Better C++ using Machine Learning on Large Projects

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Trying to Prevent Bugs

- Code reviews
- Unit tests and functional tests
- Clang-Tidy, Coverity, etc.

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- Code reviews
- Unit tests and functional tests
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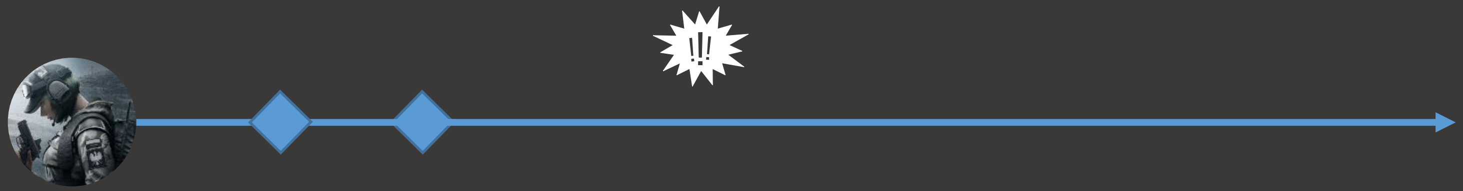
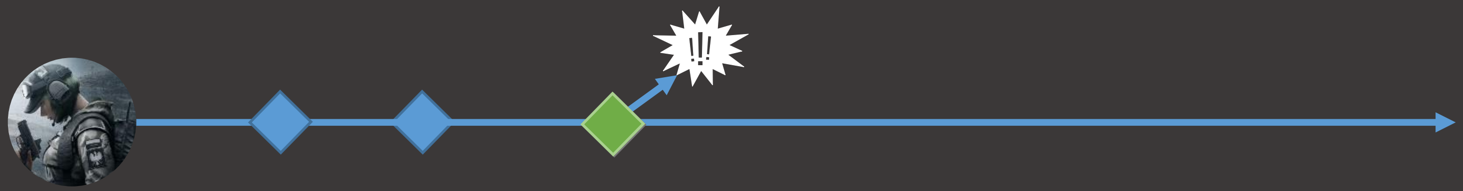
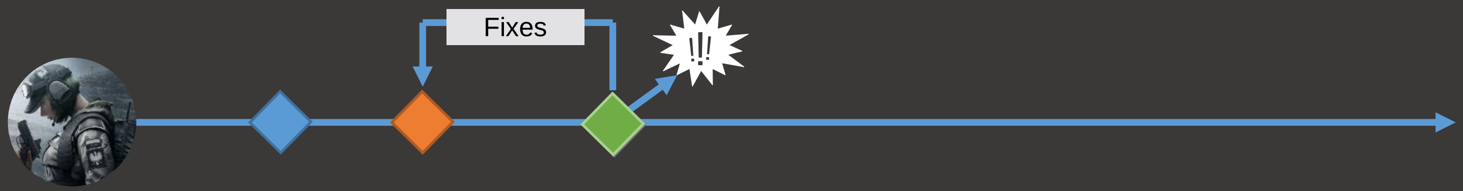
- Testers
- Beta versions, test servers

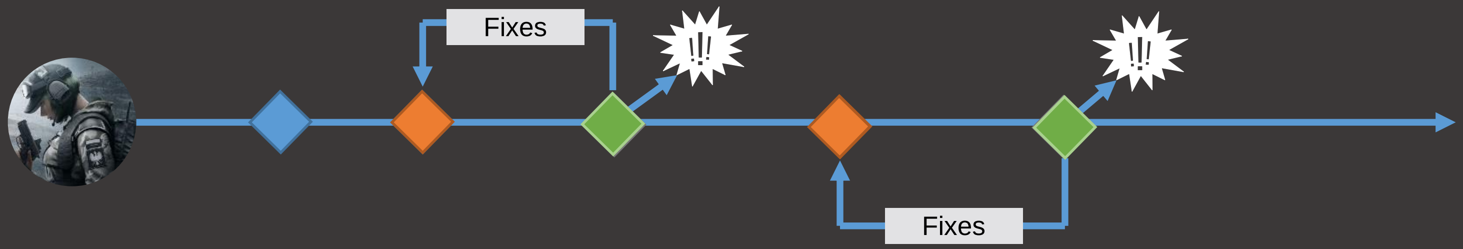
Outline

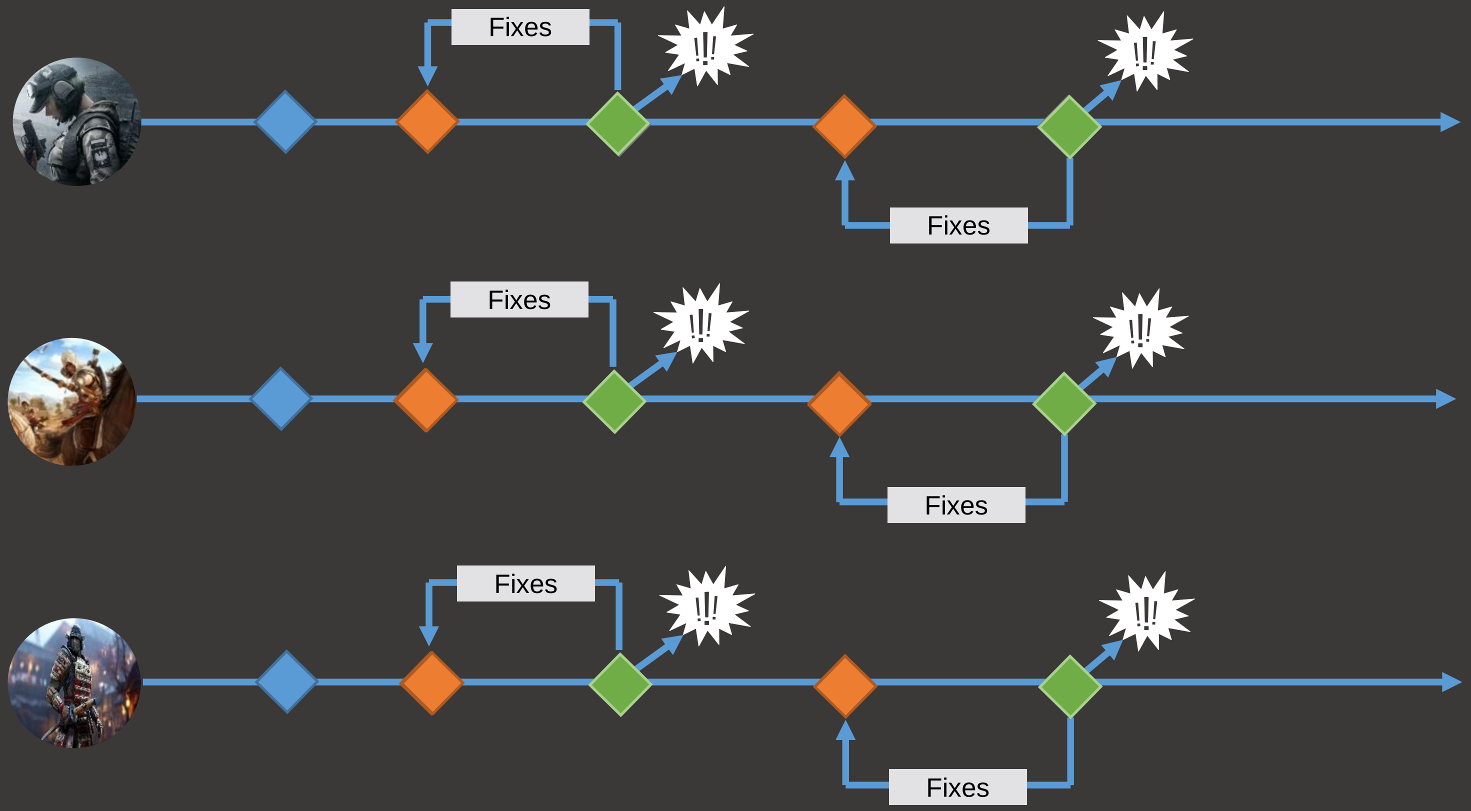
- Mathieu – How it works
  - Identify buggy commits from the past
  - Match some code contributions with past bugs
  - Use ML to predict the riskiness of a commit
- Nicolas – Application on Rainbow Six Siege
  - Bug introduction rate
  - Tools and code suggestions






Fixes
!!!


Fixes
!!!
!!!
Fixes


Fixes
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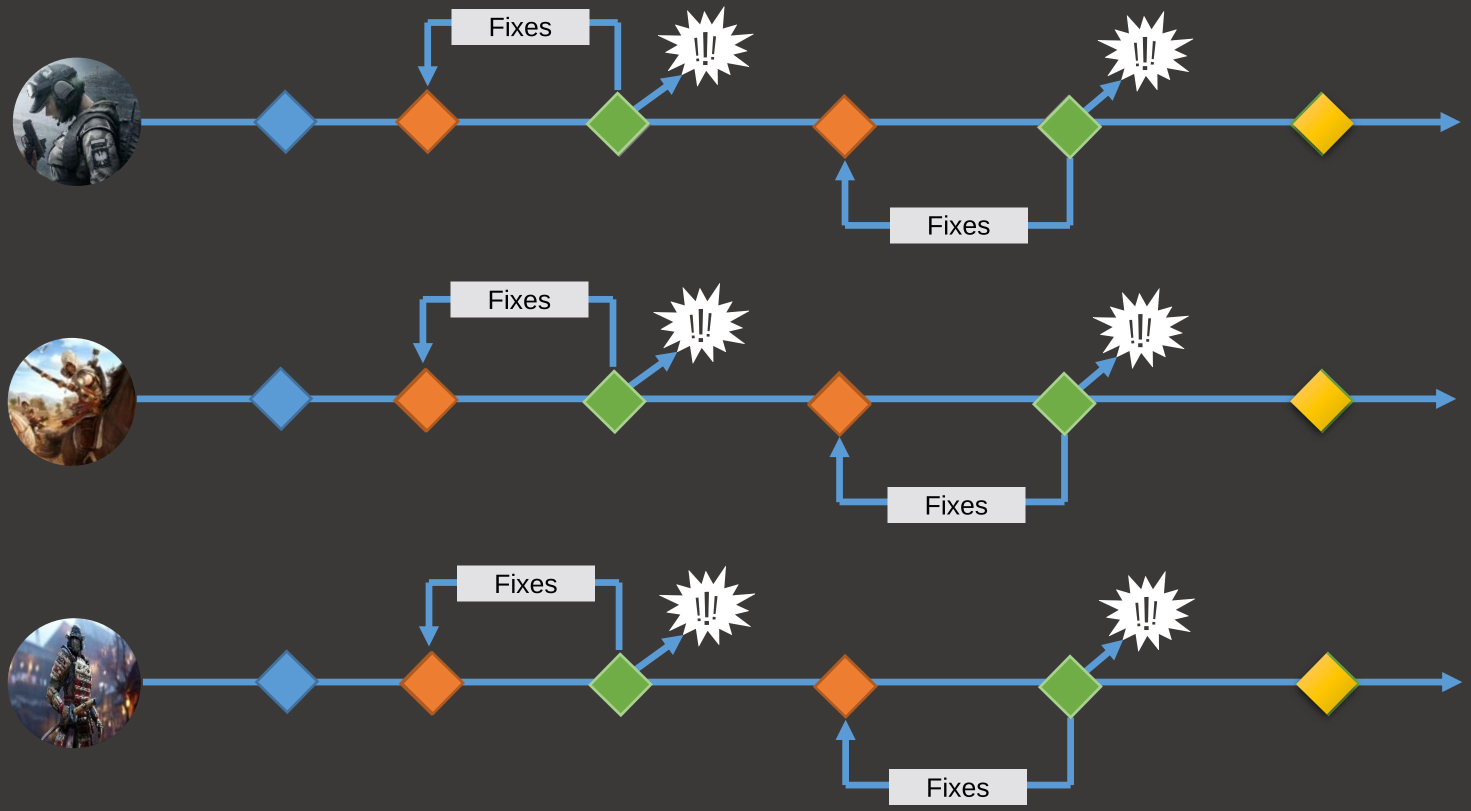
Fixes


Fixes
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Fixes
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Fixes
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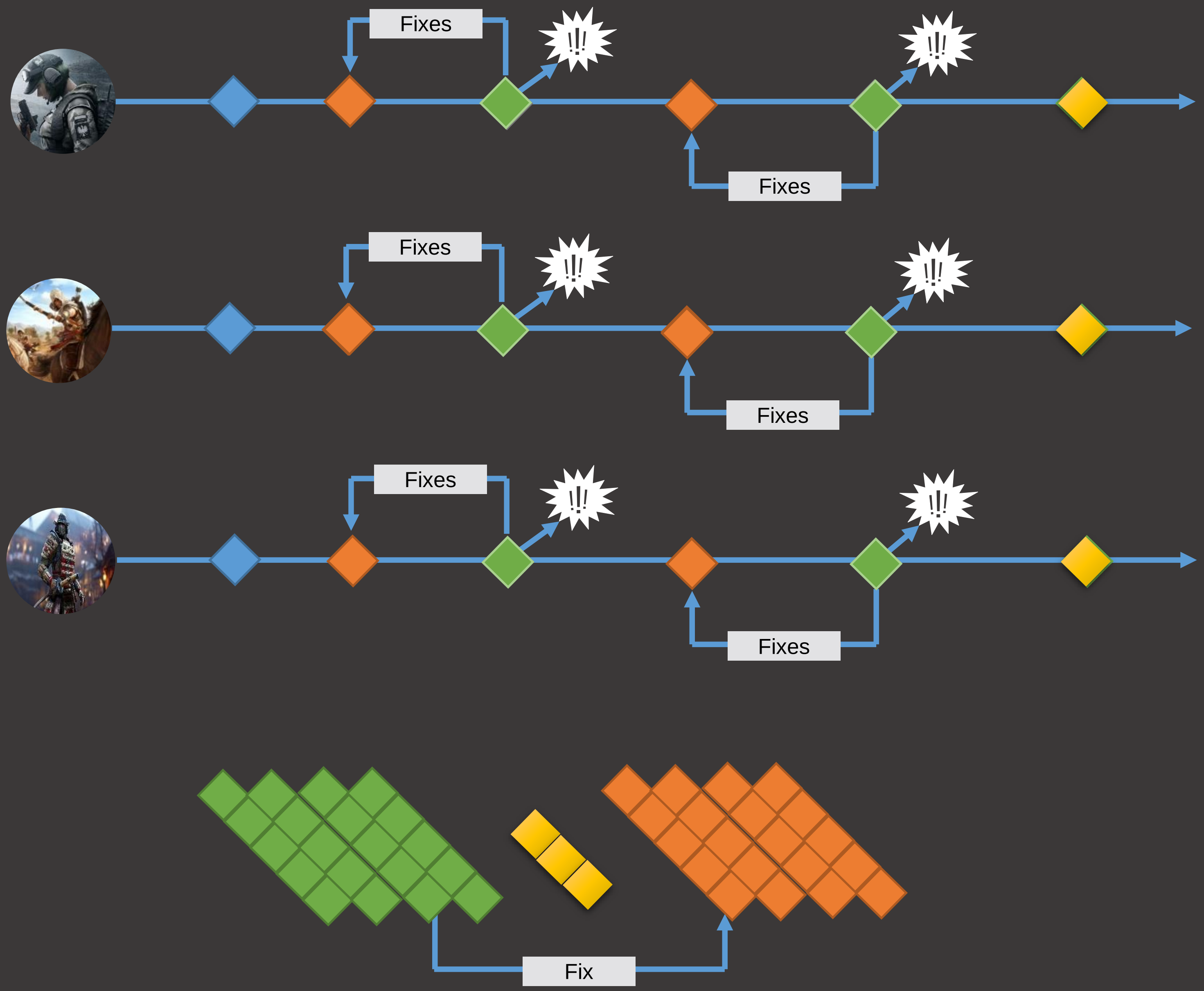
Fixes
!!!
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Fixes
Fixes
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Fixes
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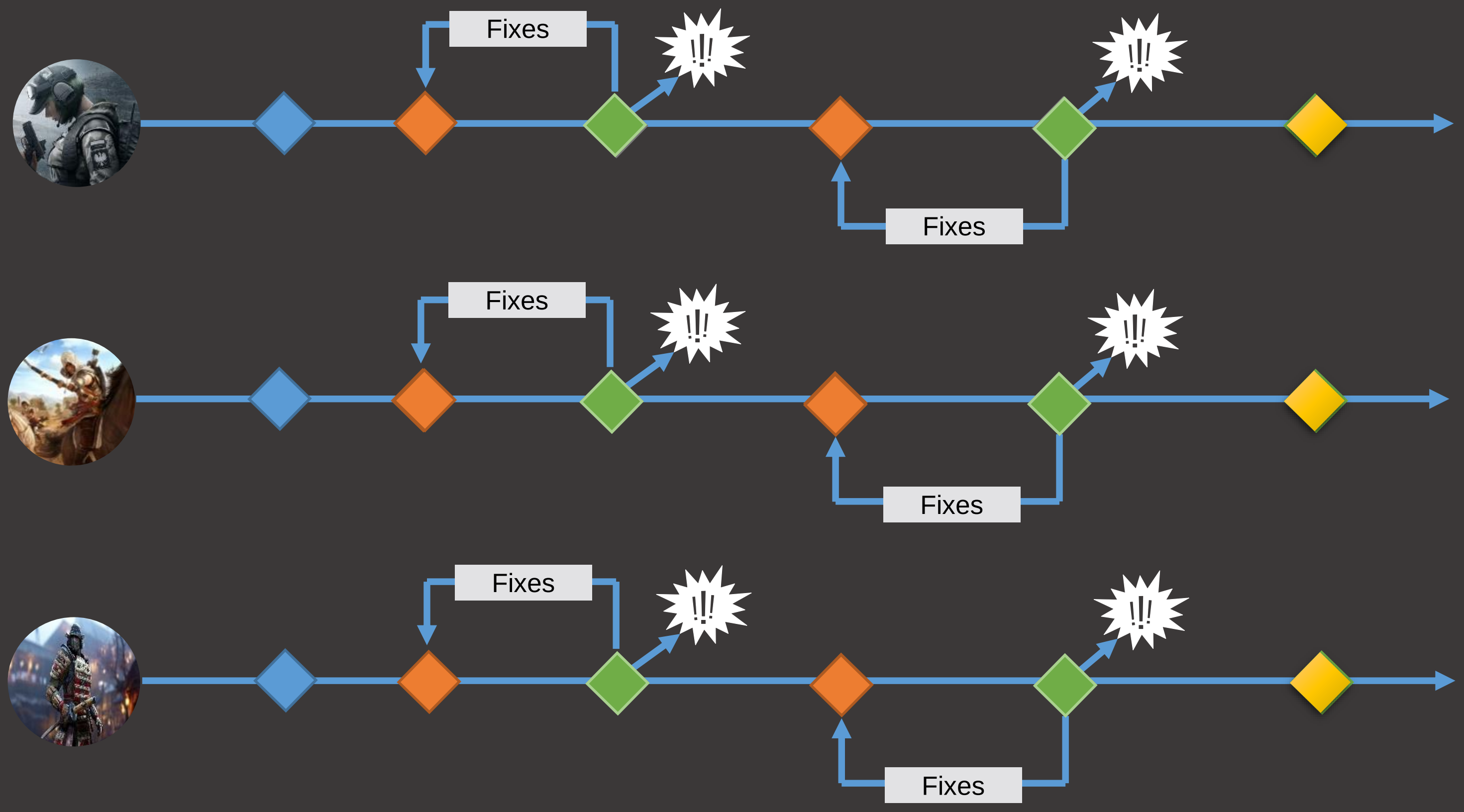
!!!
Fixes
Fix



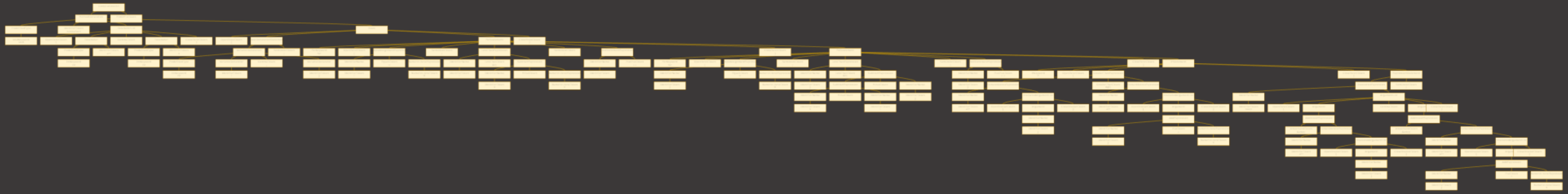
23% of Bug Introducing Commits OSS

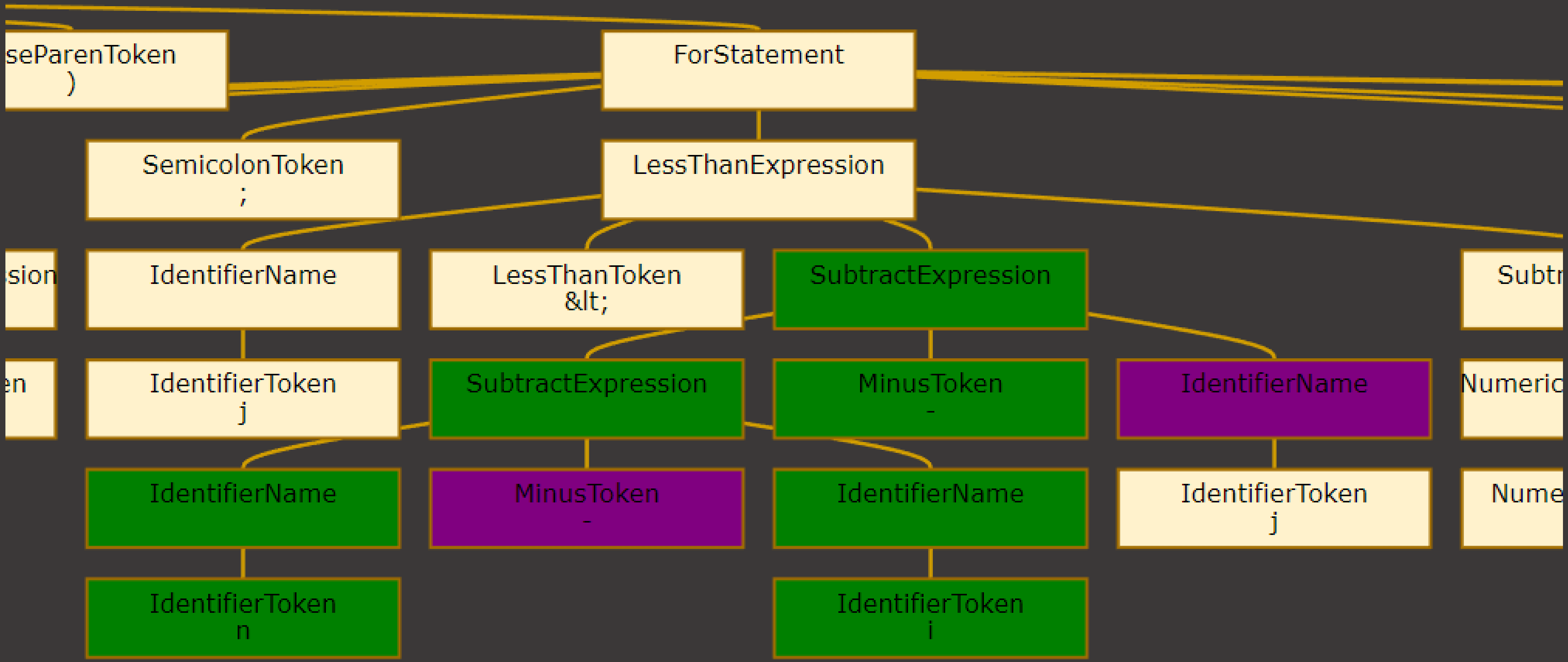
```
void bubbleSort(int arr[], int n)
{
    int i, j;
    for (i = 0; i < n-1; i++)
        for (j = 0; j < 1-j; j++)
            if (arr[j] > arr[j+1])
                swap(&arr[j], &arr[j+1]);
}
```

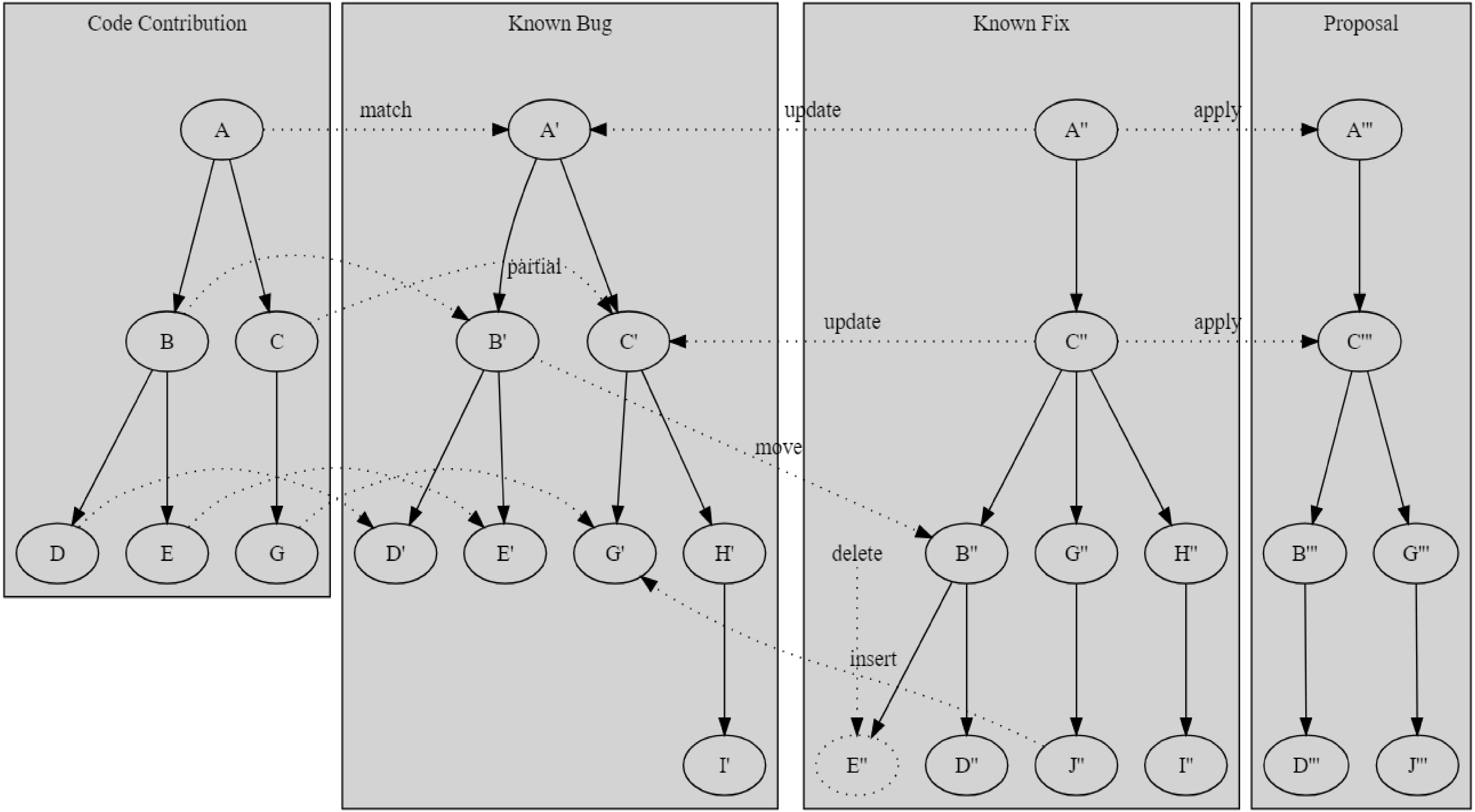
```
while (swapped) {
   swapped = false;
   j++;
   for (int i = 0; i < n - j; i++) {
      if (arr[i] > arr[i + 1]) {
         swap(&arr[i], &arr[i+1]);
         swapped = true;
      }
   }
}
```

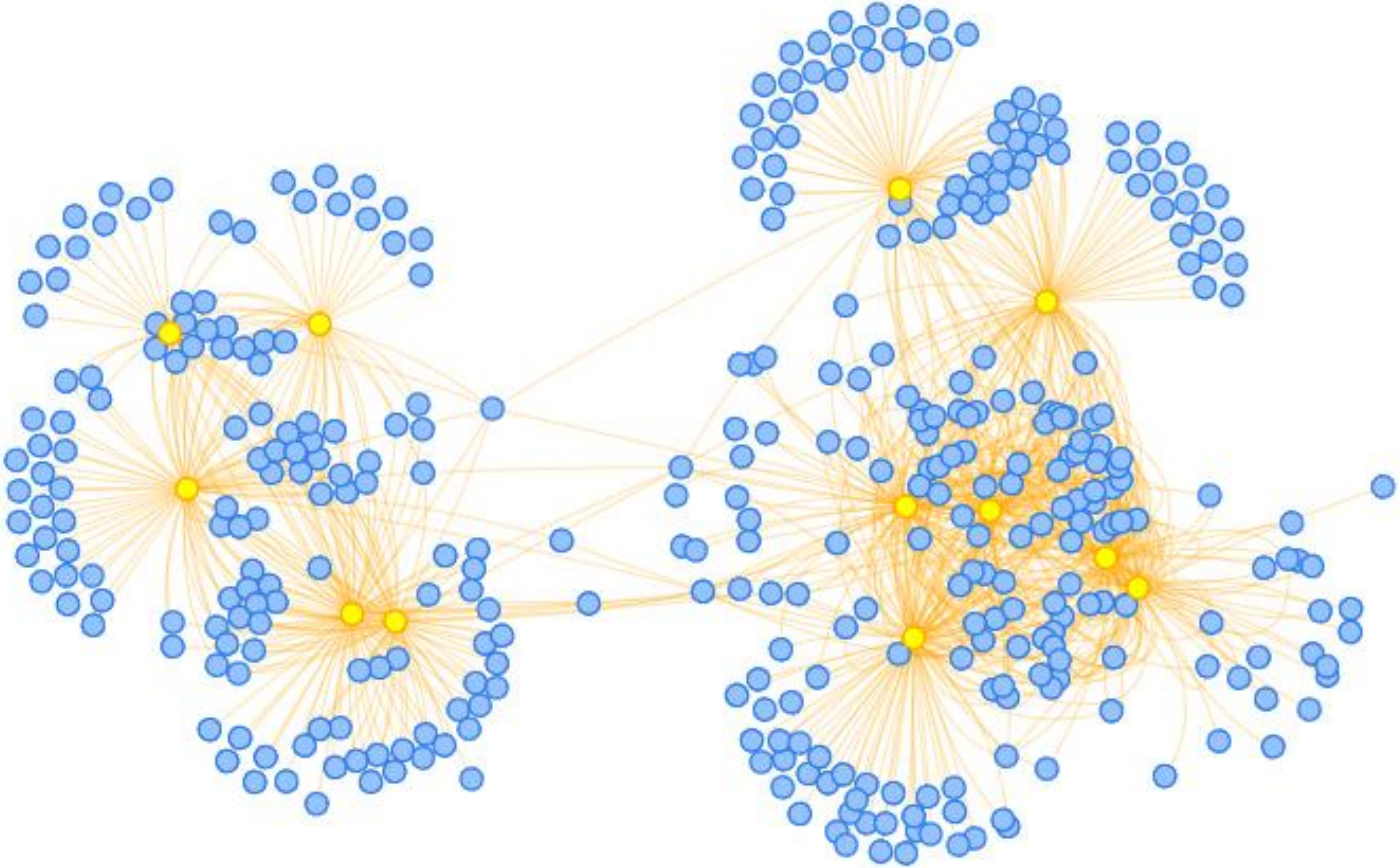
```
while (V1) {
   V1 = false;
   V2++;
   for (int V3 = 0; V3 < V4-V2; V3++) {
      if (V5[V3] > V5[V3 + 1]) {
         M1(&V5[V3], &V5[V3+1]);
         V1 = true;
      }
   }
}
```

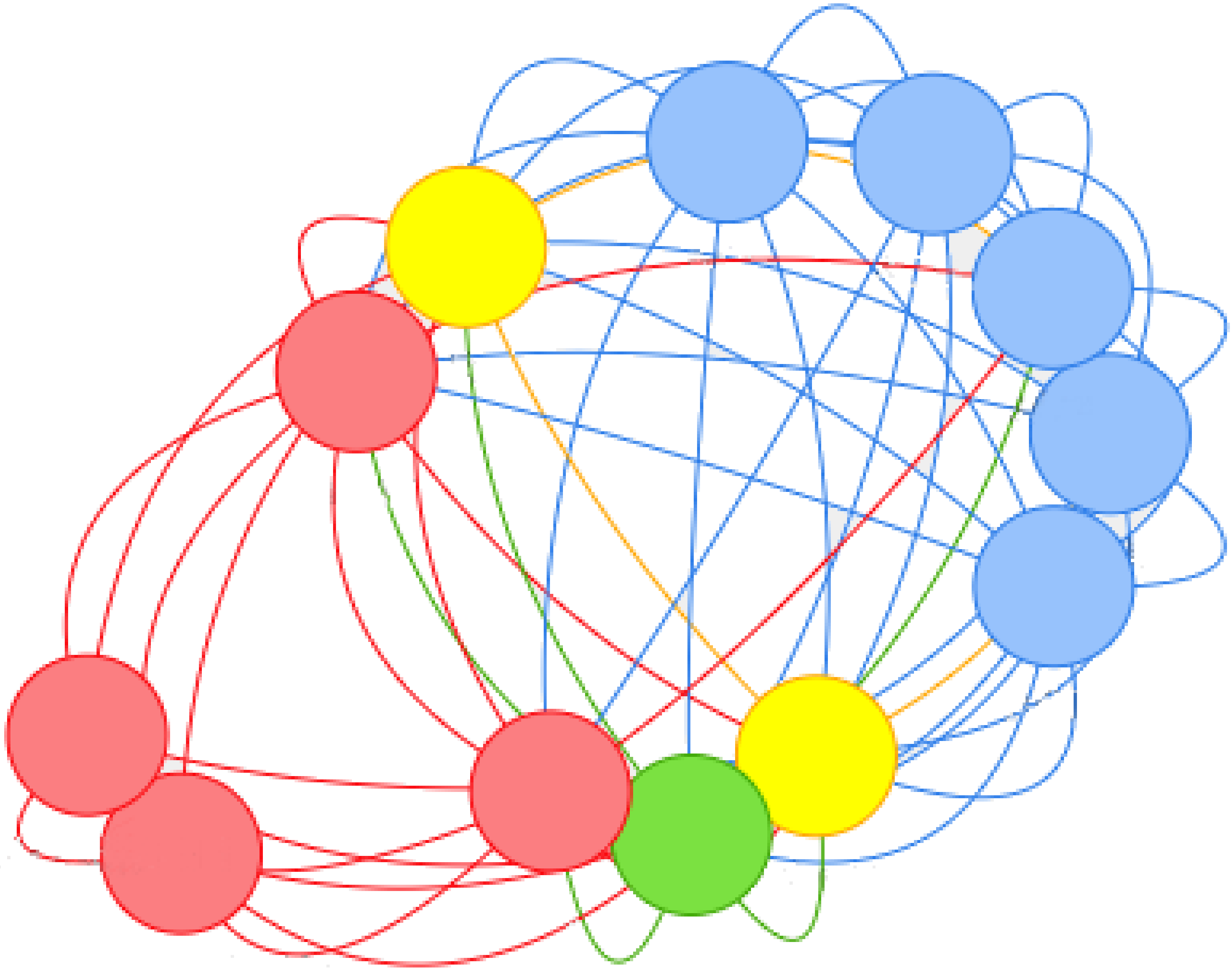
```
void M1(int V1[], int V2)
{
   int V3, V4;
   for (V3 = 0; V3 < V2-1; V3++)
      for (V4 = 0; V4 < V2-V3-1; V4++)
         if (V1[V4] > V1[V4+1])
            M2(&V1[V4], &V1[V4+1]);
}
```




seParenToken
)
ForStatement
SemicolonToken
;
LessThanExpression
sion
IdentifierName
LessThanToken
&lt;
SubtractExpression
Subtr
en
IdentifierToken
j
SubtractExpression
MinusToken
-
IdentifierName
Numeric
IdentifierName
MinusToken
-
IdentifierName
IdentifierToken
j
Nume
IdentifierToken
n
IdentifierToken
i


Code Contribution
Known Bug
Known Fix
Proposal
A
B
C
D
E
G
A'
B'
C'
D'
E'
G'
H'
I'
A''
C''
B''
G''
H''
E''
D''
J''
I''
A'''
C'''
B'''
G'''
D'''
J'''
match
partial
update
update
move
delete
insert
apply
apply





Machine Learning

Historical
Data IN

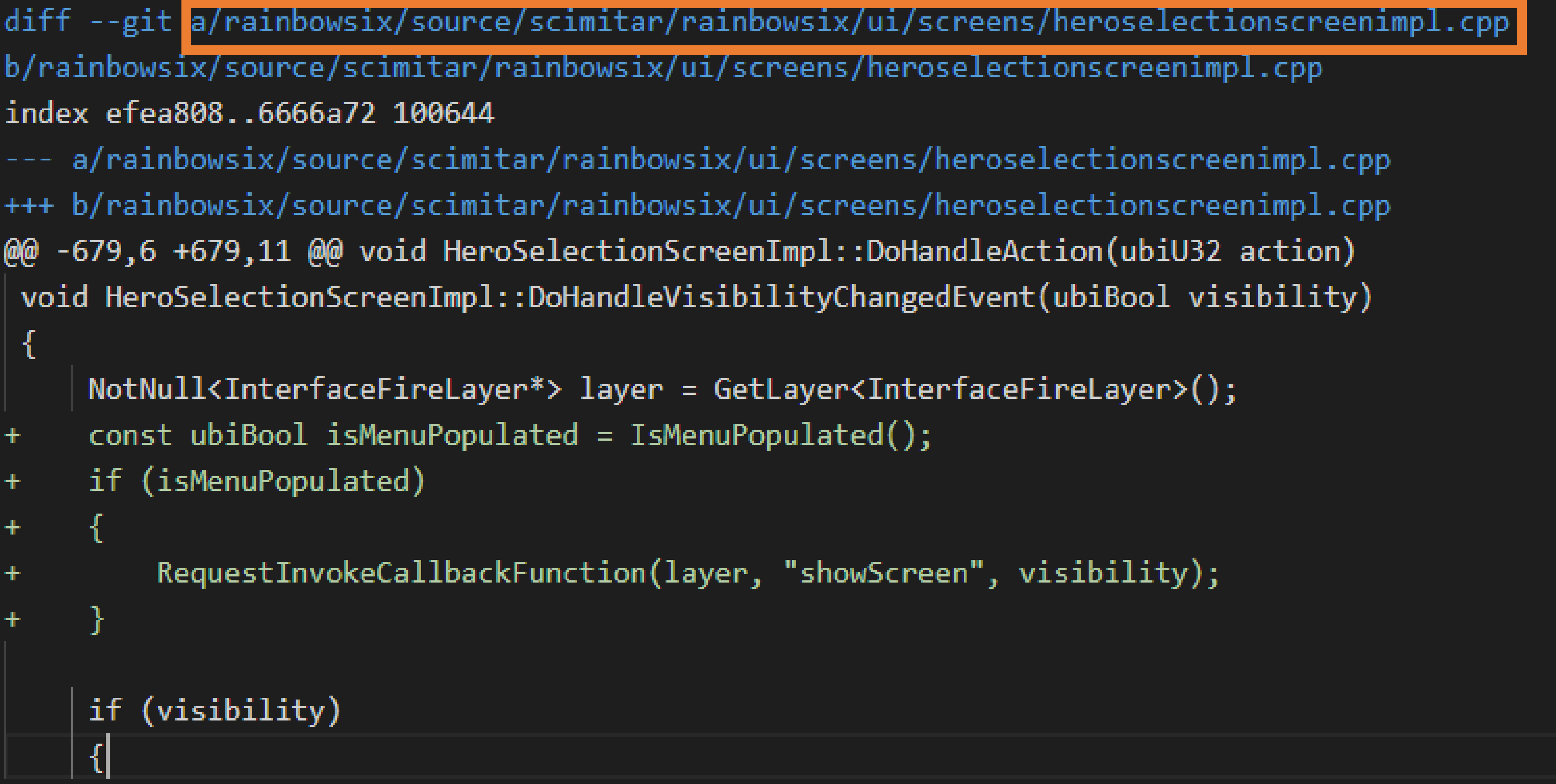
0.98	**0.10**	**0.13**	**0.14**
0.12	…	0.92	0.12
0.91	0.21	…	0.67
0.18	0.76	0.17	…

Data OUT
Model

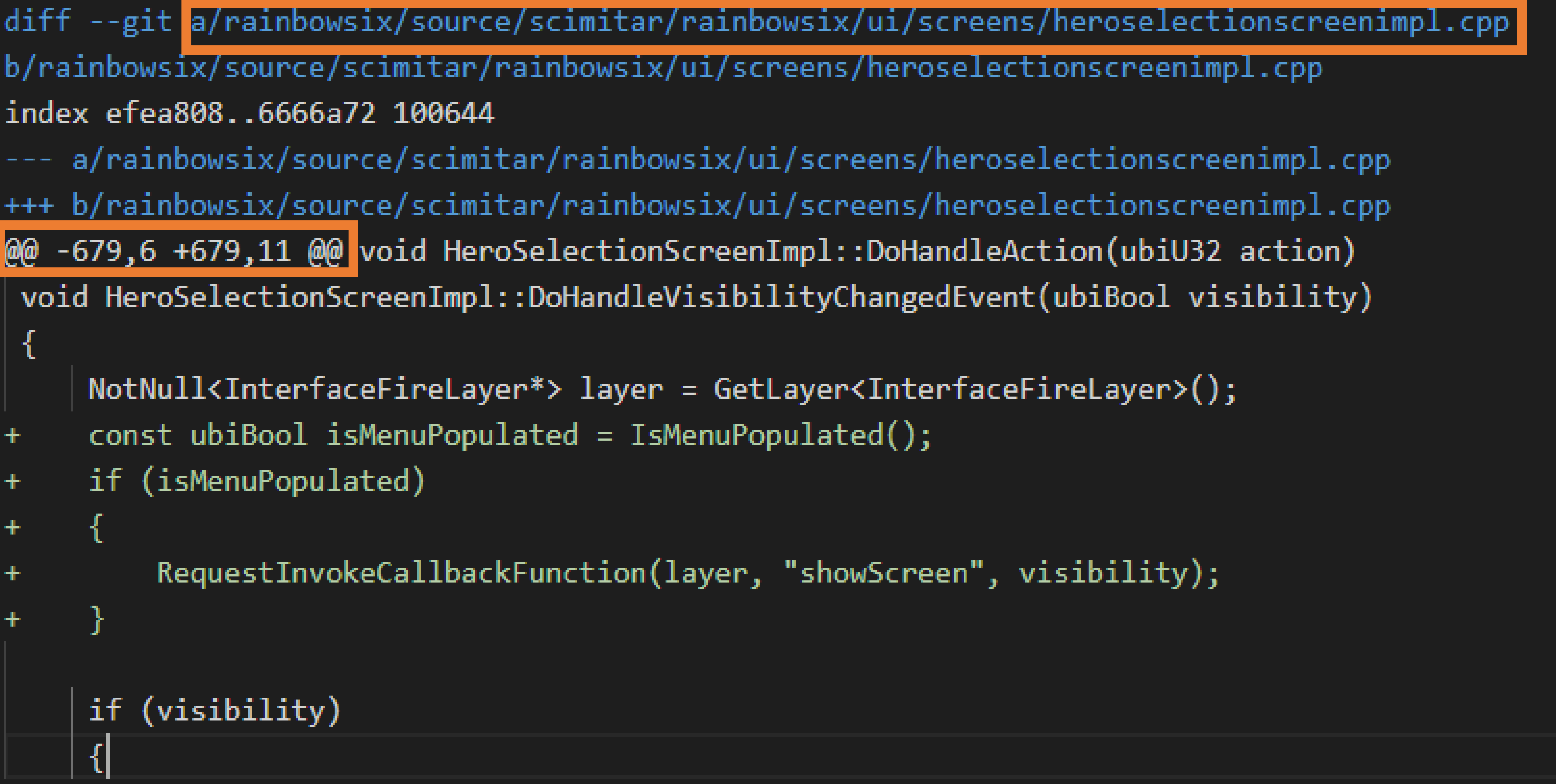
New Data

0.14	**0.153**	**0.84**	**0.14**
0.12	…	0.92	0.12
0.45	0.41	…	0.67
0.69	0.76	0.17	…

Prediction



```
diff --git a/rainbowsix/source/scimitar/rainbowsix/ui/screens/heroselectionscreenimpl.cpp
b/rainbowsix/source/scimitar/rainbowsix/ui/screens/heroselectionscreenimpl.cpp
index efea808..6666a72 100644
--- a/rainbowsix/source/scimitar/rainbowsix/ui/screens/heroselectionscreenimpl.cpp
+++ b/rainbowsix/source/scimitar/rainbowsix/ui/screens/heroselectionscreenimpl.cpp
@@ -679,6 +679,11 @@ void HeroSelectionScreenImpl::DoHandleAction(ubiU32 action)
 void HeroSelectionScreenImpl::DoHandleVisibilityChangedEvent(ubiBool visibility)
 {
     NotNull<InterfaceFireLayer*> layer = GetLayer<InterfaceFireLayer>();
+    const ubiBool isMenuPopulated = IsMenuPopulated();
+    if (isMenuPopulated)
+    {
+        RequestInvokeCallbackFunction(layer, "showScreen", visibility);
+    }
 
     if (visibility)
     {
```



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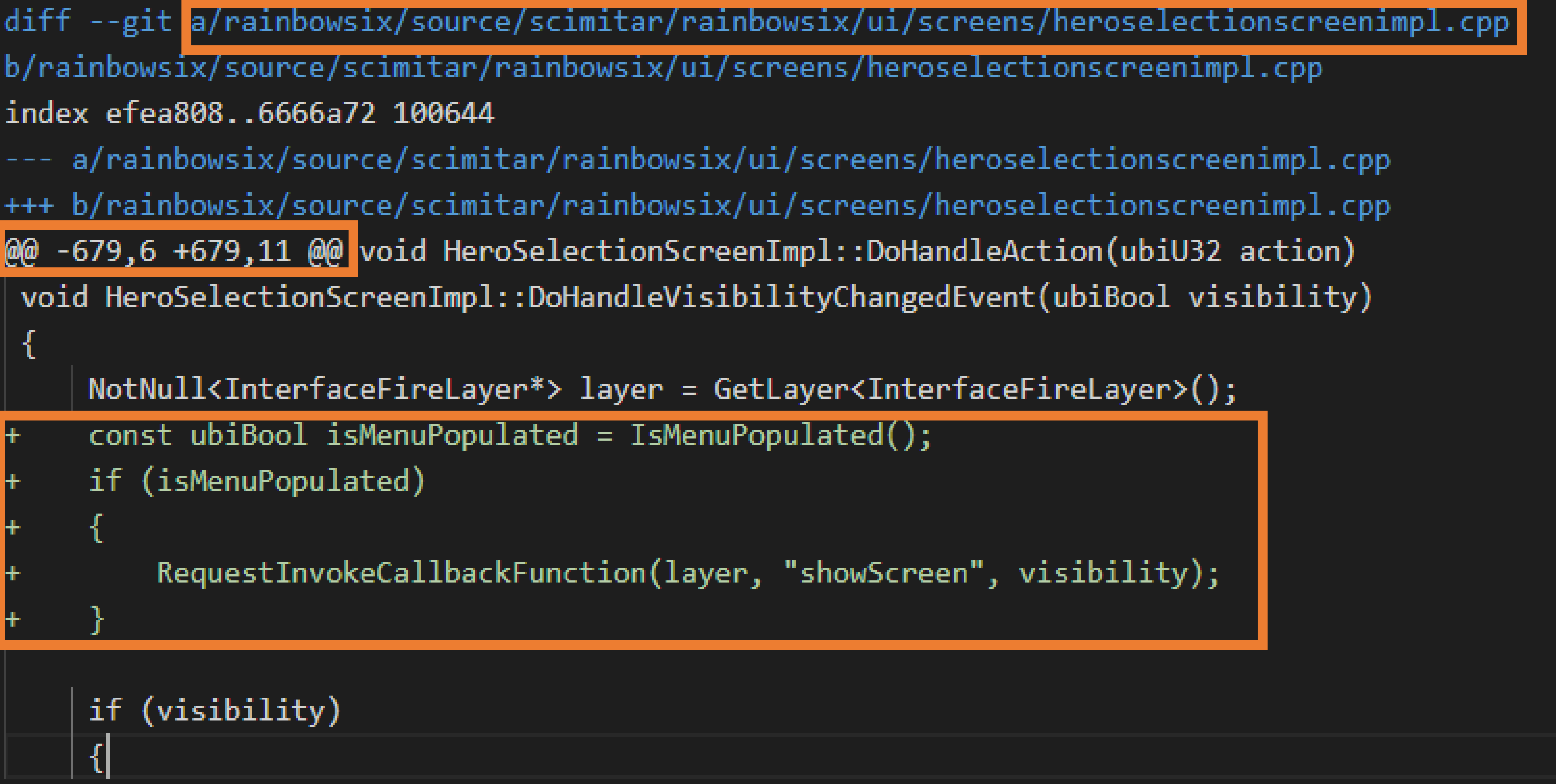

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index efea808..6666a72 100644
--- a/rainbowsix/source/scimitar/rainbowsix/ui/screens/heroselectionscreenimpl.cpp
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     if (visibility)
     {
```

Machine Learning Features

File Age

Files

Directories

Machine Learning Features

File Age

Files

Directories

Dev R-XP

Dev S-XP

Contributors

Machine Learning Features

Subsystems

Fan Out

Test Coverage

Entropy

File Age

Files

Fan In

Subsystem Stability

Directories

Dev S-XP

Dev R-XP

Unique Change

File Stability

Log Density

Complexity

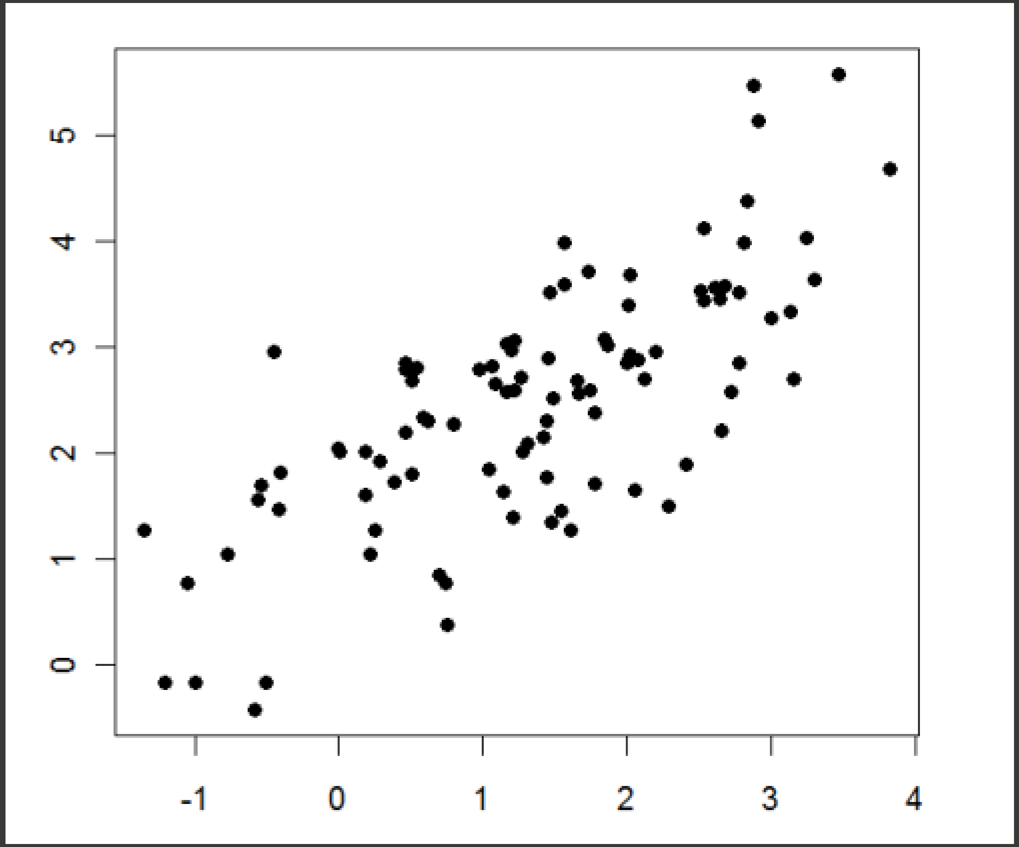
Contributors

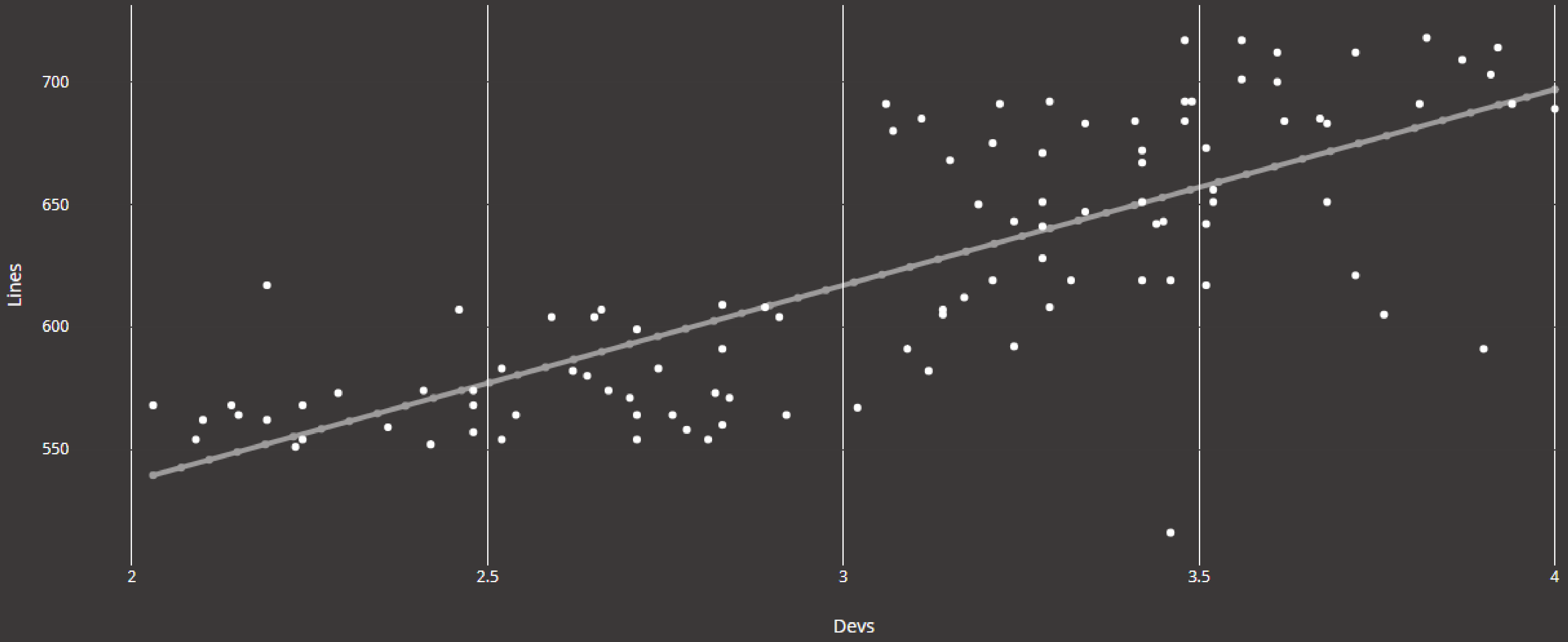
Comment Density

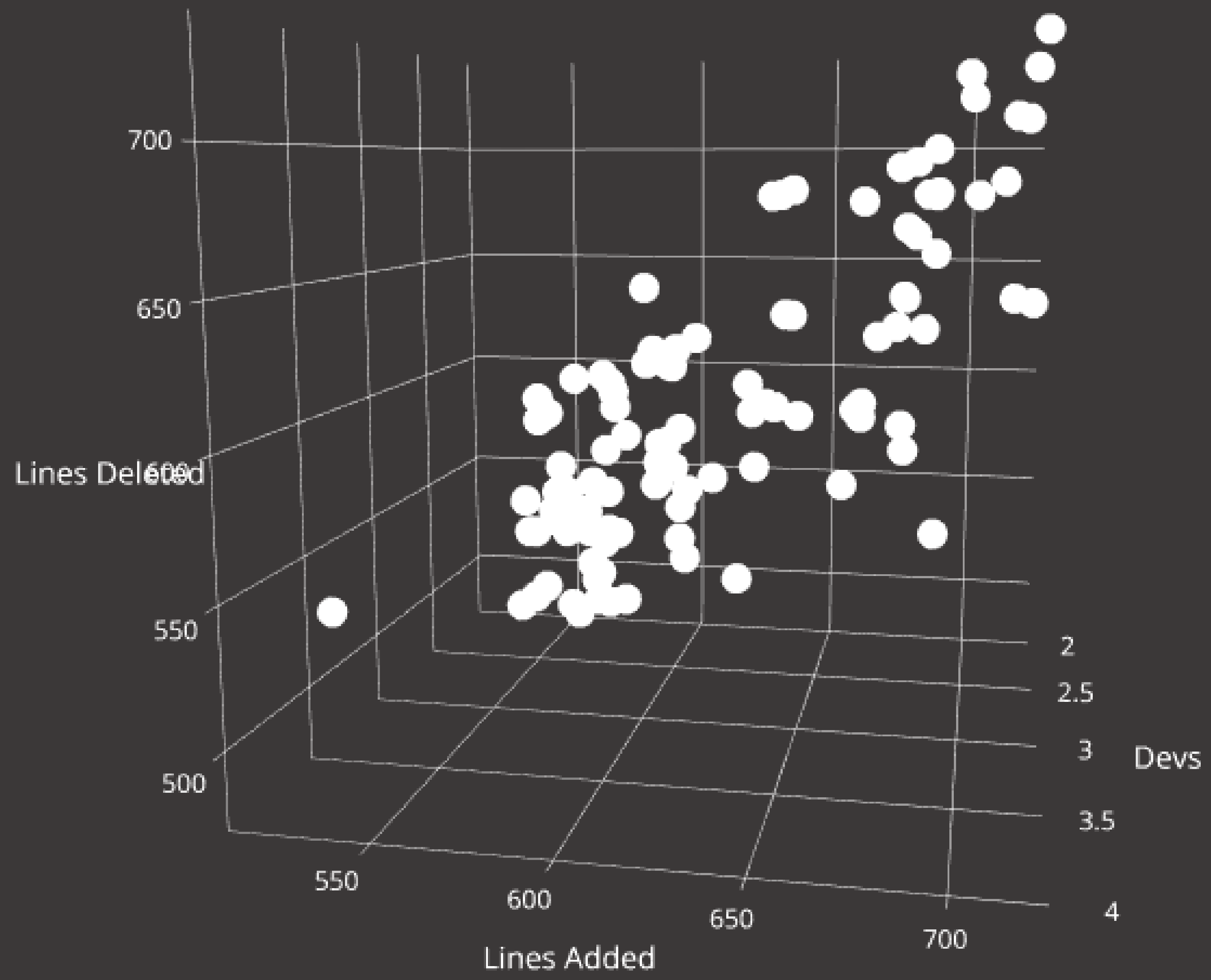
Machine Learning

$$x = \begin{bmatrix} f_{A1}\ f_{B1}\ f_{C1}\ f_{D1}\ \cdots\ f_{M1}\ C_1 \\ . \\ . \\ . \\ f_{AN}\ f_{BN}\ f_{CN}\ f_{DN}\ \cdots\ f_{MN}\ C_2 \end{bmatrix}$$

Feature Matrix




Lines
700
650
600
550
2
2.5
3
3.5
4
Devs


700
650
Lines Deleted
600
550
500
550
600
650
700
Lines Added
2
2.5
3
3.5
4
Devs

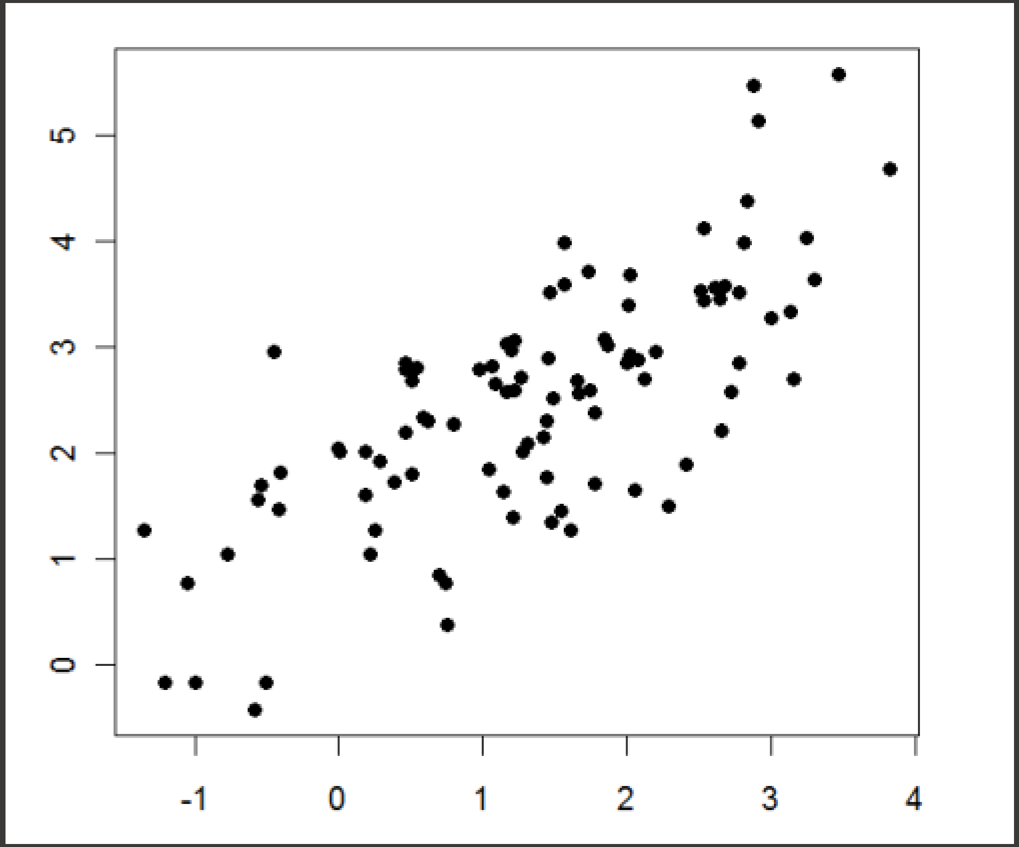
Machine Learning

$$x = \begin{bmatrix} f_{A1}\ f_{B1}\ f_{C1}\ f_{D1}\ \cdots\ f_{M1}\ C_1 \\ . \\ . \\ . \\ f_{AN}\ f_{BN}\ f_{CN}\ f_{DN}\ \cdots\ f_{MN}\ C_2 \end{bmatrix}$$

Feature Matrix

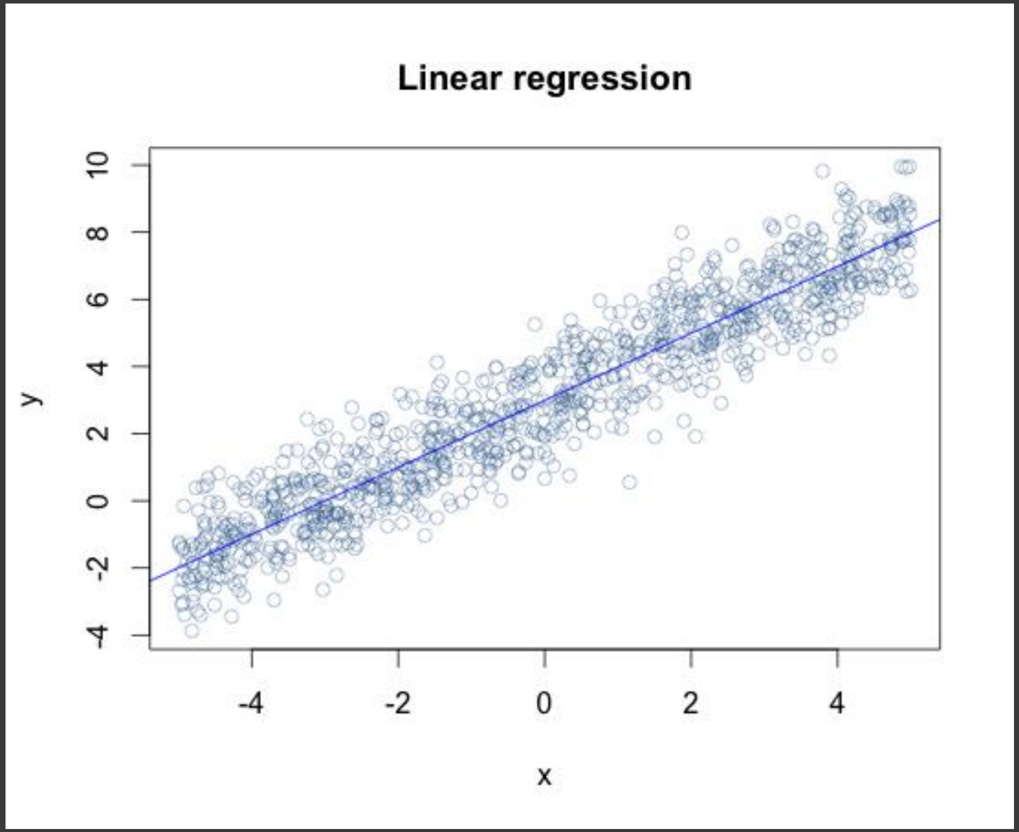
$$\sigma_{jk} = \frac{1}{n-1} \sum_{i=1}^{N} (x_{ij} - \bar{x}_{ij})(x_{ik} - \bar{x}_k)$$

Covariance Matrix

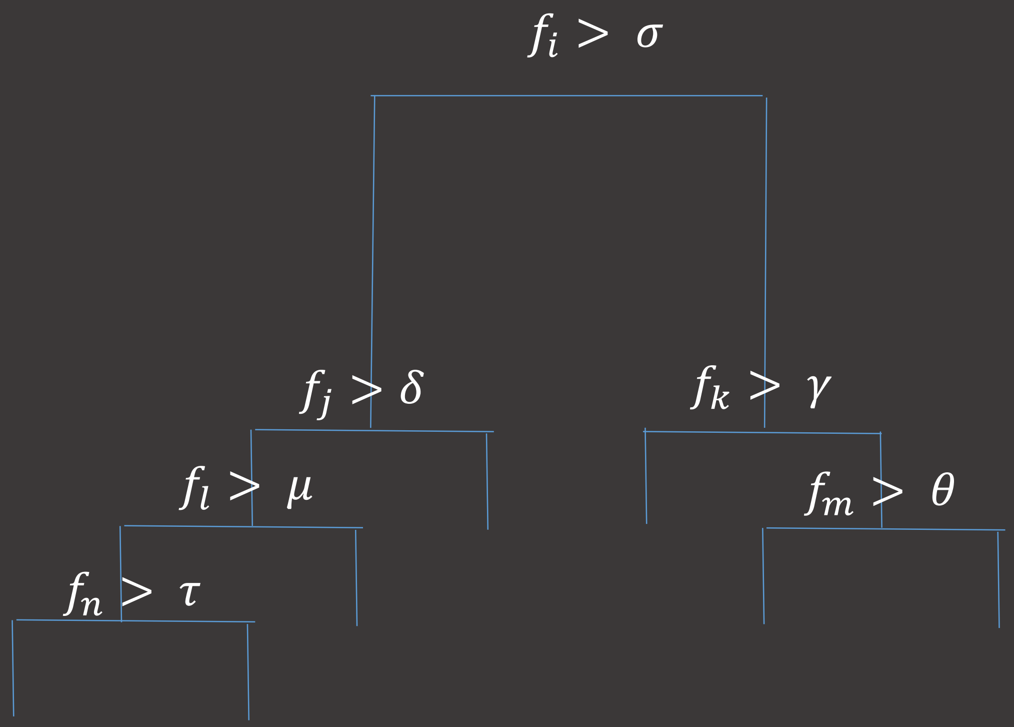


Machine Learning

*Tries to determine the best regression formulae: Subsystems*x + Directories*y + Files*z + LineAdded+l + LineDeleted*-0.00 + LineTotal*-0.00 + Devs*-0.05 + Age*0.20 + UniqueChange*0.30 + Exp*-0.00 + RExp*-0.00 + Sexp*0.50*



Machine Learning



$f_i > \sigma$

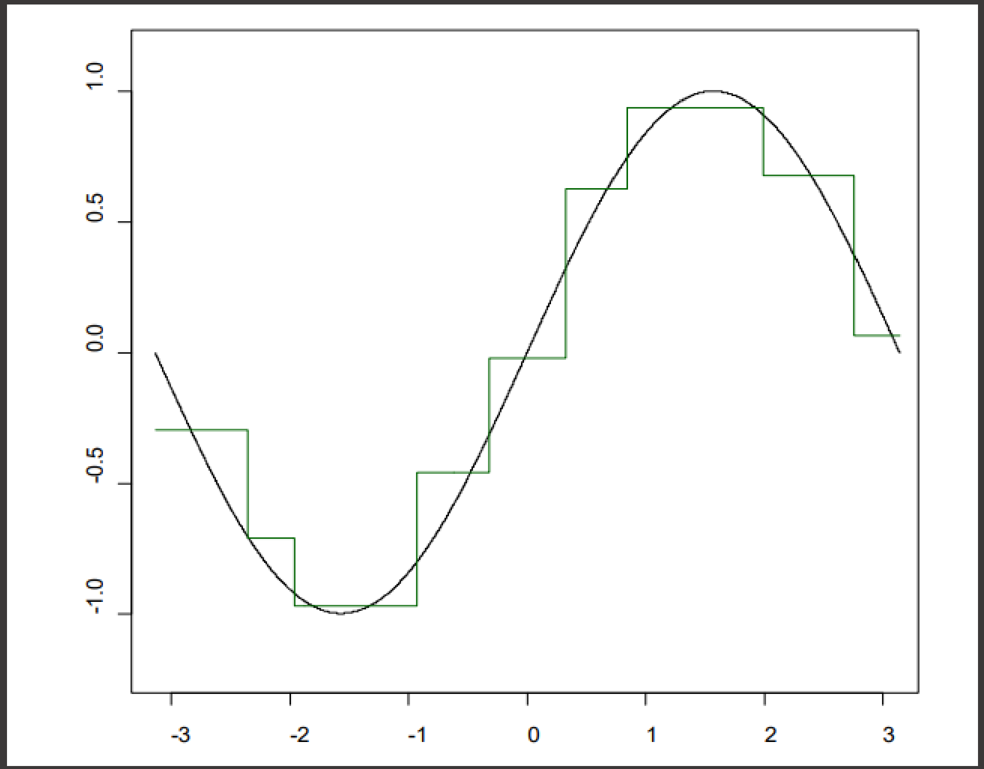
$f_j > \delta$

$f_k > \gamma$

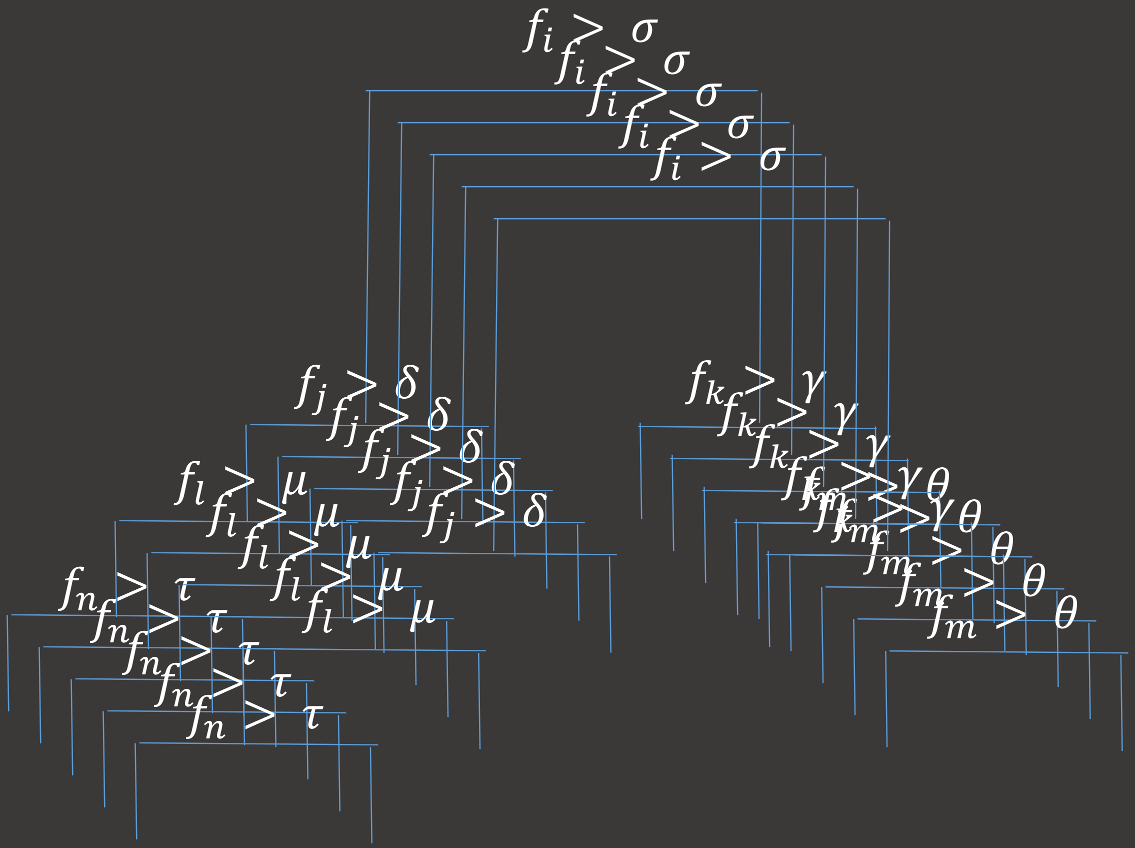
$f_l > \mu$

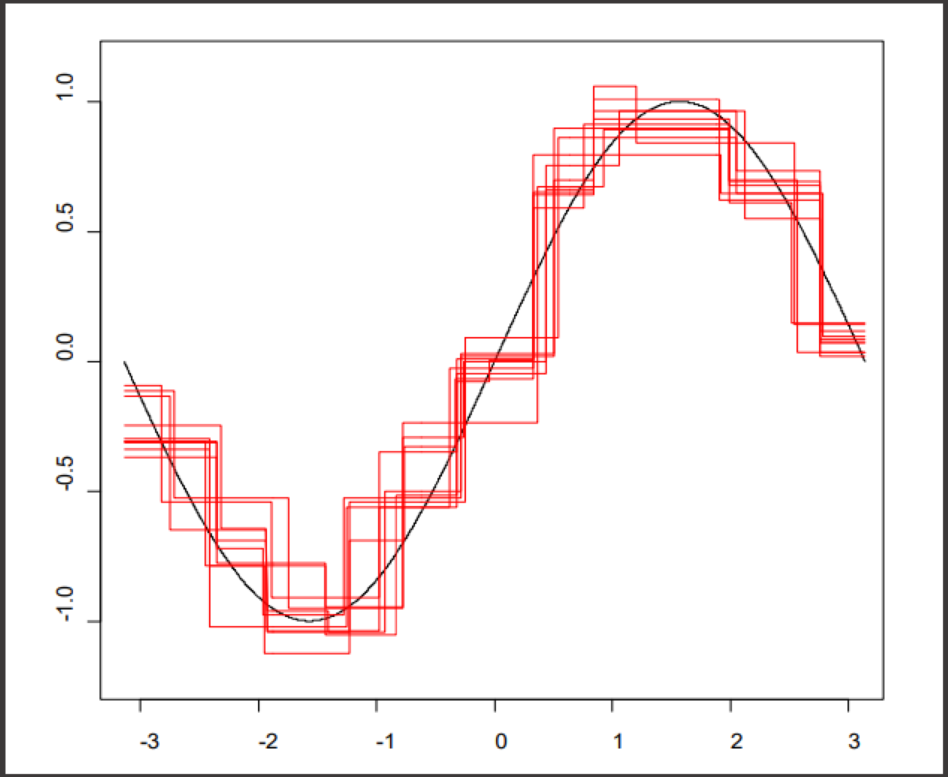
$f_m > \theta$

$f_n > \tau$

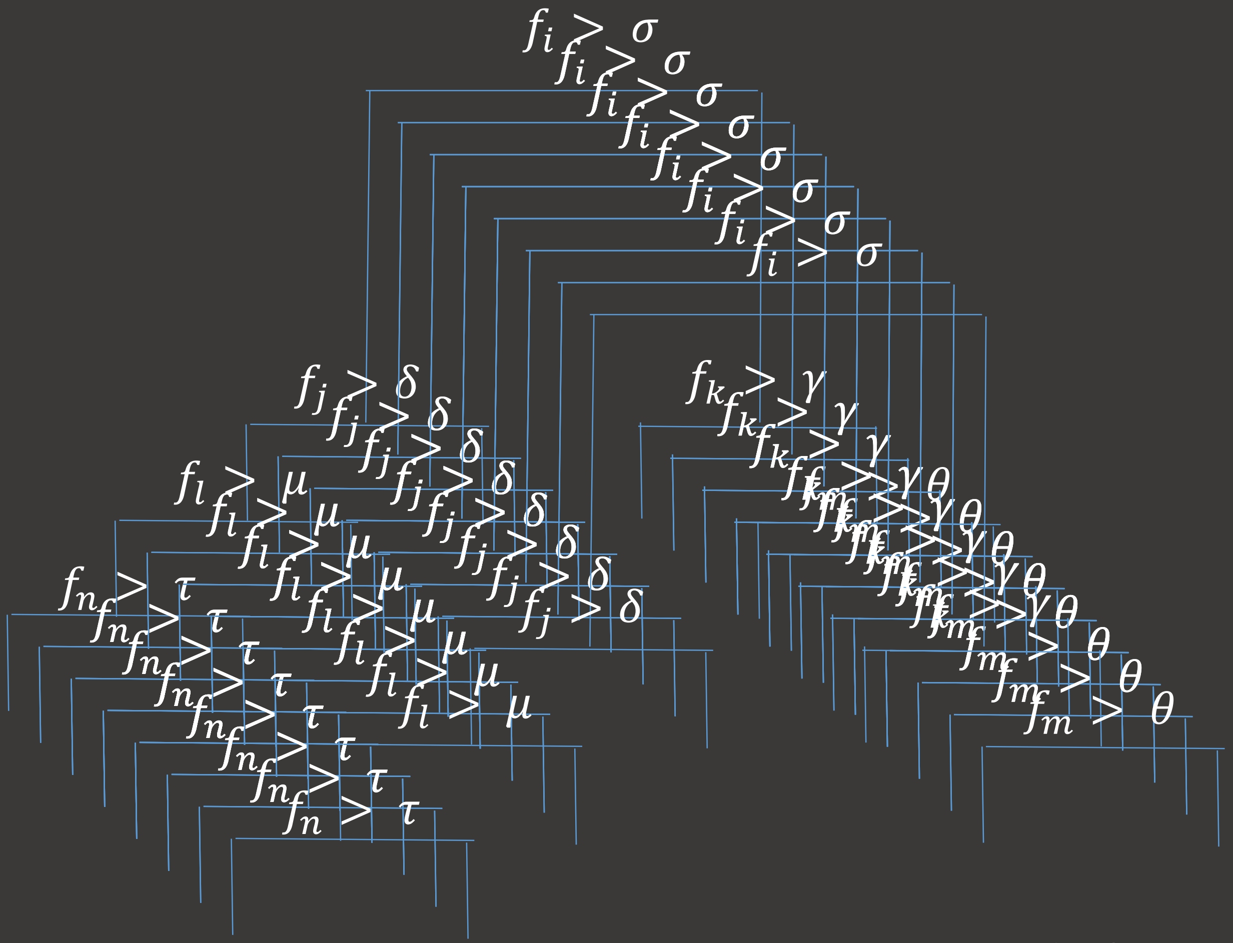


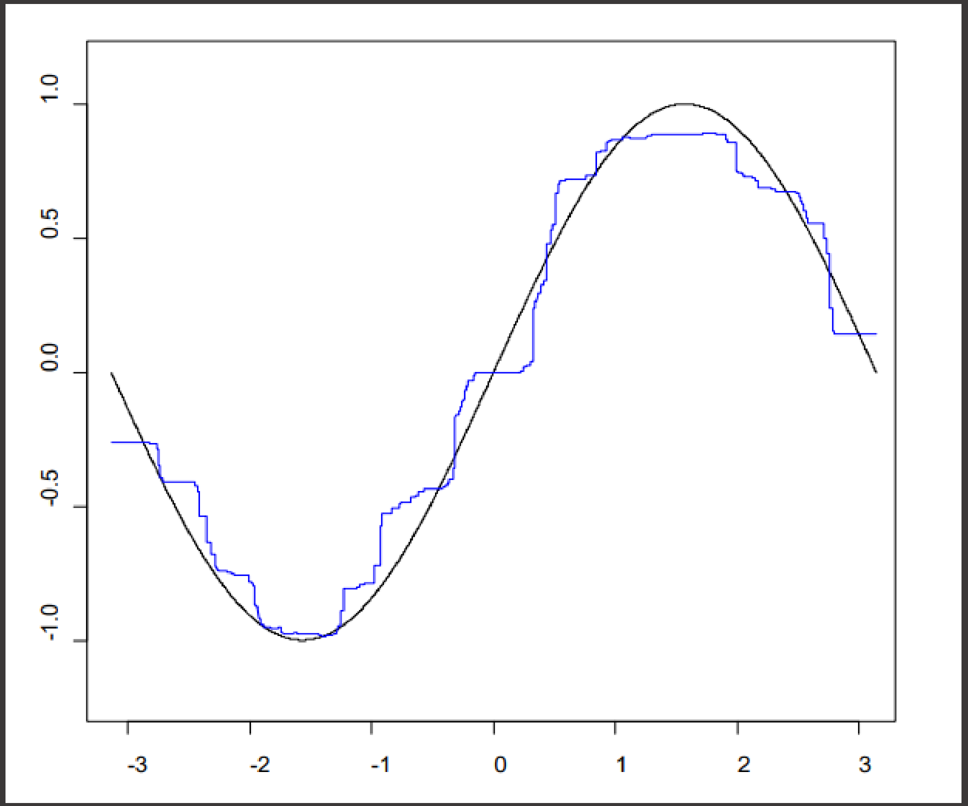
Machine Learning



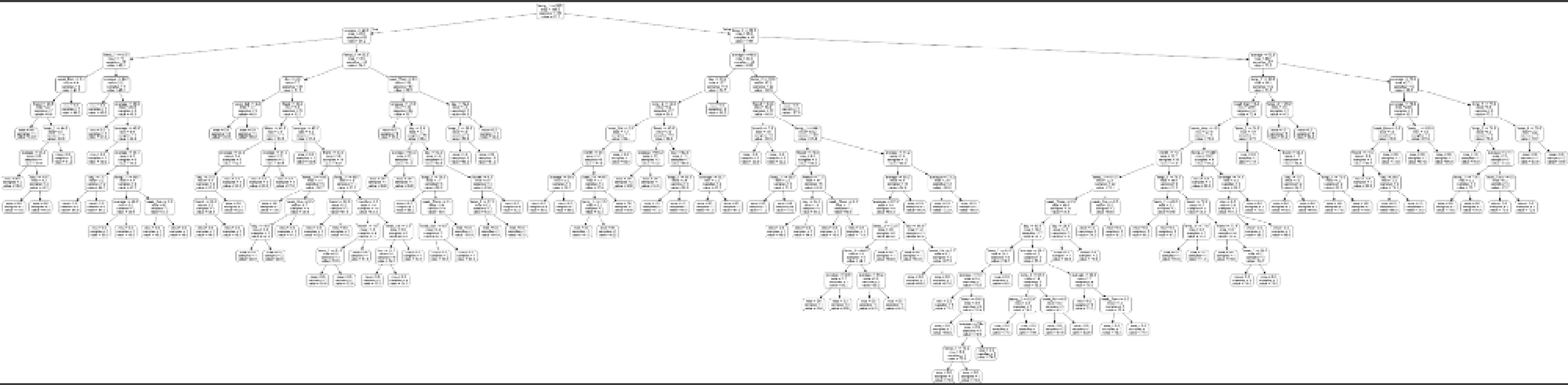


Machine Learning





Machine Learning



Machine Learning Performances

We can predict if a commit is introducing a defect with

- *70.05% precision*
- *71.40% recall*

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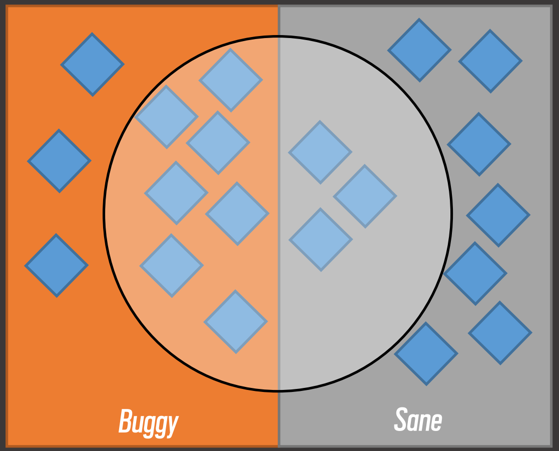
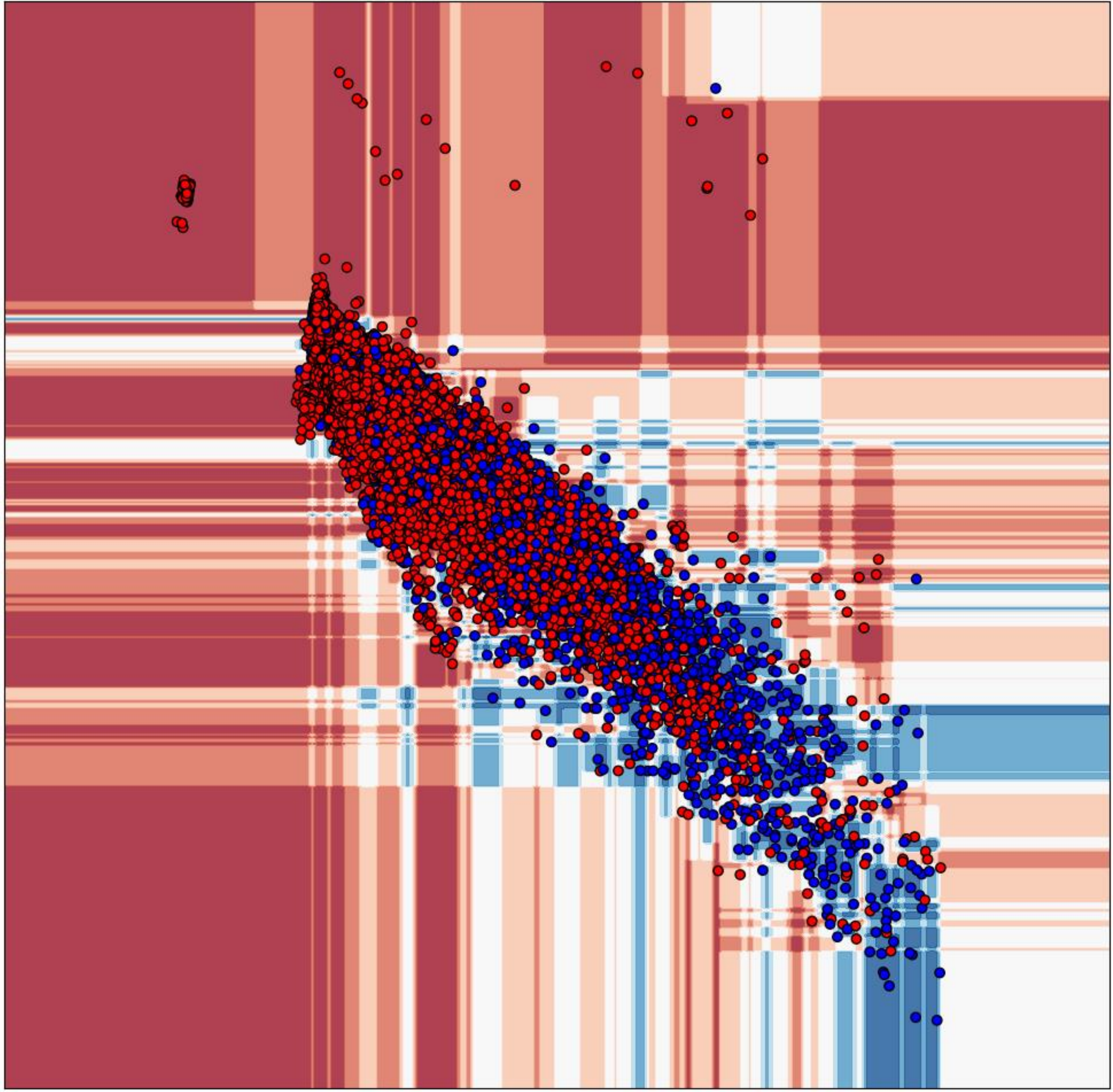
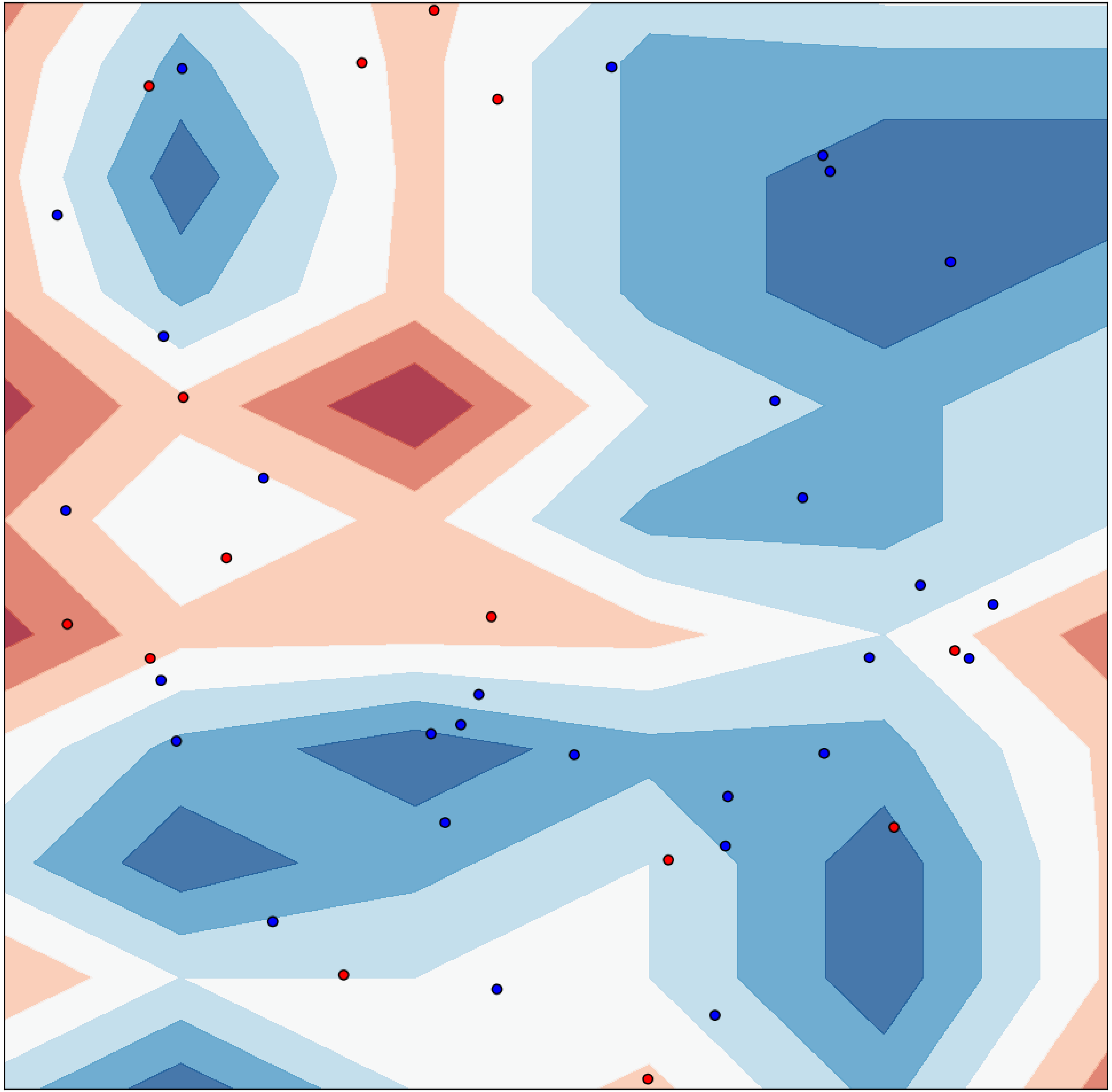
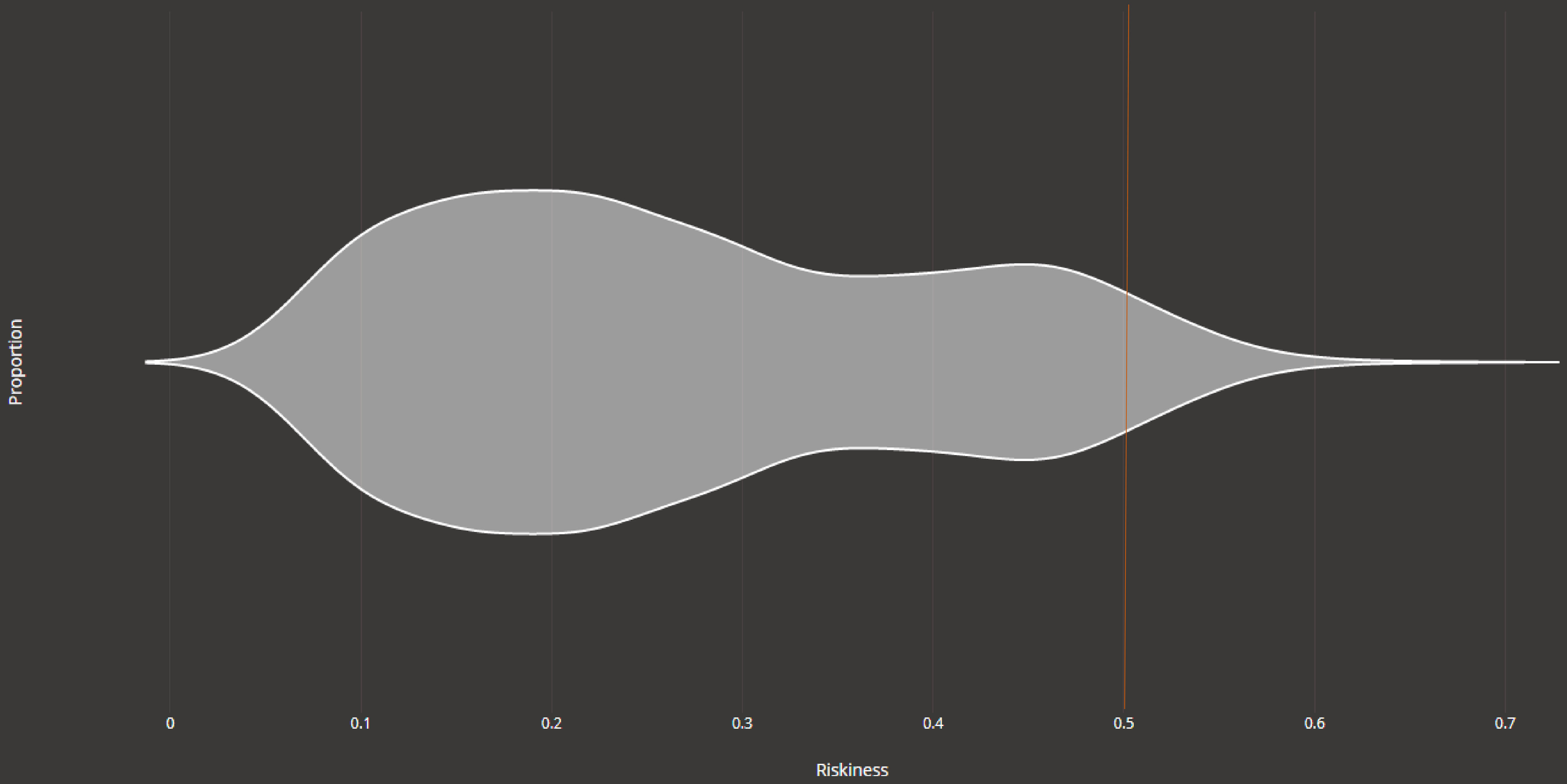
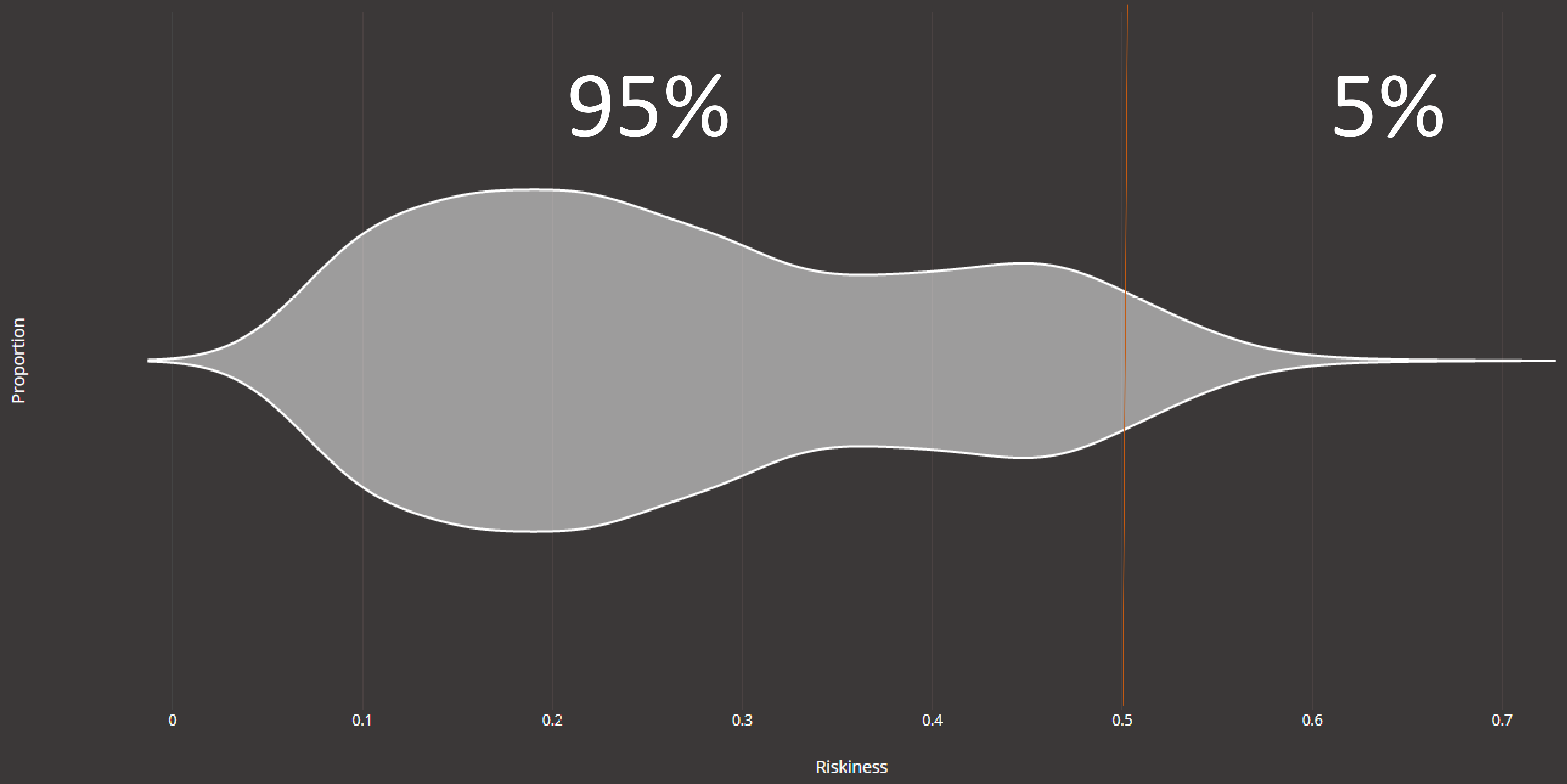


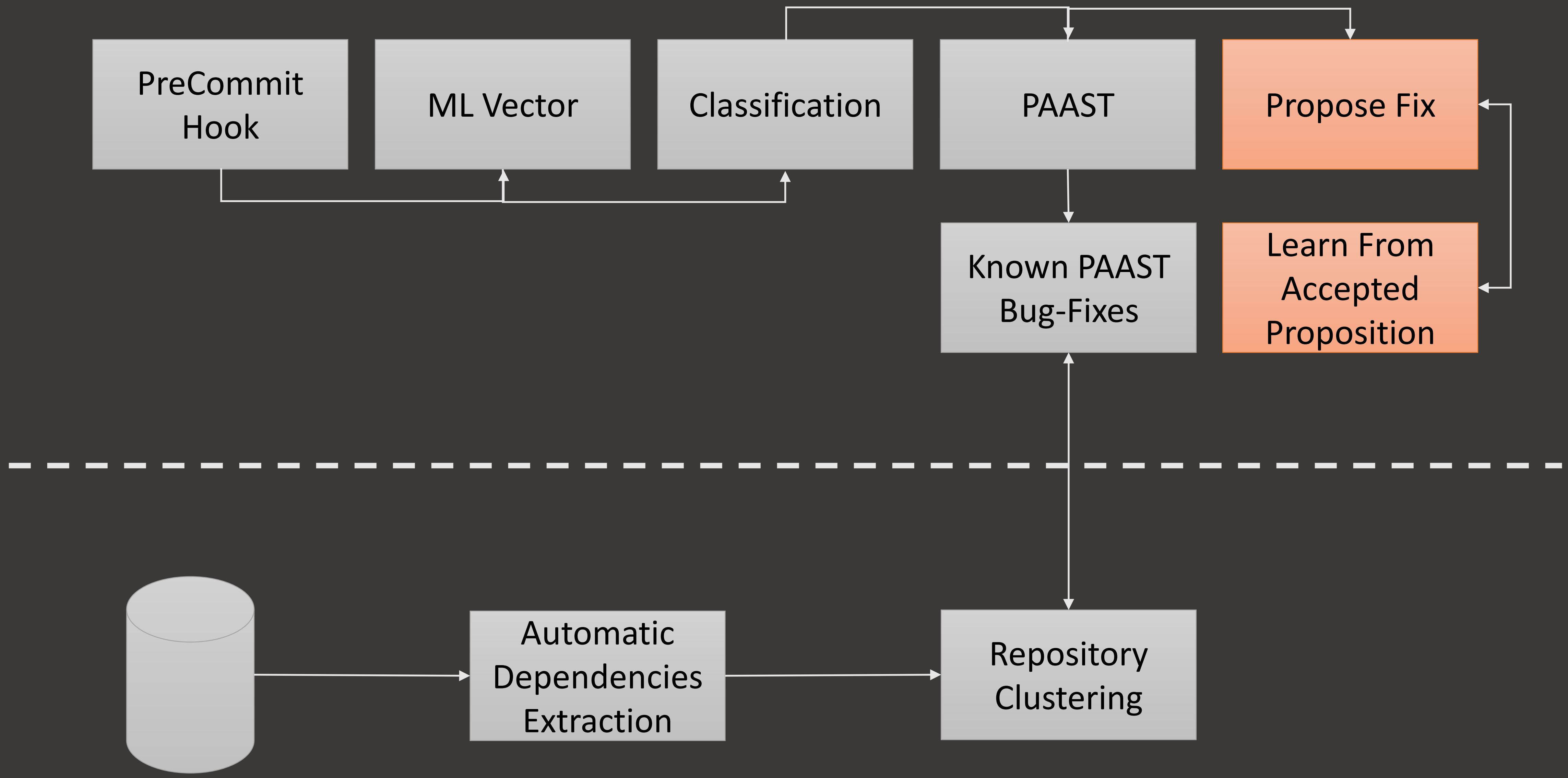





Proportion
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Riskiness


95%
5%
Proportion
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Riskiness

Prediction	Were we right?
Risk Factor %	True Positive %
0 - 10	1.45%
10 - 20	4.67%
20 - 30	11.10%
30 - 40	21.07%
40 - 50	43.95%
50 - 60	68.18%
60 – 70	79.91%
70 – 80	92.80%
80 - 90	96.11%
90 - 100	98.99%

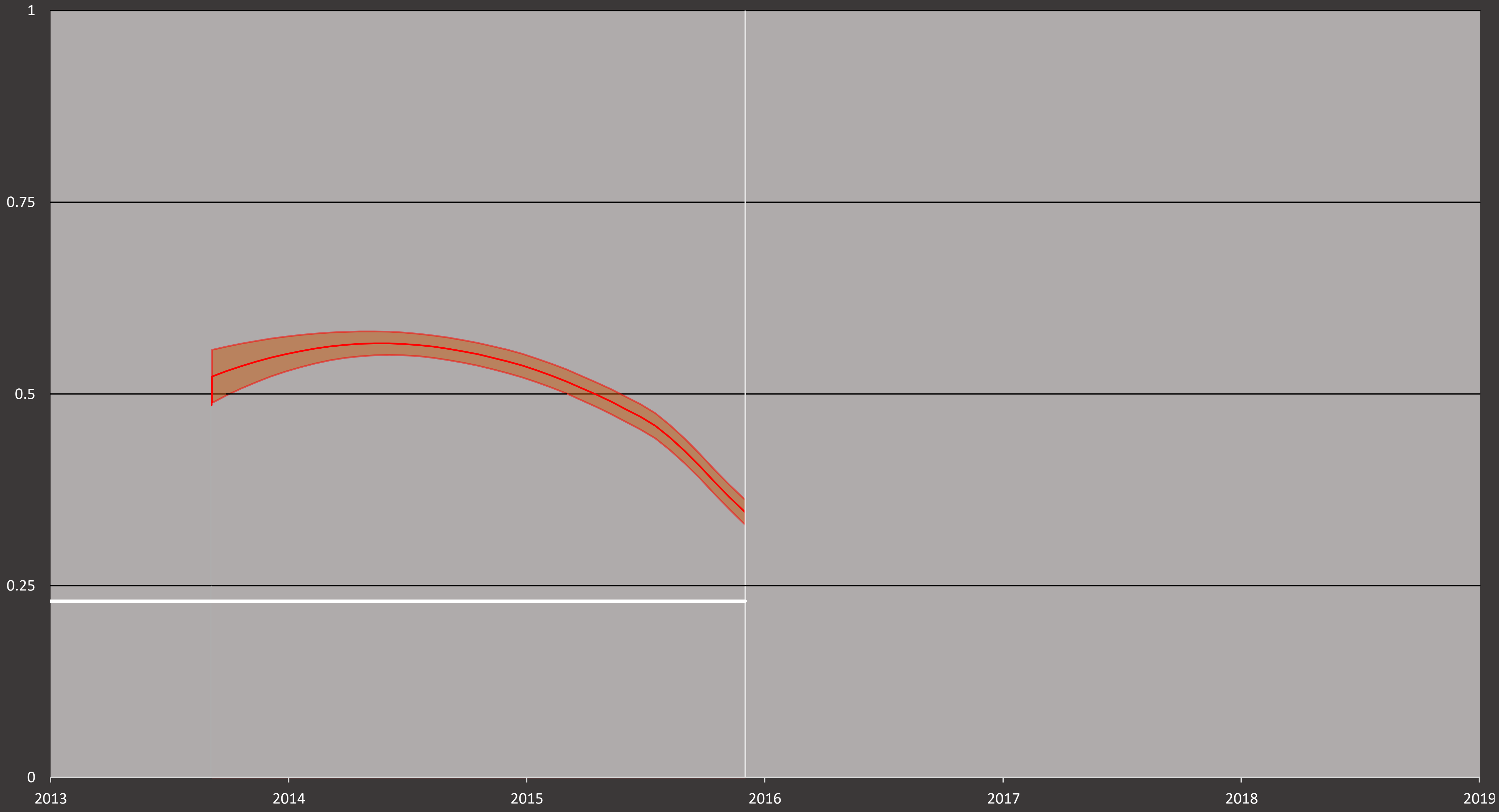

PreCommit Hook
ML Vector
Classification
PAAST
Propose Fix
Known PAAST Bug-Fixes
Learn From Accepted Proposition
Automatic Dependencies Extraction
Repository Clustering

laforge.ubisoft.com

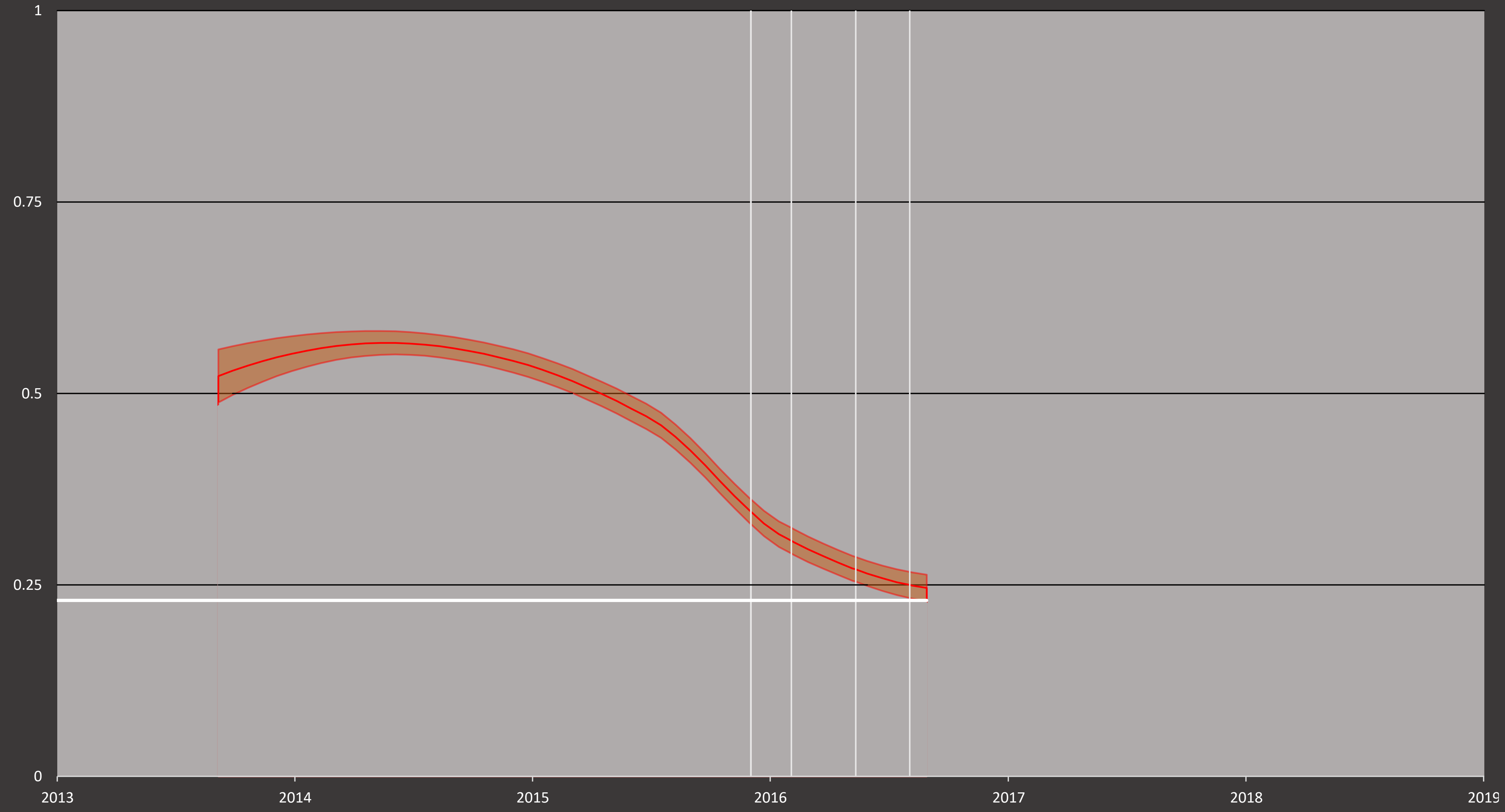
Rainbow Six Siege

- Released in December 2015
- 35+ million players
- 3 million players each day
- “Most Improved Game of 2017” according to multiple sites
- 600+ full-time people worldwide
- Around 200 testers
- Around 150 programmers
    - Around 100 programmers in game code itself

Bug Introduction Rate - Rainbow Six Siege



Bug Introduction Rate - Rainbow Six Siege



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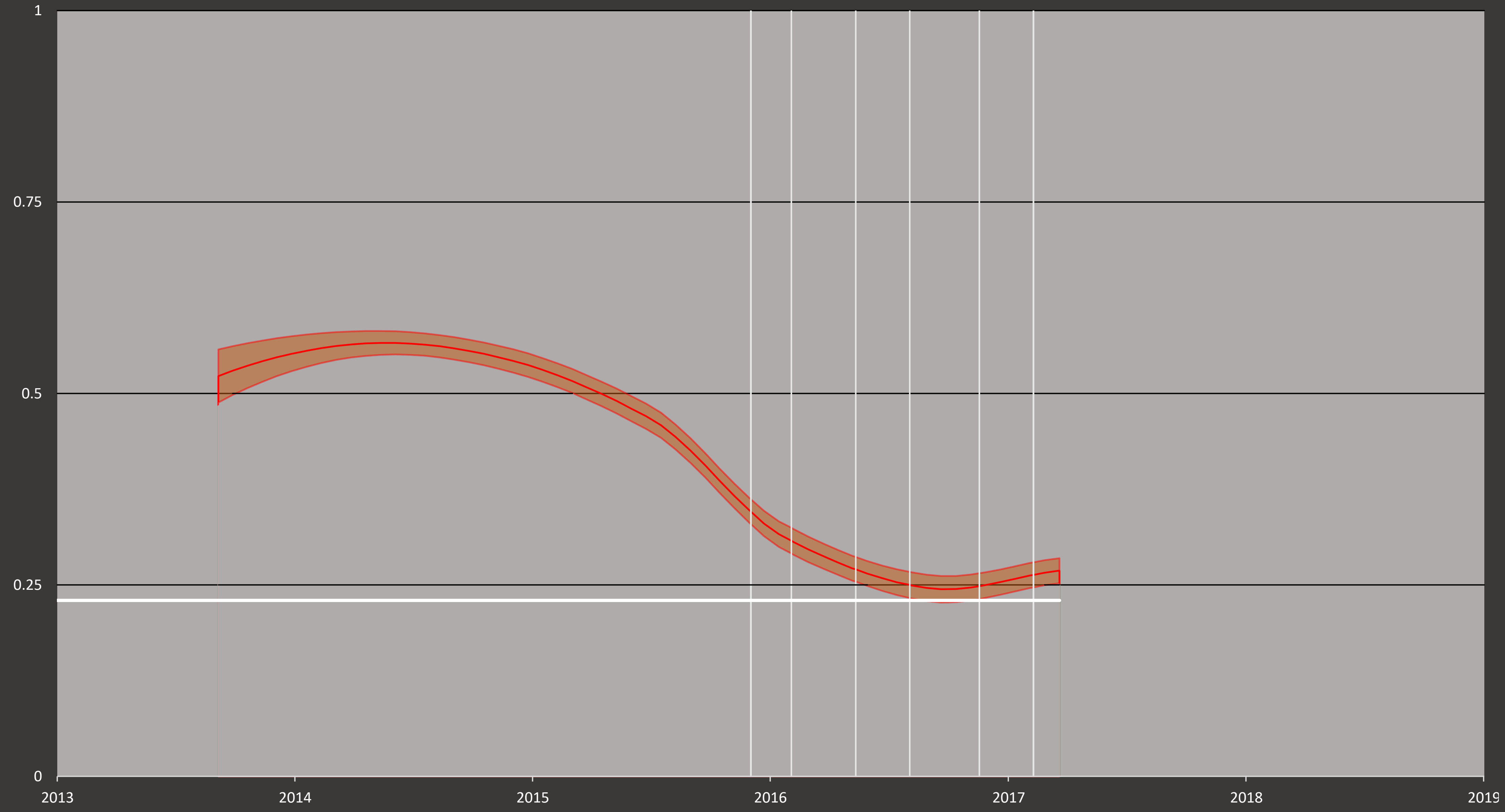
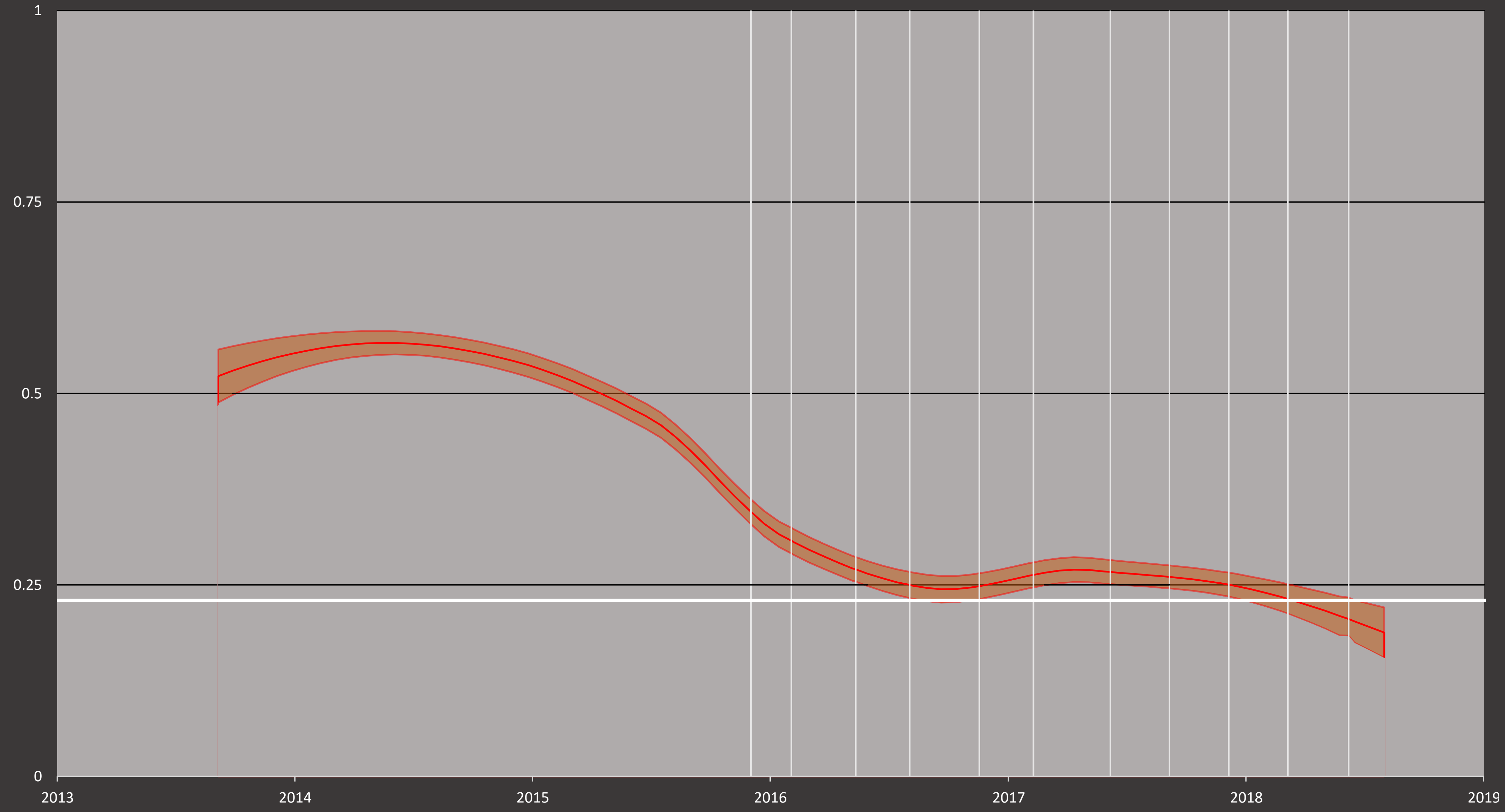
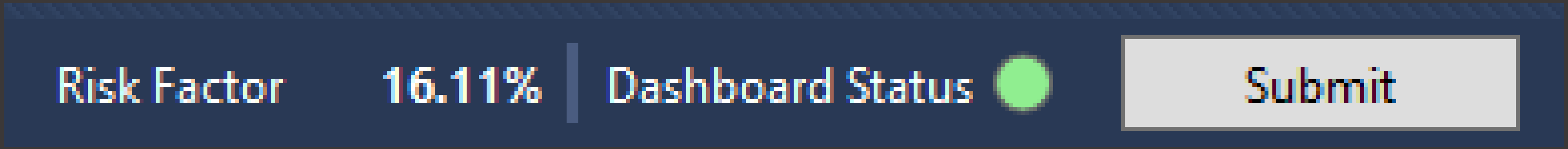


Bug Introduction Rate - Rainbow Six Siege





Risk Factor 16.11% | Dashboard Status 🟢

…/portal/sections/fullscreen/portalfullscreenviewcontentlistcontainer.h

⬇

- RS-504962 - [ShopShowcase] Tagging System - Elite Uniform is missing operator tag
- RS-501517 - [Customs][Local] Custom team names for local lobbies do not automatically update for non-host players
- RS-504185 - [ShopShowcase] Operator Icon not cleared when moving to a seasonal or universal weapon skin in the album fullscreen view
- …
- …

- RS-504962 - [ShopShowcase] Tagging System - Elite Uniform is missing operator tag
- …
- …

⬇

1. In the fullscreen view of owned weapon skins, within the Operators menu, scrolling from a normal weapon skin to a seasonal/universal one will not clear the Operator icon, causing it to overlap with the seasonal icon and text
2. When the host of a local customs lobby changes the team names using the "ALT" key (default) all joined players will not see the newly chosen names until they leave the game and rejoin it

```
EnablePlayer(position, false);
EnablePlayer(position, false, false);
```

```
manager.SetEntity(obj, true);
manager.SetEntity(obj, false);
```

Potential

- A lot of bugs can be seen in a single function.
- A lot of things to improve as well.
  - Missing .Reserve(…) calls

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  - Wrong big O

```
for (ubiU32 i = 0; i < m_SomeArray.Size();)
{
    Element* element = m_SomeArray[i];
    if (SomeCondition(element))
        m_SomeArray.RemoveAt(i)
    else
        ++i;
}
```

```
m_SomeArray.RemoveIf([](Element* e){
    return SomeCondition(e); });
```

Potential

- A lot of bugs can be seen in a single function.
- A lot of things to improve as well.
    - Missing .Reserve(…) call
    - Wrong big O
    - Bad usage of heap
        - Array -> InplaceArray (aka std::vector vs. SmallVector)

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    - std::function -> inplace_function from SG14 (if bigger than SSO buffer)

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    - Wrong big O
    - Bad usage of heap
        - Array -> InplaceArray (aka std::vector vs. SmallVector)
        - std::function -> inplace_function from SG14 (if bigger than SSO buffer)
        - String -> InplaceString (if bigger than SSO buffer)

Potential

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- A lot of things to improve as well.
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  - Wrong big O
  - Bad usage of heap
    - Array -> InplaceArray (aka std::vector vs. SmallVector)
    - std::function -> inplace_function from SG14 (if bigger than SSO buffer)
    - String -> InplaceString (if bigger than SSO buffer)
- Will false positives ruin it?

Questions?