Fixr: Mining and Understanding Bug Fixes for App-Framework Protocol Defects (TA2)





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University of Colorado Boulder

MUSE Kickoff
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PLV

A bug that manifests spectacularly …

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caused by an app-created memory leak

Ask framework devs ...

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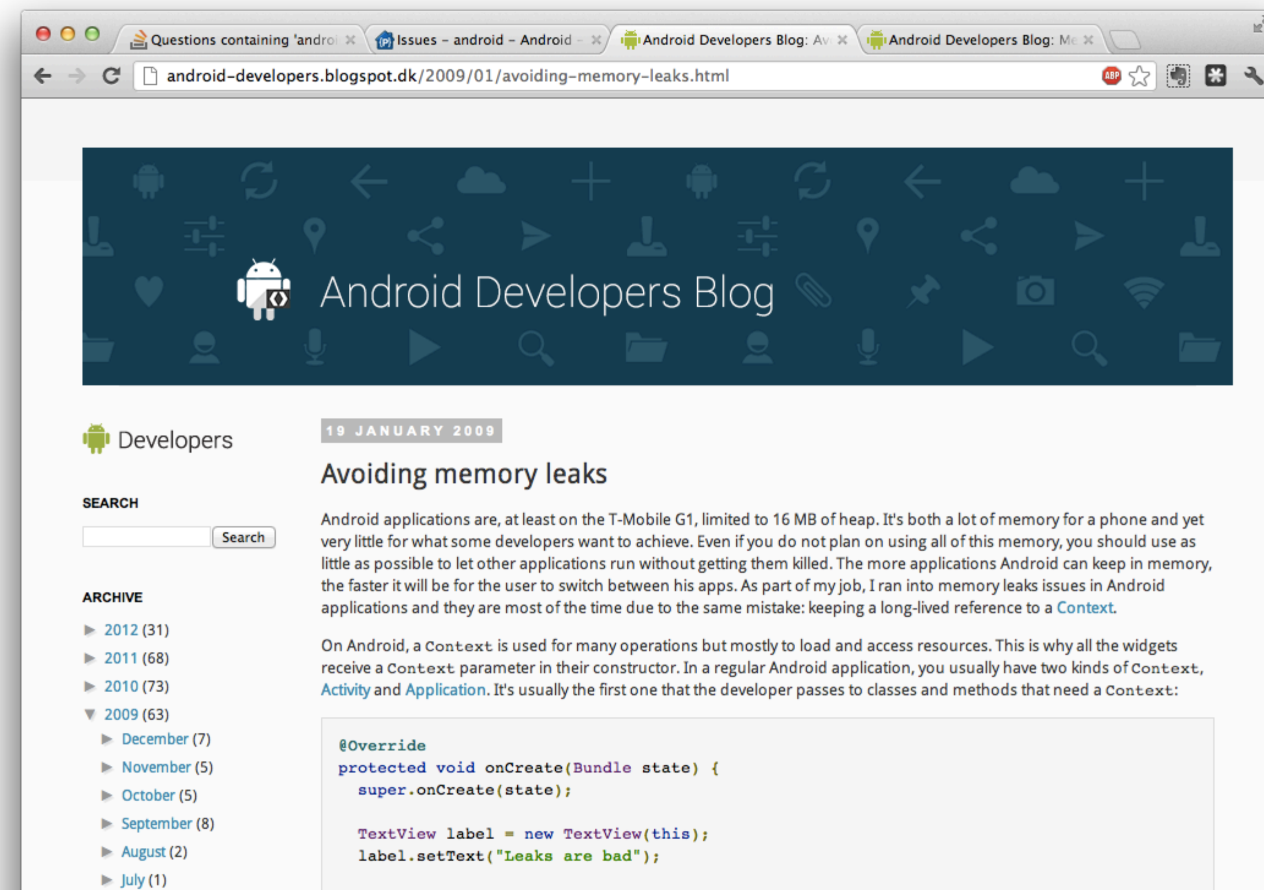
“Do not keep long-lived references to a context-activity”



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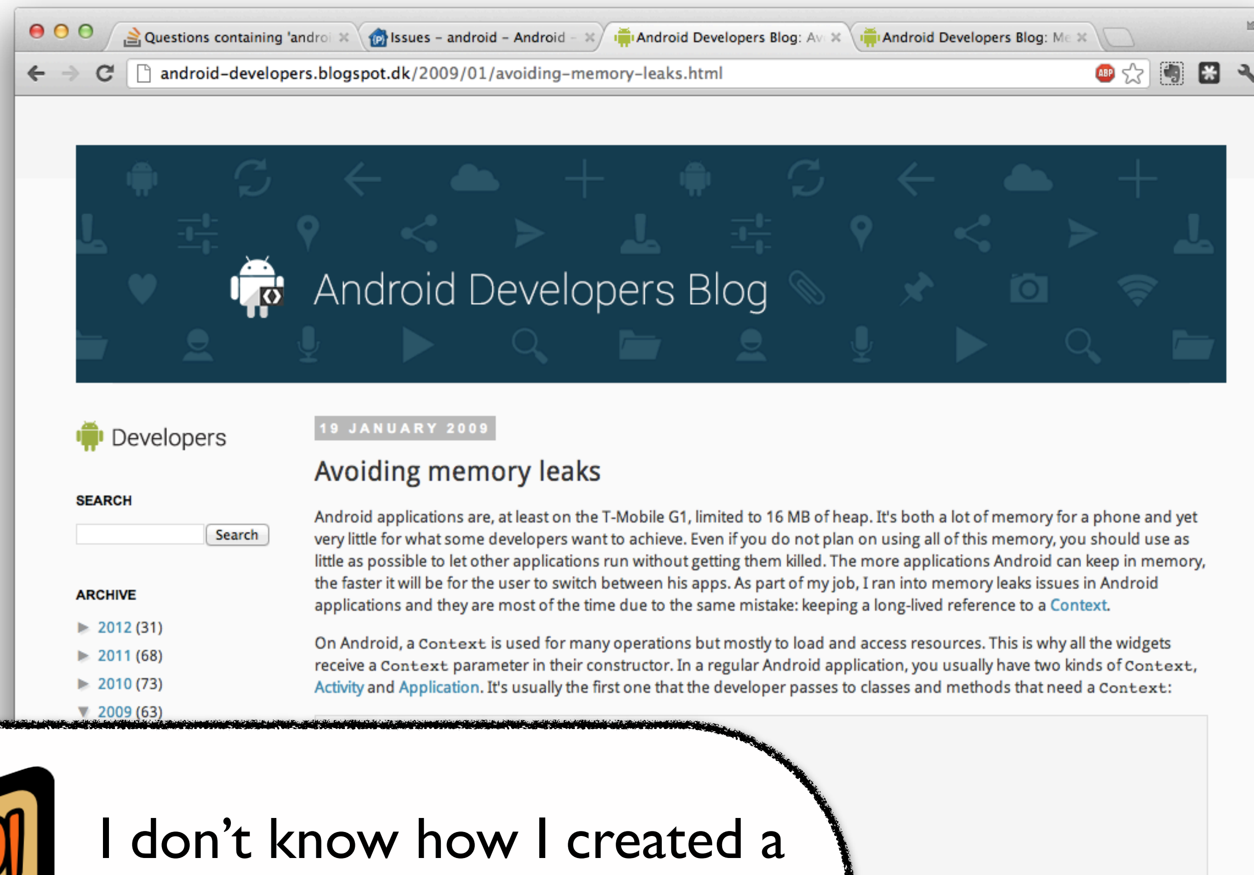

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android-developers.blogspot.dk/2009/01/avoiding-memory-leaks.html

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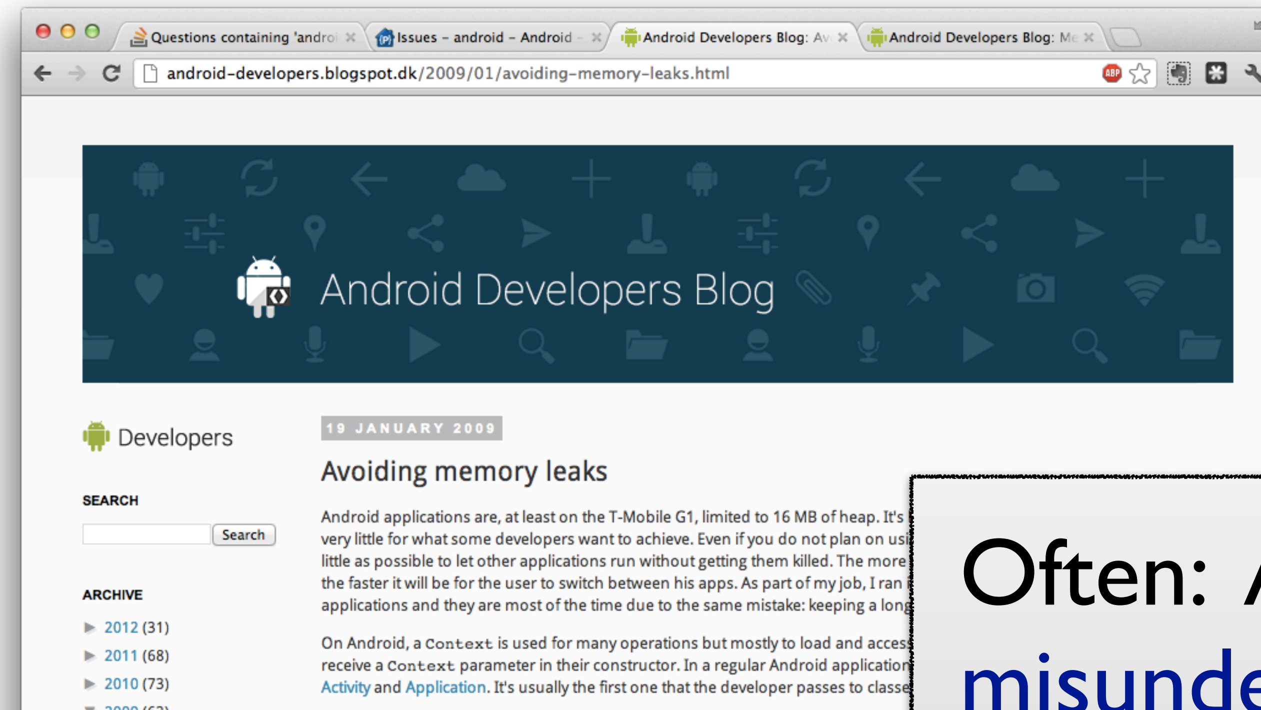
Avoiding memory leaks

Android applications are, at least on the T-Mobile G1, limited to 16 MB of heap. It's both a lot of memory for a phone and yet very little for what some developers want to achieve. Even if you do not plan on using all of this memory, you should use as little as possible to let other applications run without getting them killed. The more applications Android can keep in memory, the faster it will be for the user to switch between his apps. As part of my job, I ran into memory leaks issues in Android applications and they are most of the time due to the same mistake: keeping a long-lived reference to a Context.

On Android, a `Context` is used for many operations but mostly to load and access resources. This is why all the widgets receive a `Context` parameter in their constructor. In a regular Android application, you usually have two kinds of `Context`, Activity and Application. It's usually the first one that the developer passes to classes and methods that need a `Context`:

Ask framework devs ...

"Do not keep long-lived references to a context-activity"

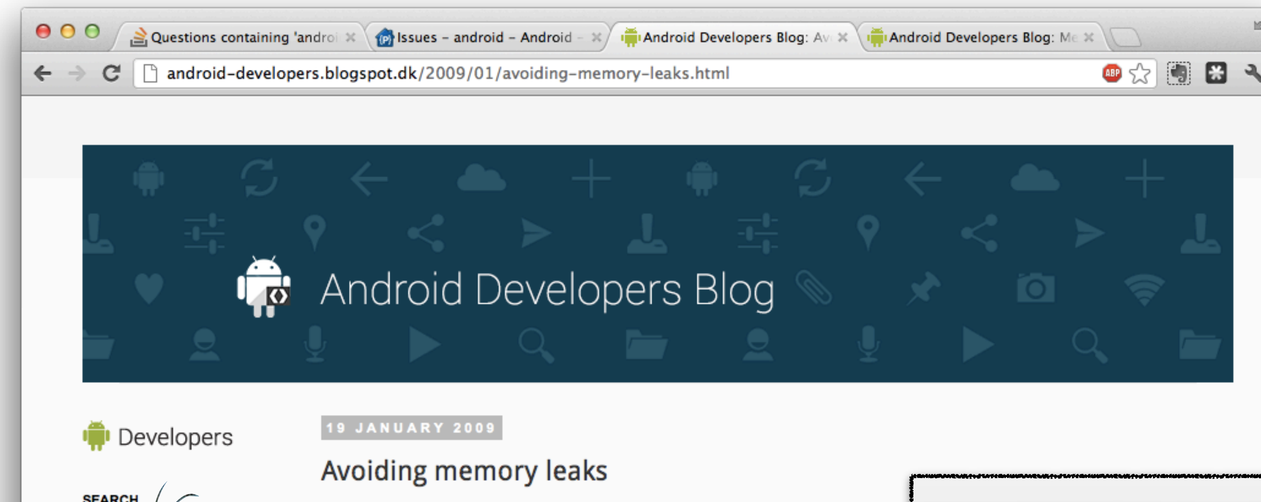


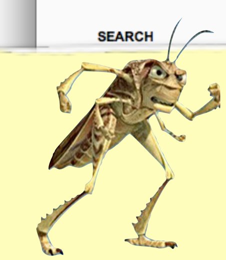
I don't know how I created a long-lived reference to an `Activity`!

Often: A **misunderstanding** of a library causes the **library** to keep the `Activity` reference.

Ask framework devs ...

"Do not keep long-lived references to a context-activity"





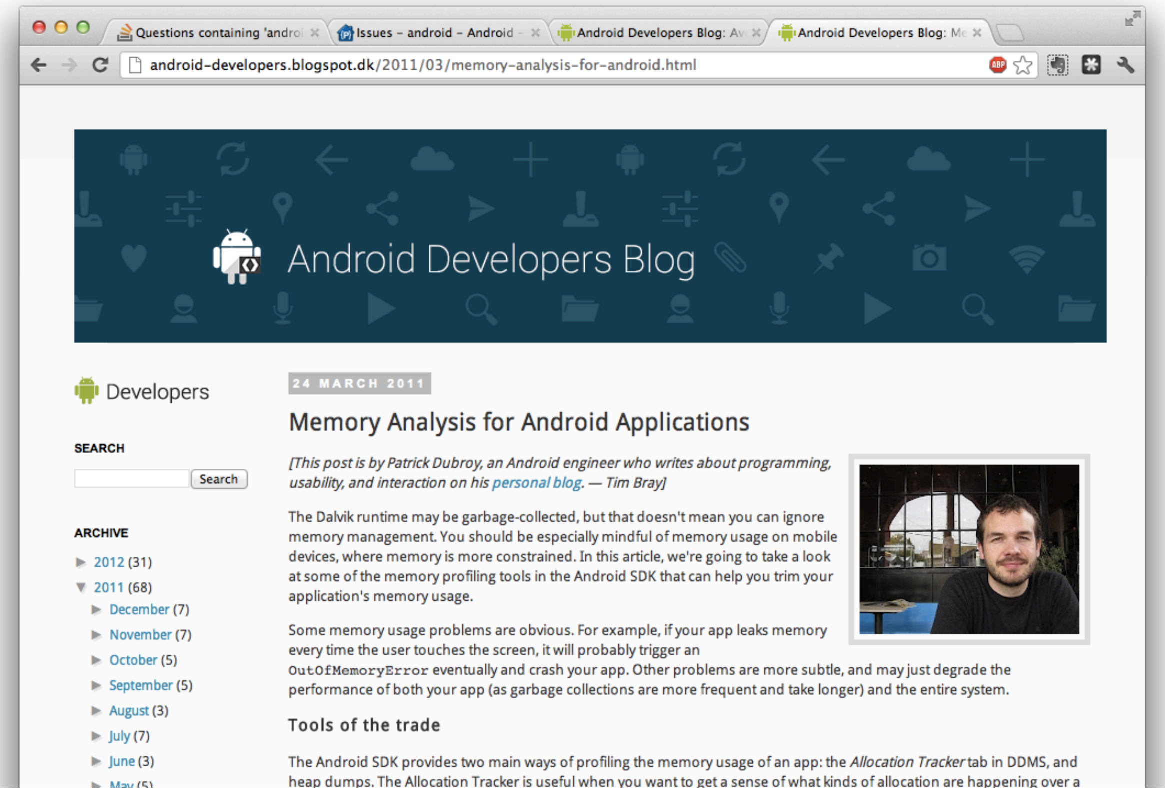
Bug from violating
(implicit) framework protocol rules

Imagining a post-MUSE scenario ...

for 

I don't know how I created a long-lived reference to an `Activity`!

Elsewhere, following the state of practice for debugging leaks ...



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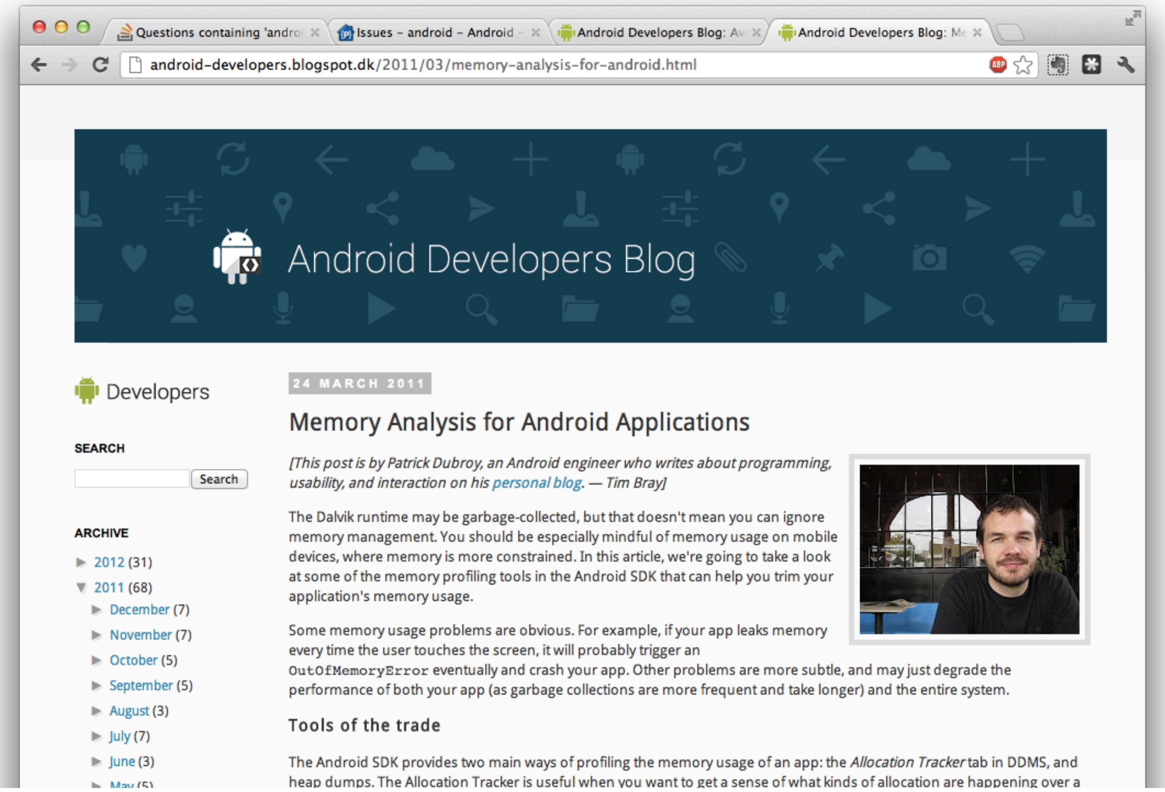

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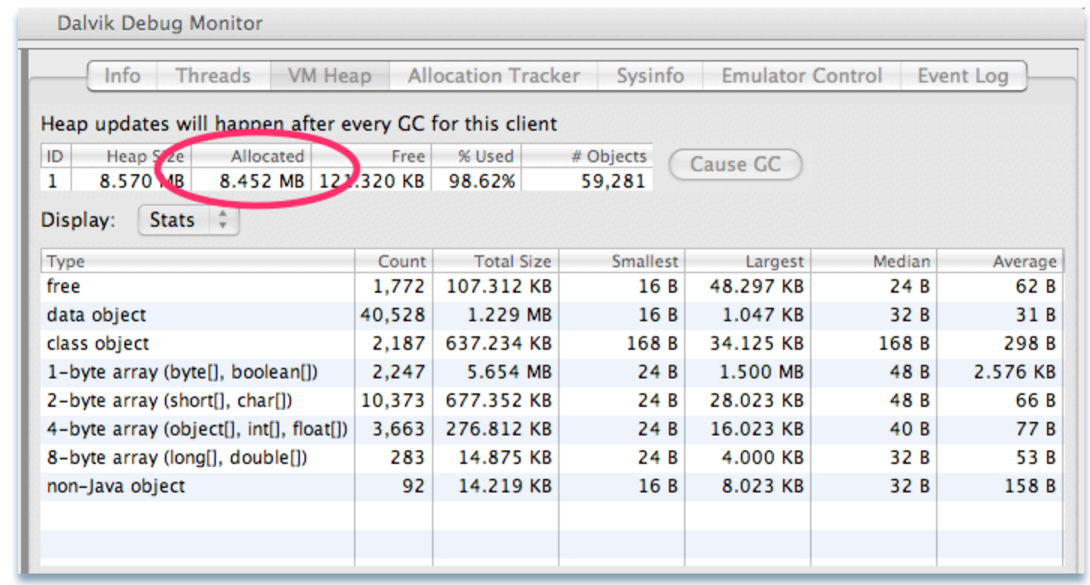

1. Run the app
2. Watch the heap usage

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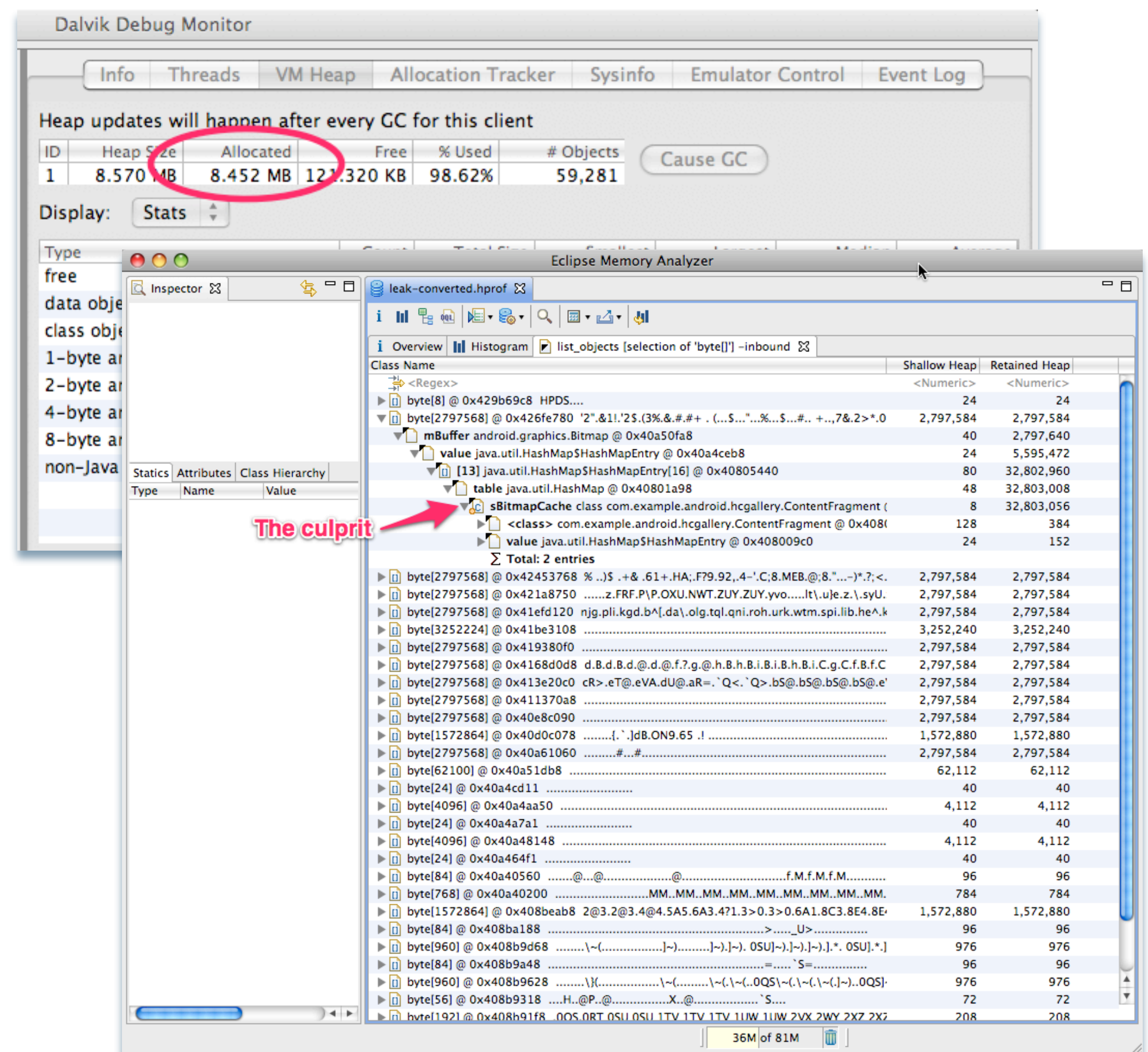

1. Run the app
2. Watch the heap usage
3. Dump the heap. Dig around and finally find the culprit!

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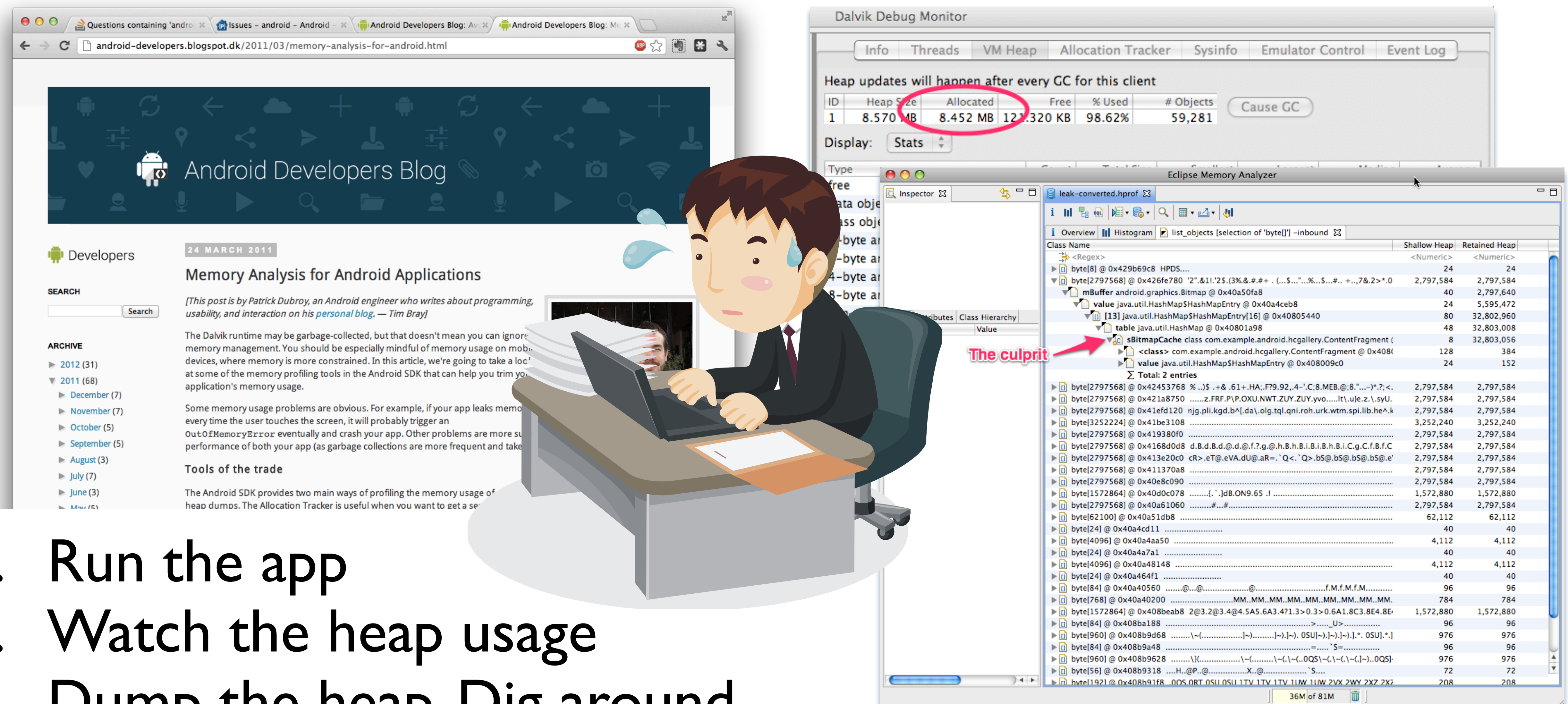

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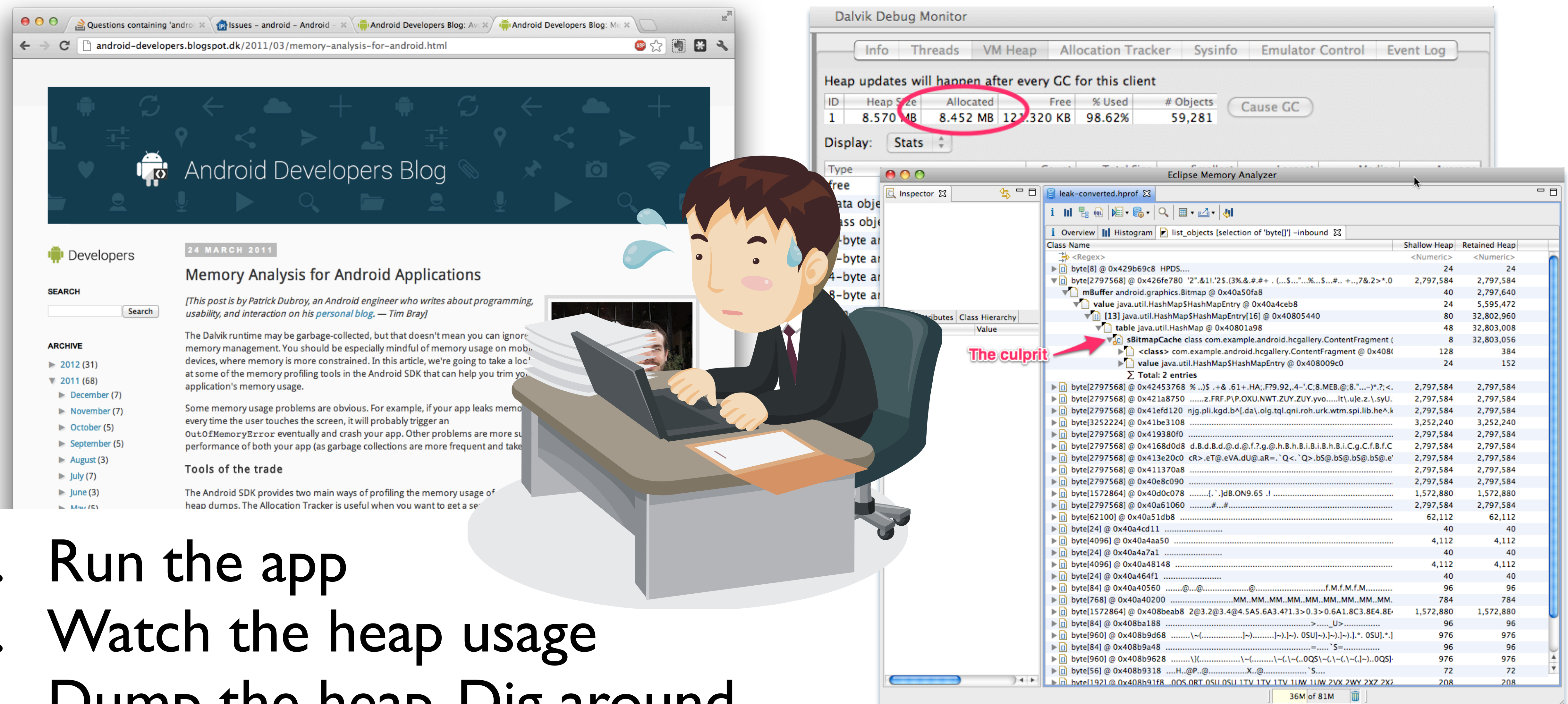

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4. Commit a bugfix

GitHub

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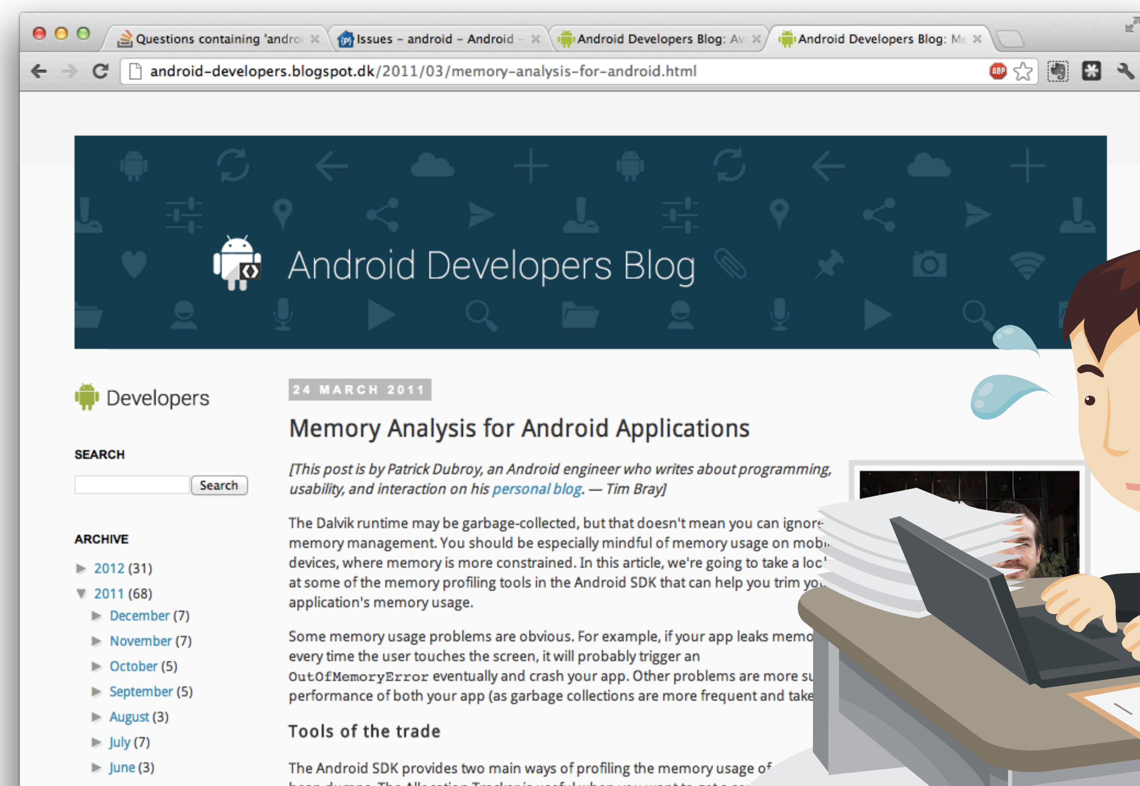

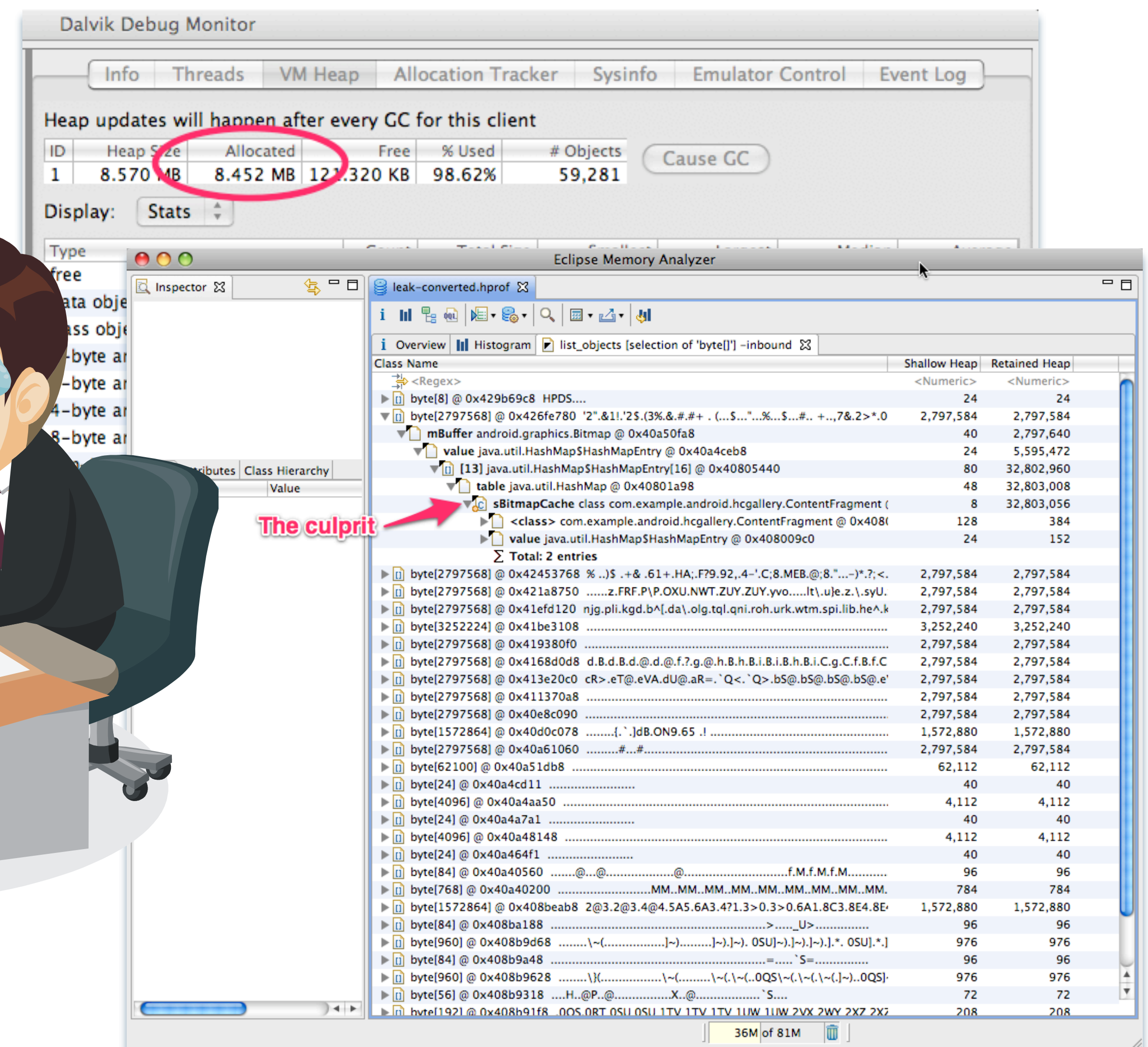

1. Run the app
2. Watch the heap usage
3. Dump the heap. Dig around and finally find the culprit!
4. Commit a bugfix
5. Bugfix is picked up by **Fixr**

GitHub

Fixr

A **Fixr**-enabled IDE responds ...

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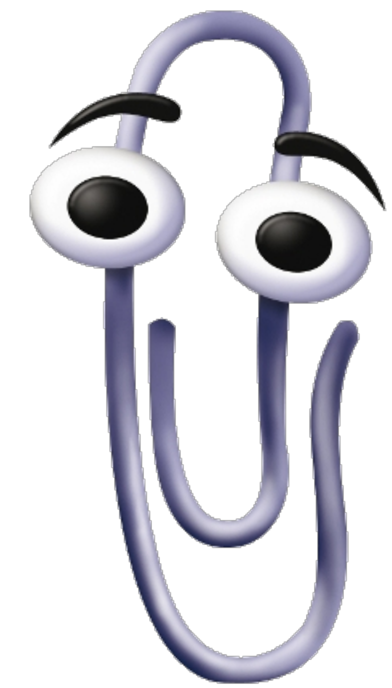

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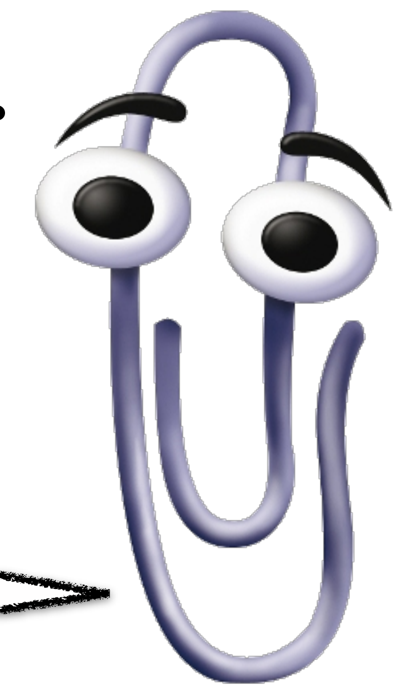

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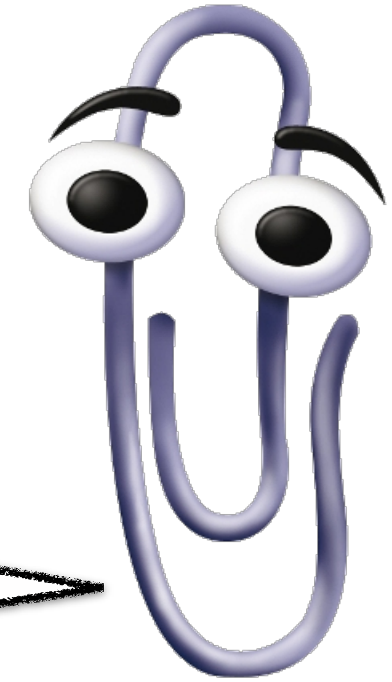

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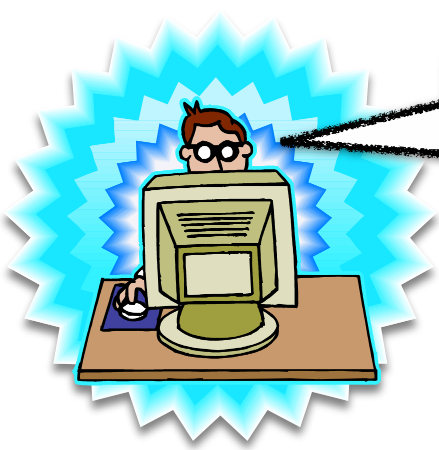
the bugfix is "transferred"



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One Sentence Summary: Mine specifications of framework rules (indirectly) from bugfixes

Leverage volume and variety of bugfixes made by the crowd of client app developers

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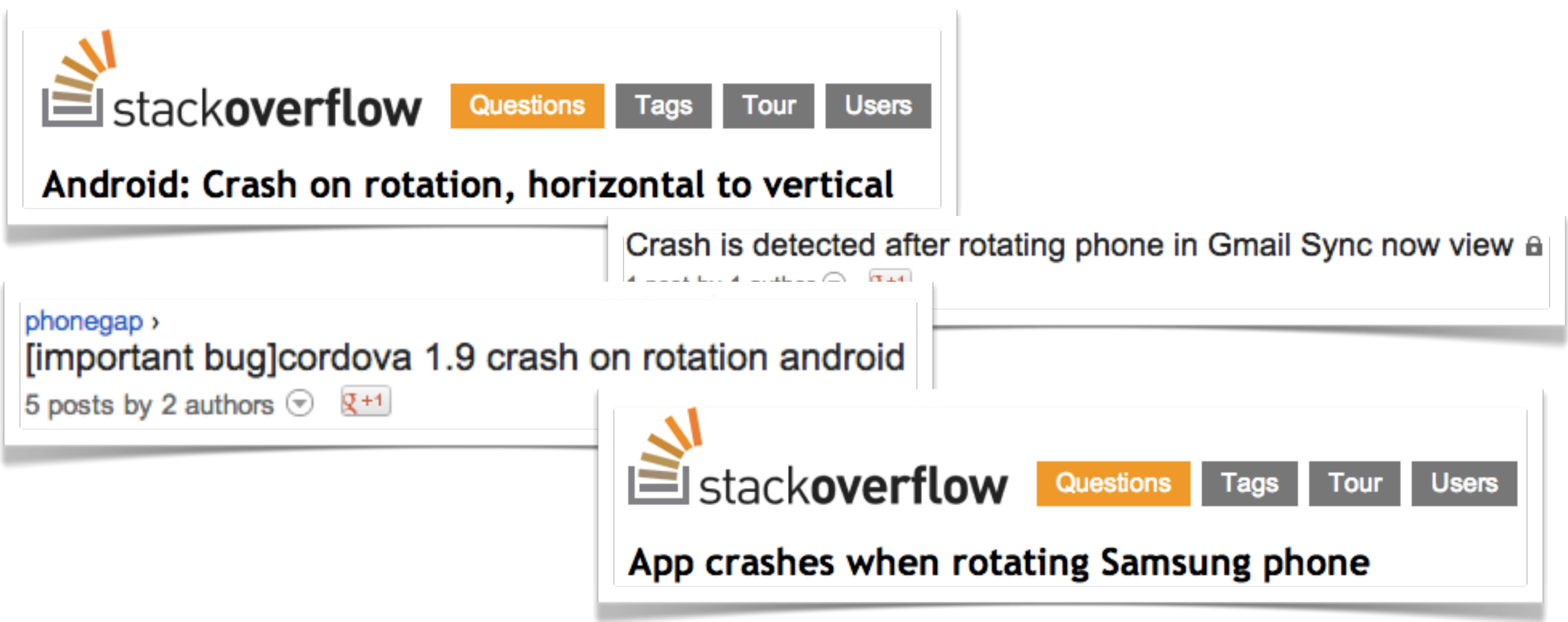

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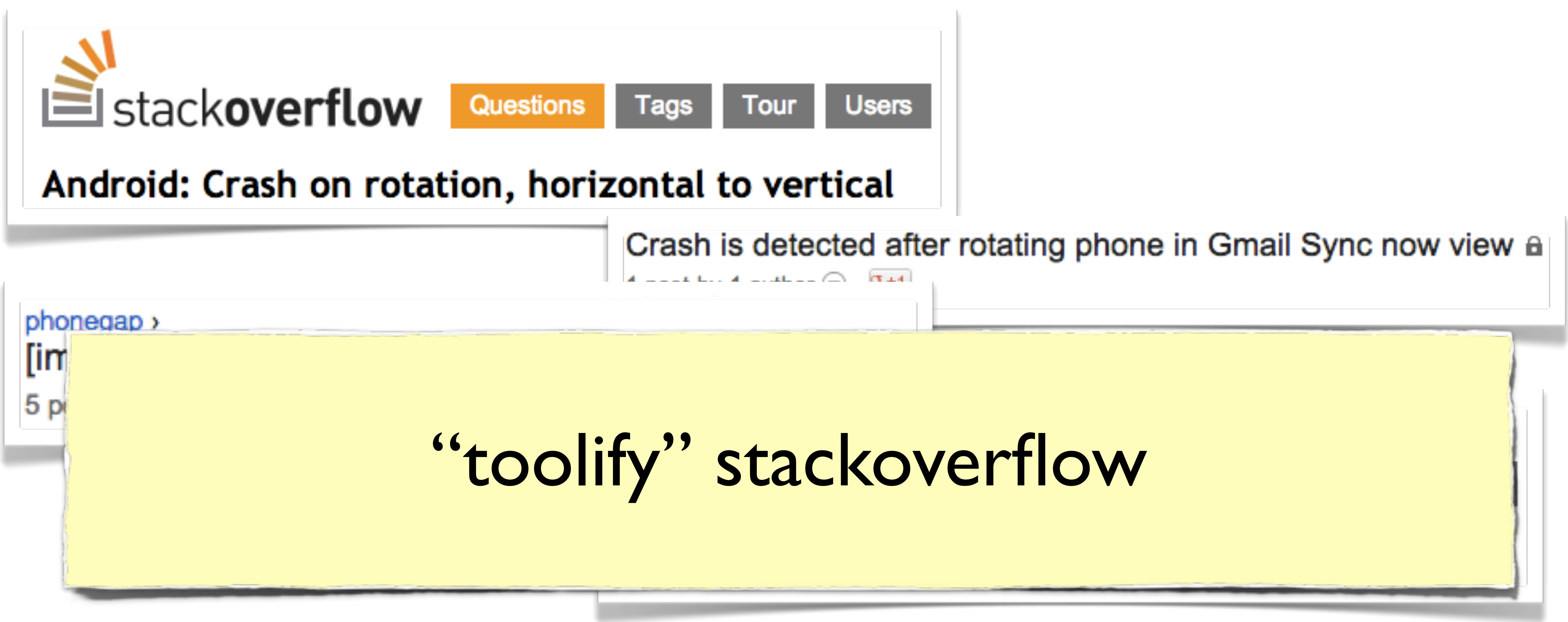

“toolify” stackoverflow

Simple motivating example: A well-understood Android bug

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a common misuse of the framework

Bug
(on Android <4)

aView.setTag(..., anObject)

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aView.setTag(..., anObject)

if anObject can reach aView

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if anObject can reach aView

Framework Invariant

```
class View {
  static WeakHashMap<View, SparseArray<Object>> sTags;
  Object mTag;
}
```

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A Fix

~~aView.setTag(..., anObject)~~
aView.setTag(anObject)

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A Fix

~~aView.setTag(..., anObject)~~

aView.setTag(anObject)

uses mTag instead

Bug
(on Android <4)

aView.setTag(..., anObject)

bug pre

if anObject can reach aView

Framework
Invariant

```
class View {
  static WeakHashMap<View, SparseArray<Object>> sTags;
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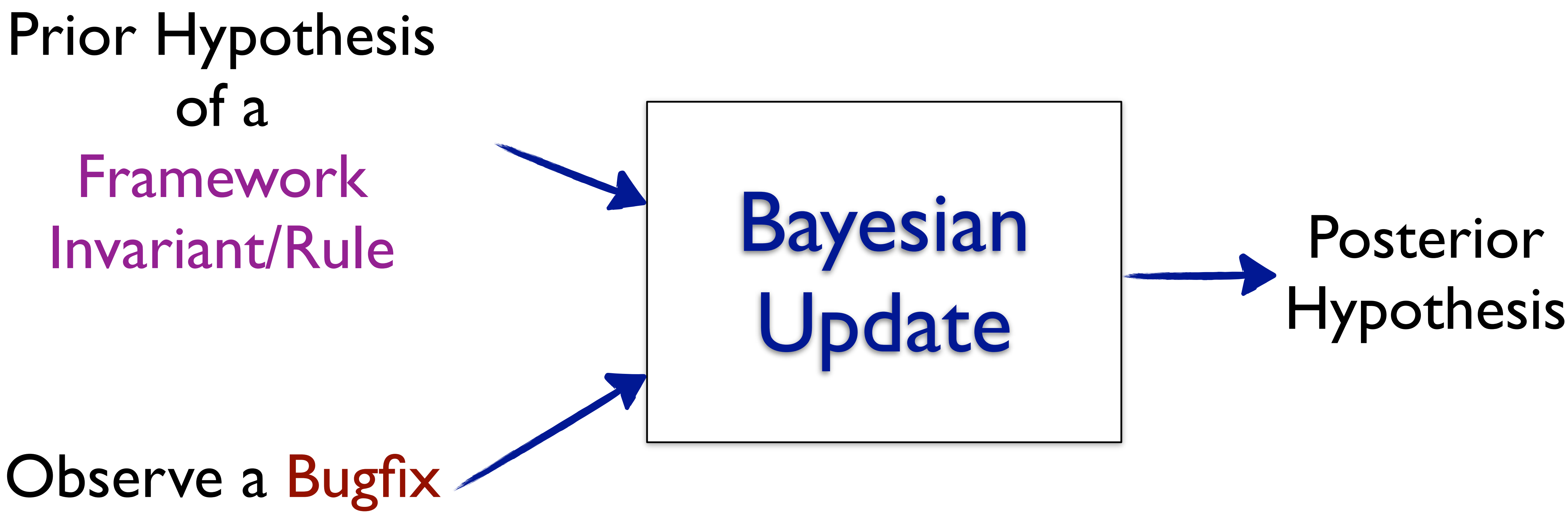
}
```

invariant

because of an unspecified class invariant: sTags' values (:Object) must not reach their keys (:View)

Goal: Produce this repair specification: *bug pre, framework invariant, fix suggestion*

Mining framework specifications with bugfixes



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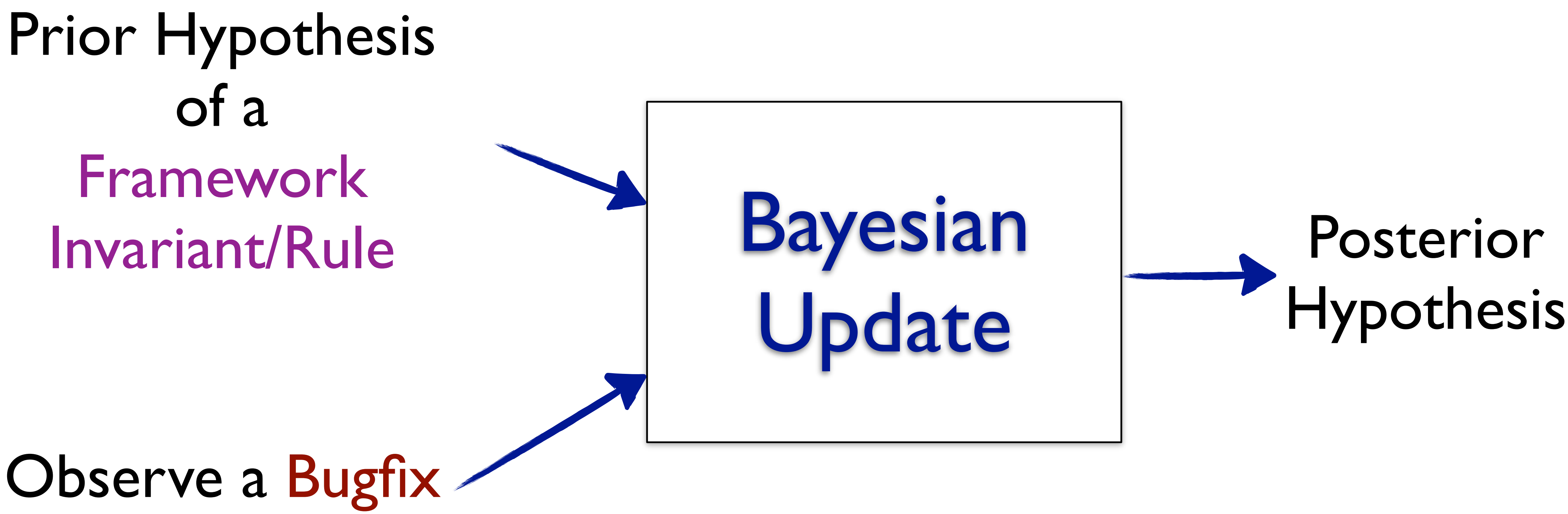
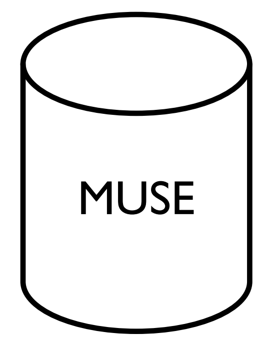


The **Fixr** Loop:
Create as many observations as possible

The **Fixr** Loop: Component by Component

Fixr: Proposed System



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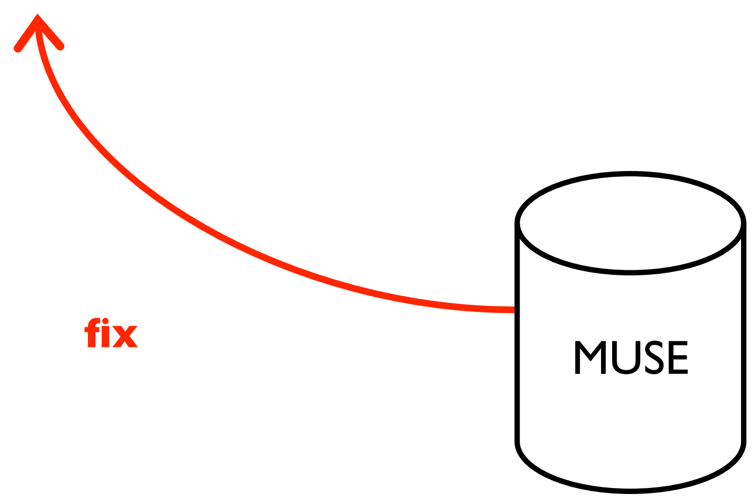

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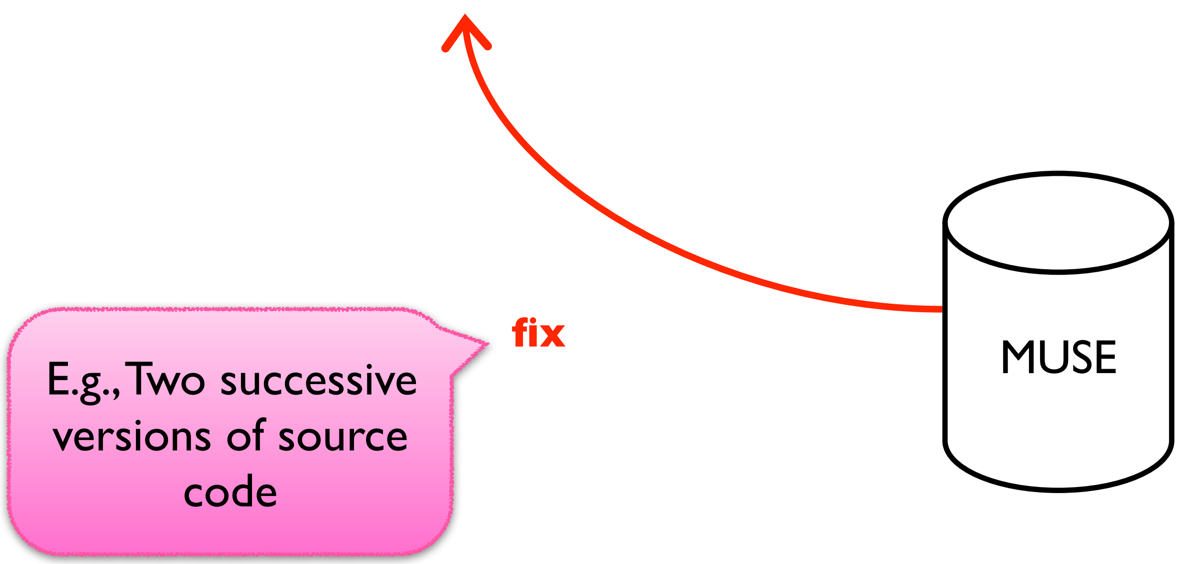

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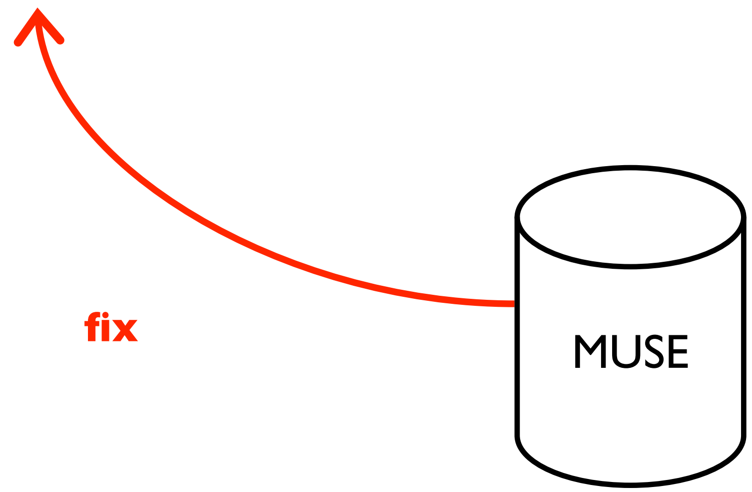

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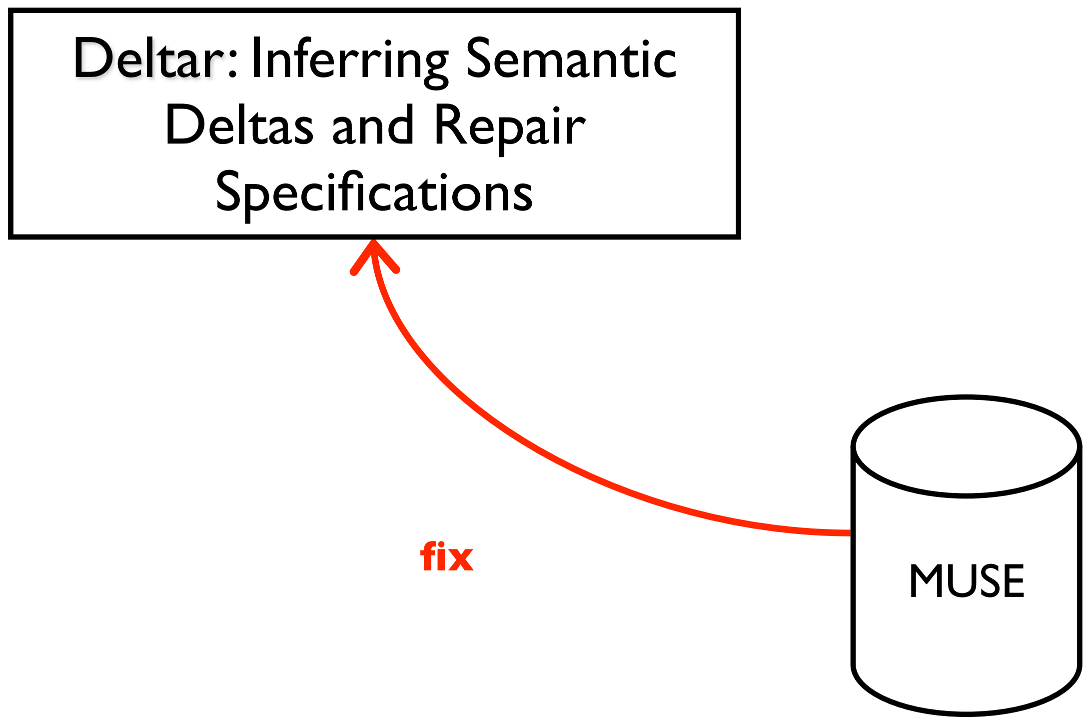

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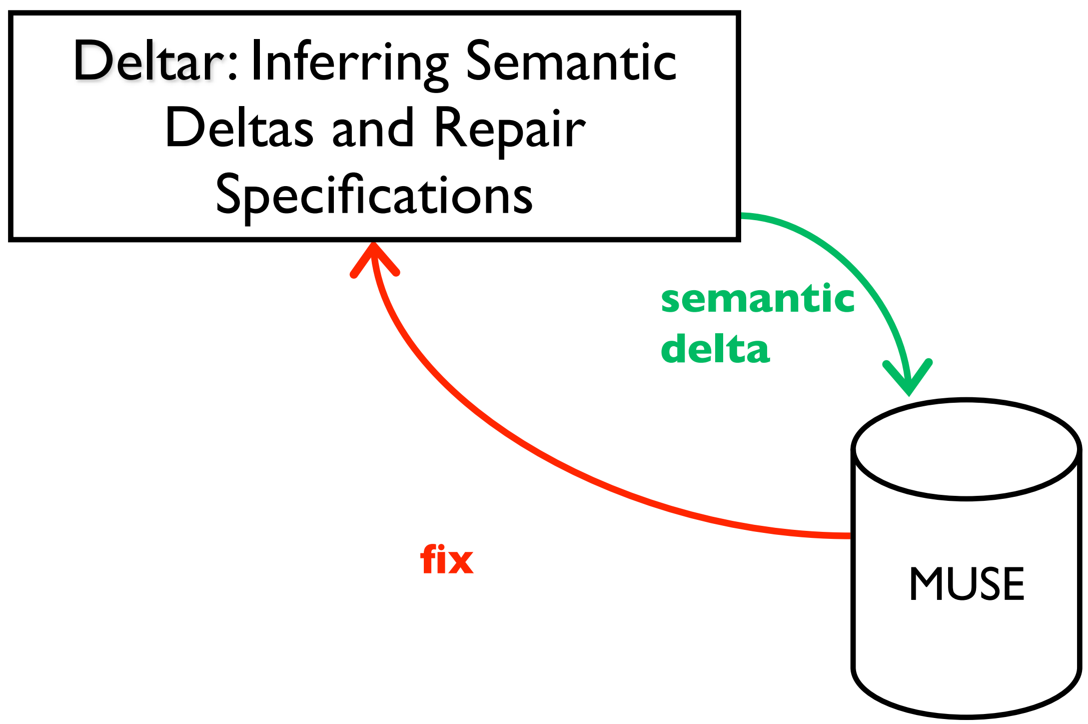

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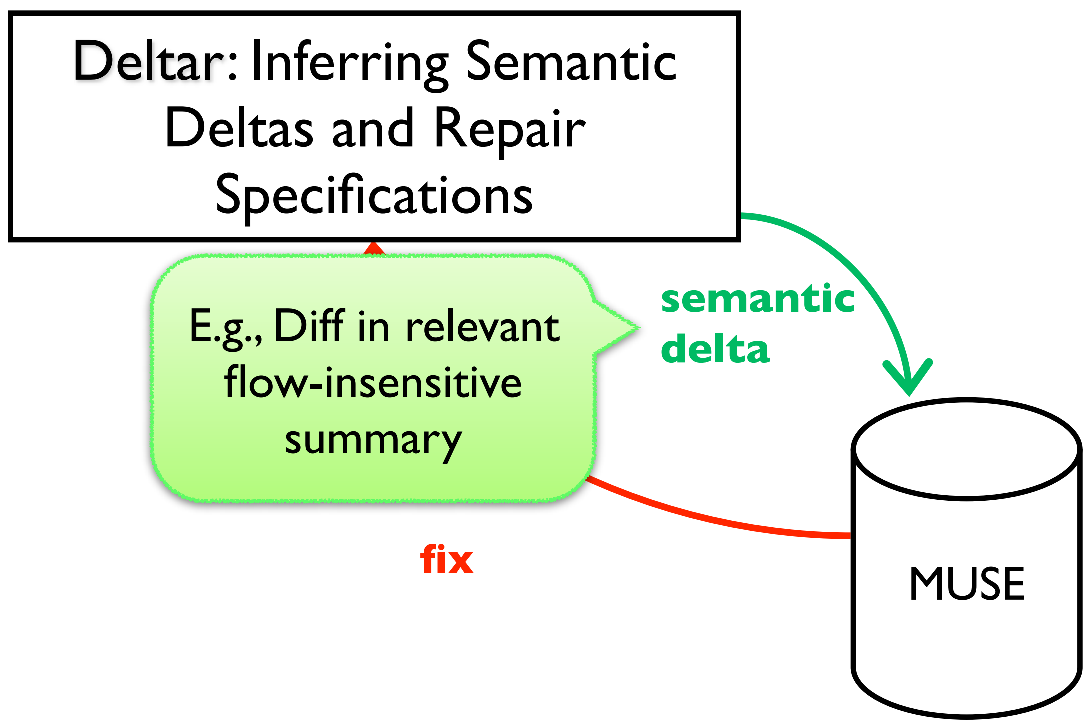

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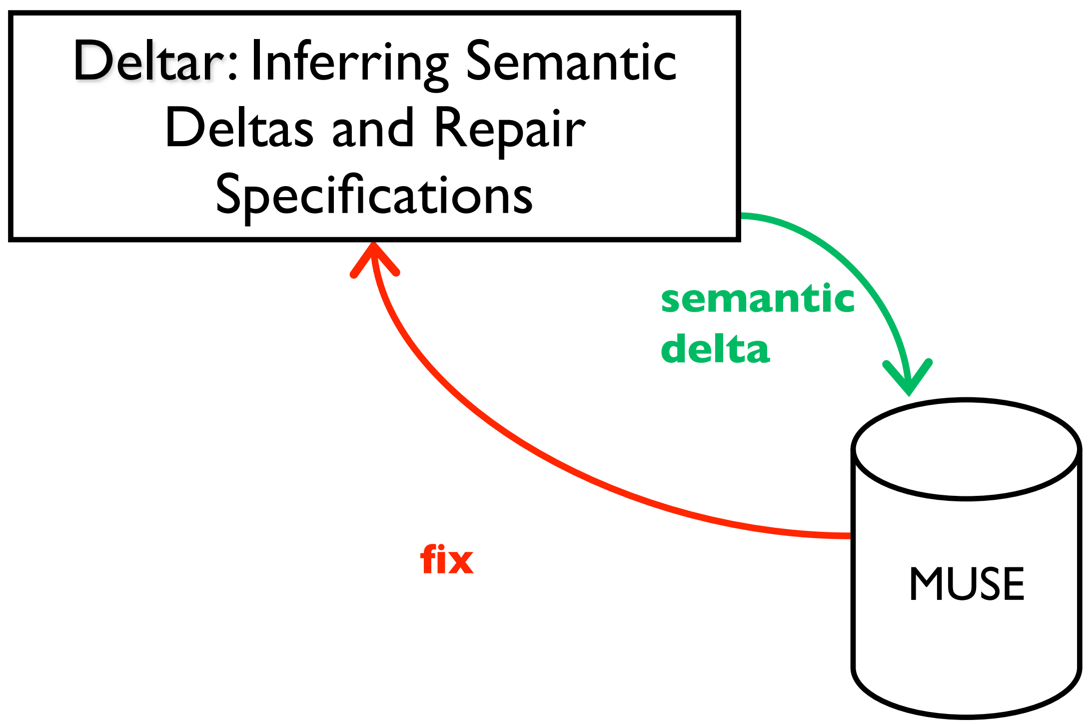

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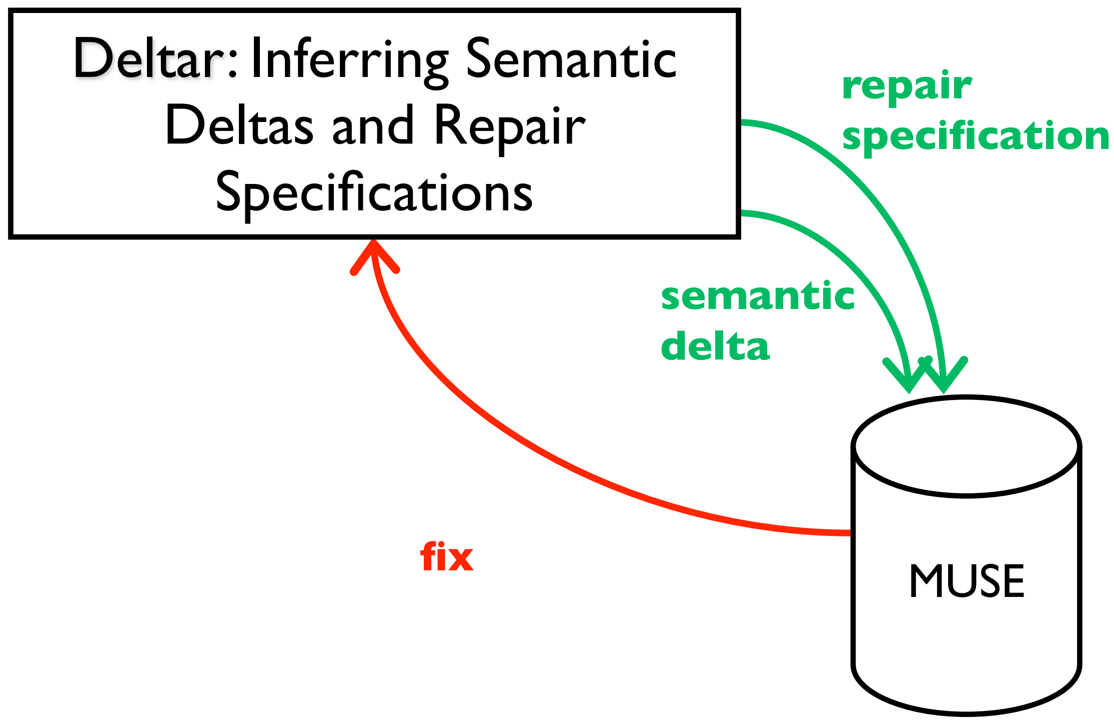

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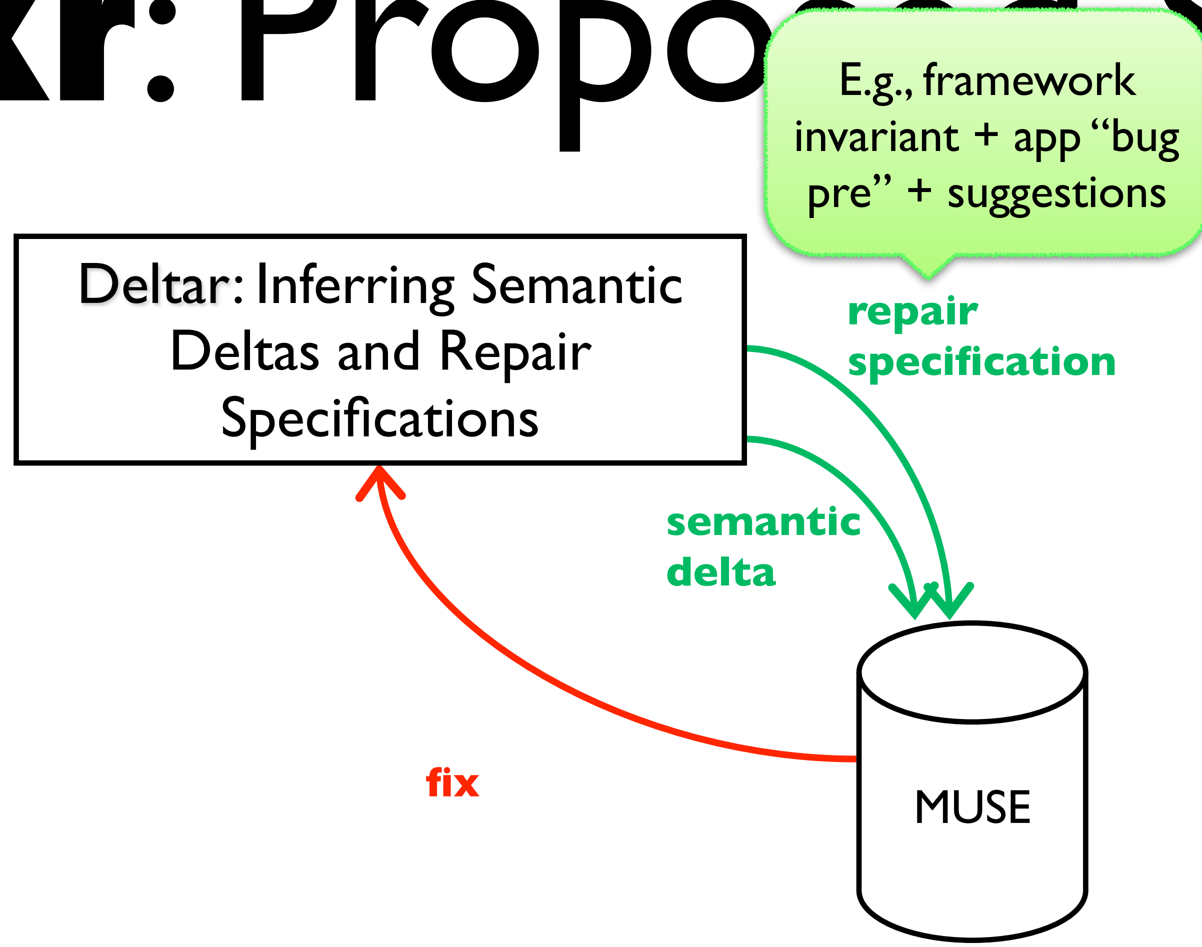

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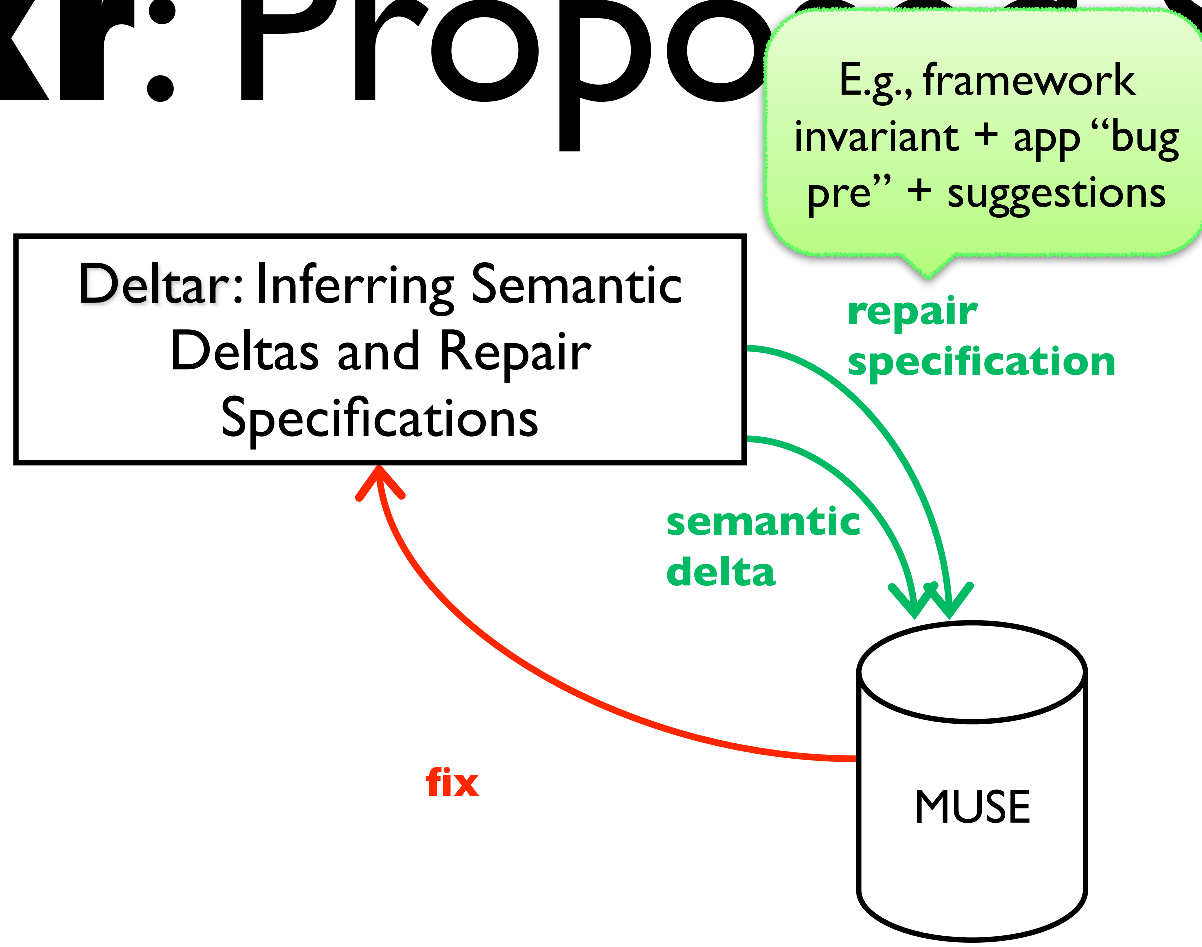

Component: Deltar *maps* fixes to semantic difference summaries and candidate repair specifications

Deltar

Deltar

A Fix

~~aView.setTag(..., anObject)~~

aView.setTag(anObject)

Deltar

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Problem: Need to mine and check candidate framework invariants

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Delta

~~WeakHashMap$Entry → MyView~~

Deltar

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Candidate Invariant

sTags == **null** $\wedge$ mTag != **null**

Deltar

A Fix

~~aView.setTag(..., anObject)~~

aView.setTag(anObject)

Problem: Need to mine and check candidate framework invariants

Delta

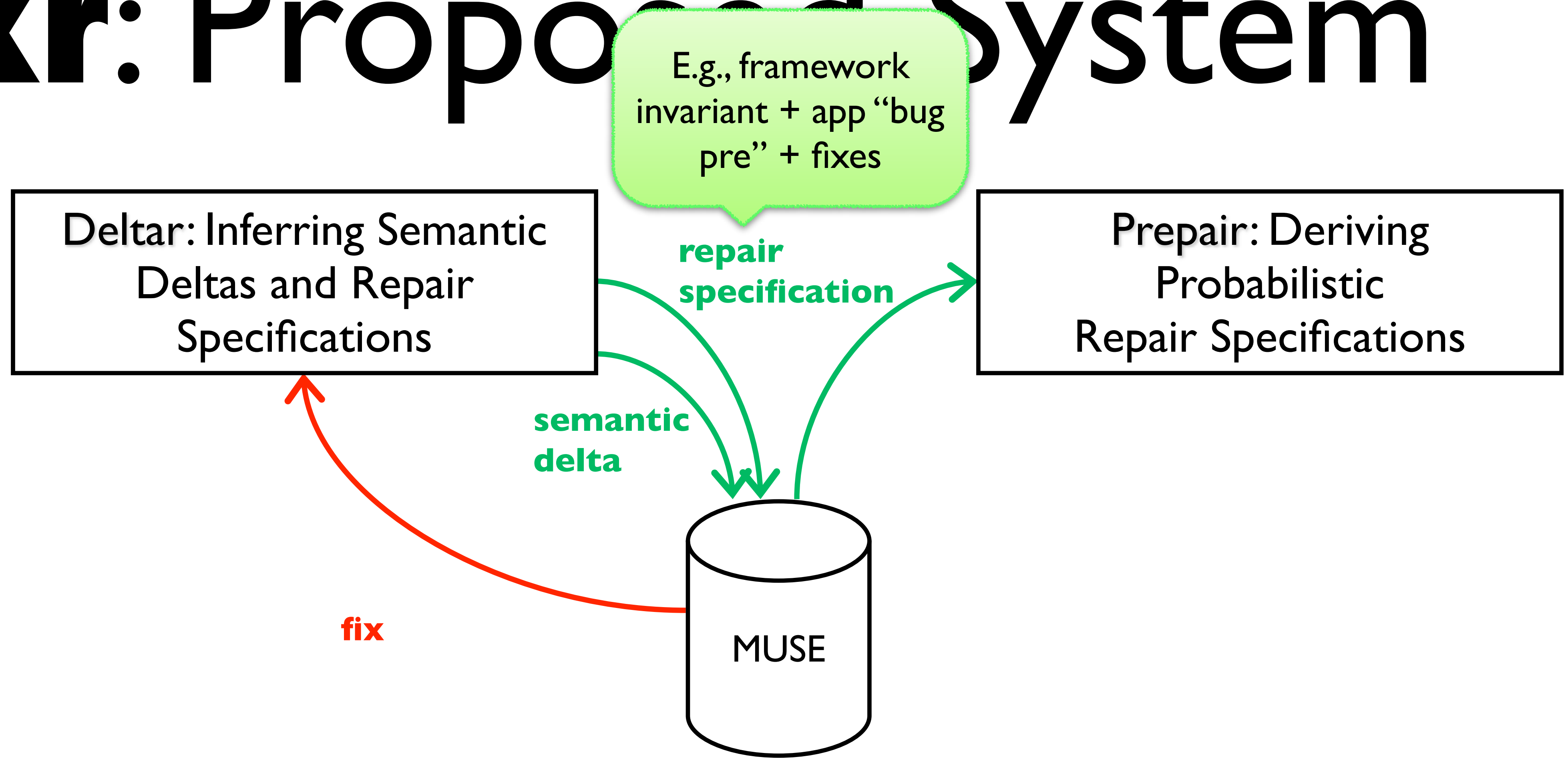
~~WeakHashMap$Entry → MyView~~

Candidate Invariant

sTags == **null** ∧ mTag != **null**

Approach: Refine coarse, global summaries and verify candidate invariant on fixed version (scalably with "almost everywhere type analysis")

Fixr: Proposed System



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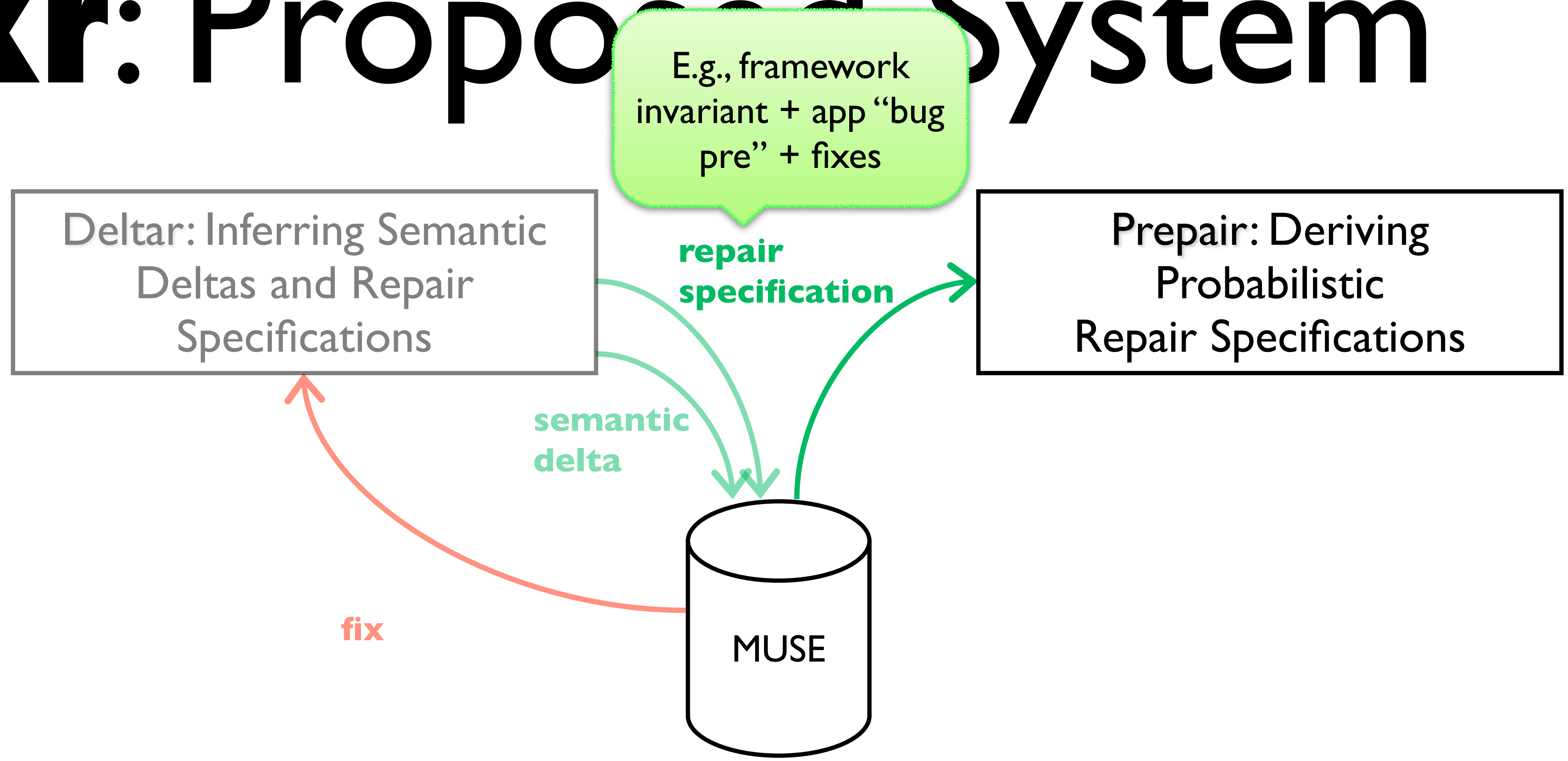

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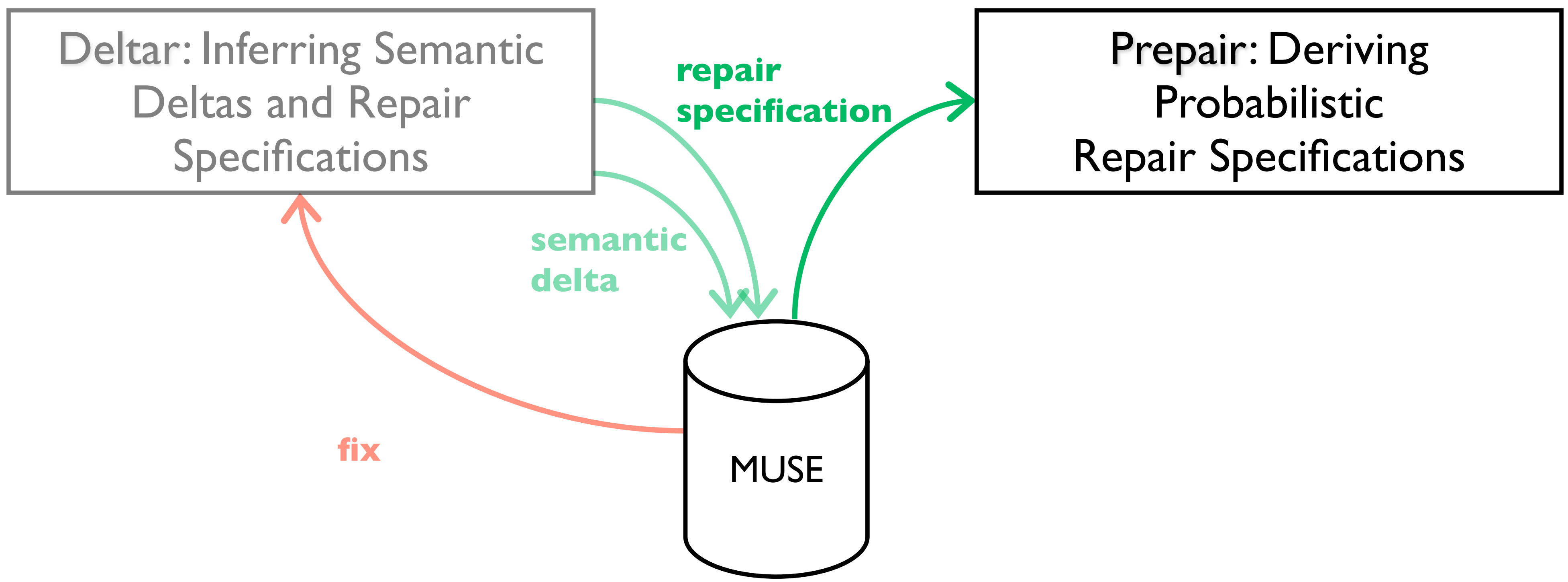

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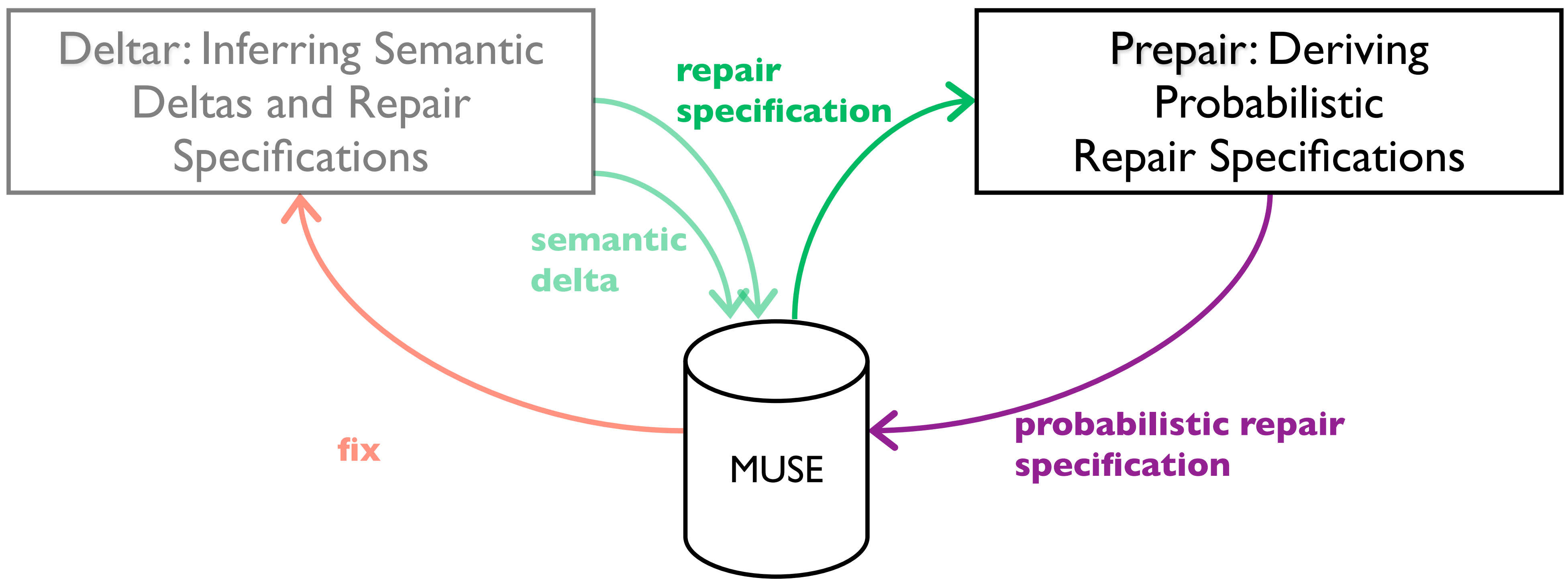

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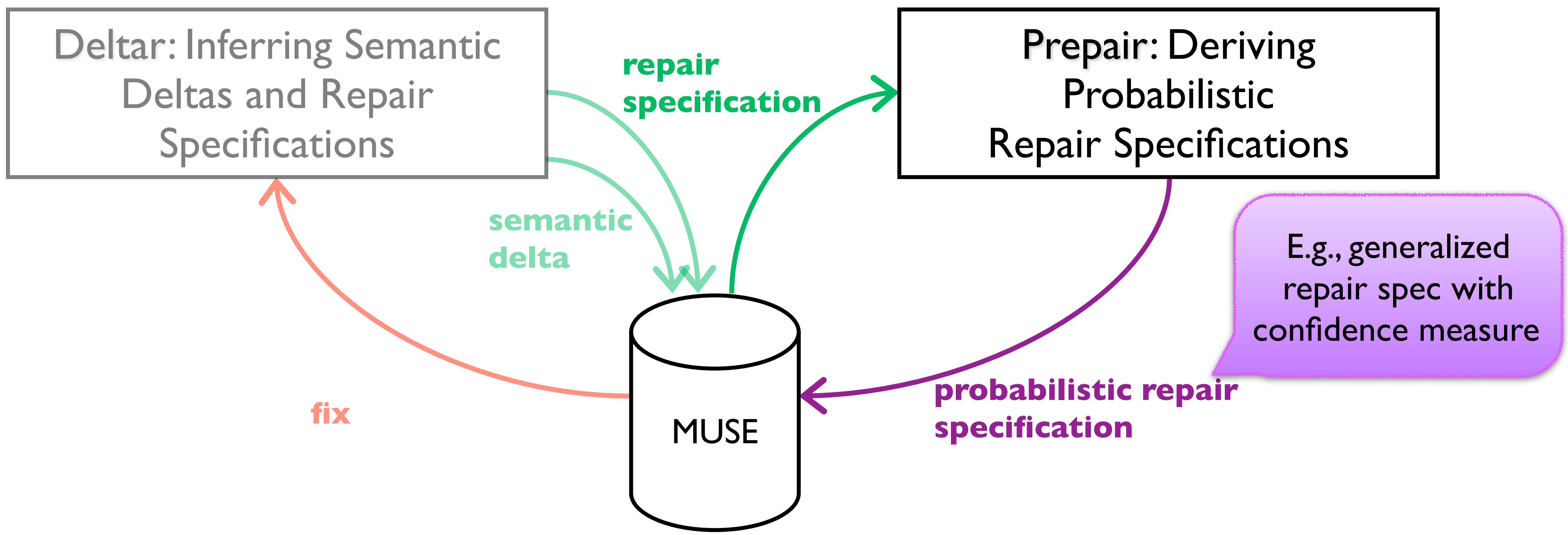

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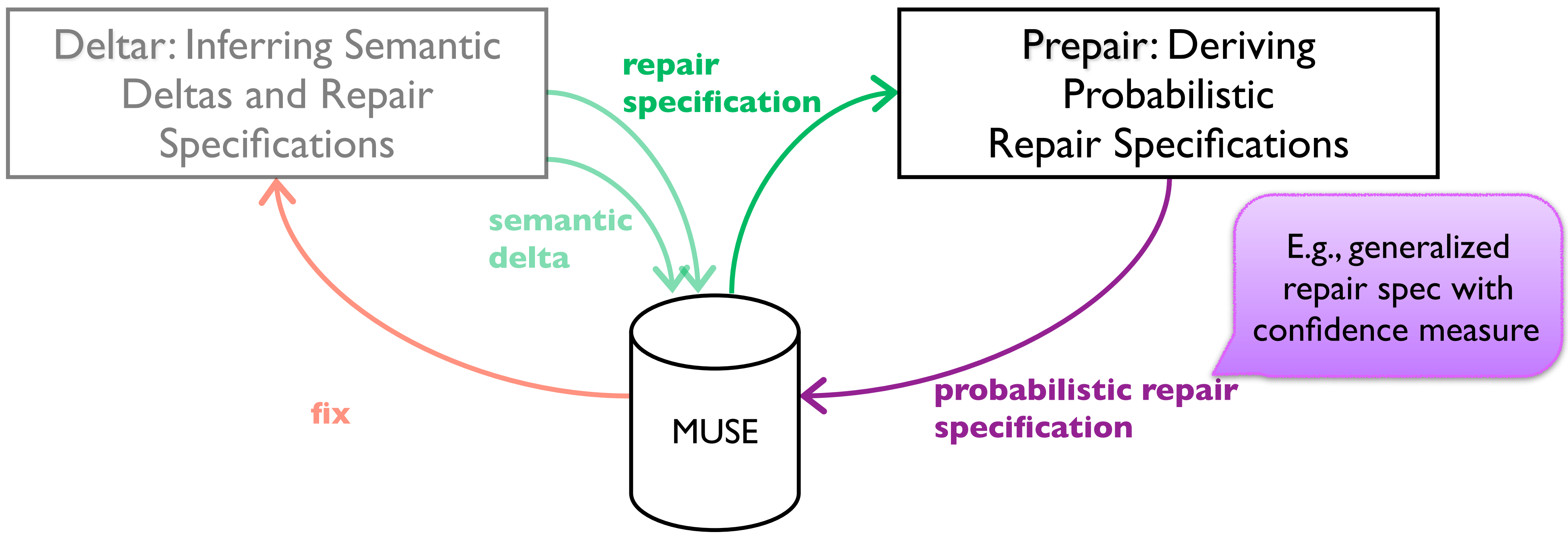

Component: Prepair *reduces* candidate repair specifications to generalized probabilistic repair specifications

Prepair

Prepair

Candidate Invariant

sTags == **null** ∧ mTag != **null**

Prepair

Candidate Invariant

sTags == **null** $\wedge$ mTag != **null**

$\forall i.$ sTags$[v][i] \nrightarrow v$

Prepair

Candidate Invariant

sTags == **null** $\wedge$ mTag != **null**

$\forall i$. sTags[v][i] $\not\rightarrow$ v

$\forall v$. sTags[v][0] $\not\rightarrow^*$ v

Prepair

Candidate Invariant

sTags == **null** $\wedge$ mTag != **null**

$\forall i$. sTags[v][i] $\nrightarrow v$

$\forall v$. sTags[v][0] $\nrightarrow^{*} v$

Problem: Multiple (overly-specific or under-specified) candidate repair specifications

Prepair

Candidate Invariant

sTags == **null** ∧ mTag != **null**

$\forall i.$ sTags$[v][i] \nrightarrow v$

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Problem: Multiple (overly-specific or under-specified) candidate repair specifications

Approach: Static analysis as a form of Bayesian updating of priors to derive posteriors. Prevalence of fixes in MUSE database provides priors.

Prepair

Candidate Invariant

$\text{sTags} == \textbf{null} \wedge \text{mTag} \mathrel{!=} \textbf{null}$ *0.9*

$\forall i.\ \text{sTags}[v][i] \nrightarrow v$ $\sqcup$

$\forall v.\ \text{sTags}[v][0] \nrightarrow^{*} v$

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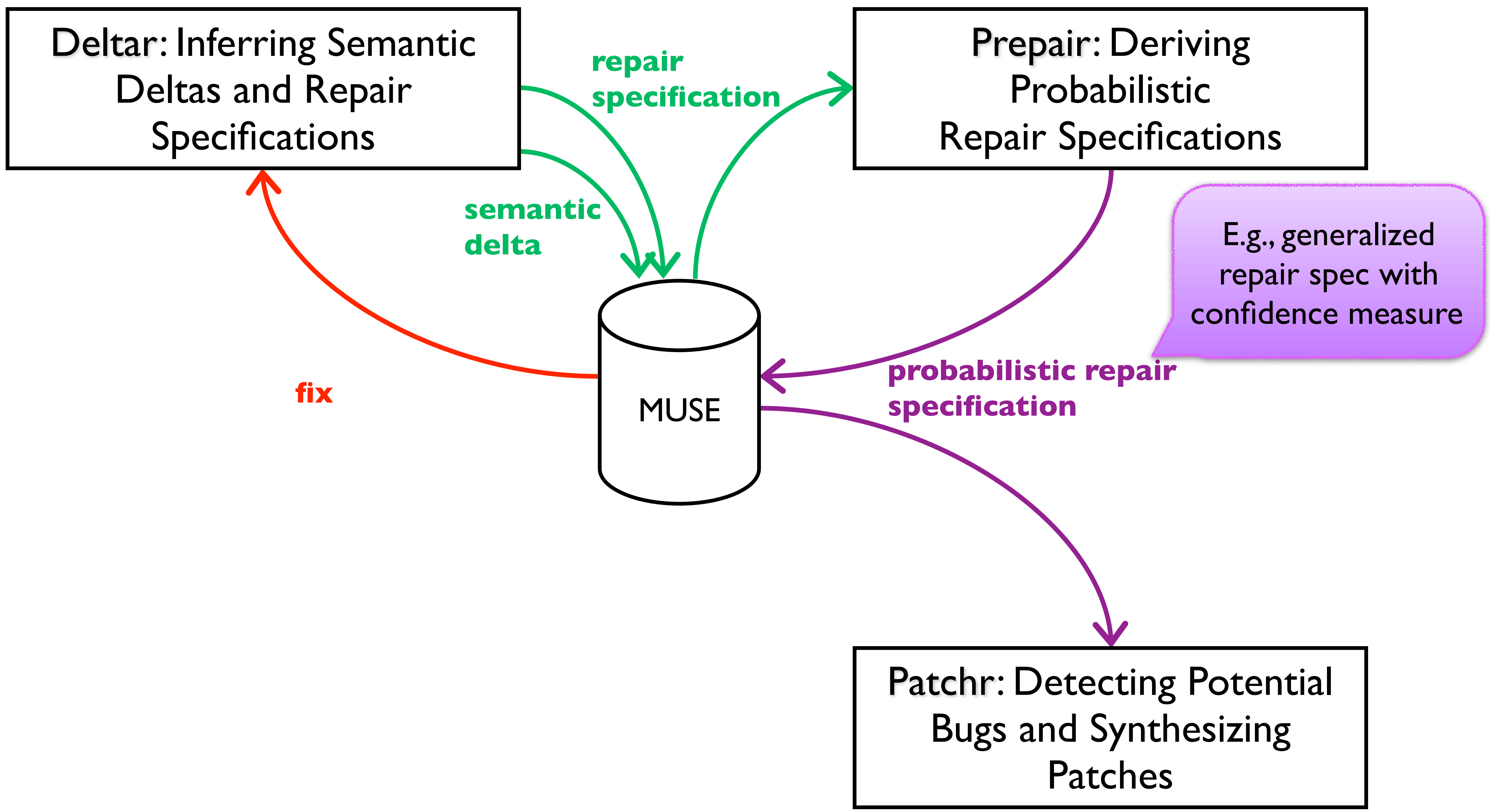

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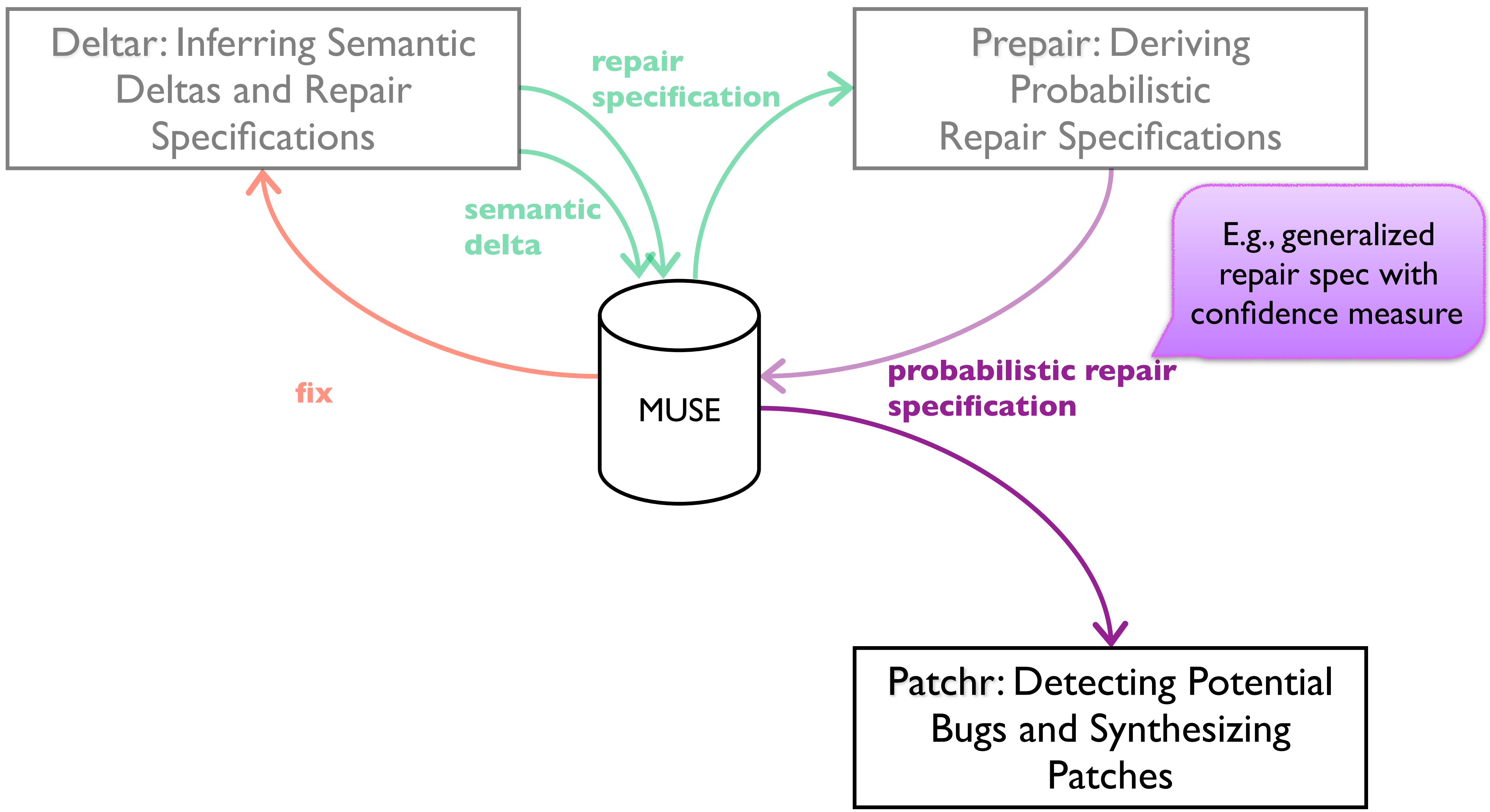

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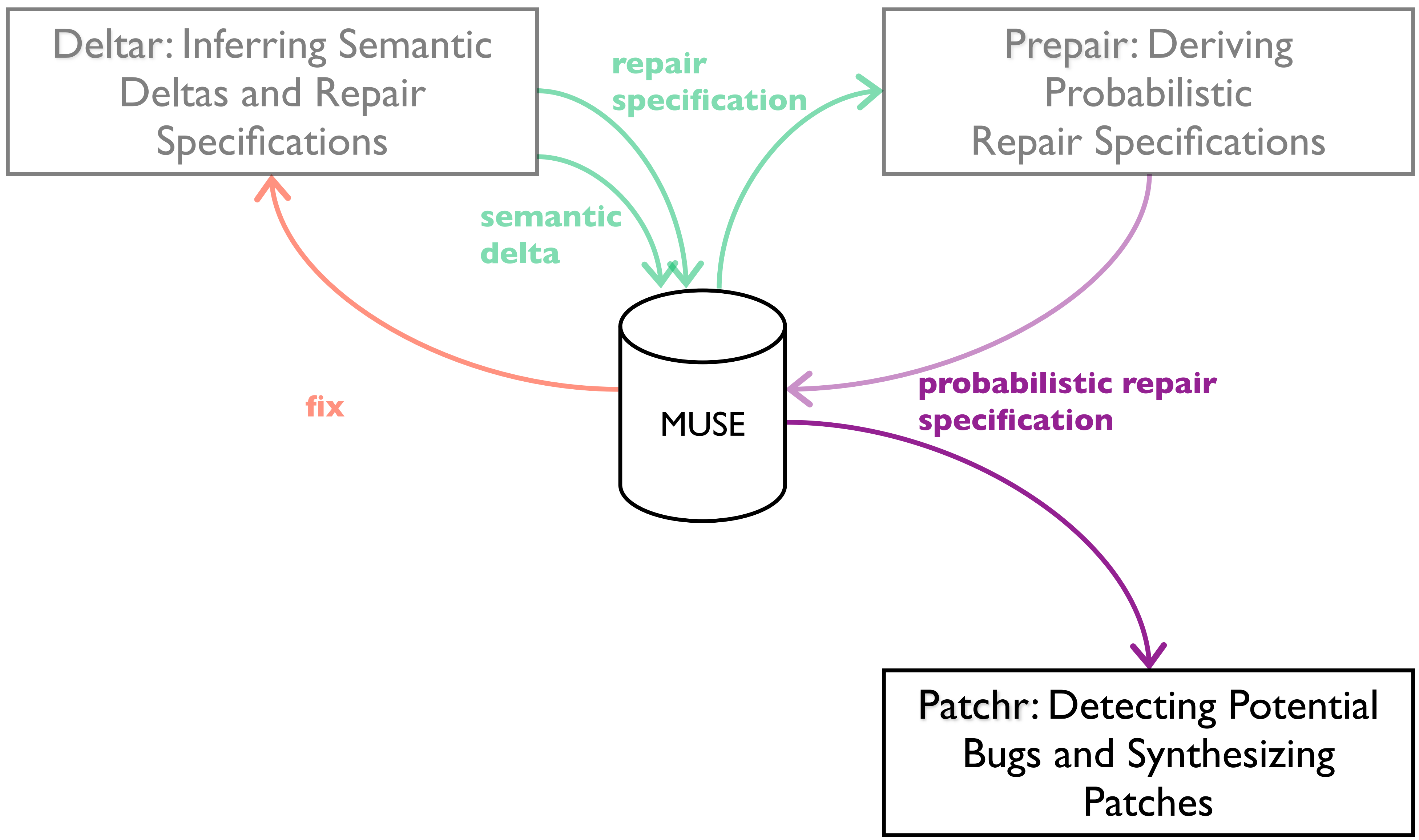

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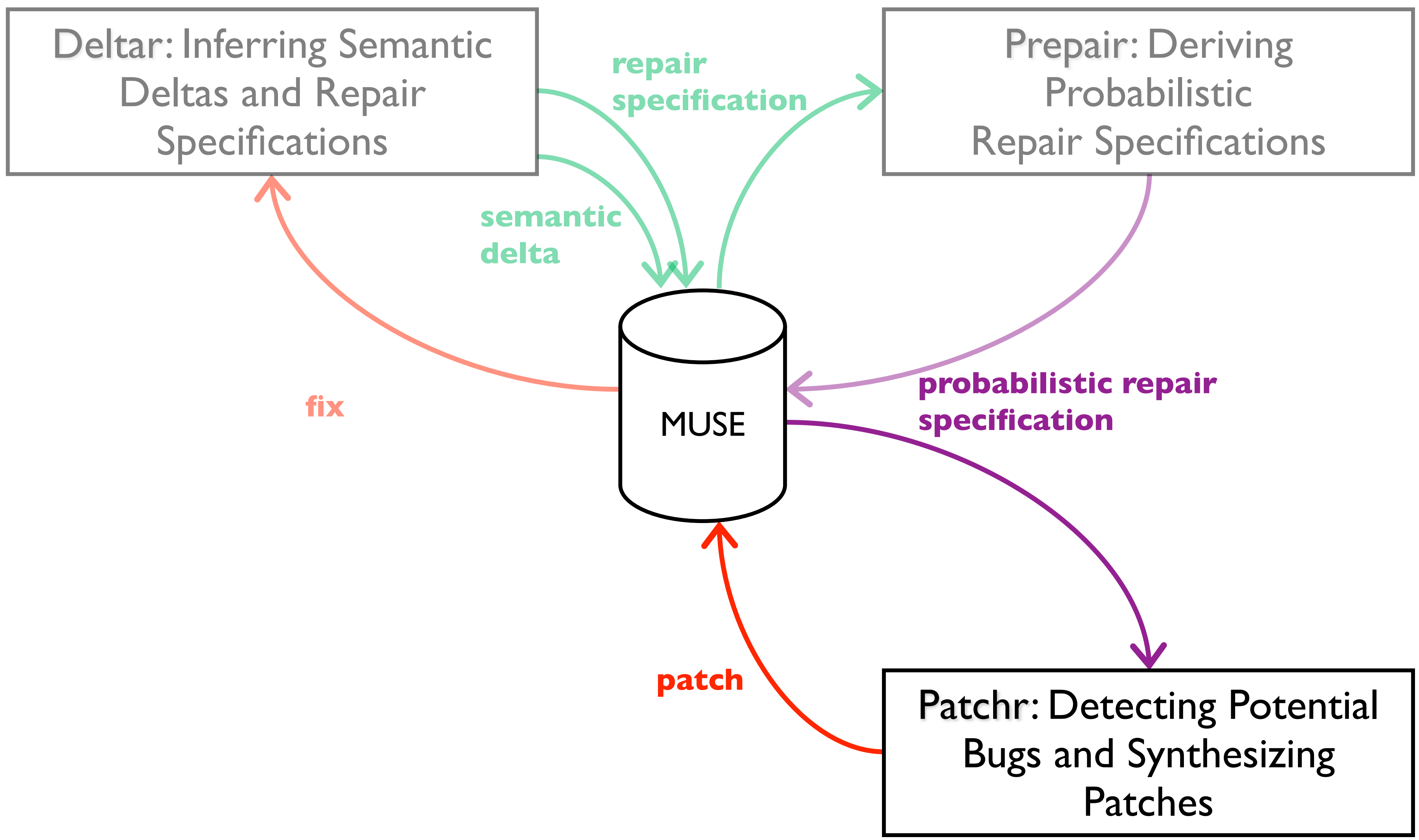

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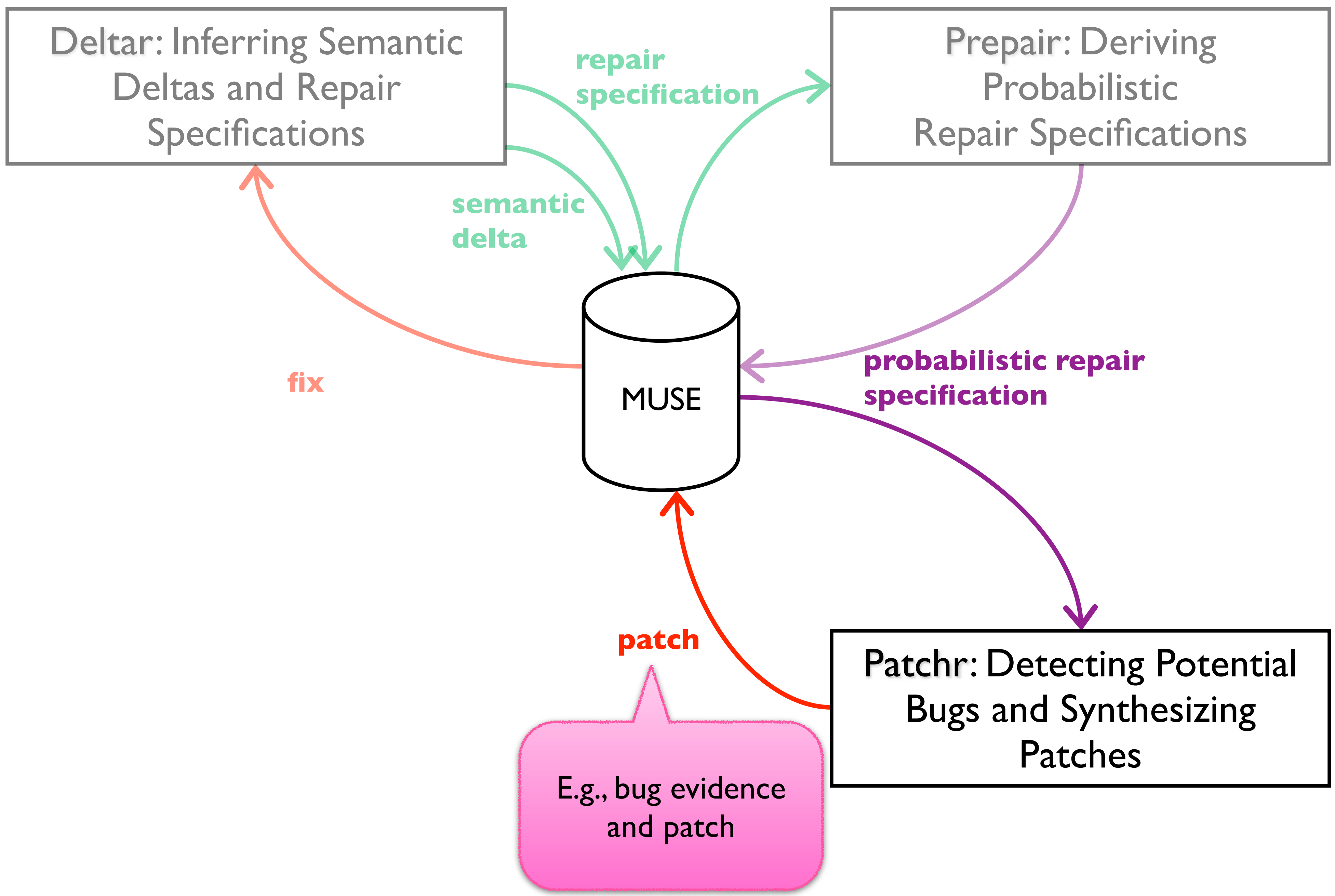

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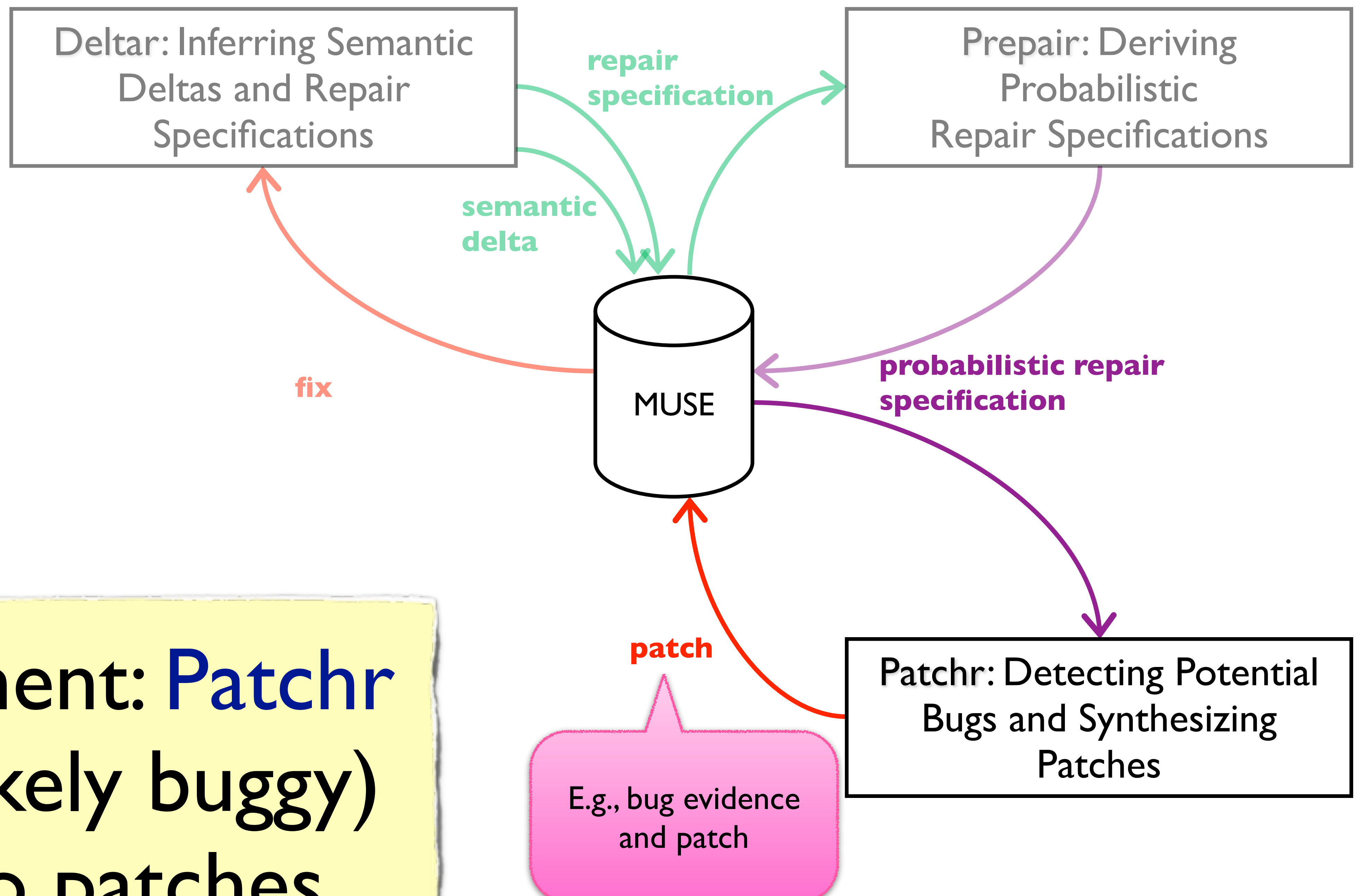

Component: Patchr *maps* (likely buggy) apps to patches

Patchr

Patchr

Candidate Invariant

sTags == **null** $\wedge$ mTag != **null** *0.9*

Patchr

Candidate Invariant

sTags == **null** ∧ mTag != **null** *0.9*

Problem: How do we validate repair specifications?

Patchr

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Problem: How do we validate repair specifications?

Approach: Synthesize patches for human validation (easier to understand and immediately useful)

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A Patch

~~otherView.setTag(..., o)~~

otherView.setTag(o)

Patchr

Candidate Invariant

sTags == **null** $\wedge$ mTag != **null** *0.9*

Problem: How do we validate repair specifications?

Approach: Synthesize patches for human validation (easier to understand and immediately useful)

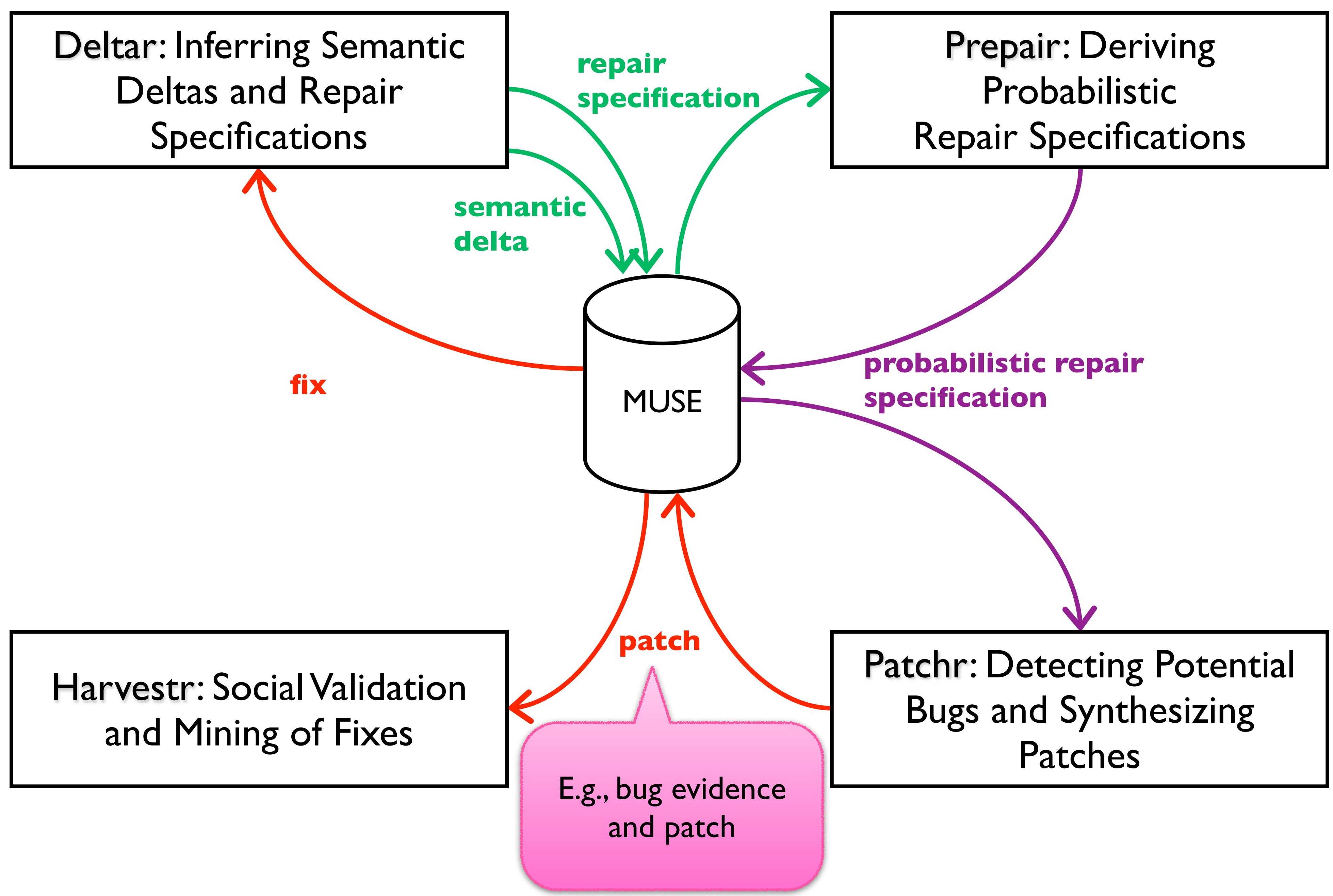
A Patch

~~otherView.setTag(..., o)~~

otherView.setTag(o)

need to find apps satisfying “bug pre”

Fixr: Proposed System



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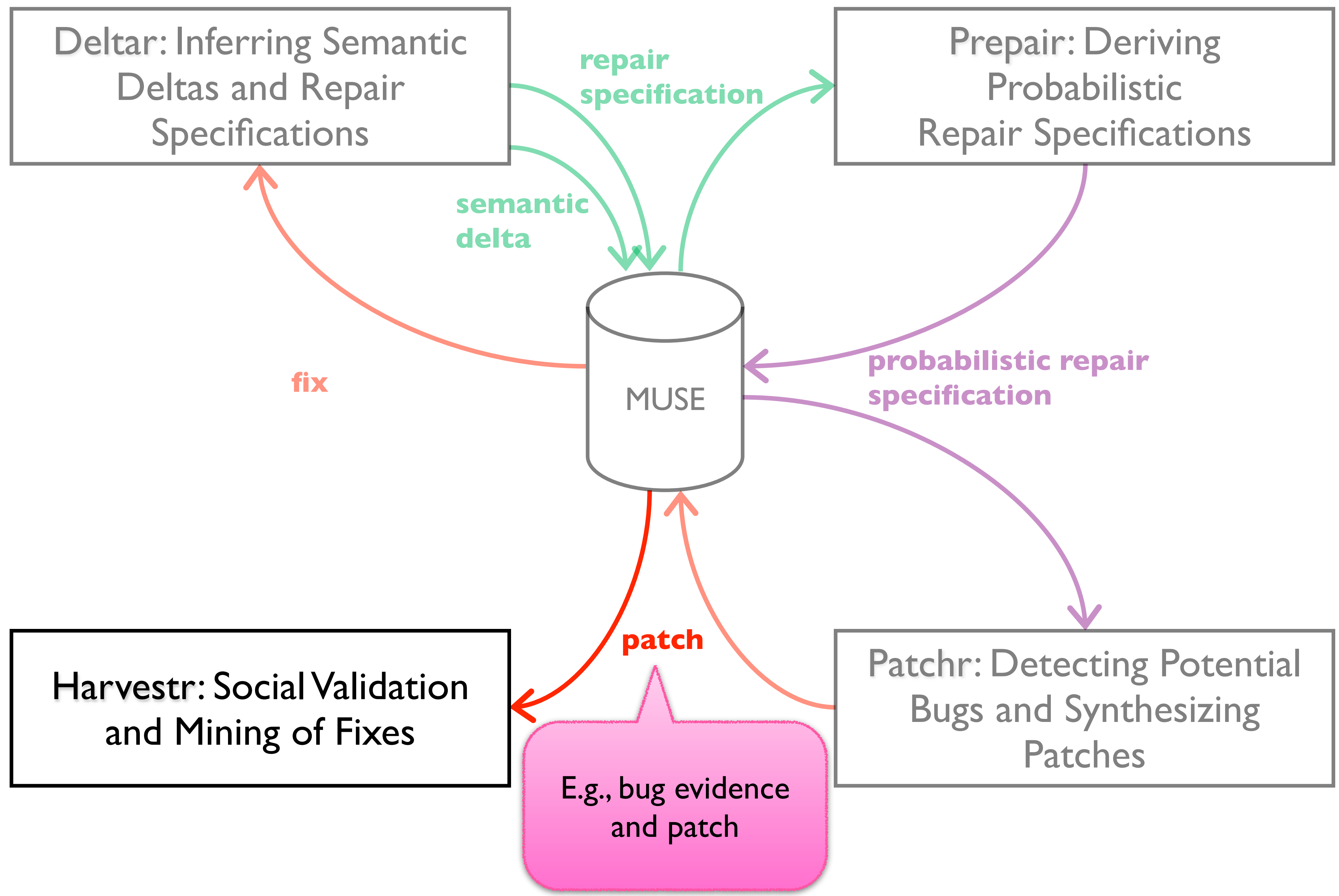
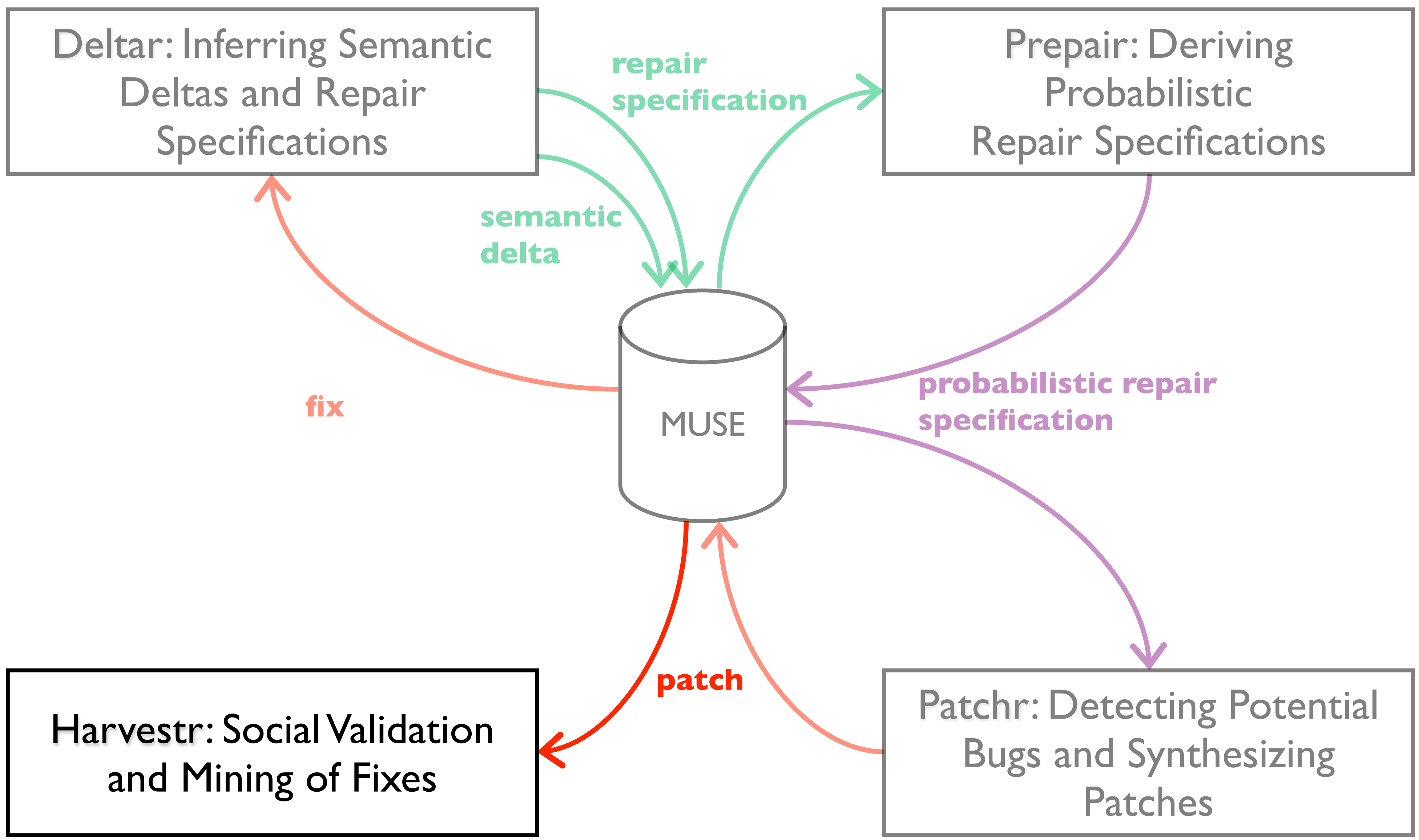


Fixr: Proposed System



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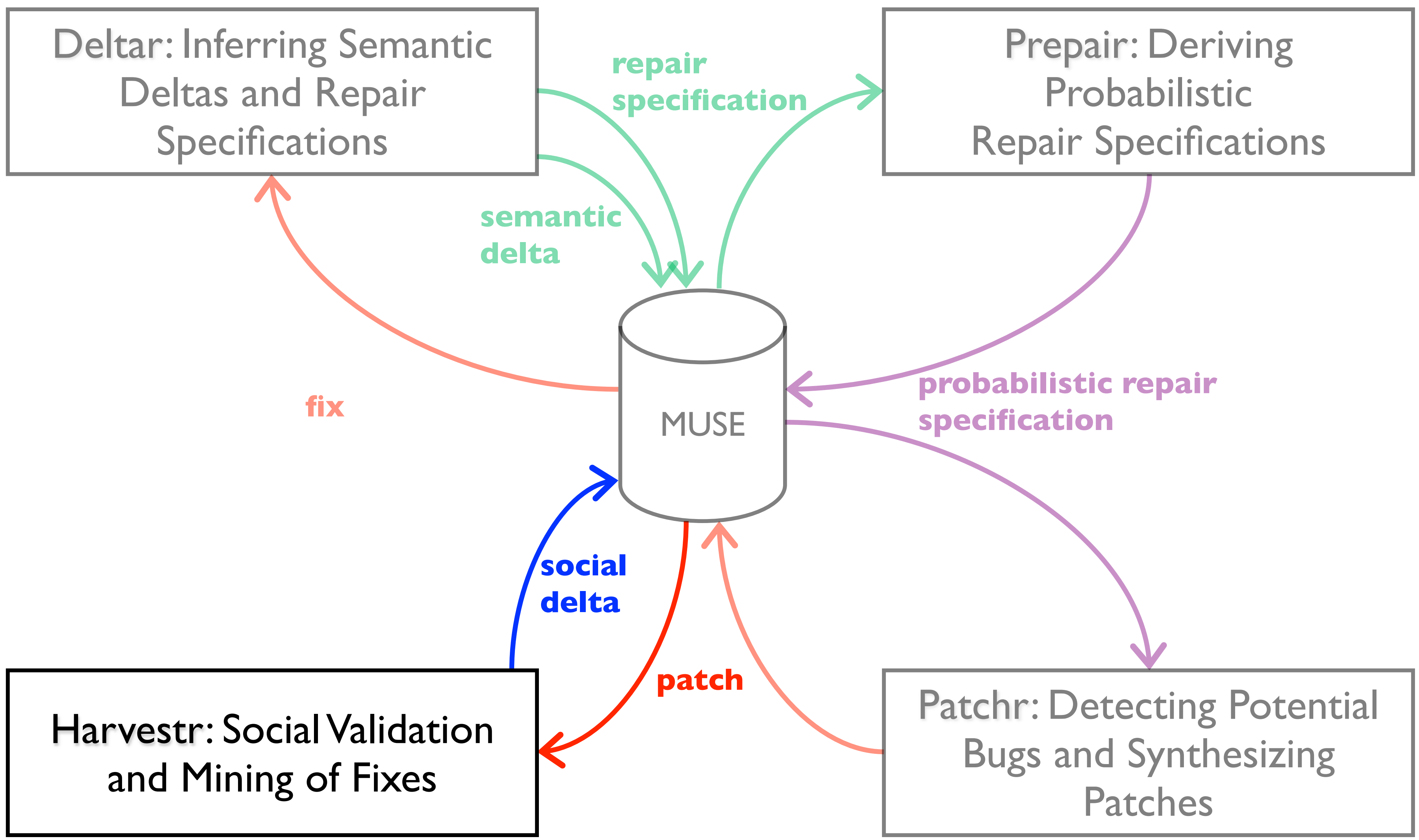

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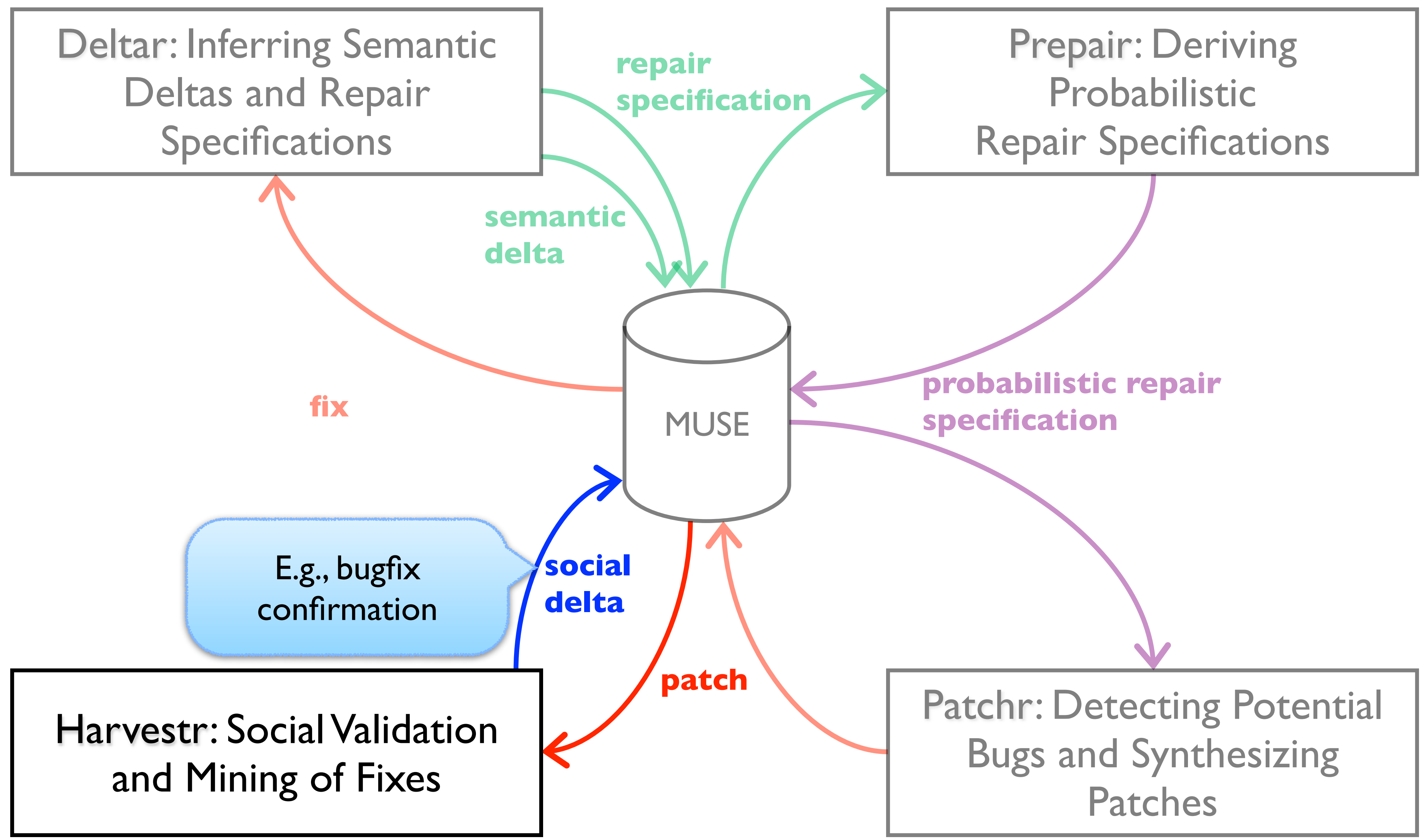

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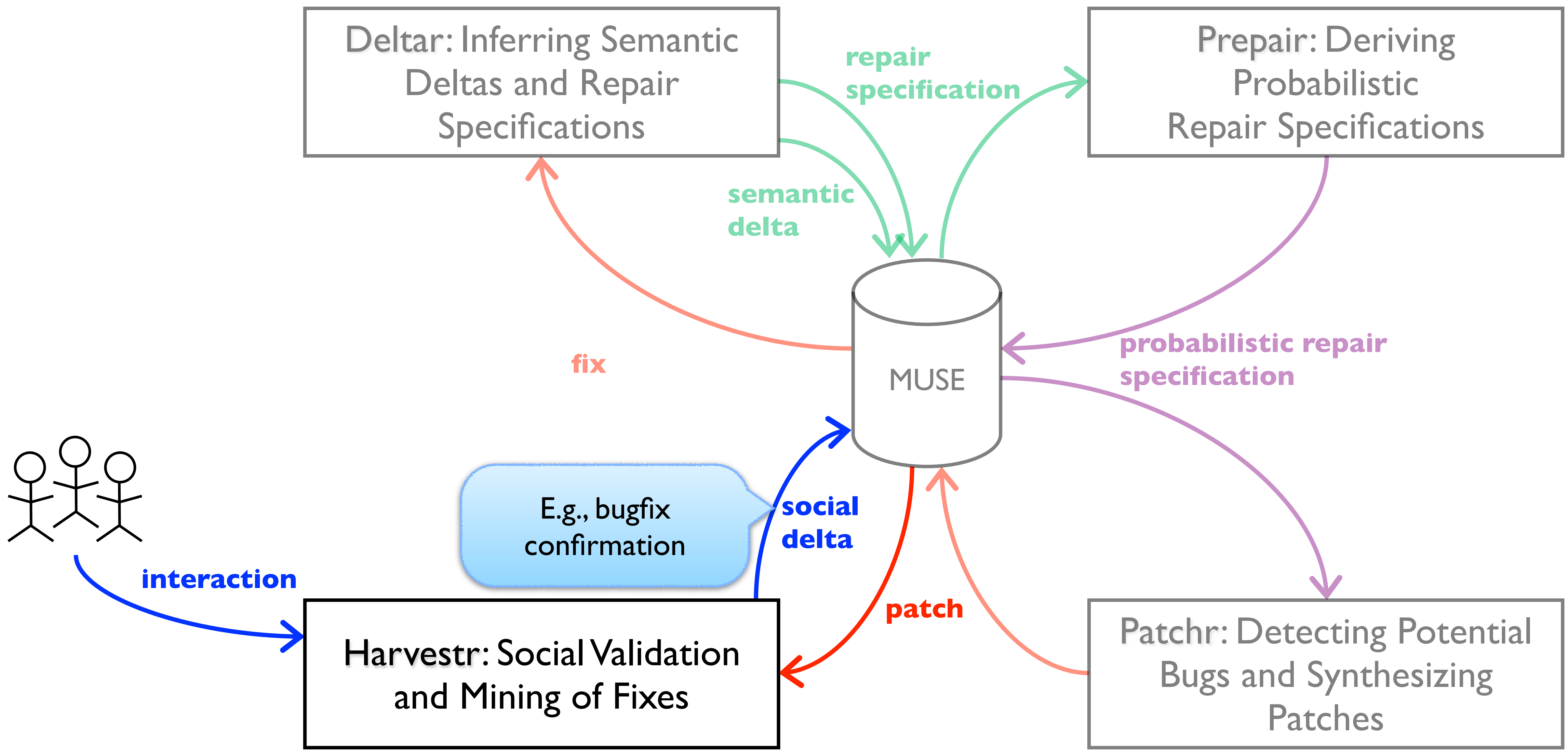

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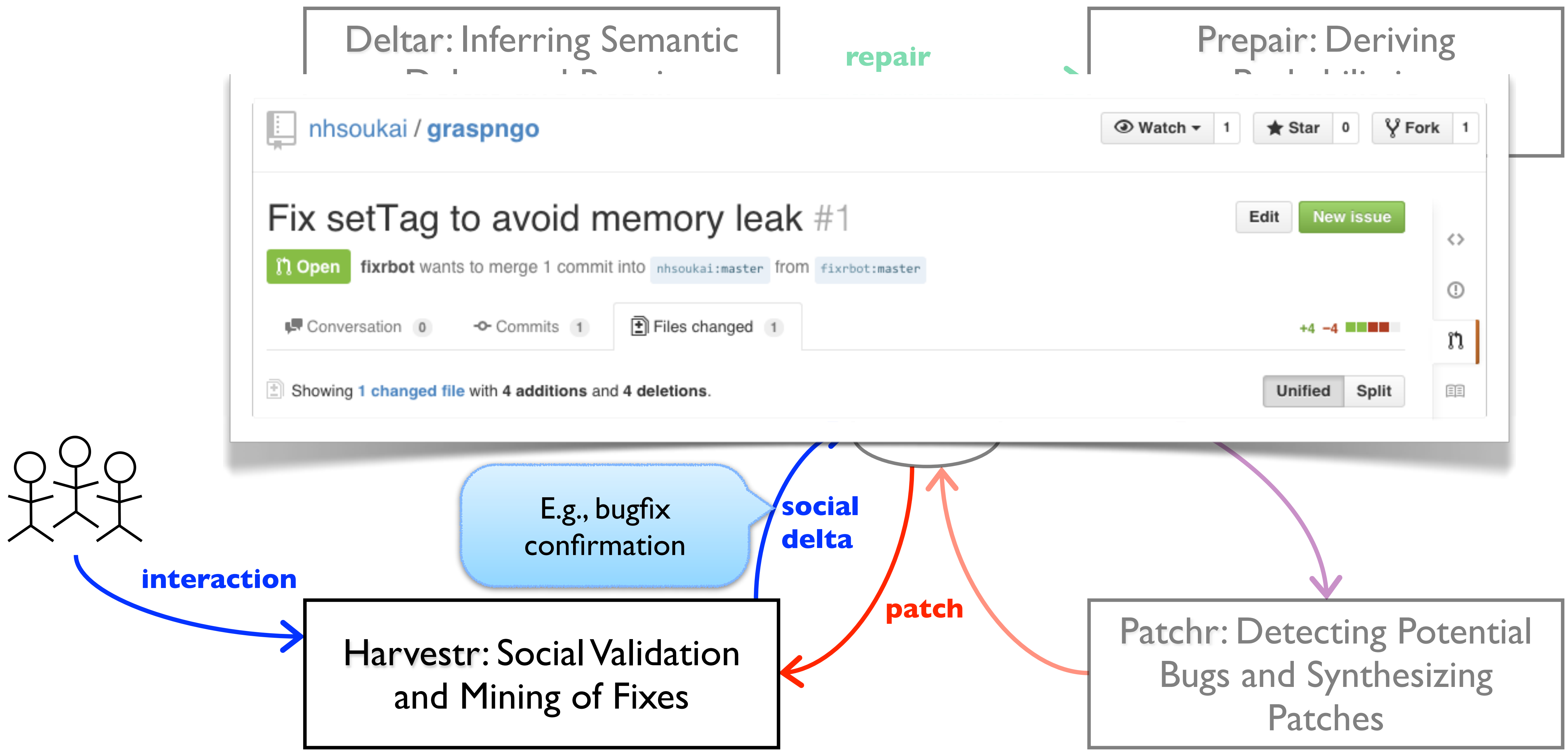

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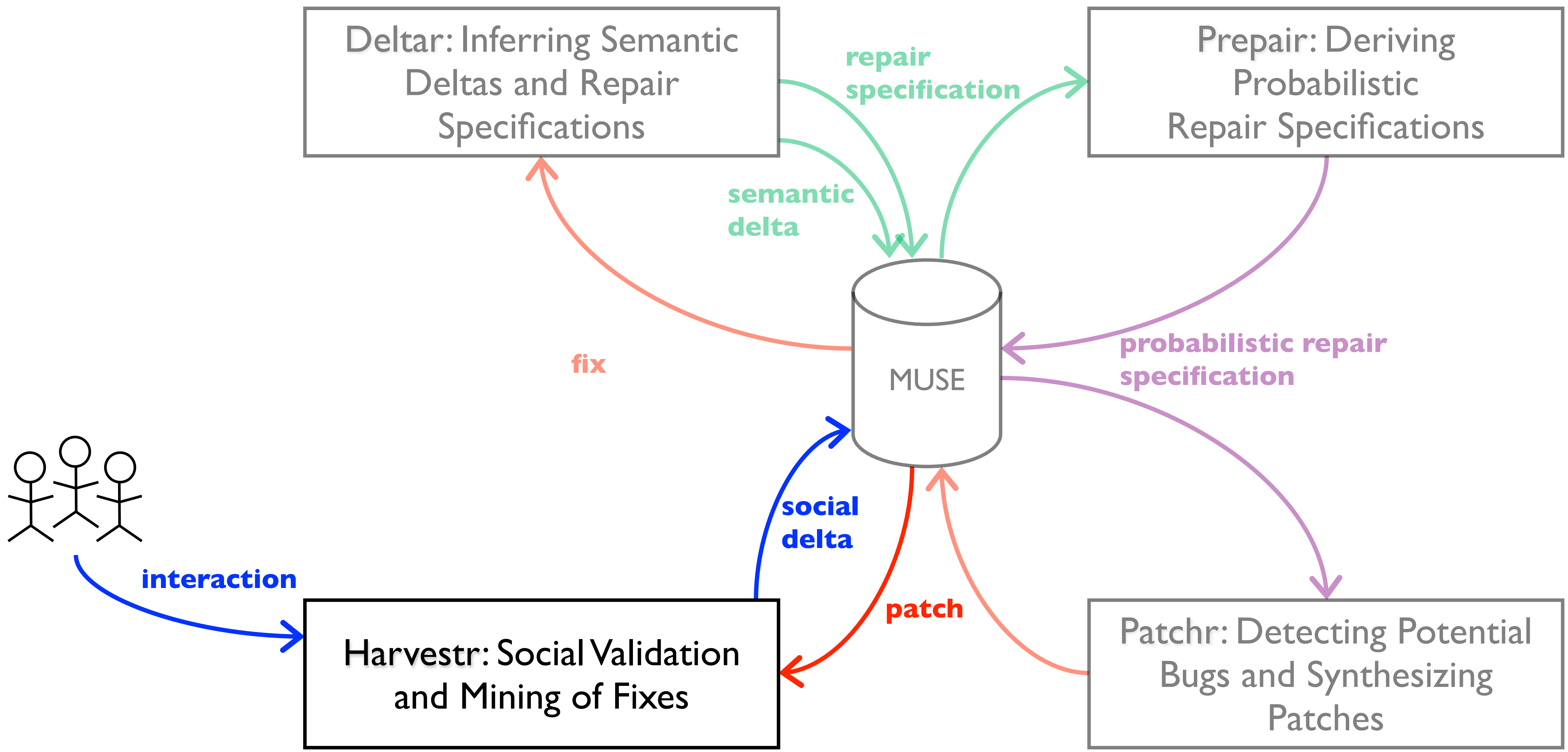

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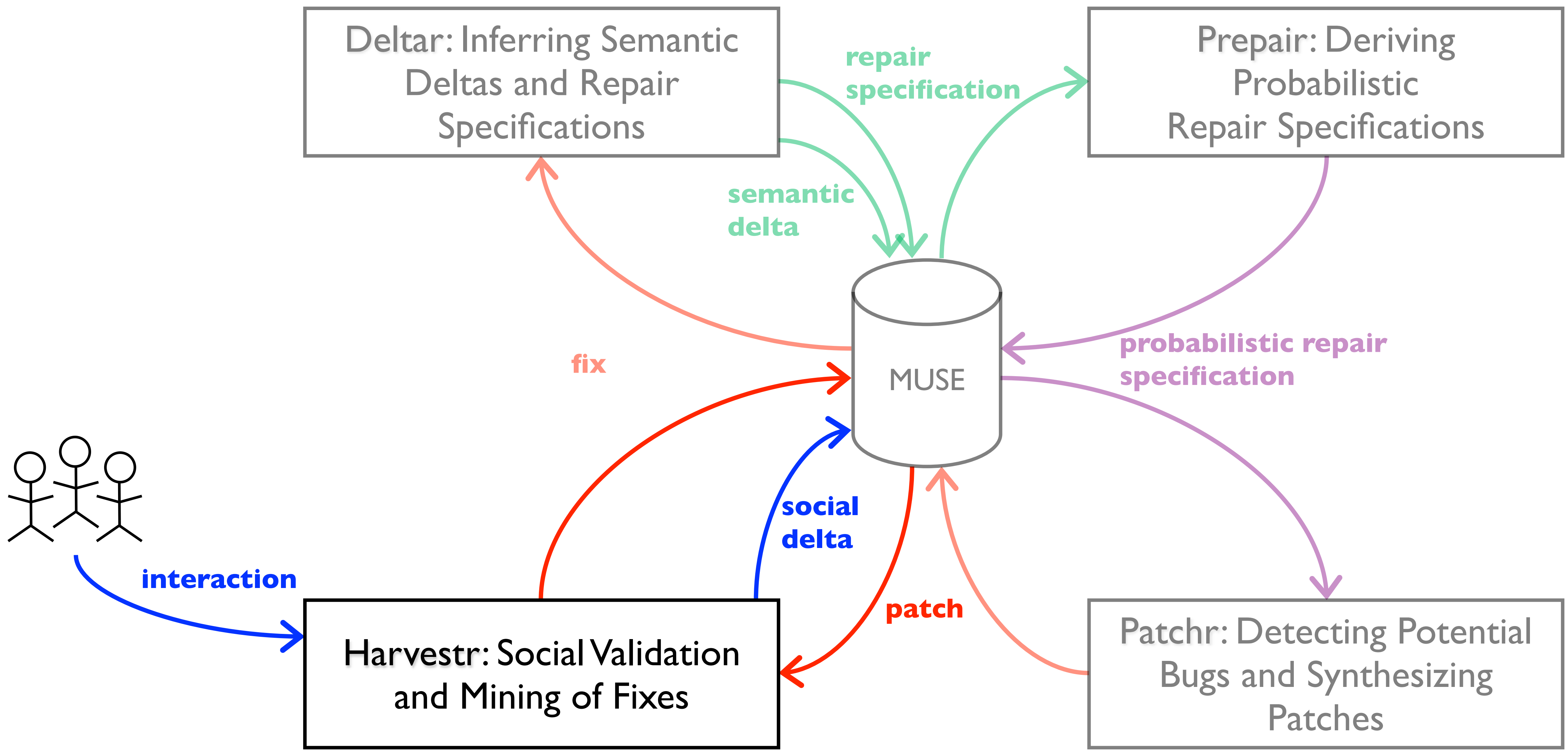

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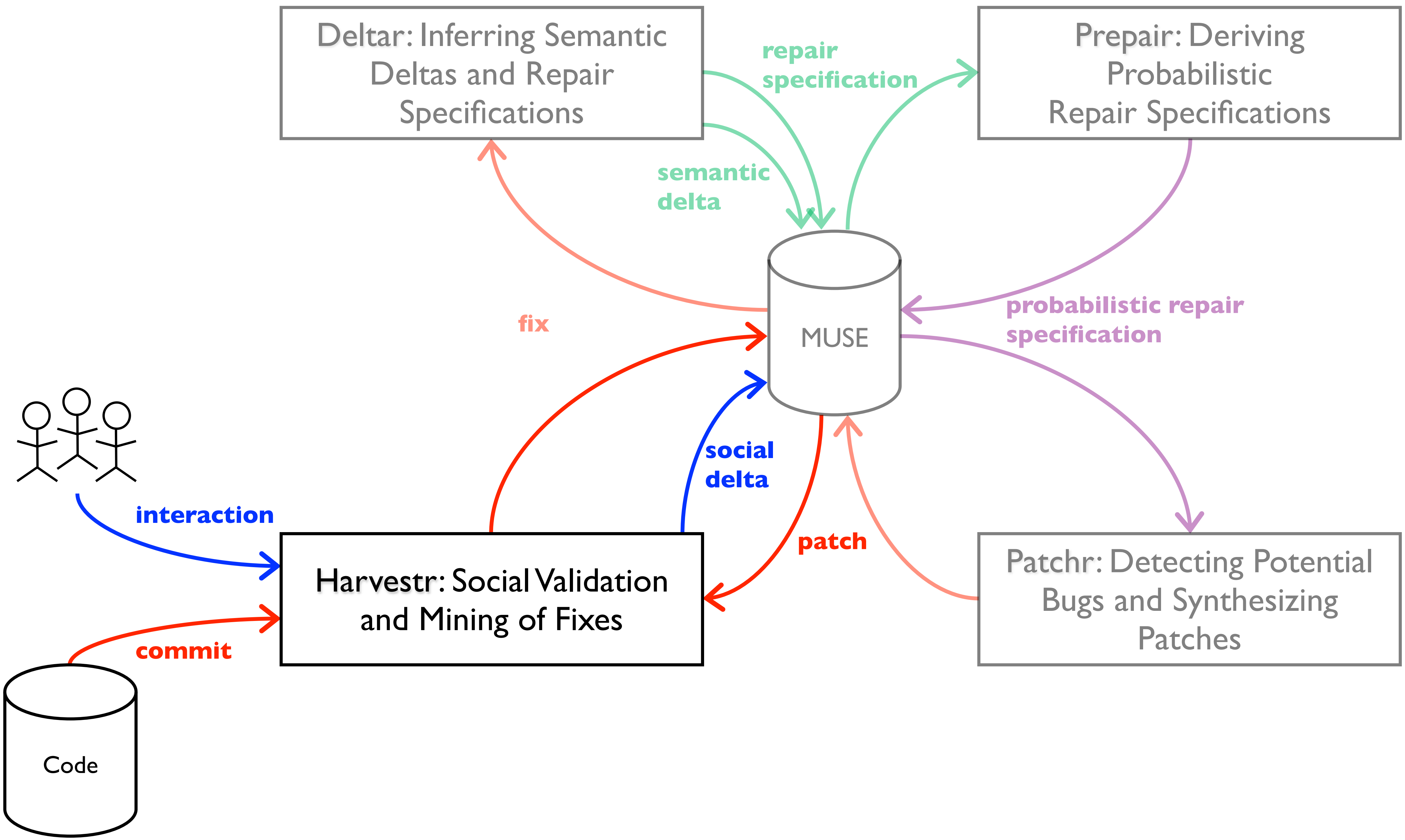
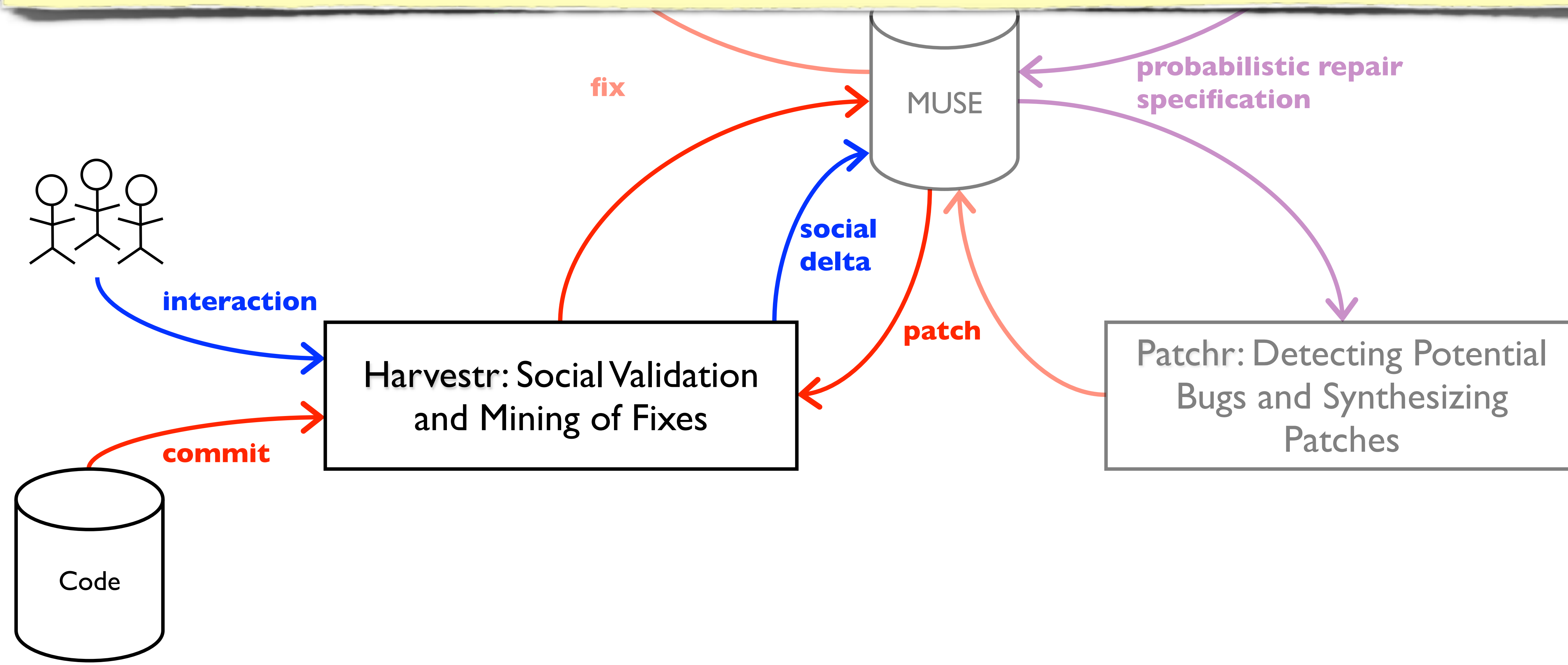


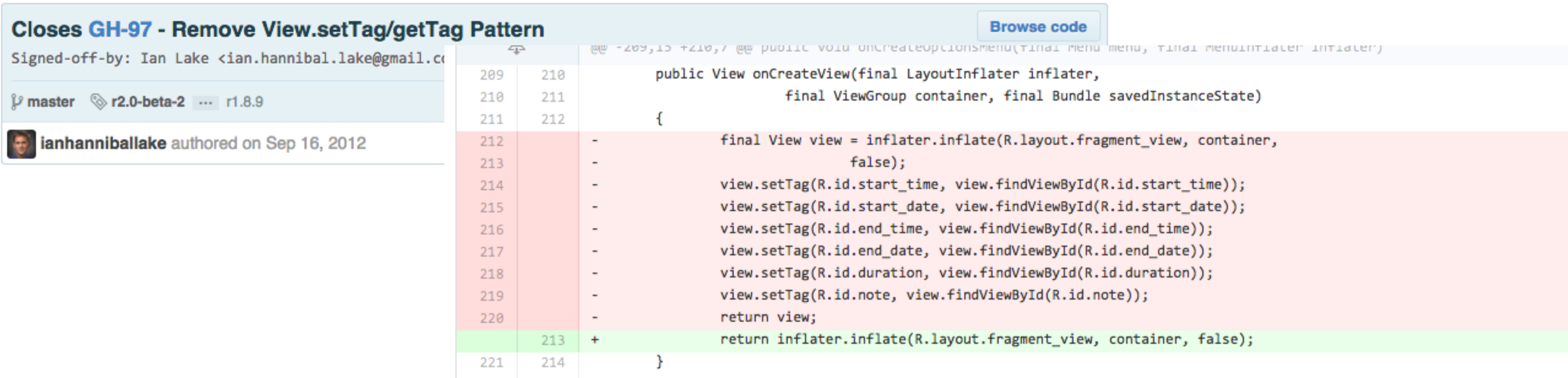
Fixr: Proposed System

Component: Harvestr *maps* commits and patches to candidate fixes



Harvestr

Harvestr



Closes GH-97 - Remove View.setTag/getTag Pattern Browse code

Signed-off-by: Ian Lake <ian.hannibal.lake@gmail.c

master r2.0-beta-2 ... r1.8.9

ianhanniballake authored on Sep 16, 2012

```
@@ -209,15 +210,7 @@ public void onCreateOptionsMenu(final Menu menu, final MenuInflater inflater)
         public View onCreateView(final LayoutInflater inflater,
                     final ViewGroup container, final Bundle savedInstanceState)
         {
-            final View view = inflater.inflate(R.layout.fragment_view, container,
-                        false);
-            view.setTag(R.id.start_time, view.findViewById(R.id.start_time));
-            view.setTag(R.id.start_date, view.findViewById(R.id.start_date));
-            view.setTag(R.id.end_time, view.findViewById(R.id.end_time));
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-            view.setTag(R.id.duration, view.findViewById(R.id.duration));
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-            return view;
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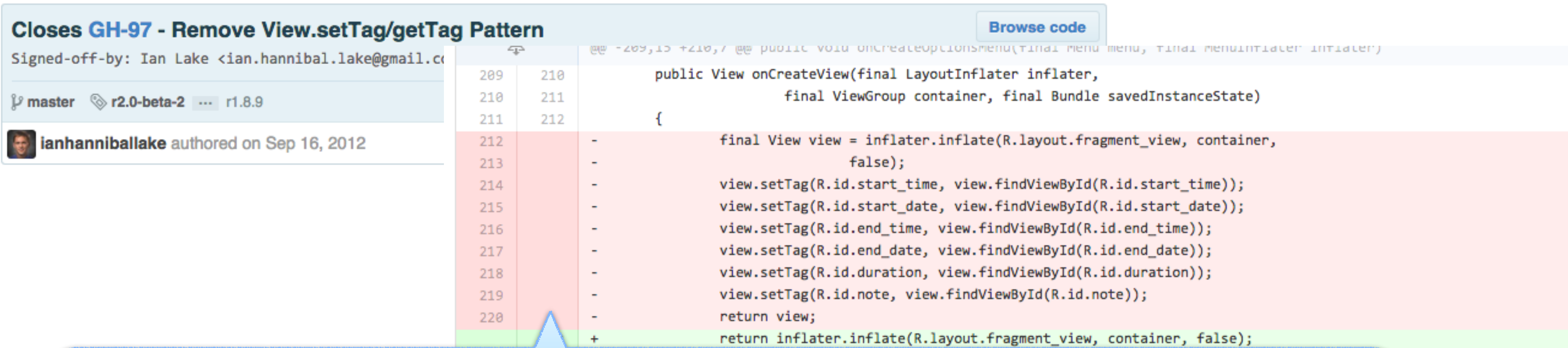
Harvestr



Problem: How do we find relevant bugfixes?

Harvestr

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`Signed-off-by: Ian Lake <ian.hannibal.lake@gmail.c`

master r2.0-beta-2 ... r1.8.9

 **ianhanniballake** authored on Sep 16, 2012

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ianhanniballake commented on Sep 16, 2012 Owner

Remove View.setTag/getTag pattern to prevent crashes due to out of memory error as per Lint error:

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Harvestr

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Signed-off-by: Ian Lake <ian.hannibal.lake@gmail.c

master r2.0-beta-2 … r1.8.9

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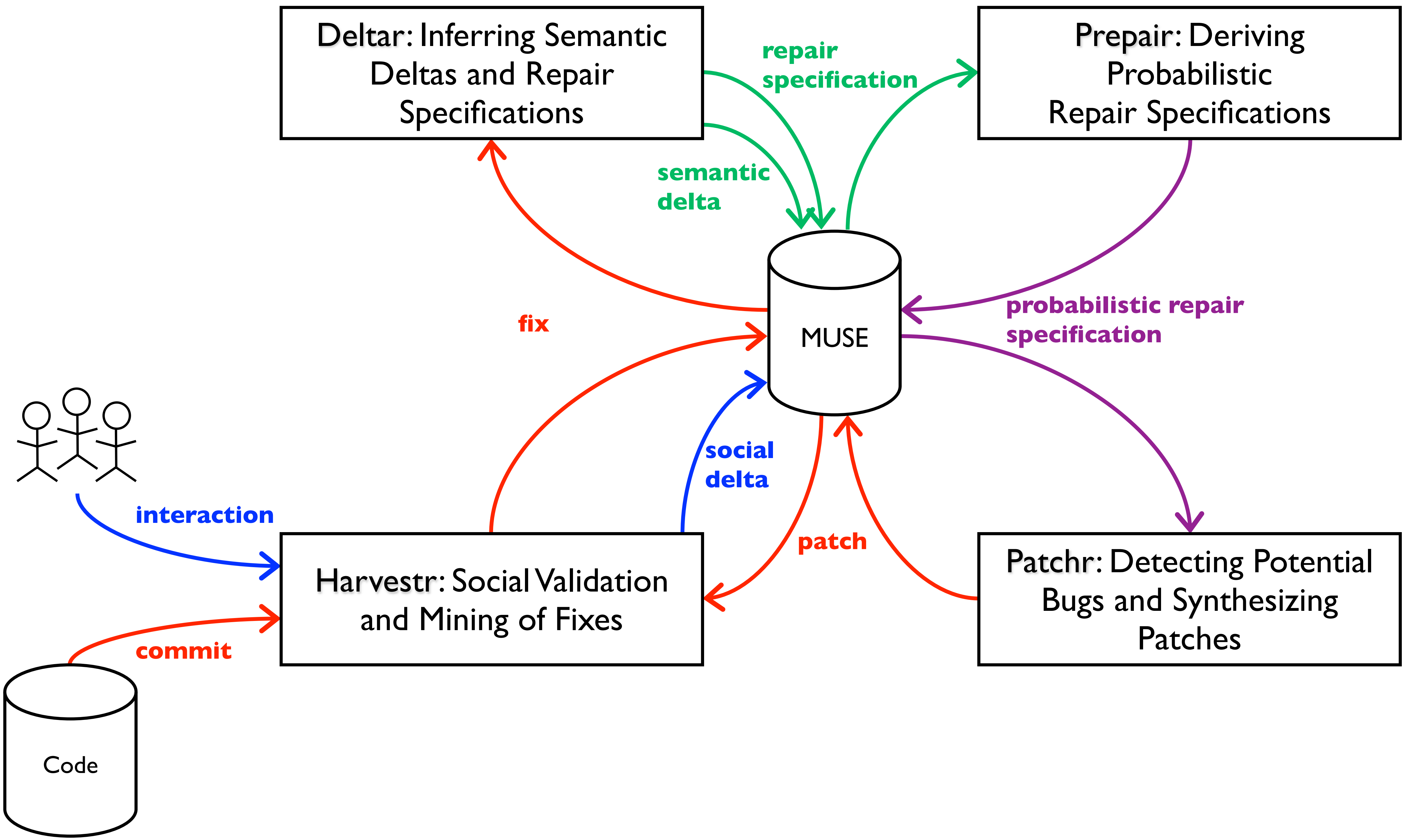
Approach: Mine meta-data artifacts

Fixr: Proposed System



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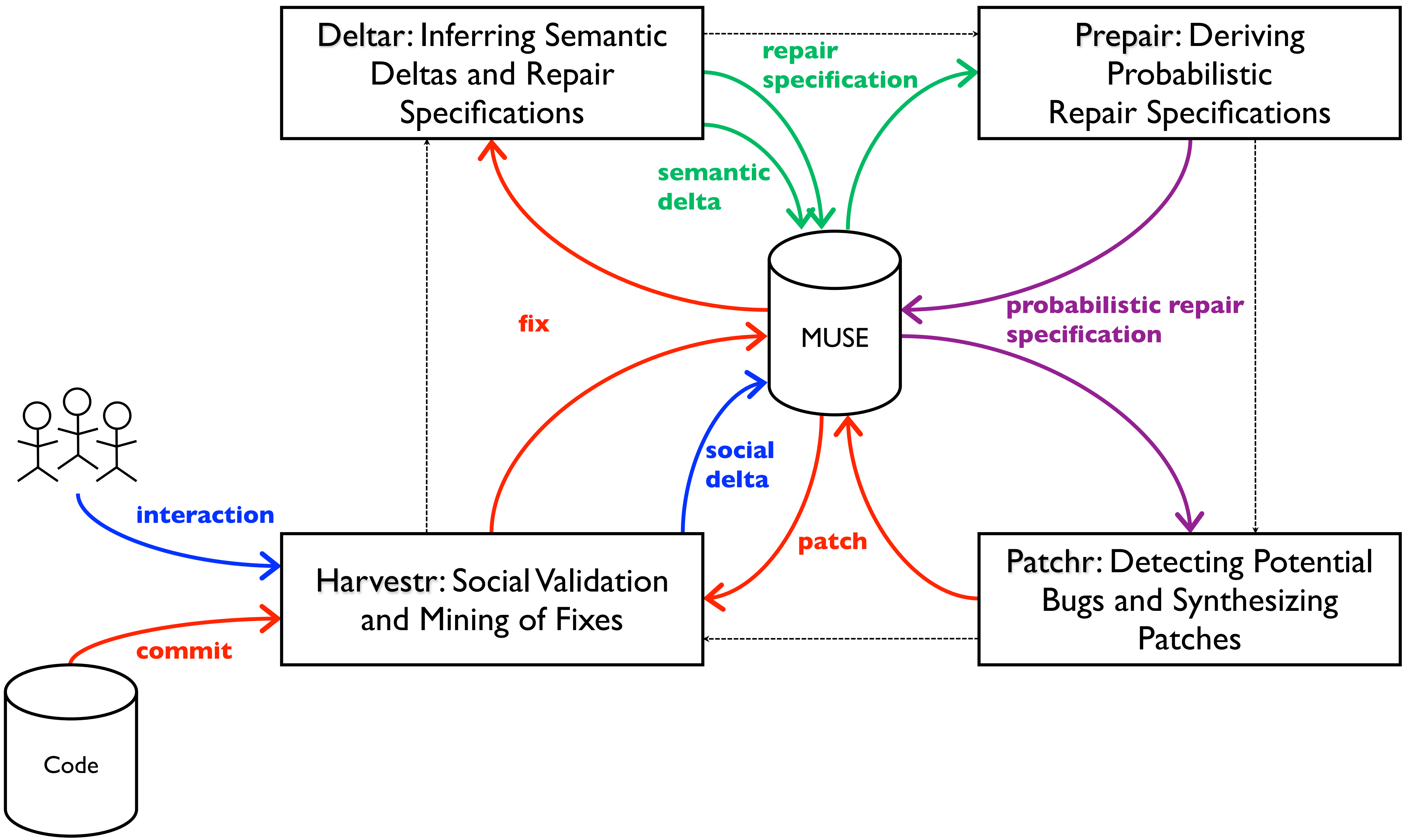

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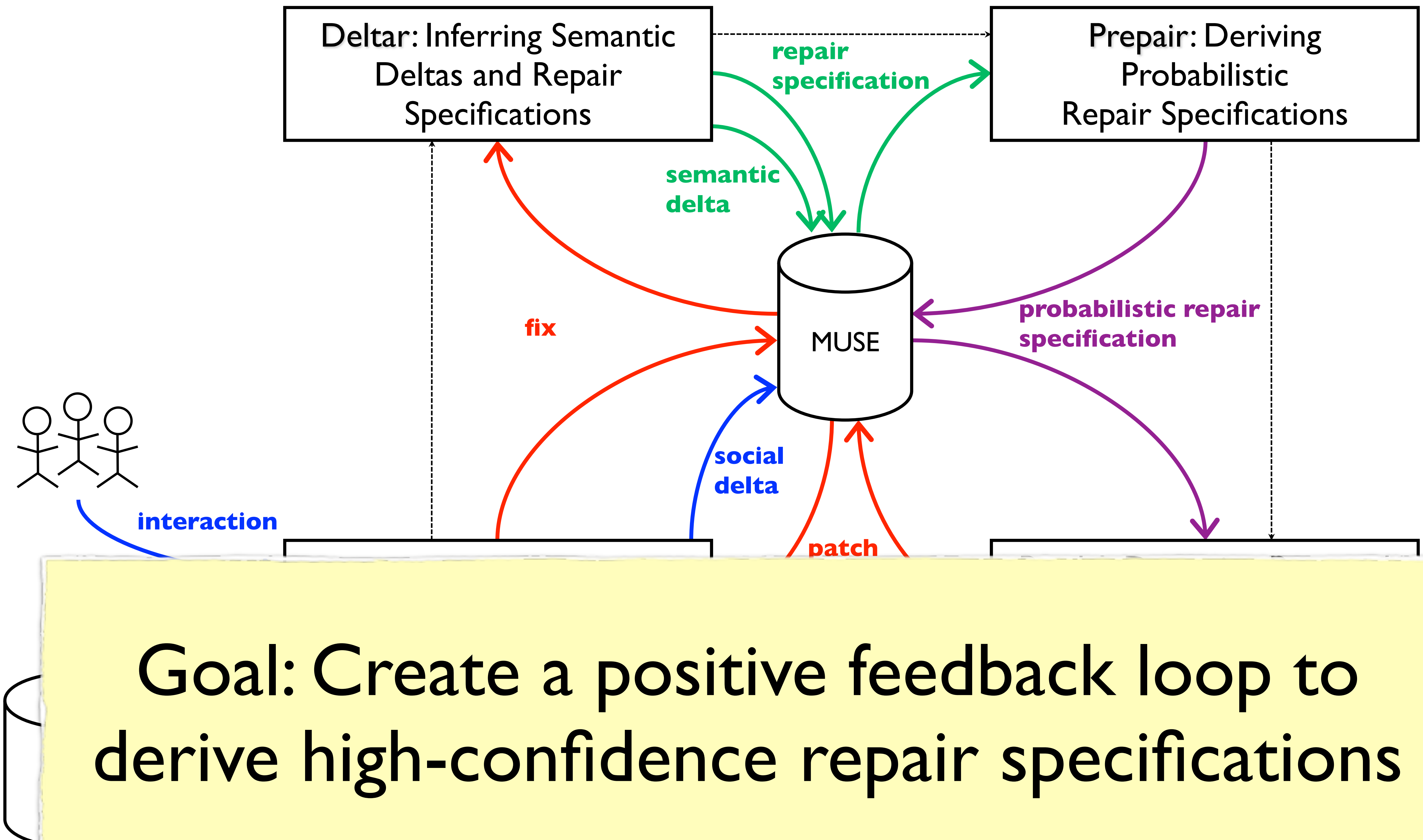
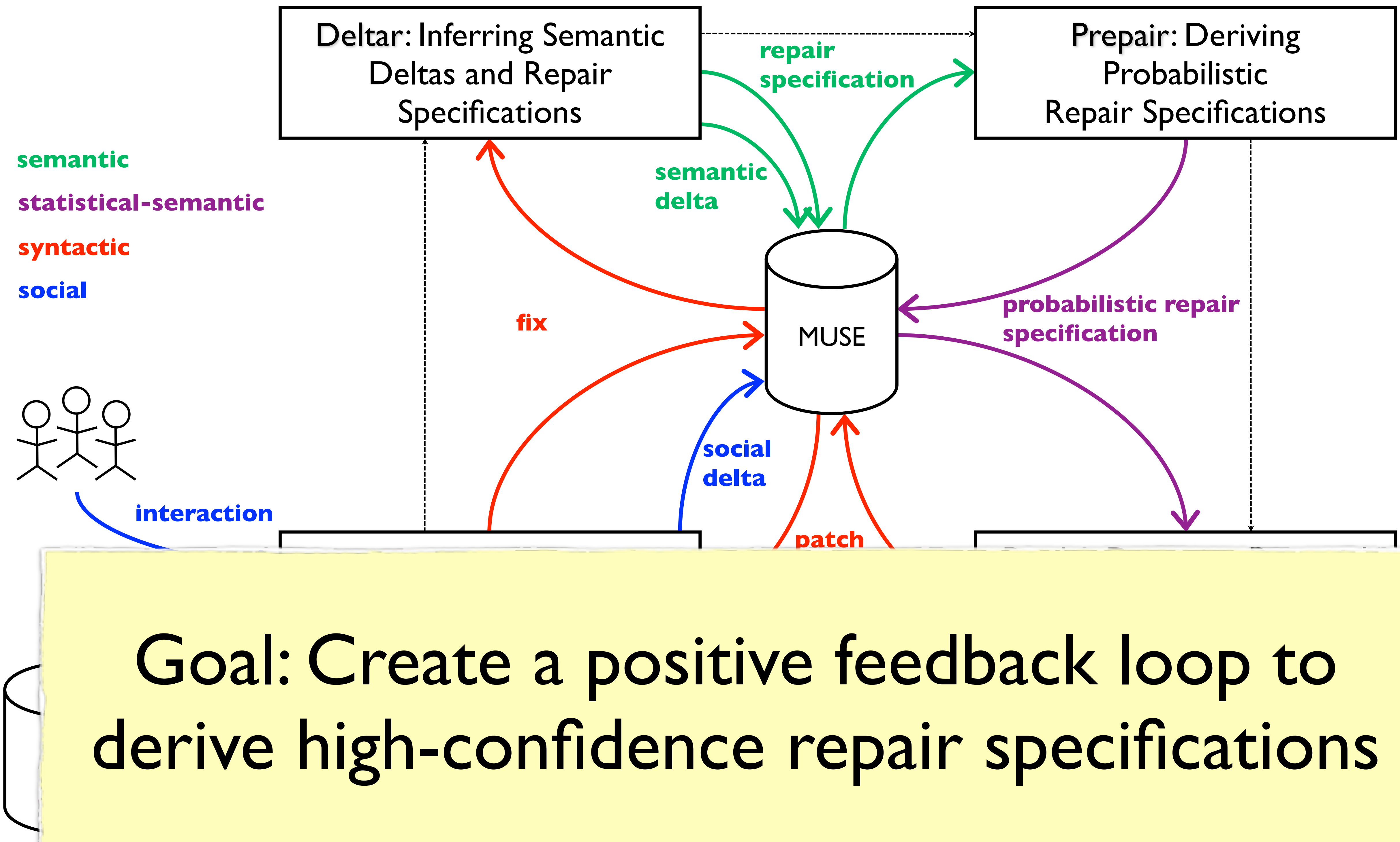


Goal: Create a positive feedback loop to derive high-confidence repair specifications

Fixr: Proposed System



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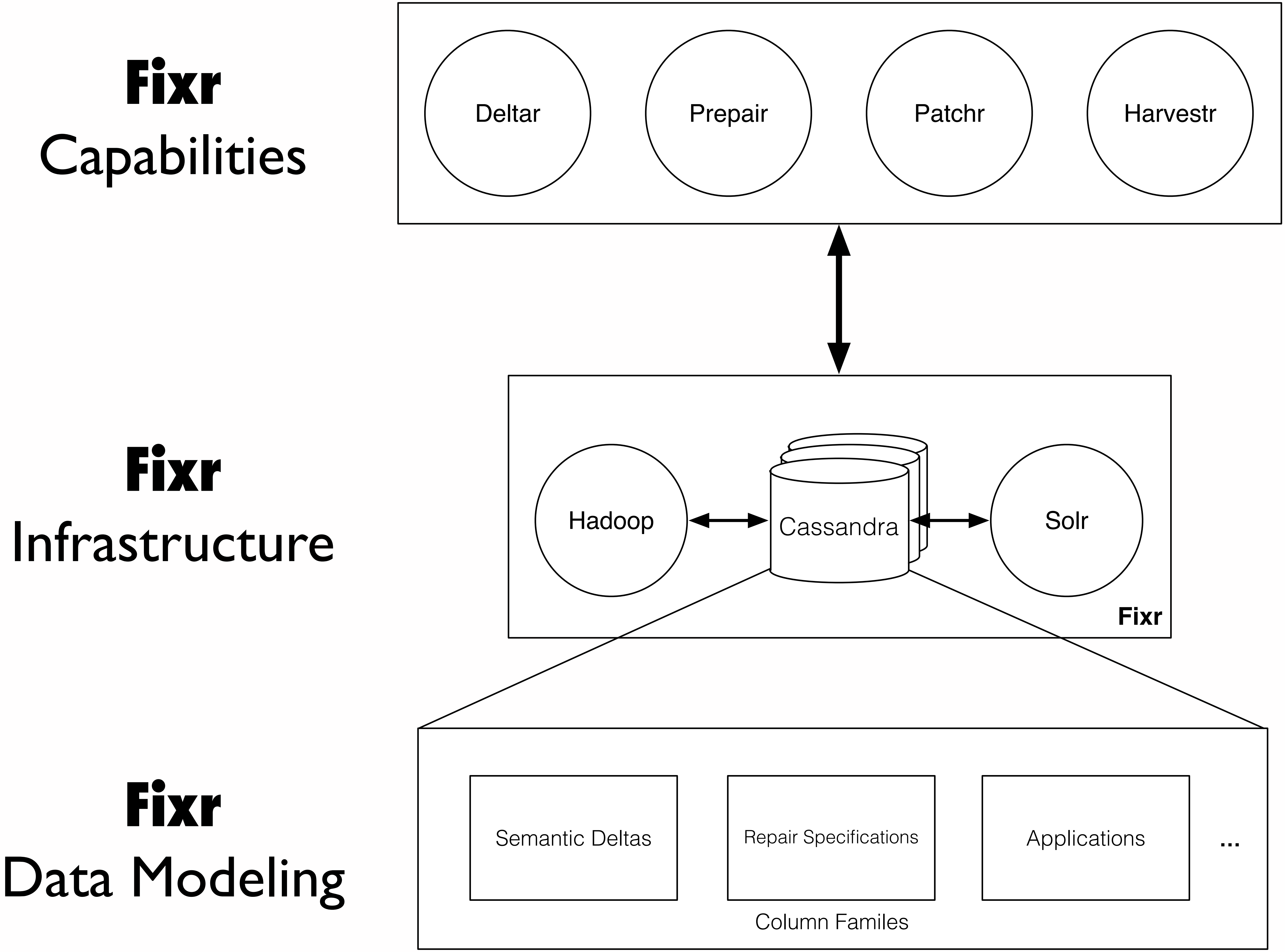
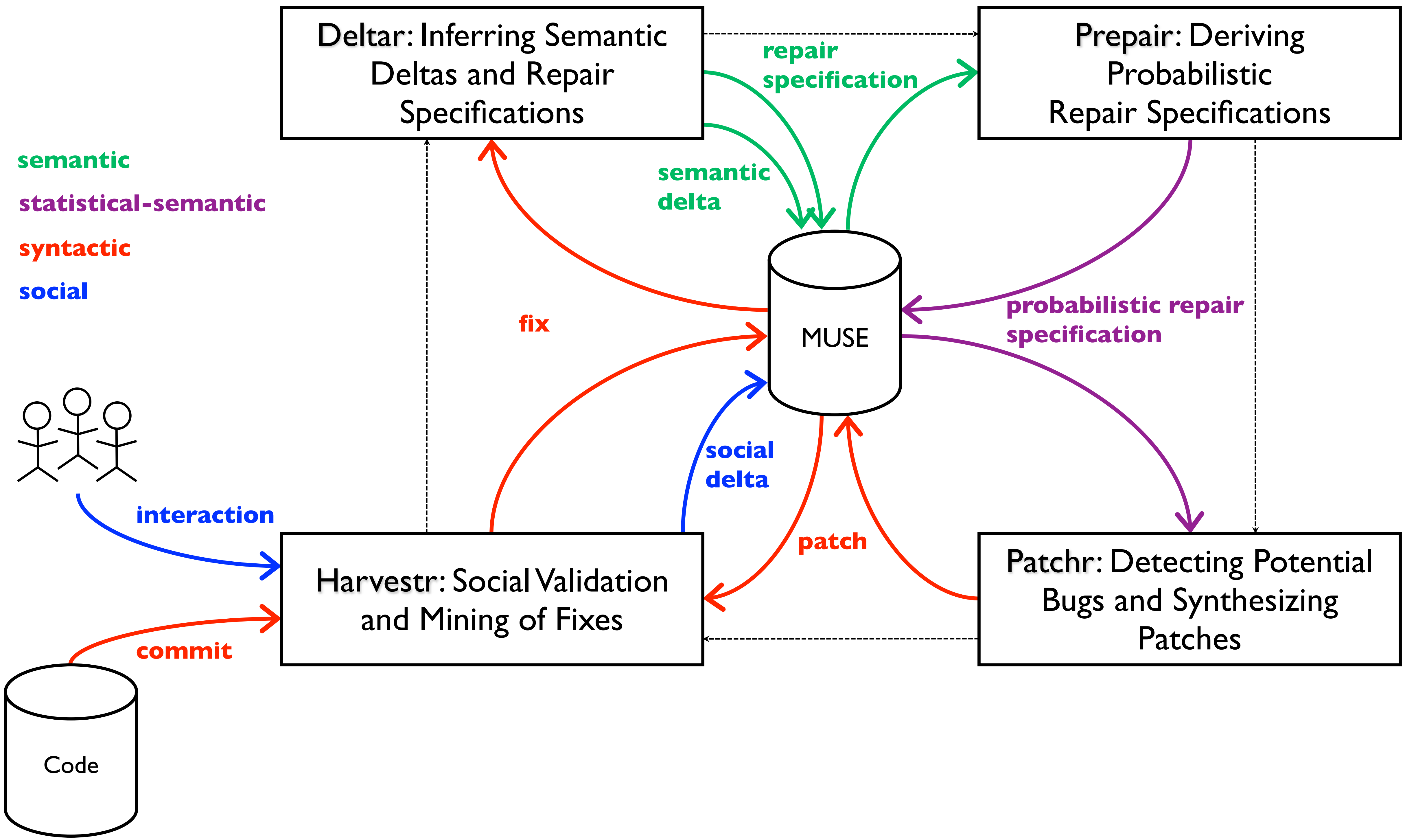


Fixr
Capabilities
Deltar
Prepair
Patchr
Harvestr
Fixr
Infrastructure
Hadoop
Cassandra
Solr
Fixr
Fixr
Data Modeling
Semantic Deltas
Repair Specifications
Applications
...
Column Familes


Deltar: Inferring Semantic Deltas and Repair Specifications
Prepair: Deriving Probabilistic Repair Specifications
repair specification
semantic
statistical-semantic
syntactic
social
semantic delta
MUSE
fix
probabilistic repair specification
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interaction
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patch
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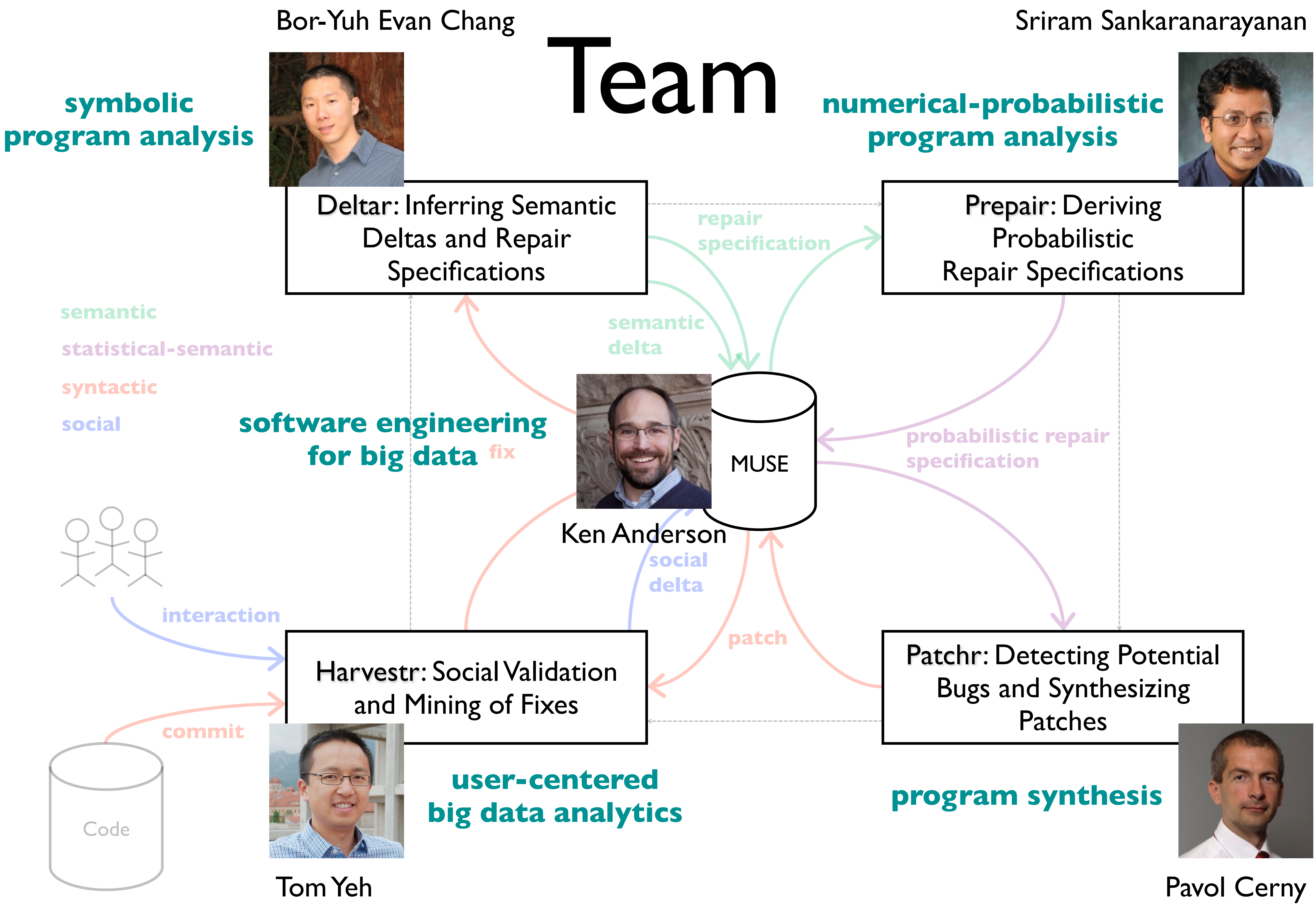
commit
Code

Team



Bor-Yuh Evan Chang
symbolic program analysis
Sriram Sankaranarayanan
numerical-probabilistic program analysis
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repair specification
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Code
user-centered big data analytics
program synthesis
Tom Yeh
Pavol Cerny

Evaluation Questions

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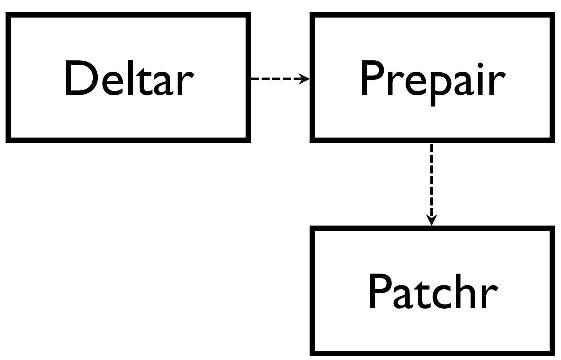

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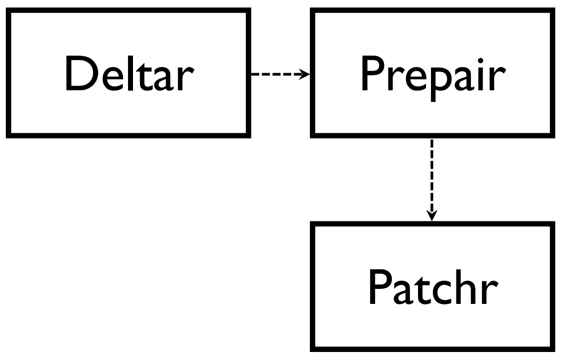

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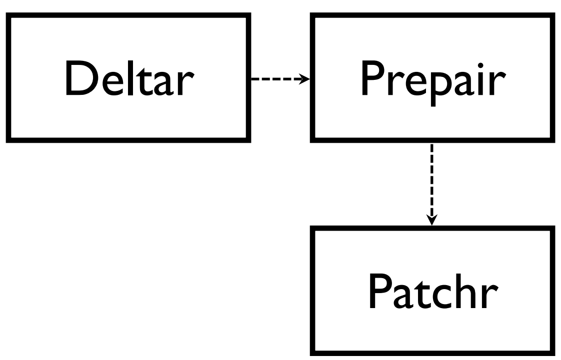

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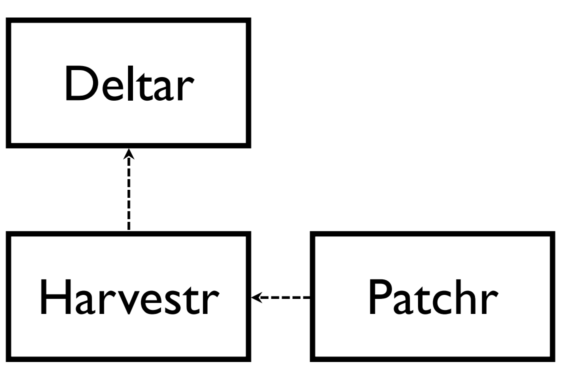

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Prepair for **Fixr**

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pl.cs.colorado.edu

PLV

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Deltar

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