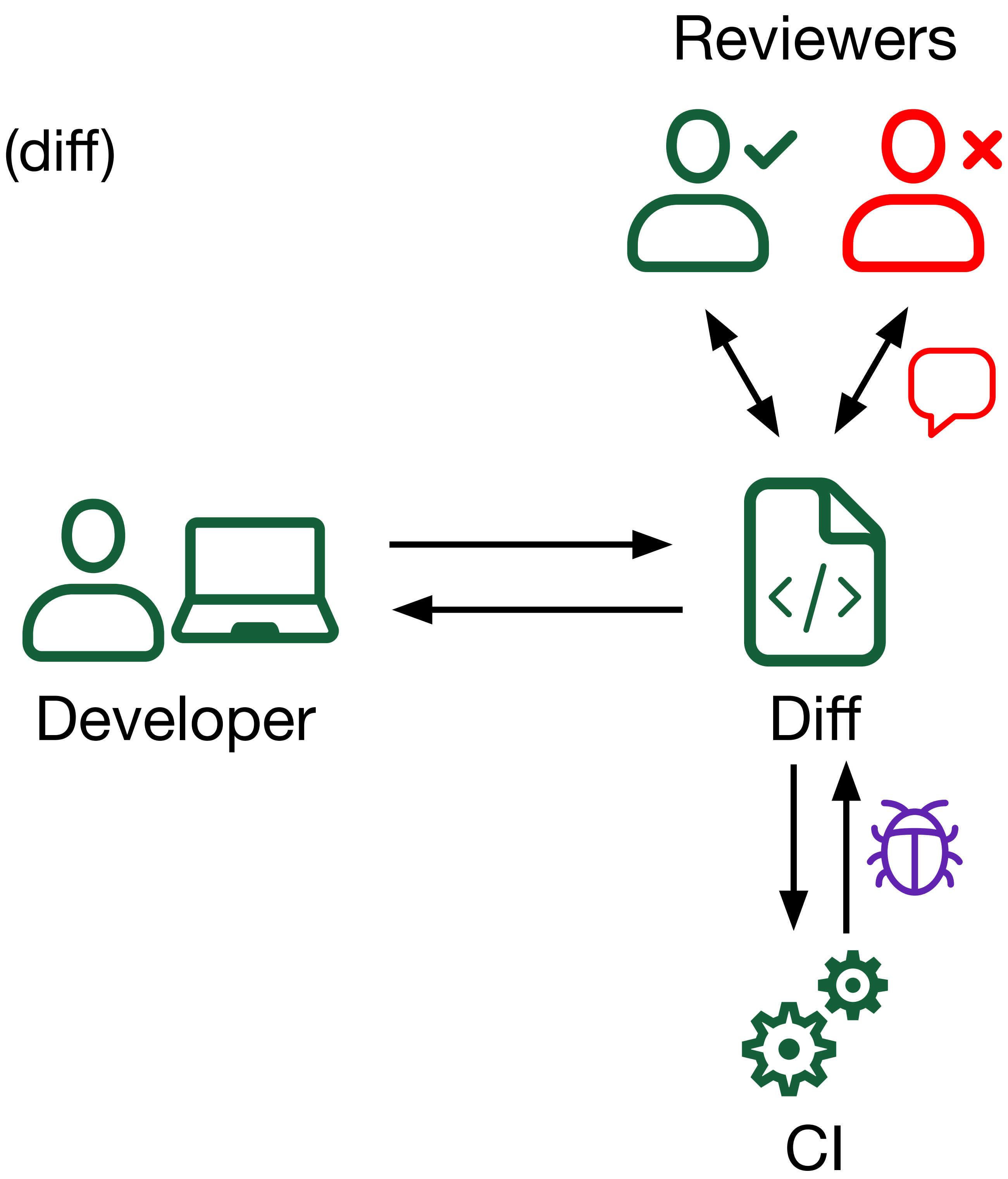
#1 Sources: performance critical (e.g. UI event handlers)
Sinks: computationally expensive (e.g. worker thread, file IO)
Sanitizers: not shipped in production (tests, debug utils)

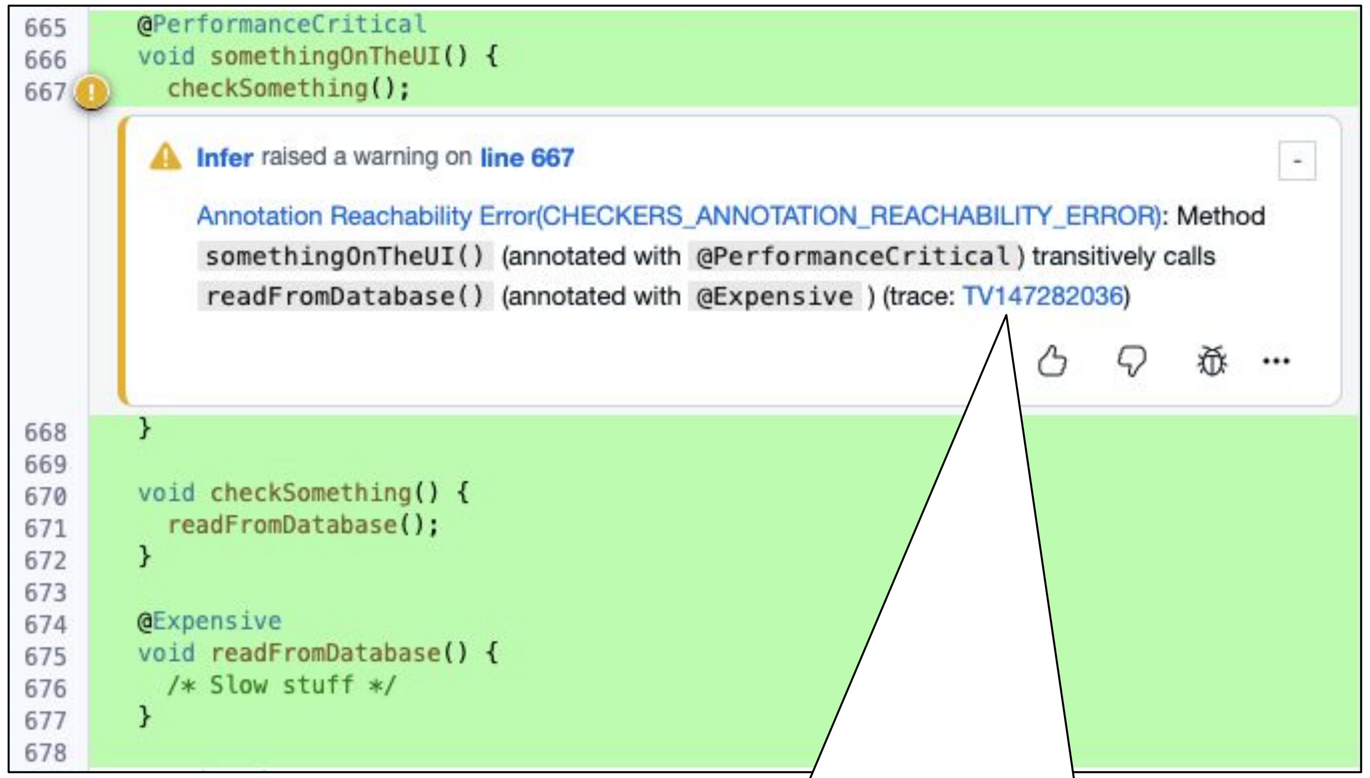
#2 Incompatible threading annotations (worker thread calling main)

	Annotations			Regexps			Coverage		
Prop.	src	snk	san	src	snk	san	src	snk	san
#1	1	2	2	2	3	3	0.356%	2.689%	0.198%
#2	2	1	0	0	3	0	16.267%	0.002%	0.000%

Deployment

Code changes (diff)



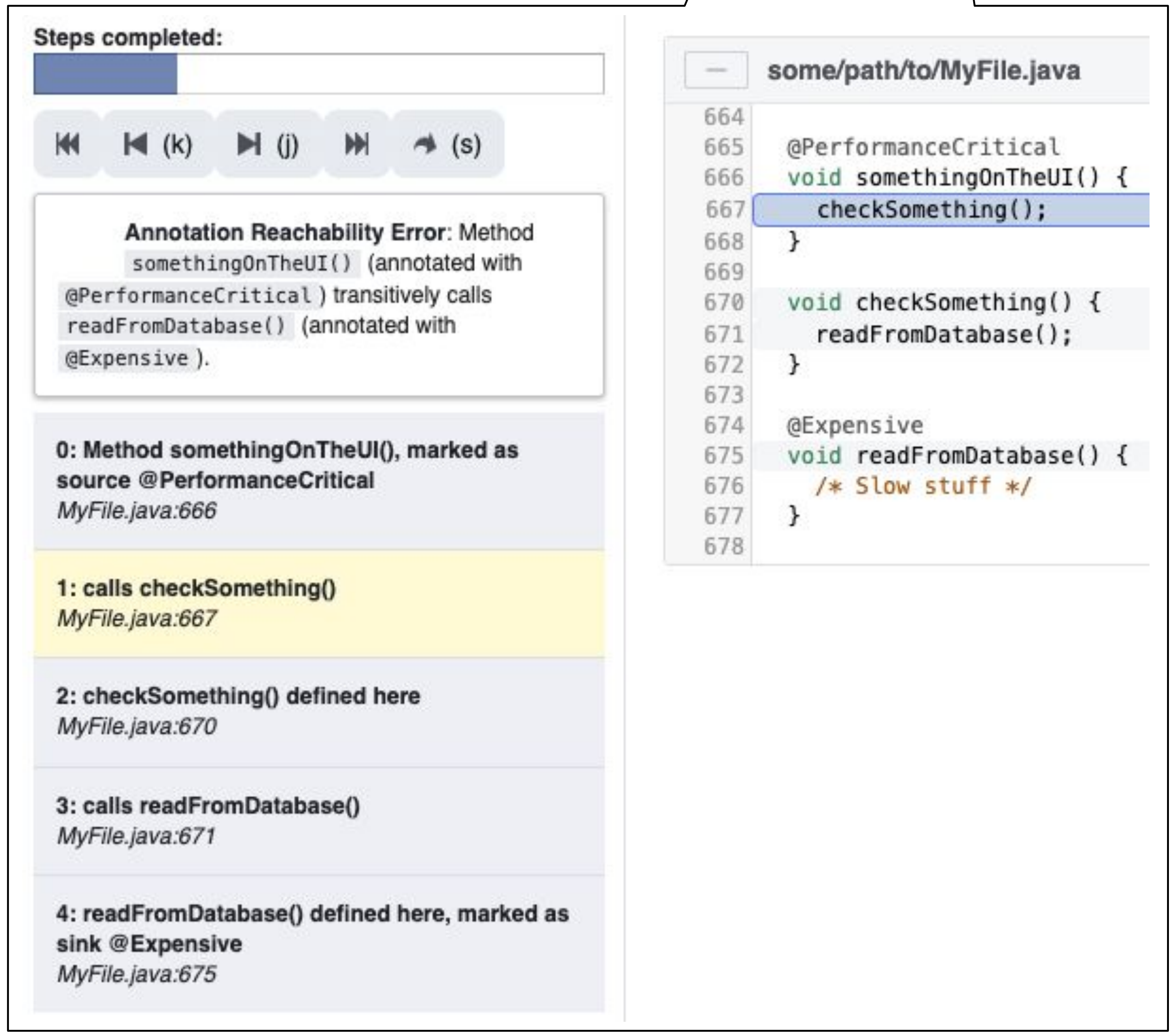


```
665   @PerformanceCritical
666   void somethingOnTheUI() {
667     checkSomething();
```

⚠ **Infer** raised a warning on **line 667**

Annotation Reachability Error(CHECKERS_ANNOTATION_REACHABILITY_ERROR): Method `somethingOnTheUI()` (annotated with `@PerformanceCritical`) transitively calls `readFromDatabase()` (annotated with `@Expensive`) (trace: TV147282036)

```
668   }
669
670   void checkSomething() {
671     readFromDatabase();
672   }
673
674   @Expensive
675   void readFromDatabase() {
676     /* Slow stuff */
677   }
678
```



Steps completed:

Annotation Reachability Error: Method `somethingOnTheUI()` (annotated with `@PerformanceCritical`) transitively calls `readFromDatabase()` (annotated with `@Expensive`).

0: Method somethingOnTheUI(), marked as source @PerformanceCritical
MyFile.java:666

1: calls checkSomething()
MyFile.java:667

2: checkSomething() defined here
MyFile.java:670

3: calls readFromDatabase()
MyFile.java:671

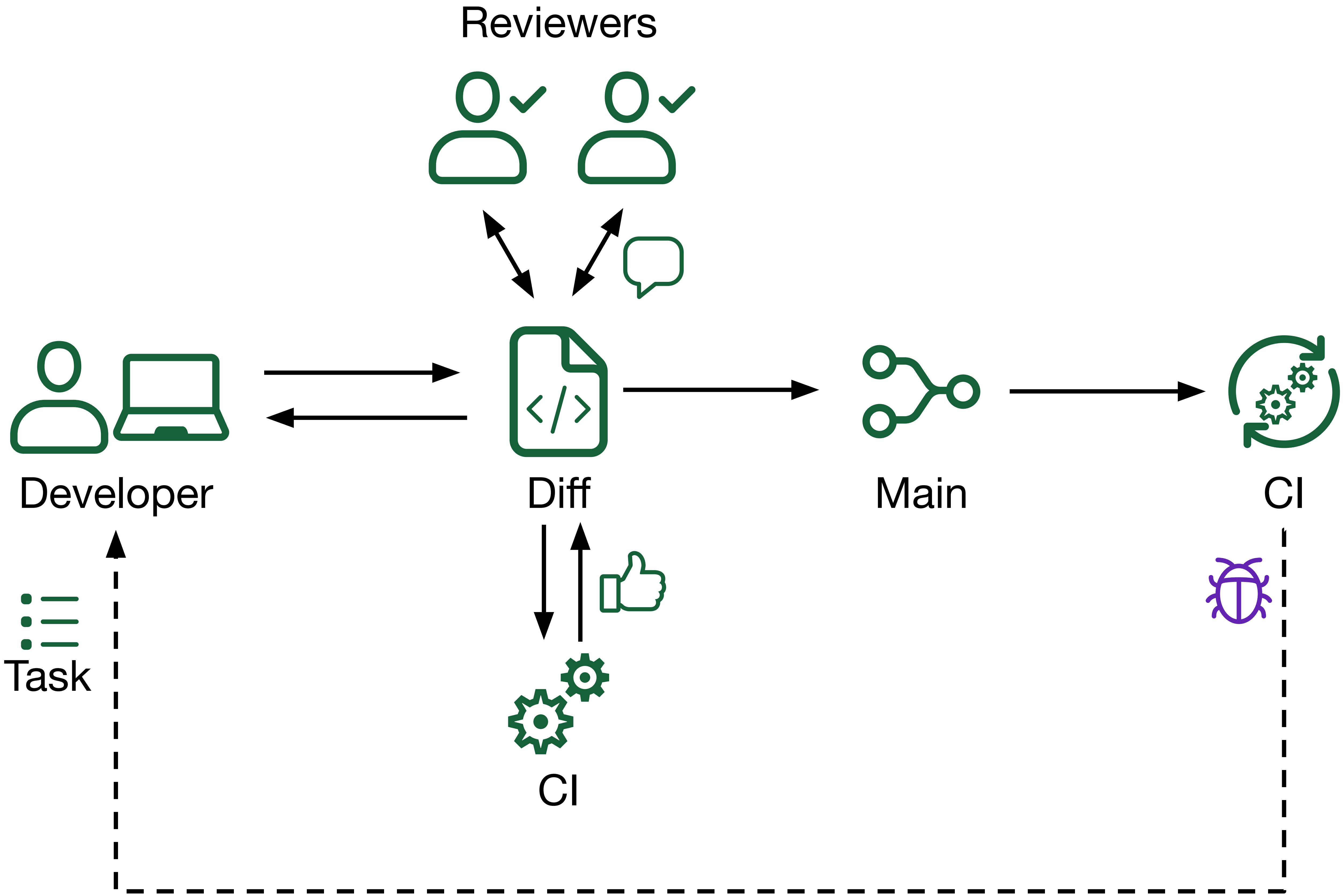
4: readFromDatabase() defined here, marked as sink @Expensive
MyFile.java:675

some/path/to/MyFile.java

```
664
665   @PerformanceCritical
666   void somethingOnTheUI() {
667     checkSomething();
668   }
669
670   void checkSomething() {
671     readFromDatabase();
672   }
673
674   @Expensive
675   void readFromDatabase() {
676     /* Slow stuff */
677   }
678
```

Deployment

Continuous



Deployment

Pre-existing issues

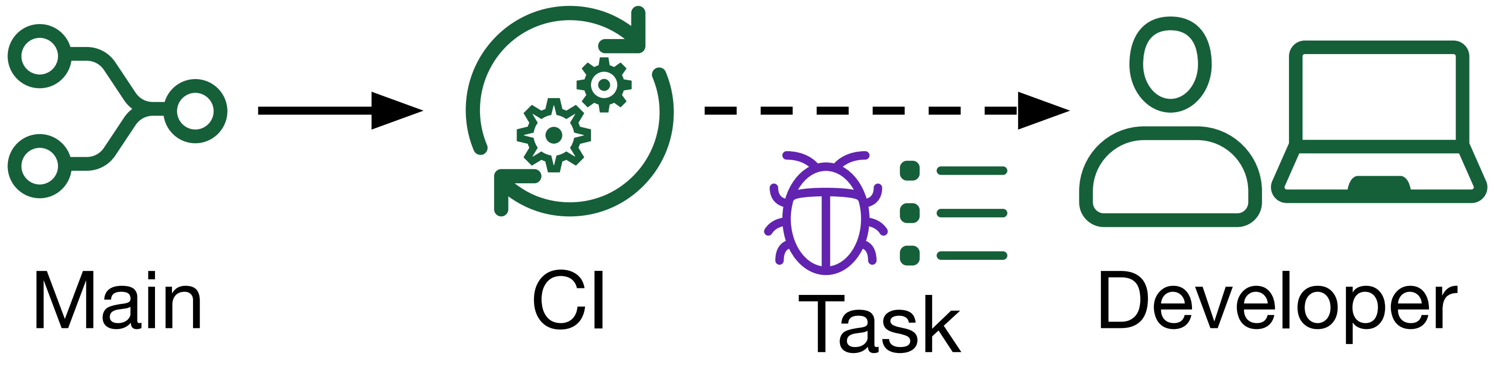
- Quality
- Volume

	No sink min.	Sink min.
No source min.	12 500	1 600
Source min.	10 600	1 100

Code changes: shadow mode → early adopters → full rollout

Results

Pre-existing



Main

CI

Task

Developer

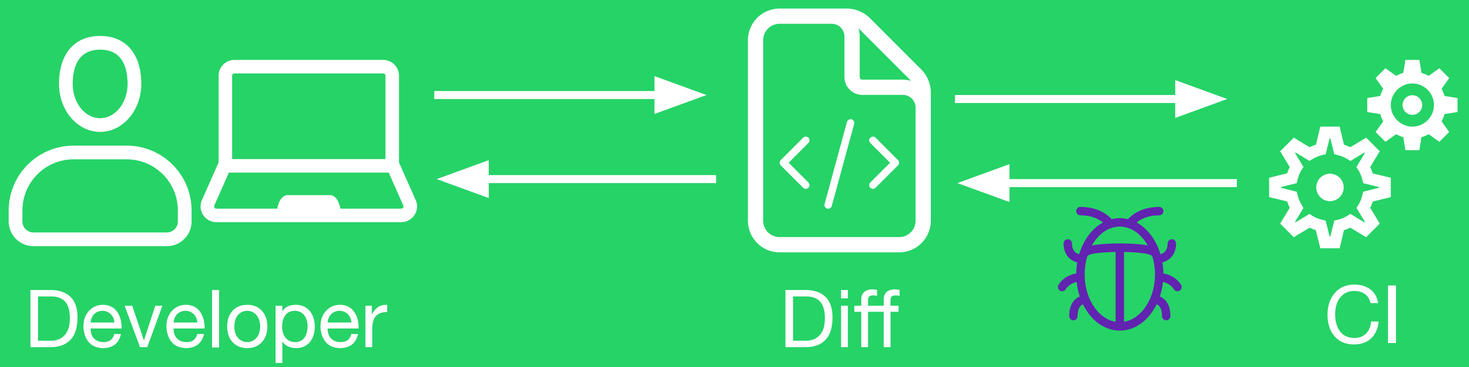
59 tasks filed, 7 fixed

Example:

reduced ANRs by 0.56%

1.25% chat loading speedup globally

Code changes



Developer

Diff

CI

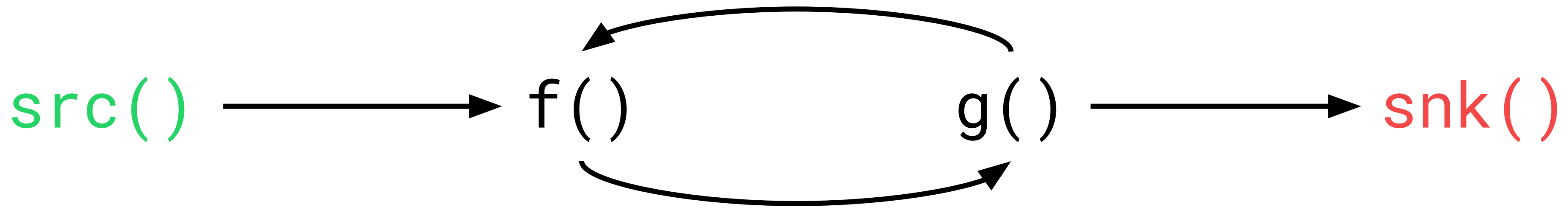
3 months

174 reported, 92 fixed

53% fixrate

Unfixed

Kotlin conversion



src() f() g() snk()

Mutual recursion & scheduling

Flow- and path-insensitivity

```
void source() { // Needs path-sensitivity
 if (is_debug()) sink();
}
```

```
void source() { // Needs flow-sensitivity
 beginSanitizing();
 sink();
 endSanitizing();
}
```

Performance

Hard to measure: caching, multiple checkers, parallelism

Continuous (p90 execution time)

33 mins

Compilation

53 mins

Analysis (all checkers)

15 mins

Reachability only

Code changes (p90 execution time)

32 mins

Total time: parent+current, all checkers, changed files (and deps) only

Takeaway

Fast enough to run multiple times a day in continuous mode

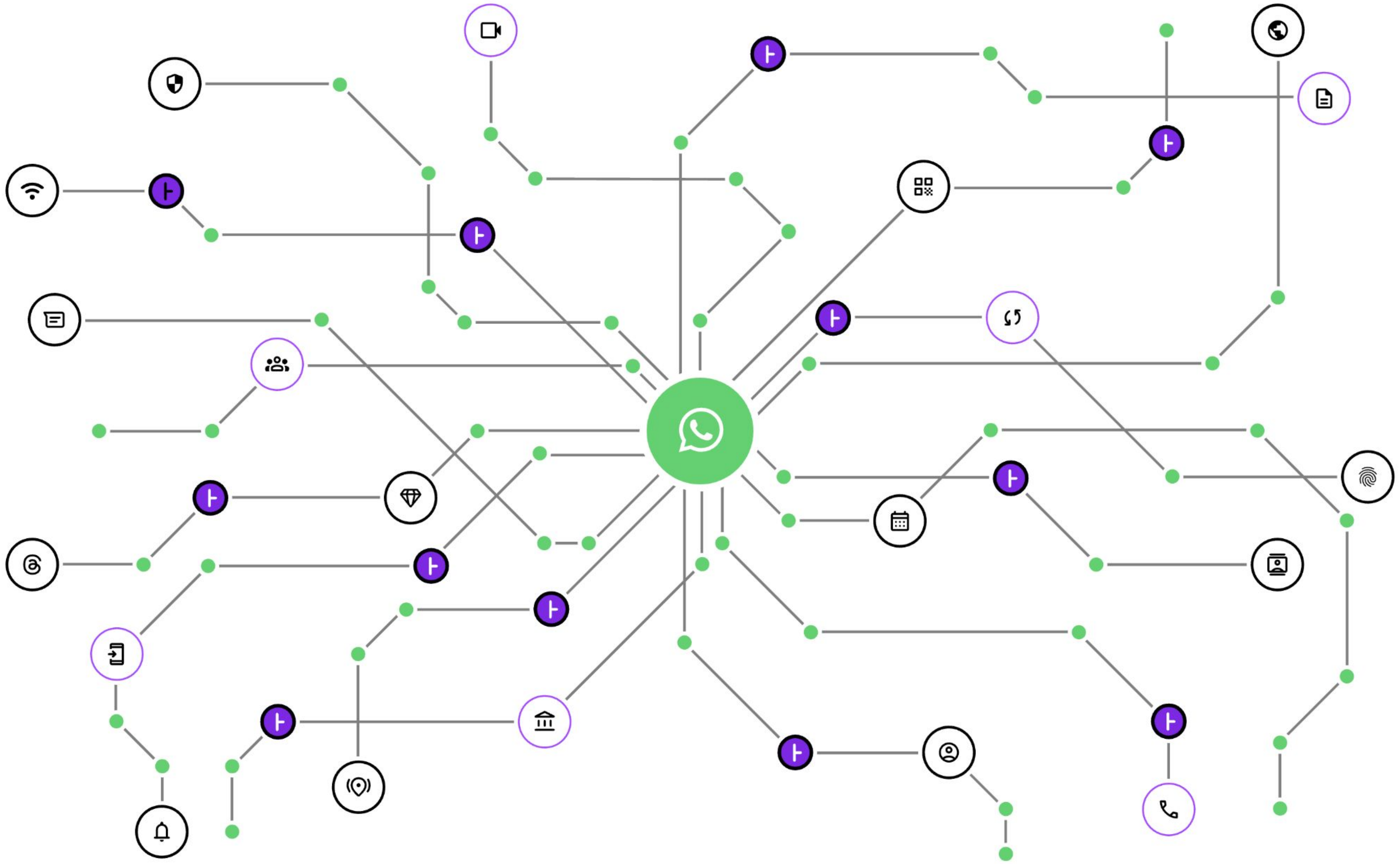
Provide timely feedback on code changes

Reachability is not the bottleneck

Summary

Callgraph reachability for WhatsApp Android app health via Infer

3 months, prevented 92 regressions + 7 pre-existing fixes, end-user measurable impact



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