Finding the cracks between the analyses

Reshabh Sharma

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Finding the bugs caused by the interactions between the compiler analyses

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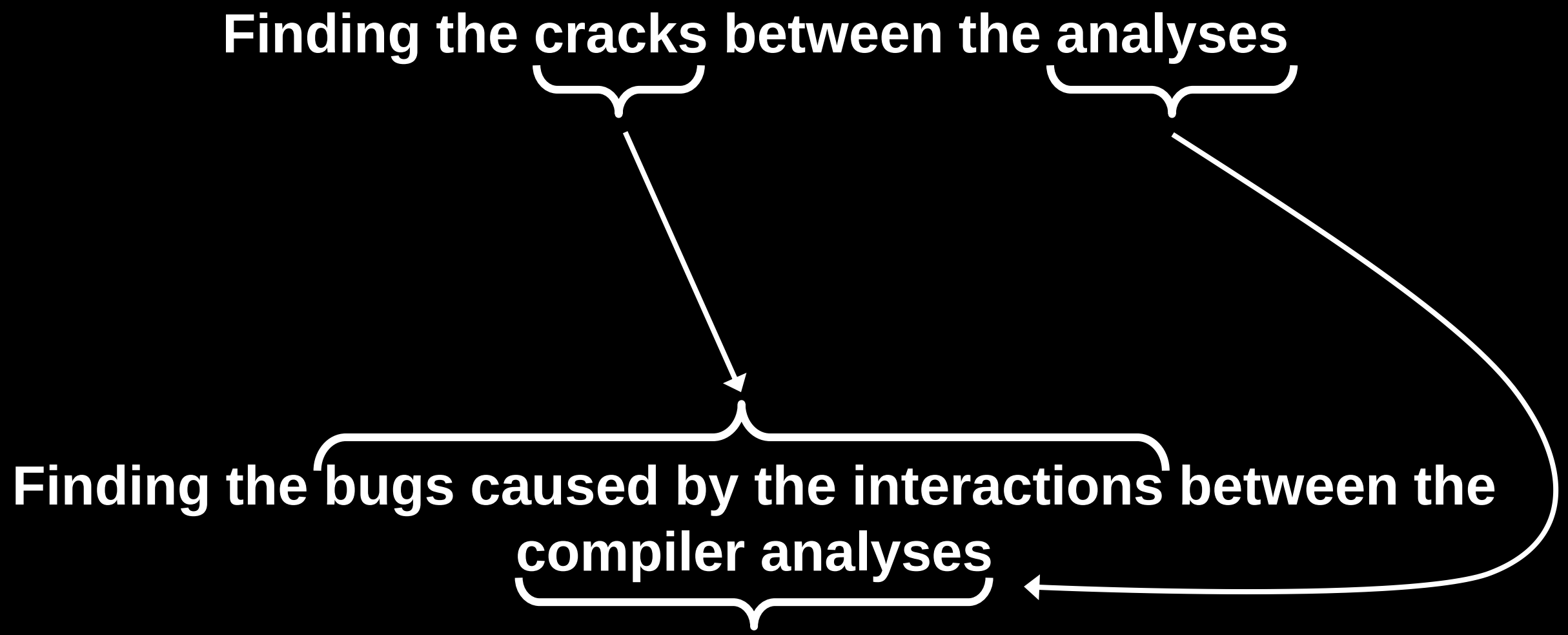
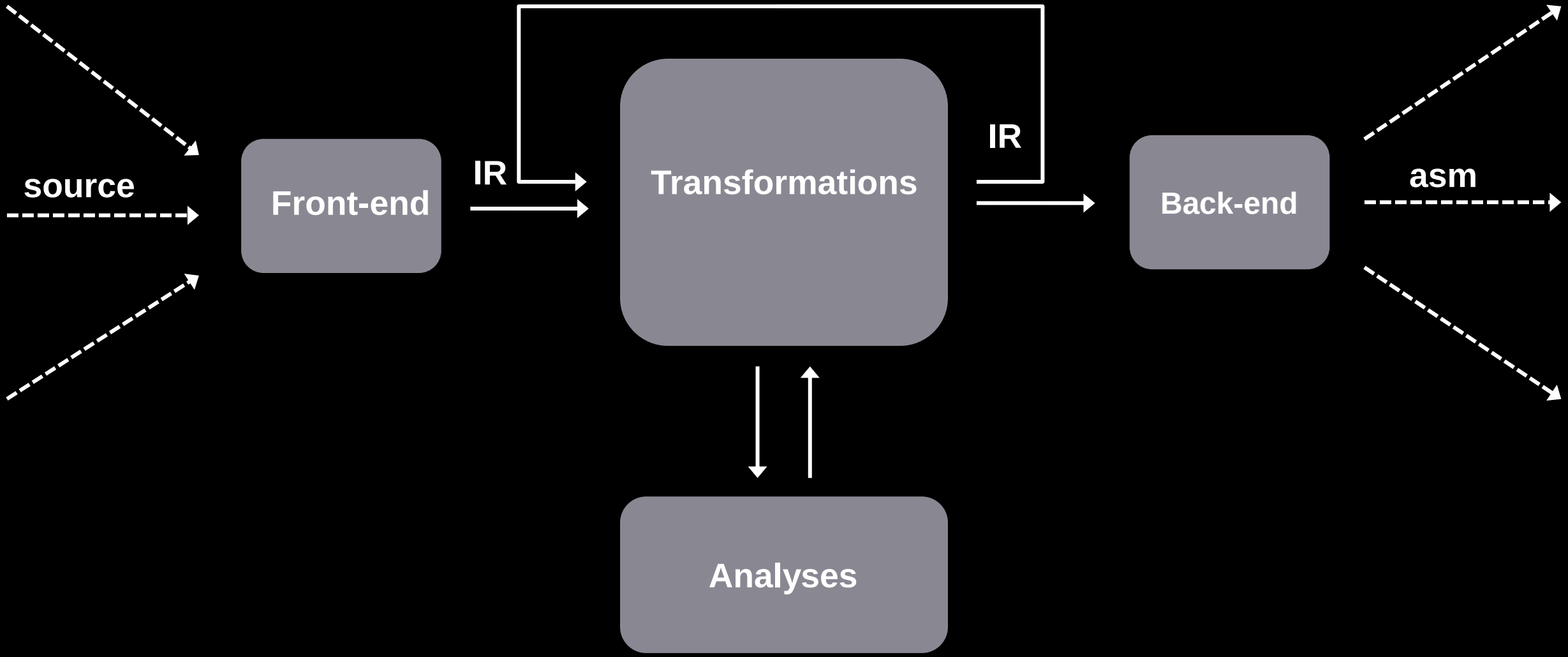
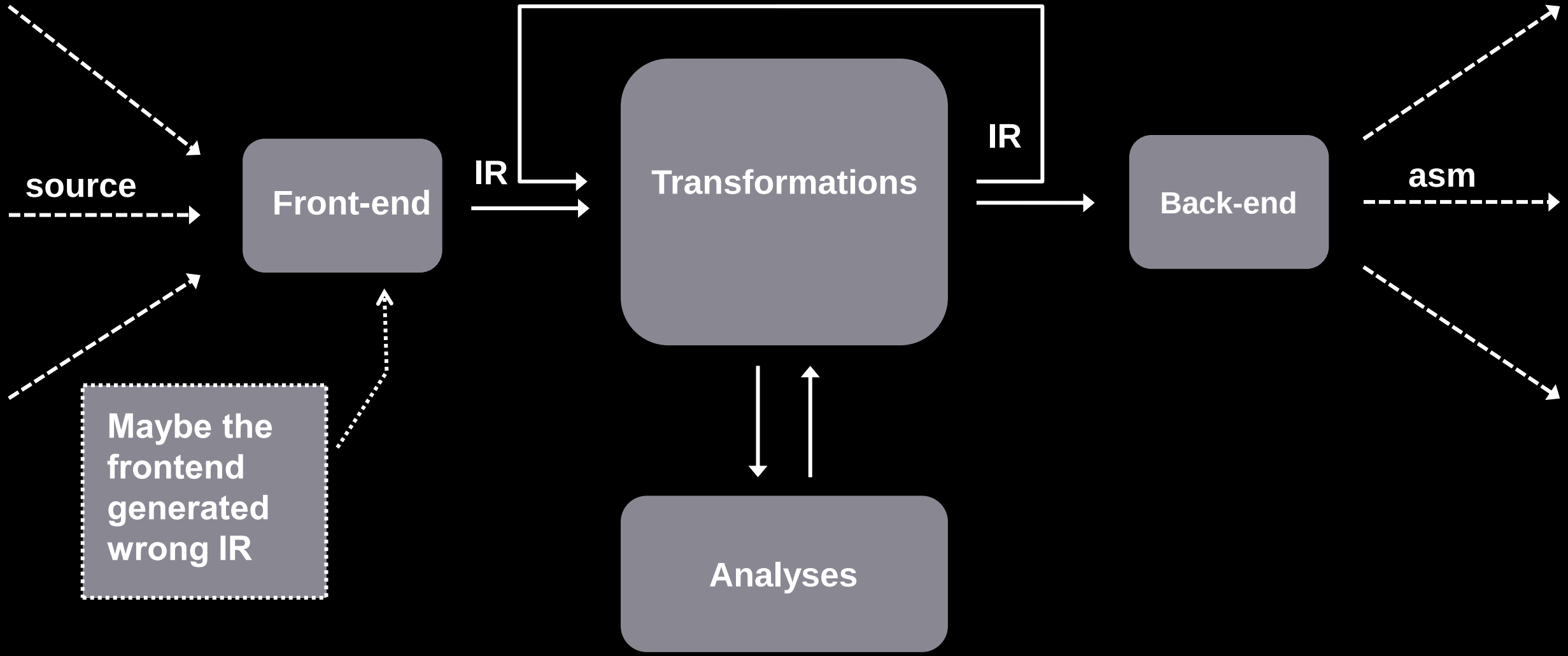

Finding the cracks between the analyses
Finding the bugs caused by the interactions between the compiler analyses

Revisiting how LLVM optimizes the IR



What may go wrong?



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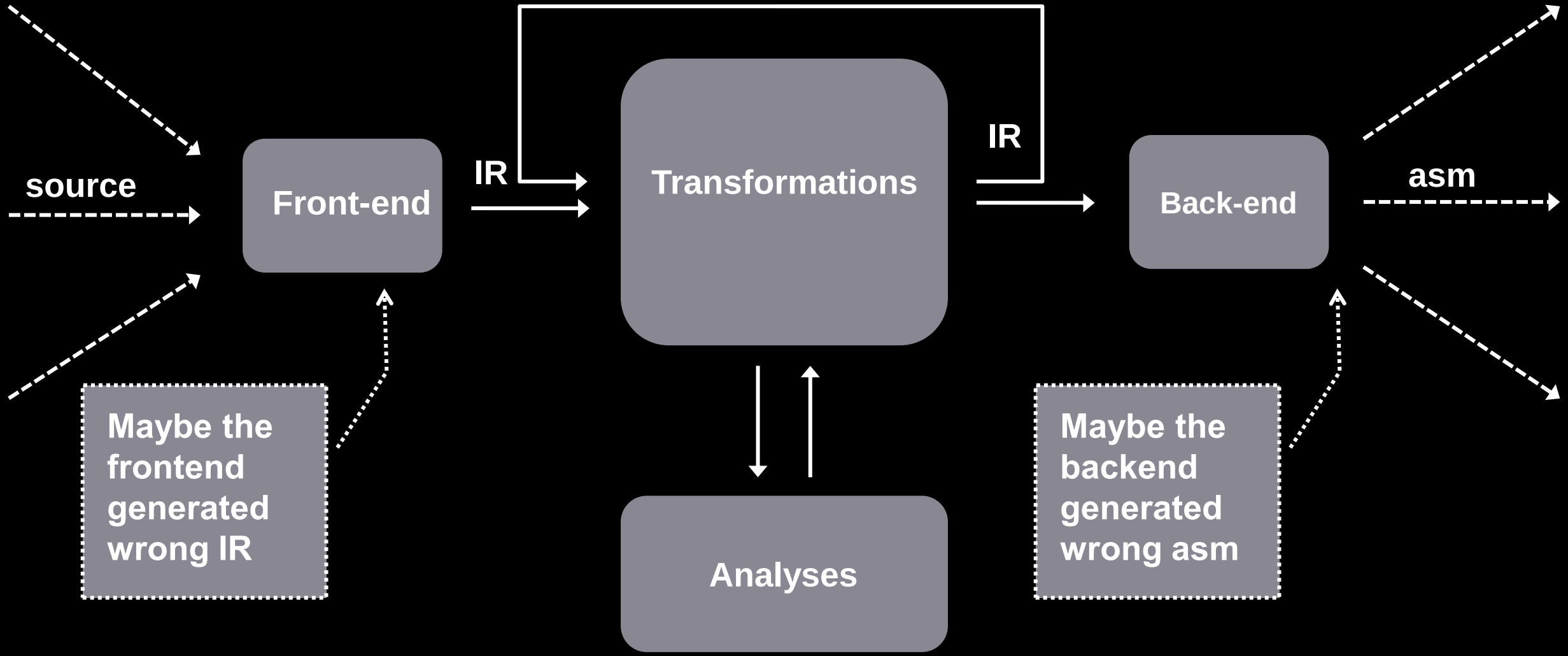

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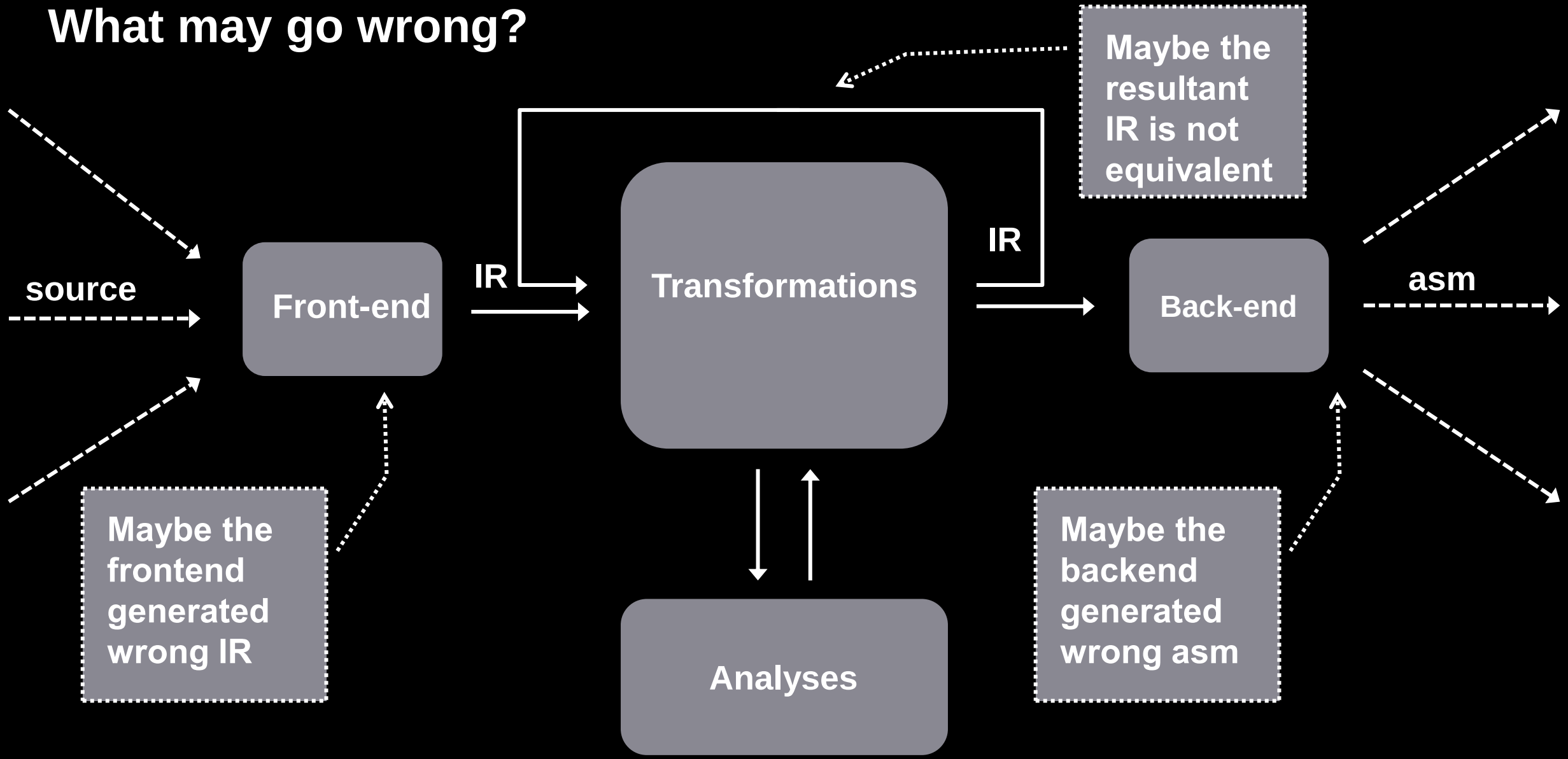

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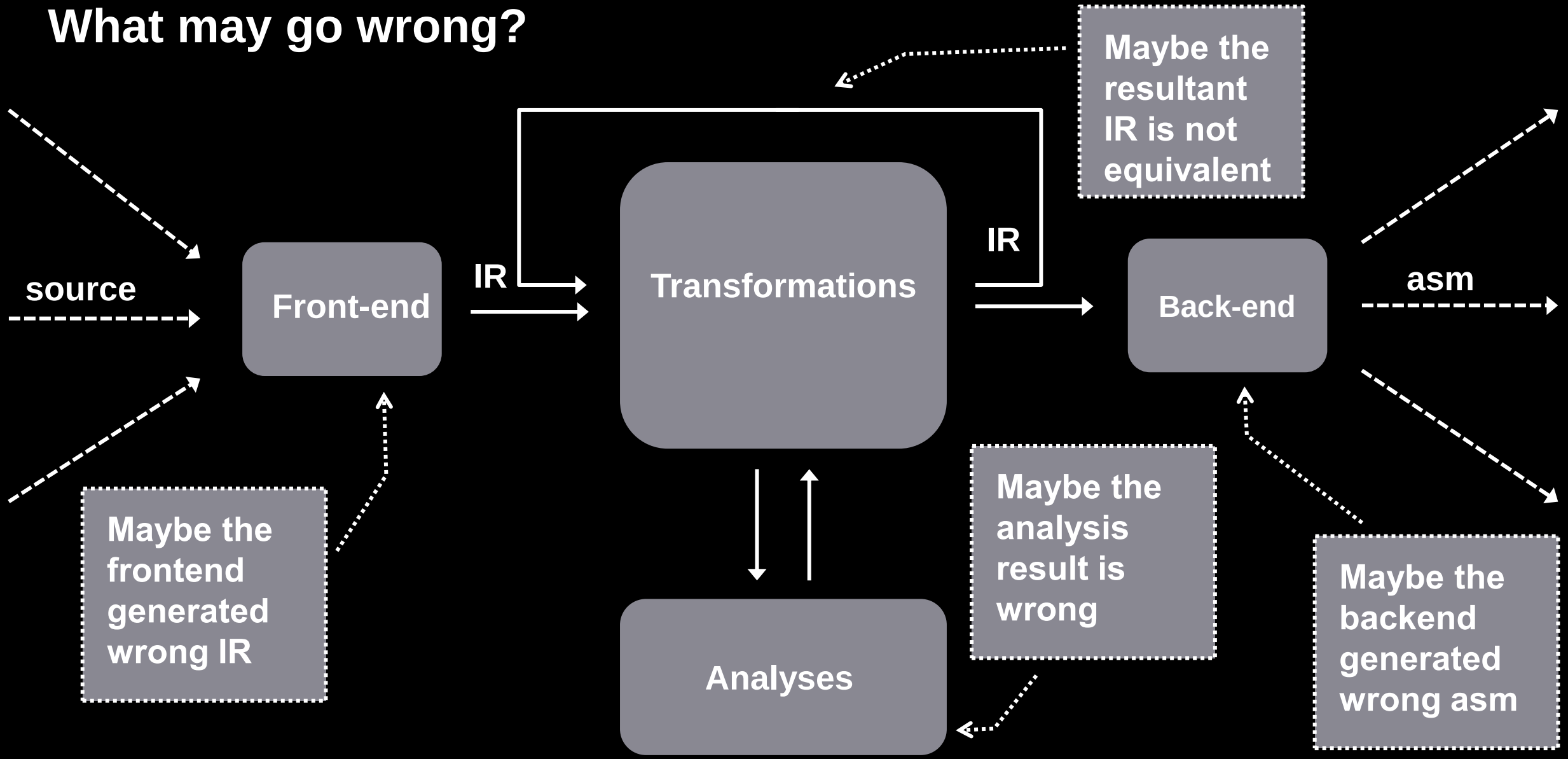

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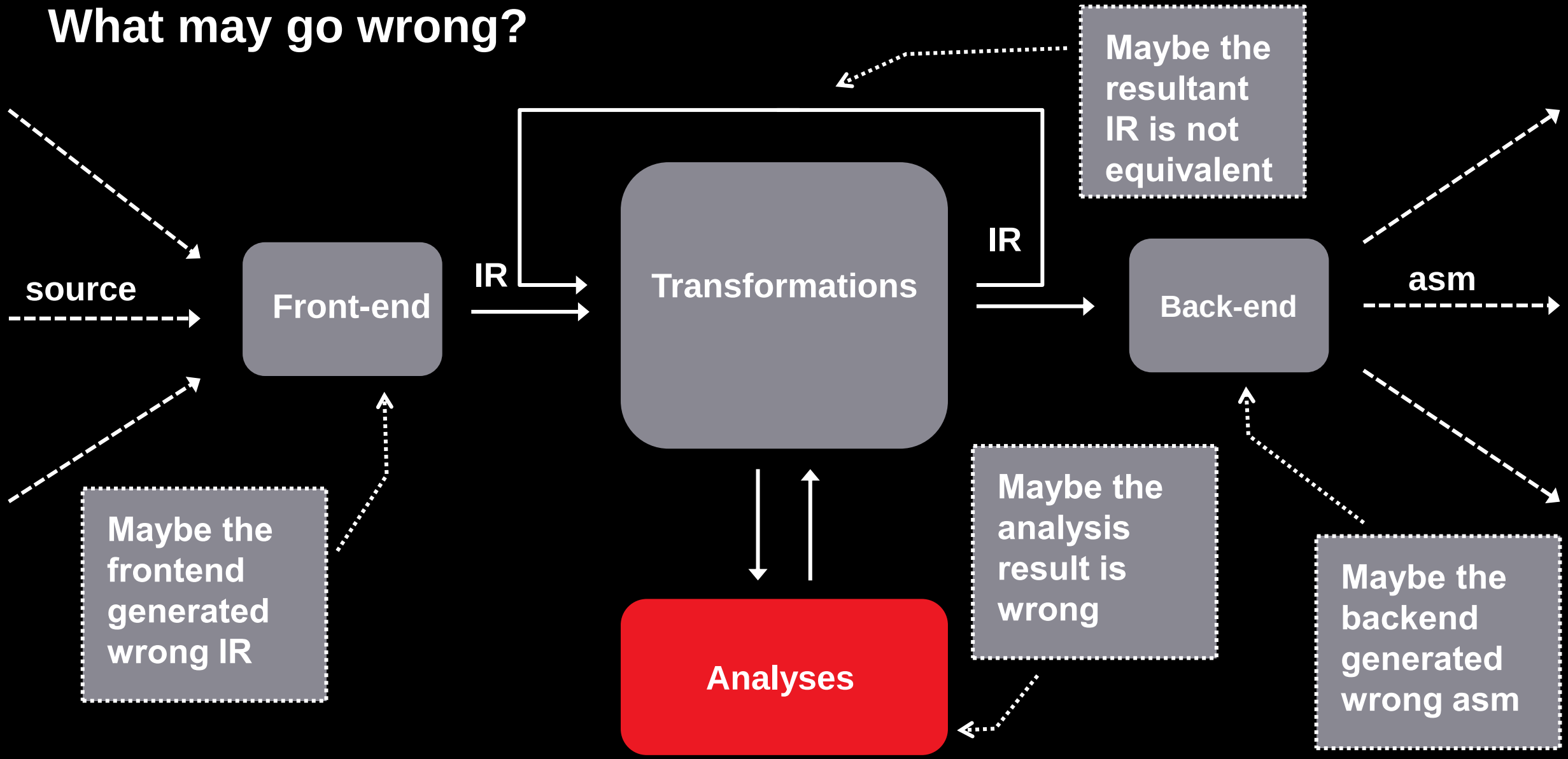
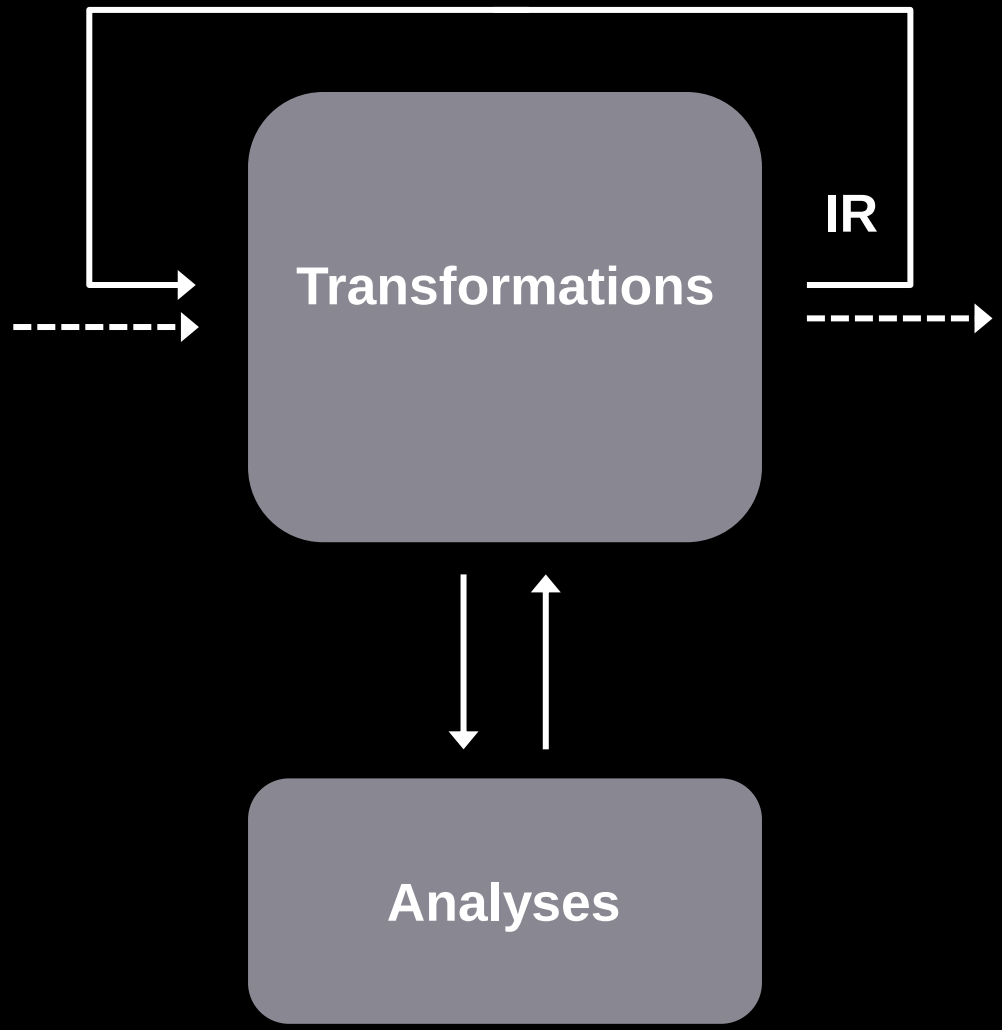


Transformations use analyses



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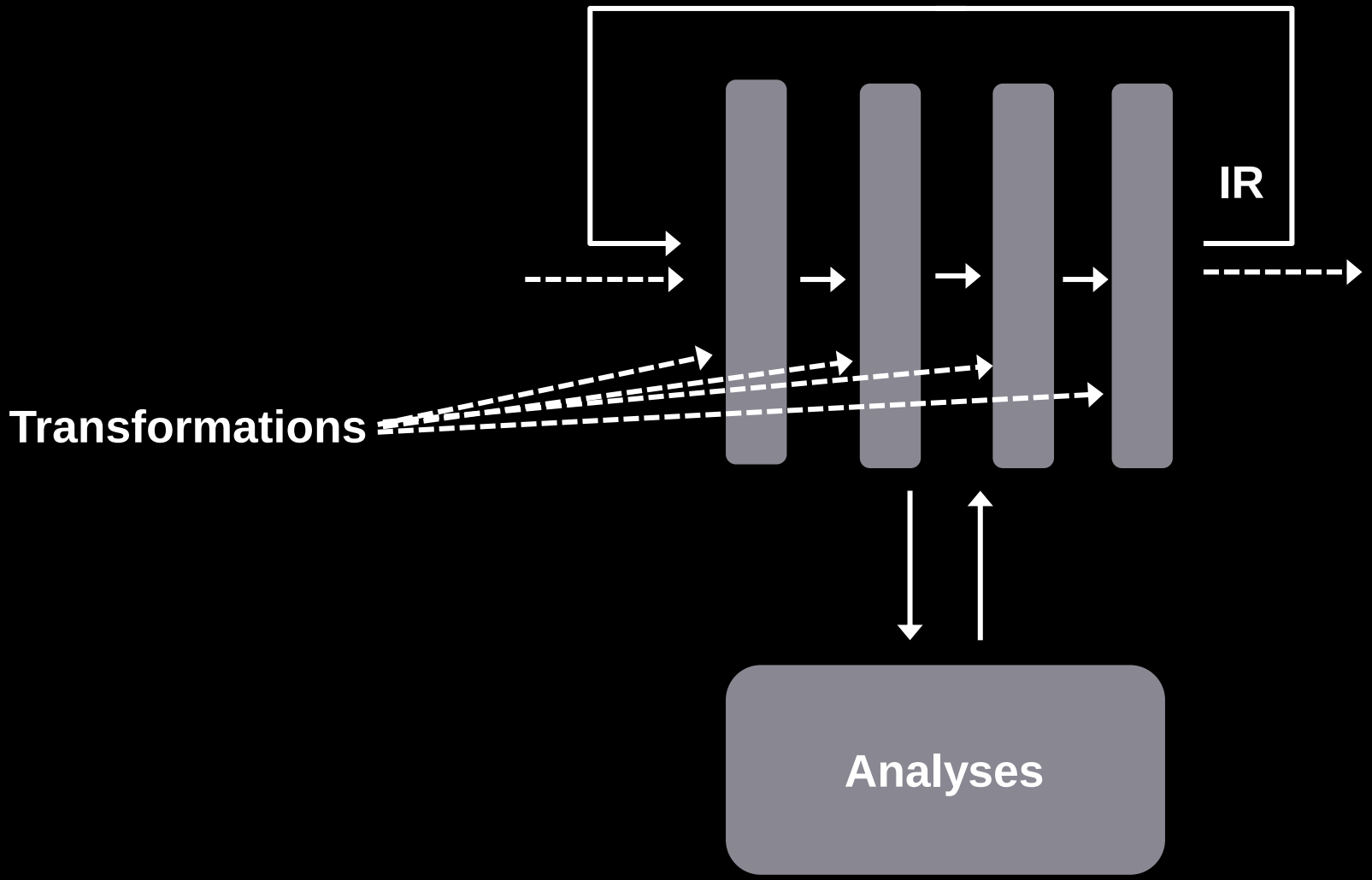
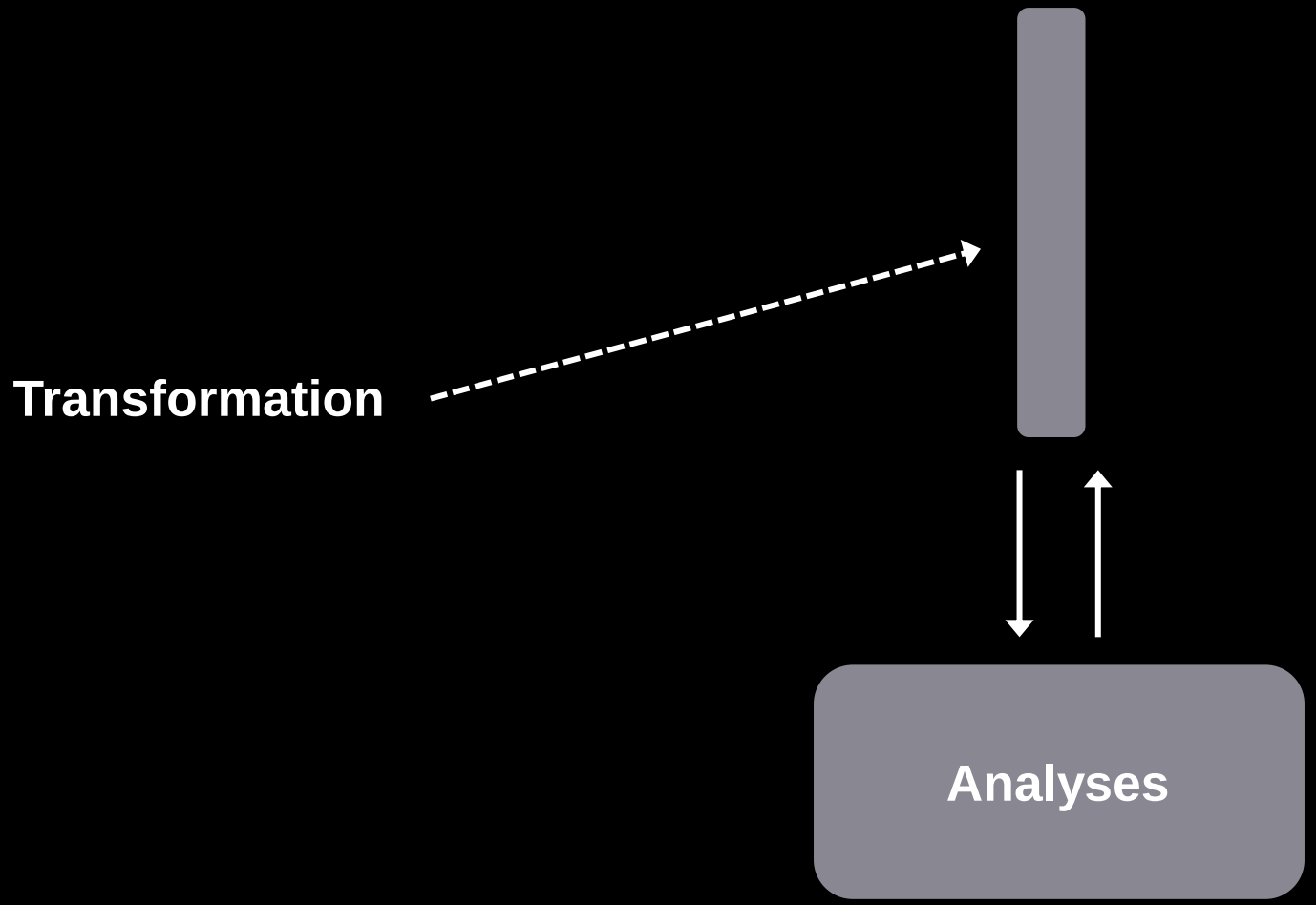


Transformations use analyses



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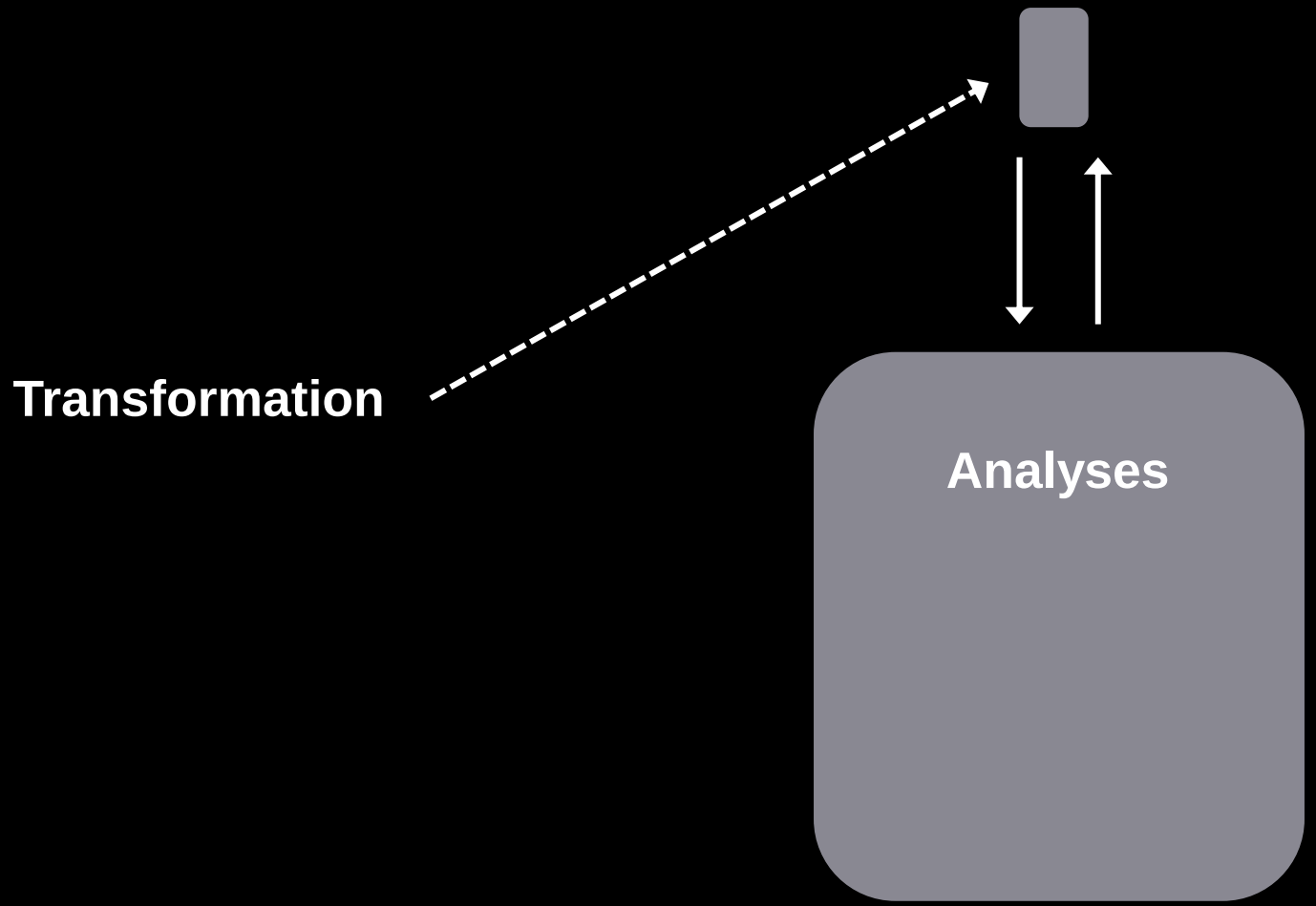

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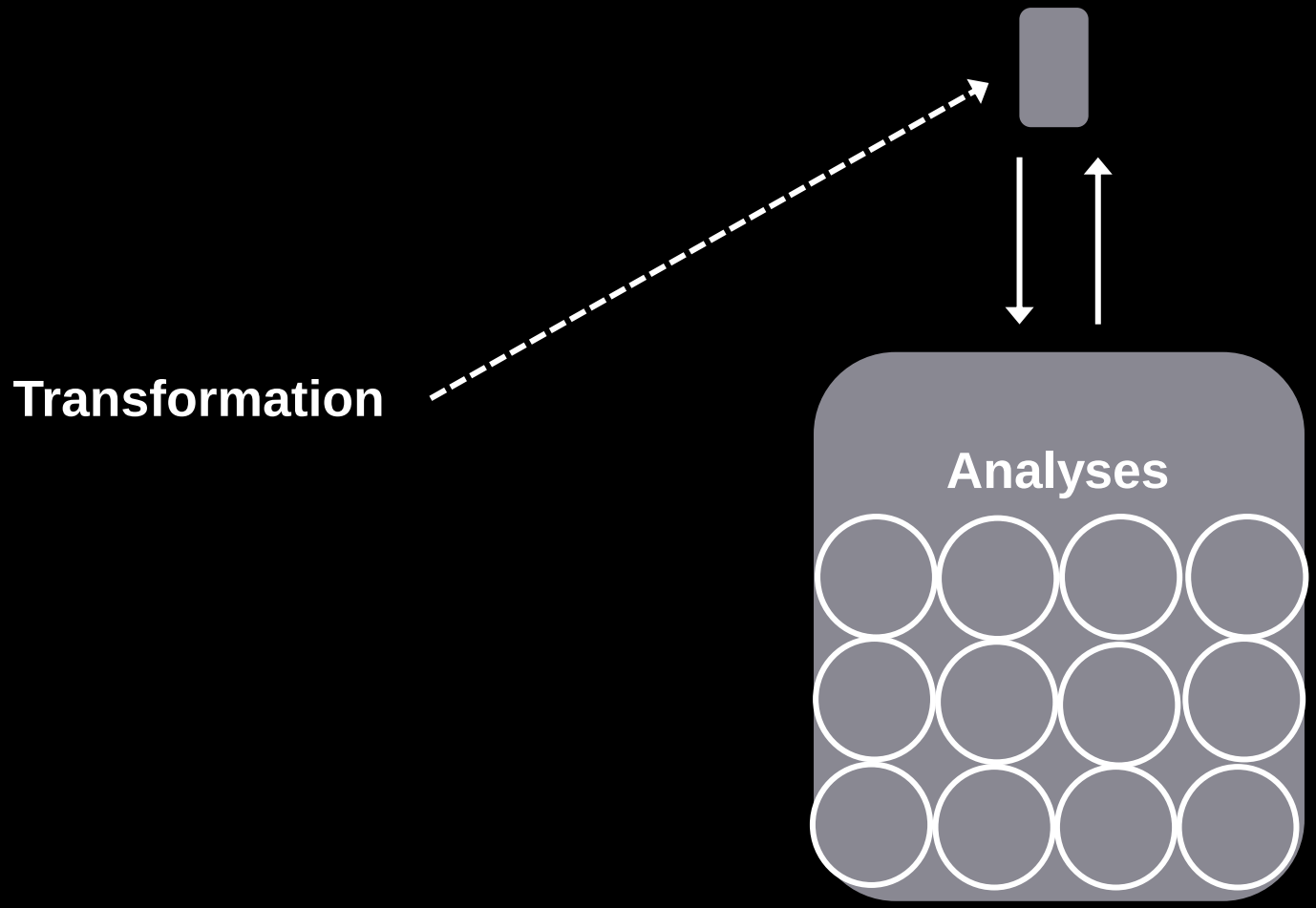

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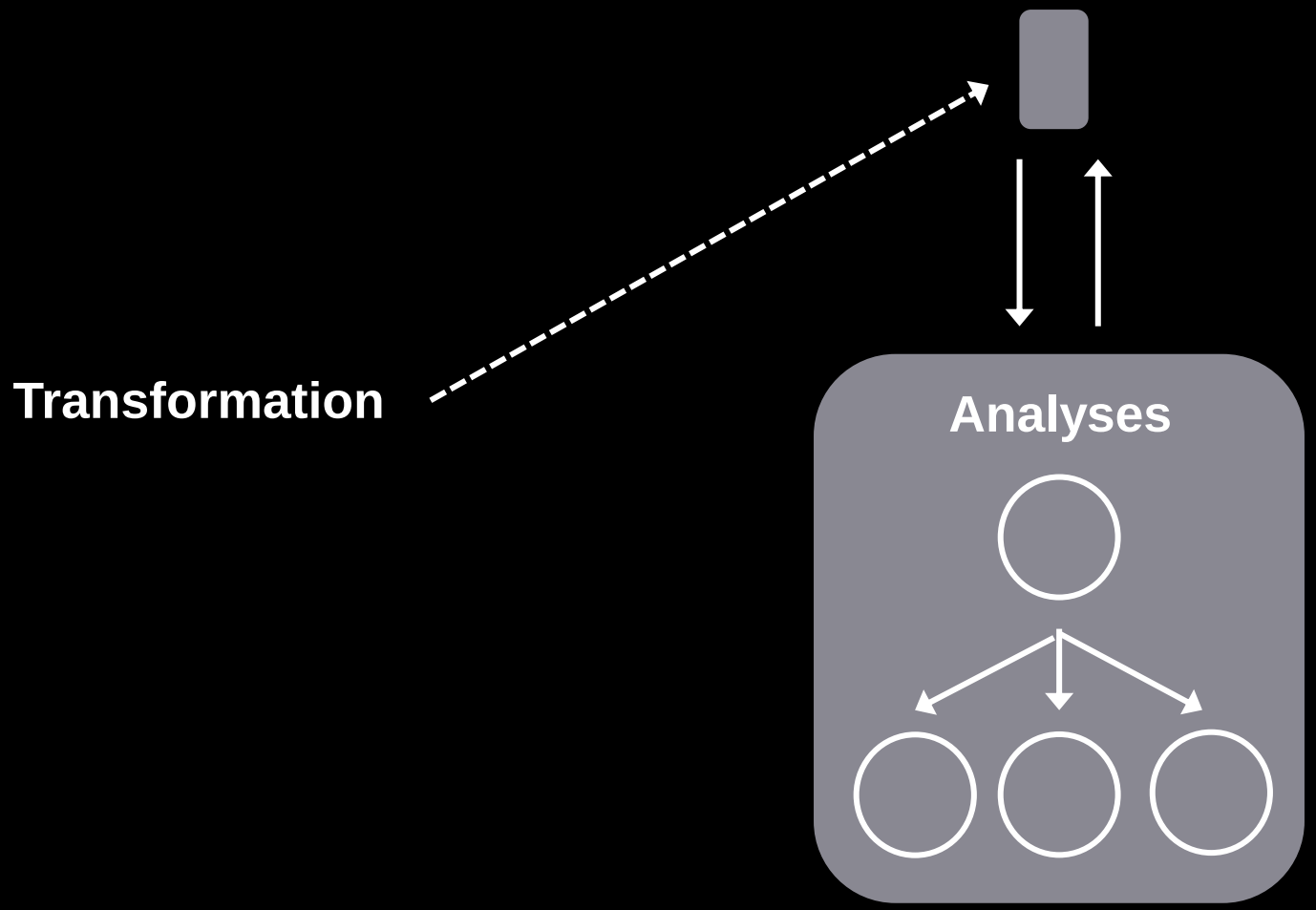

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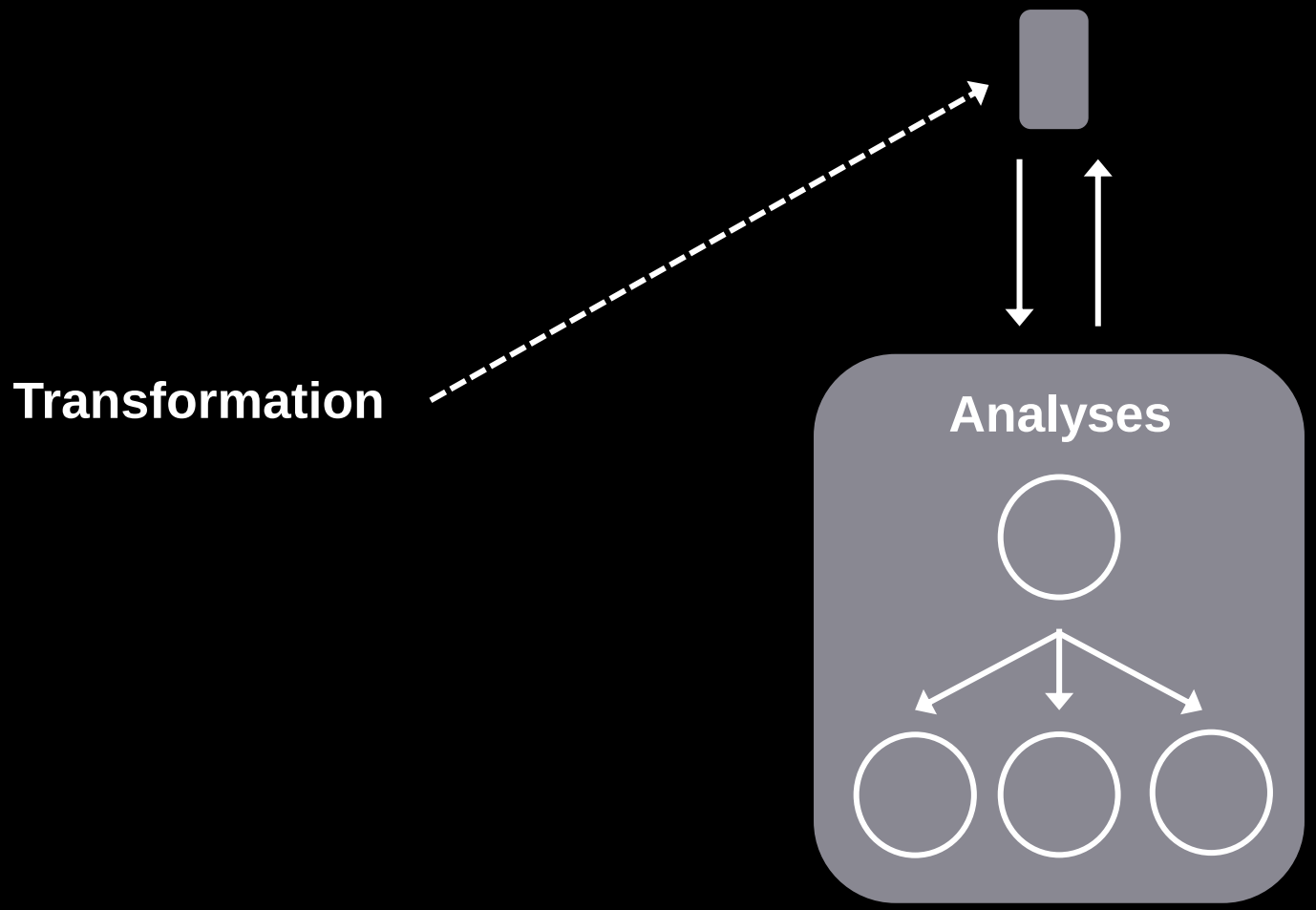

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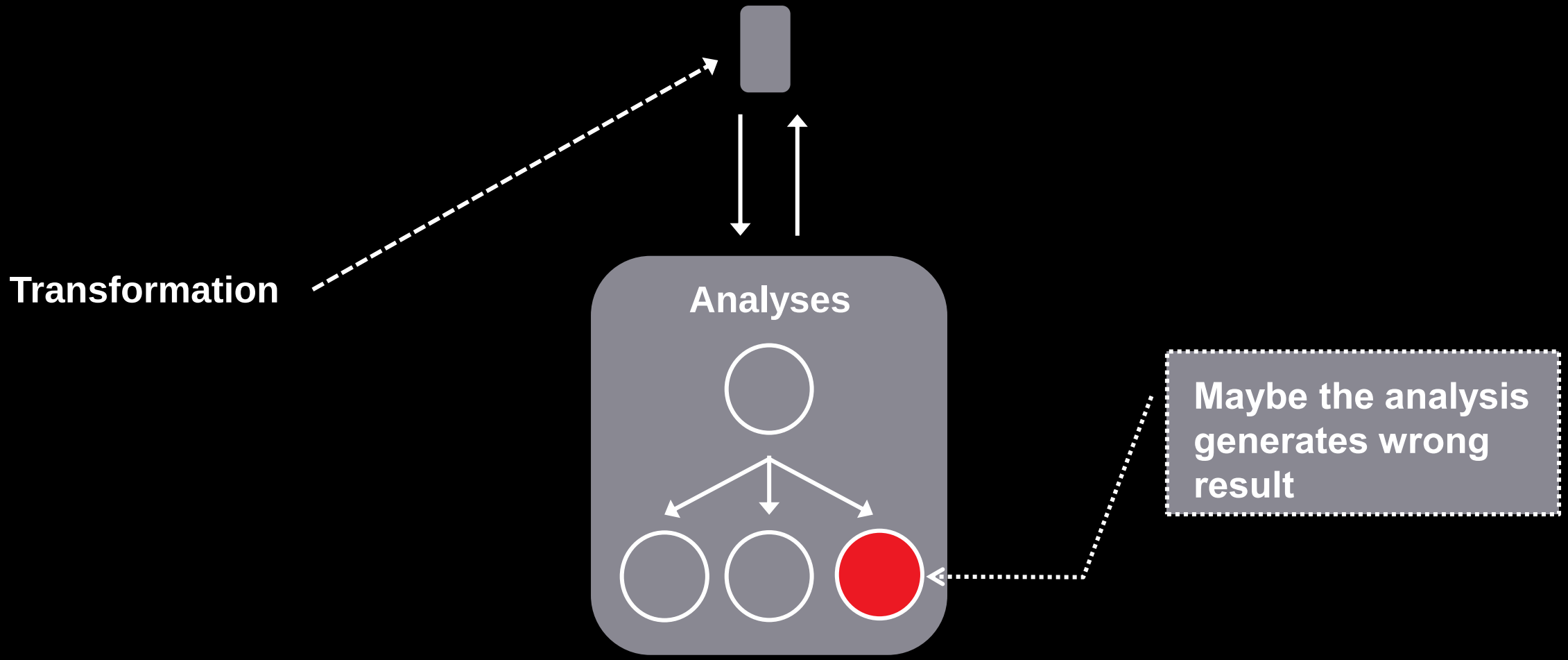
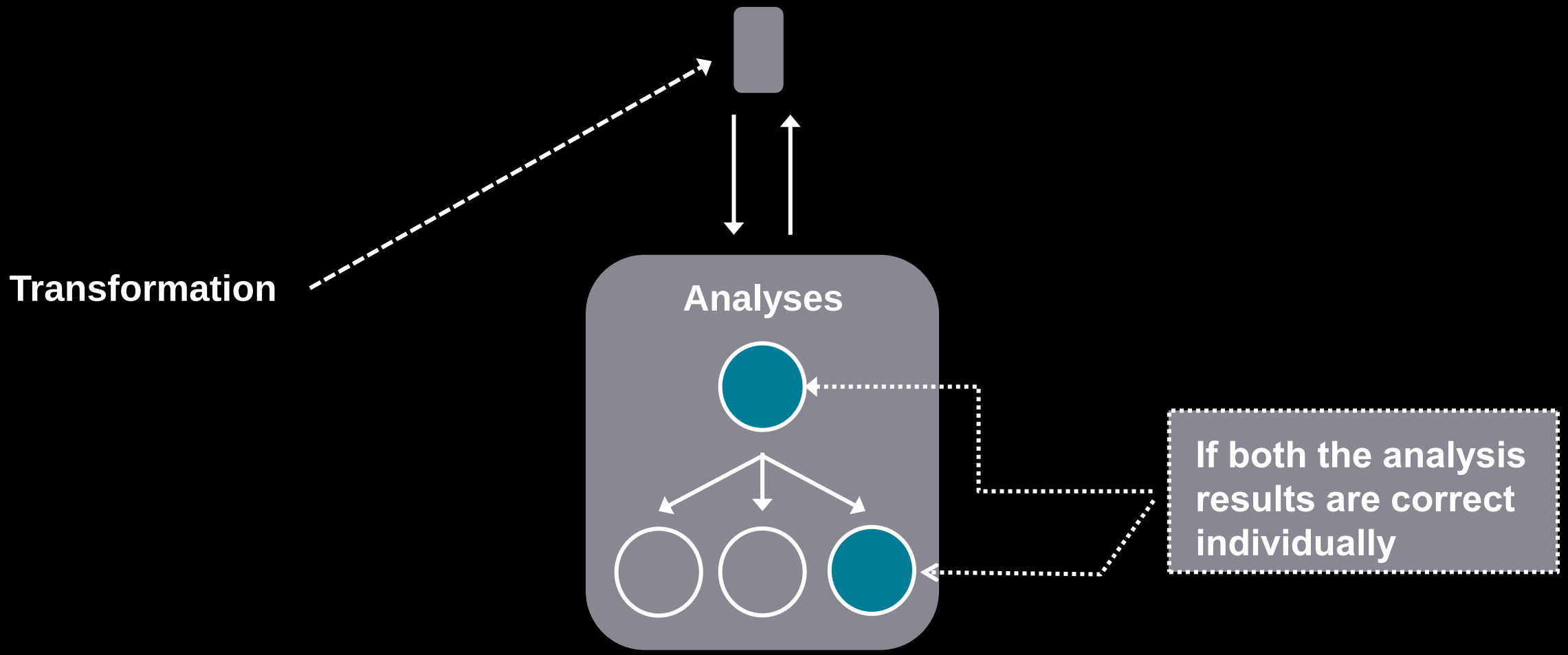


Interaction between the analyses



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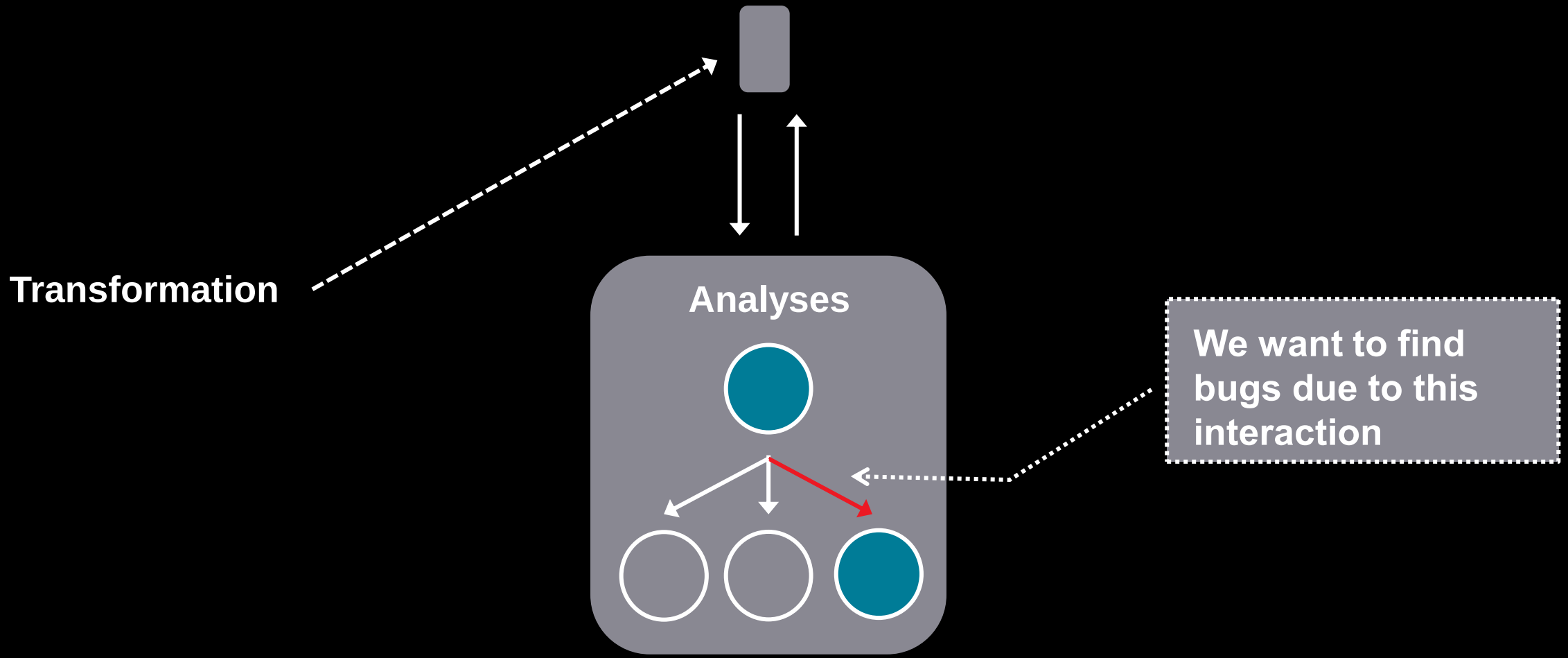
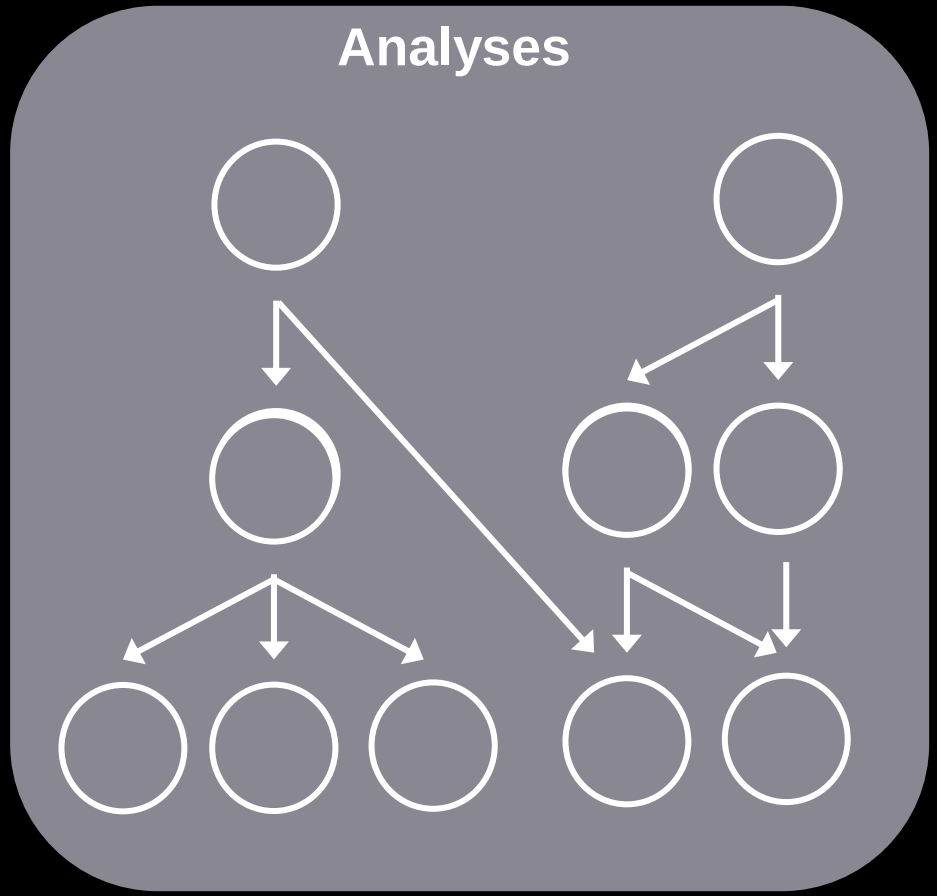
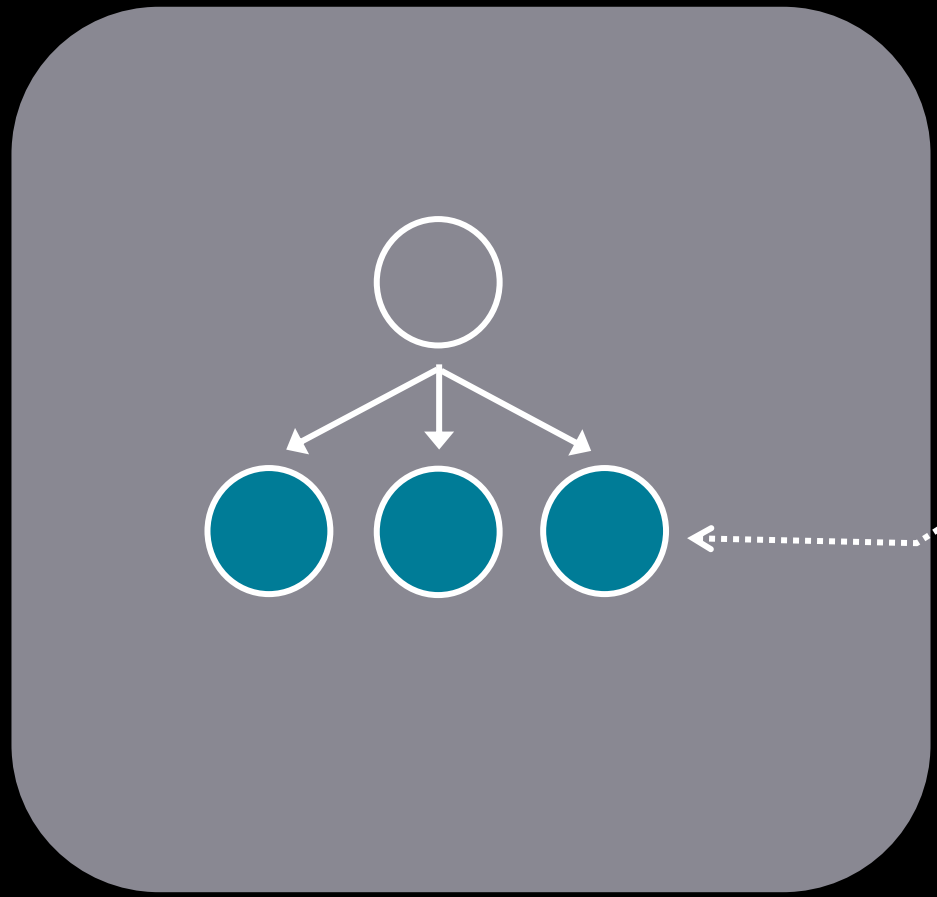


Analyses

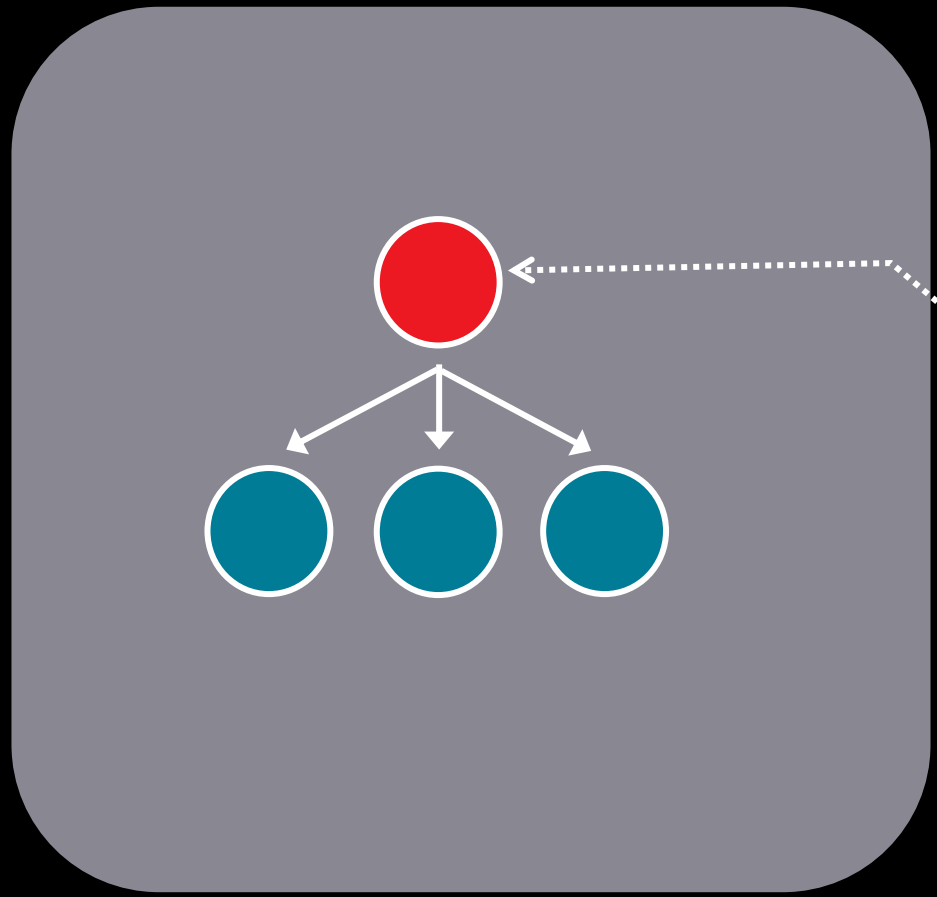


Fundamental Analyses



These analyses do not depend on any other analysis

Derived or dependent Analyses



This analysis depends on the results from other analyses

Testing differentially

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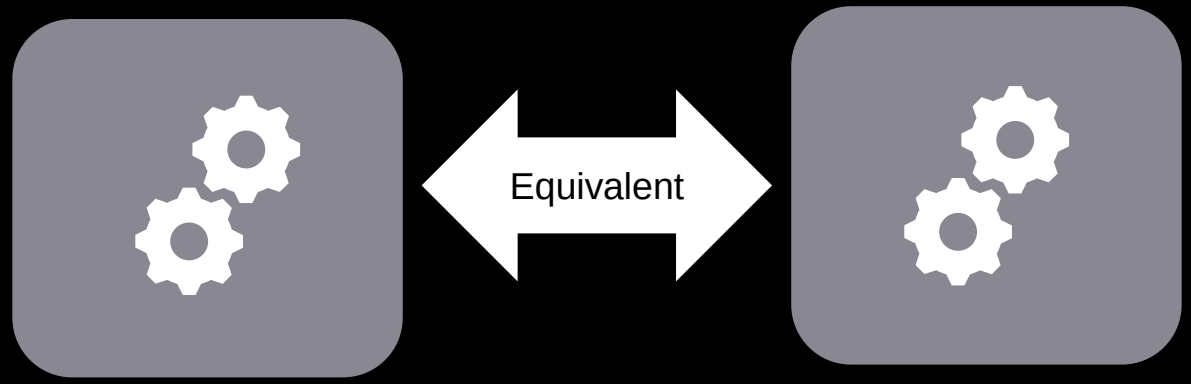

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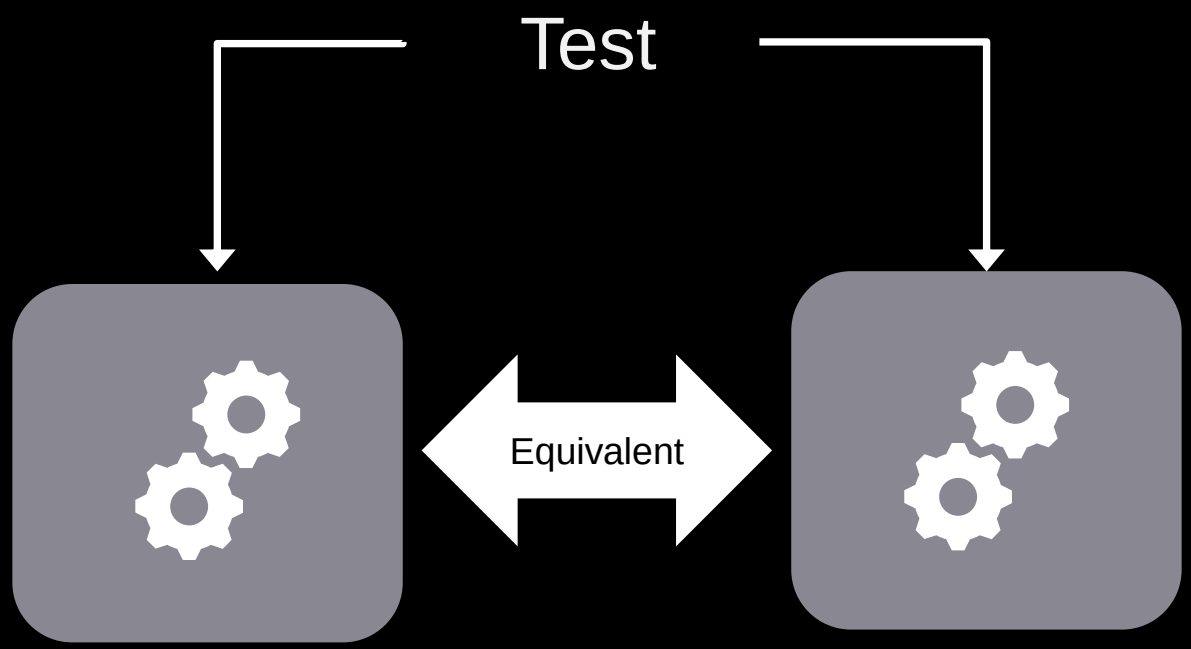

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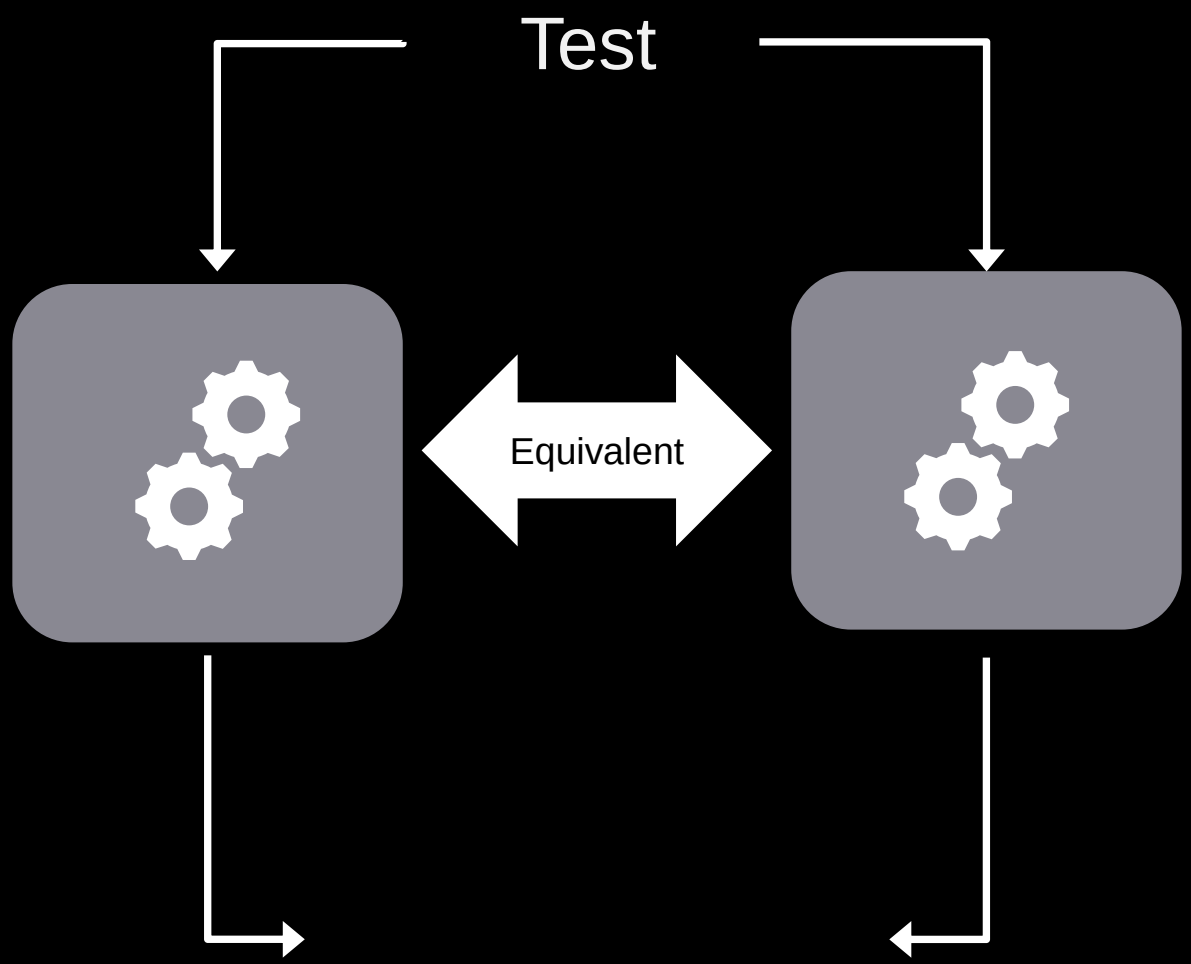

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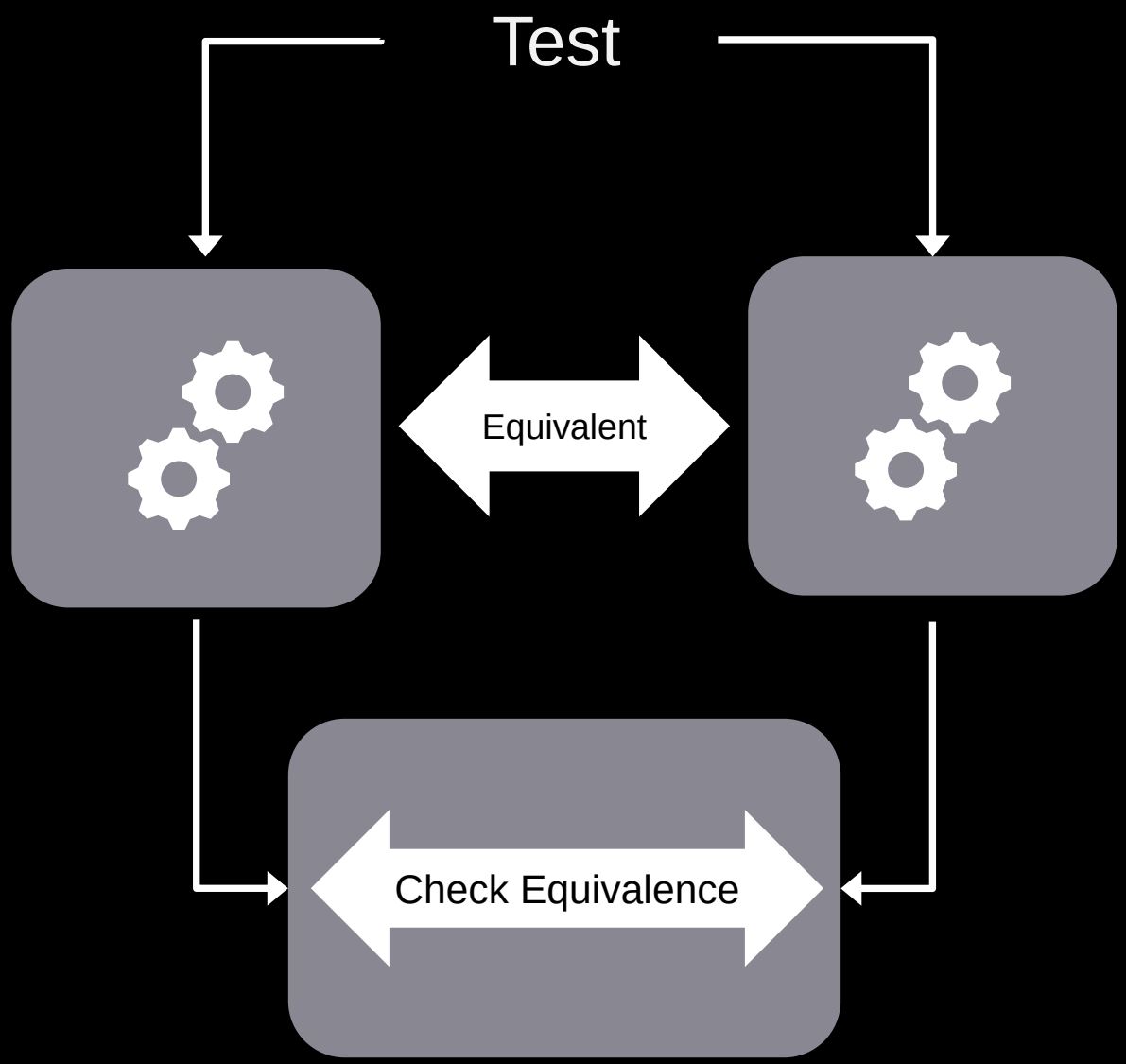

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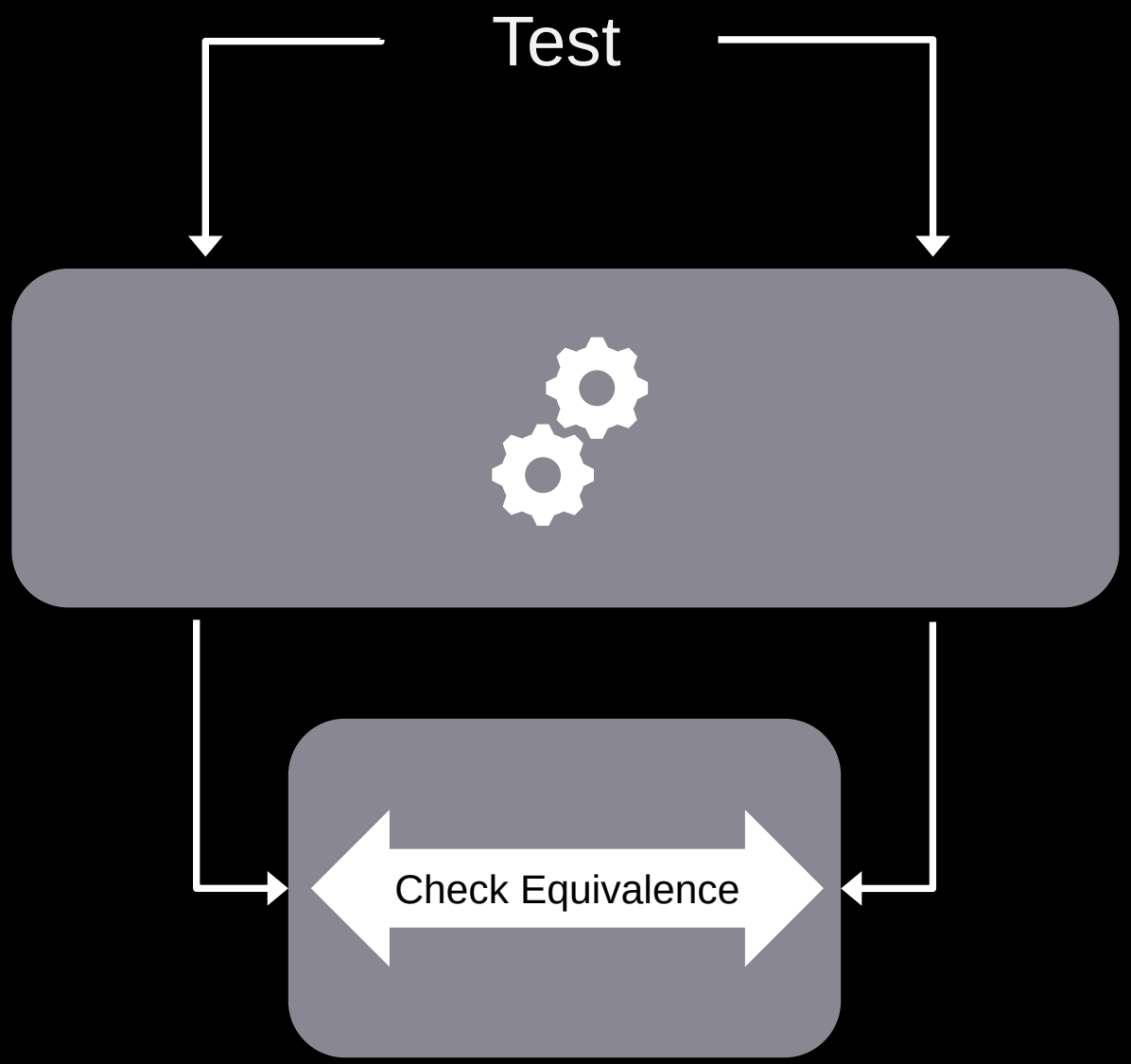

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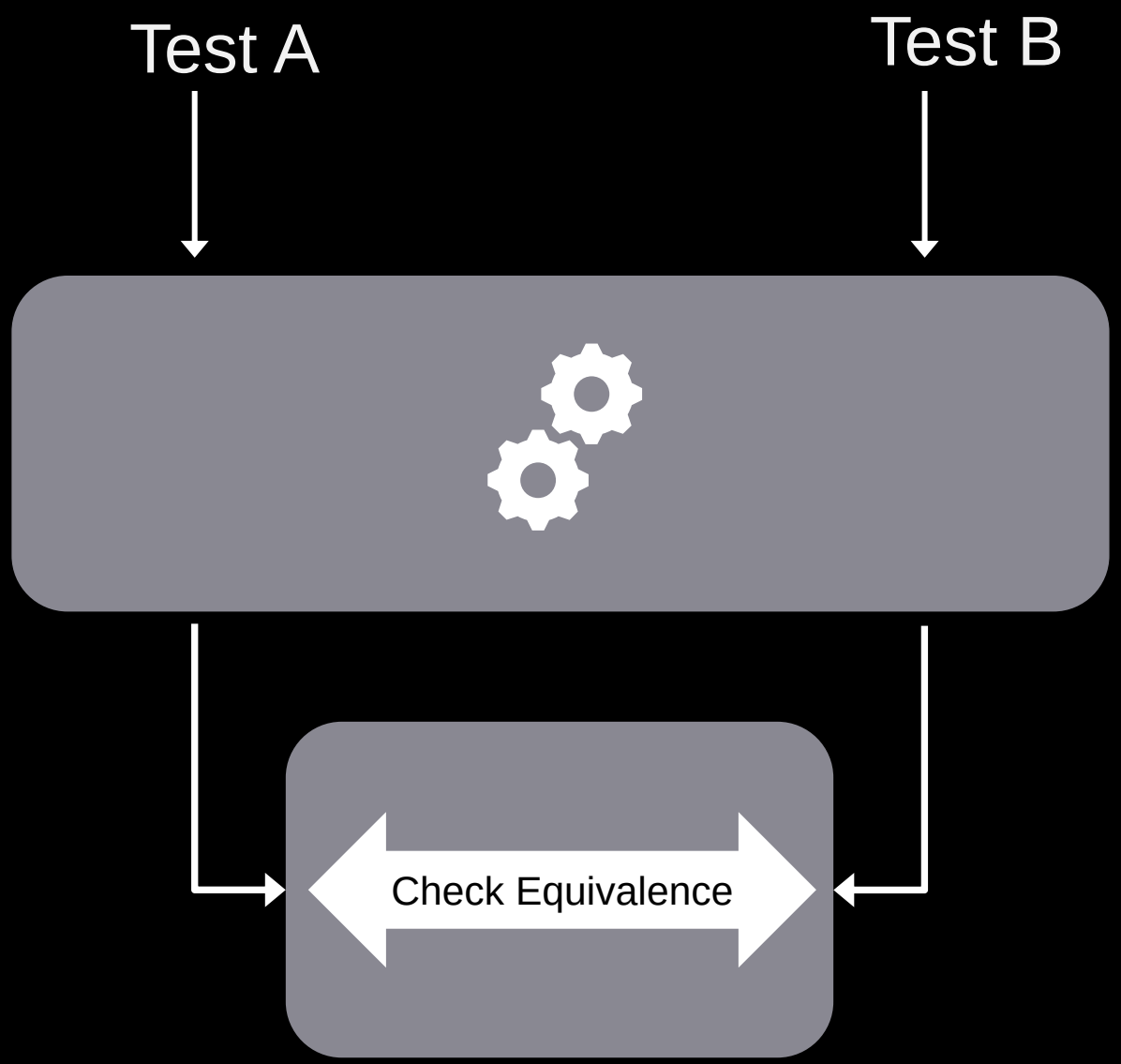

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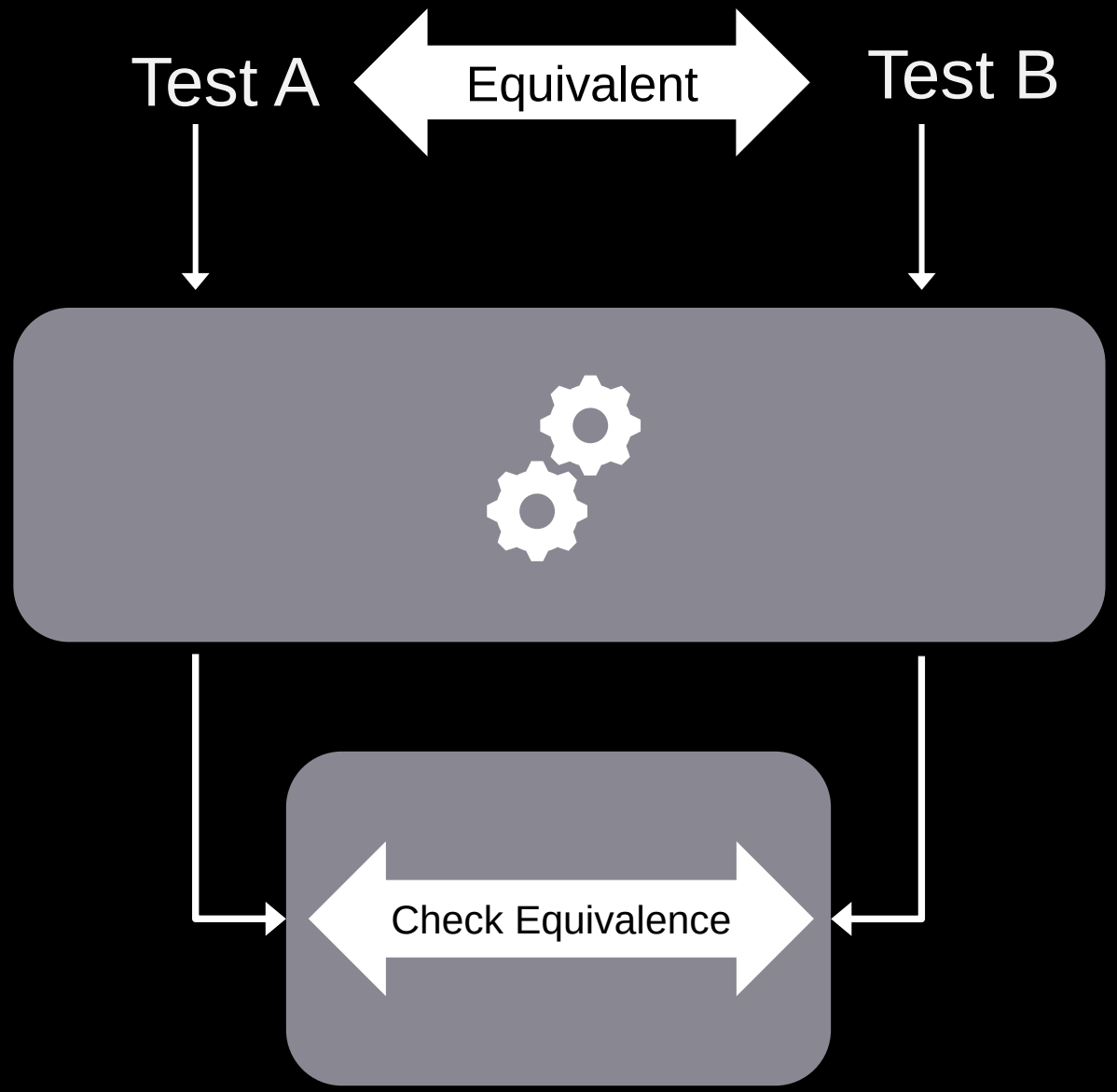

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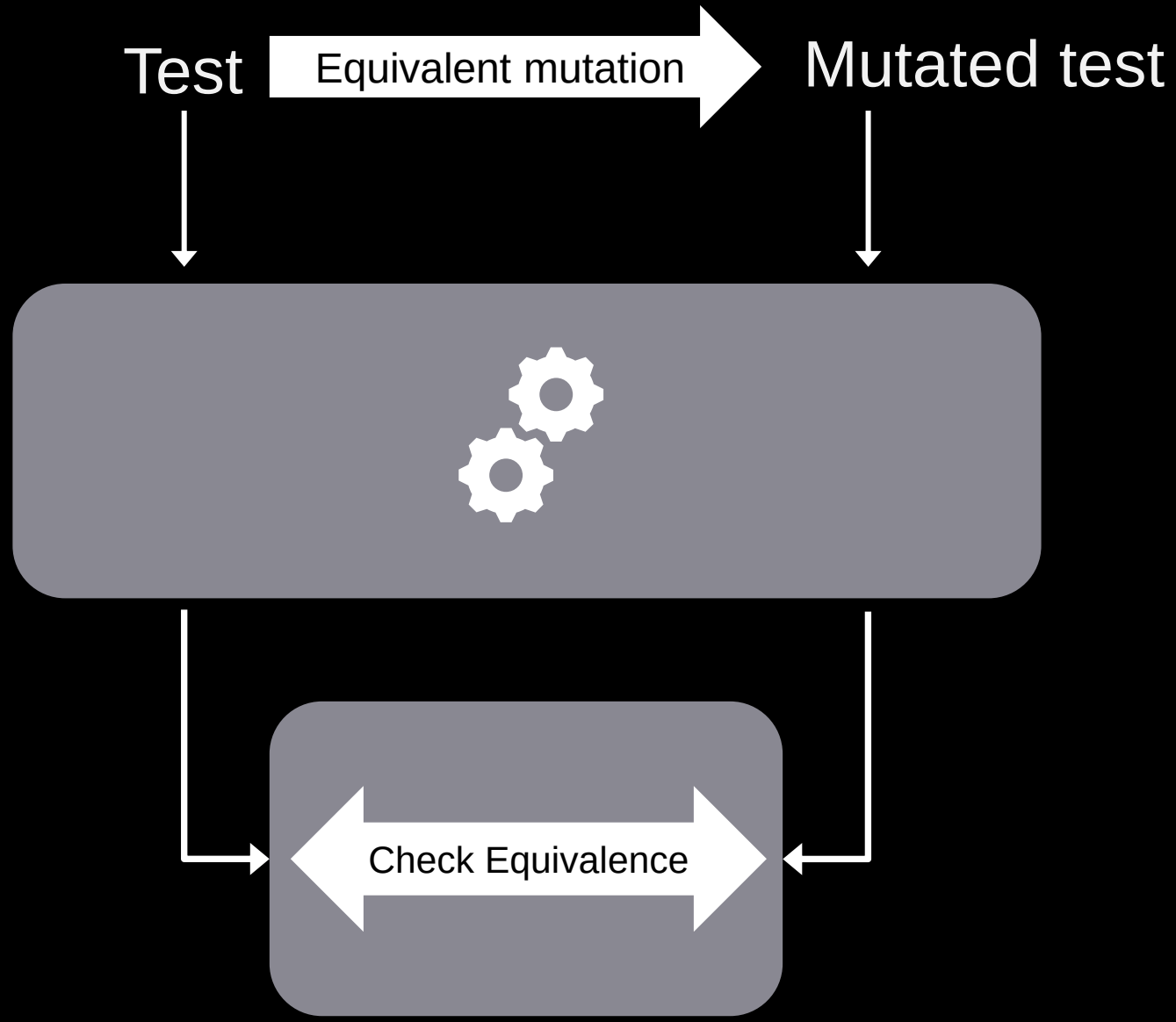
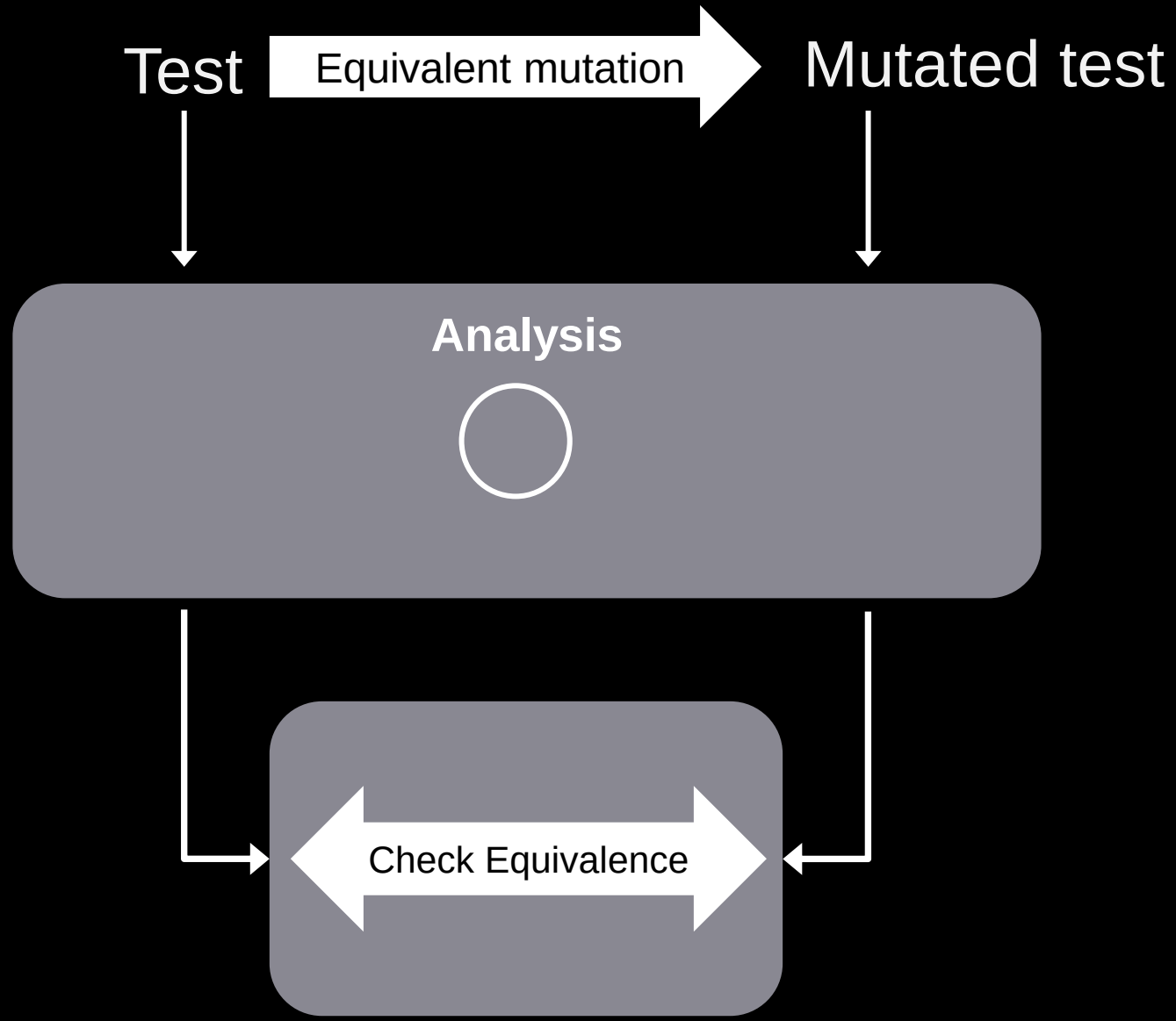
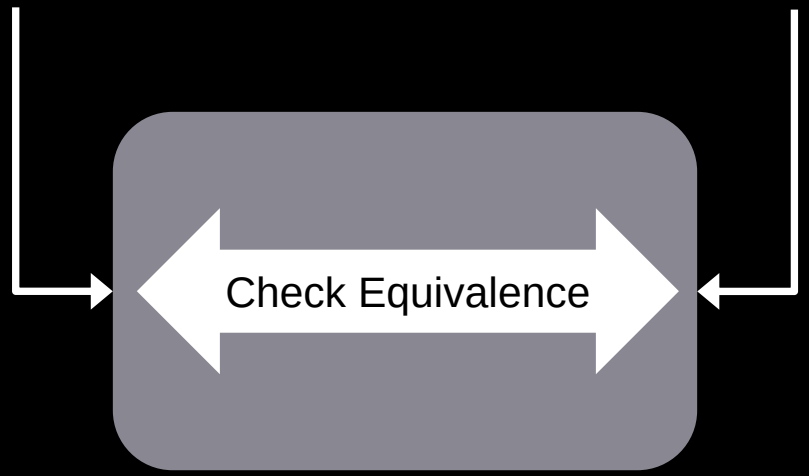


Testing analysis differentially



Checking equivalence of analyses result

It is not straight forward, and a notion of equivalence needs to be established for each analysis result



Case study: SwapTrueFalse (STF)

- STF is a structural mutation
- It swaps true and false branches

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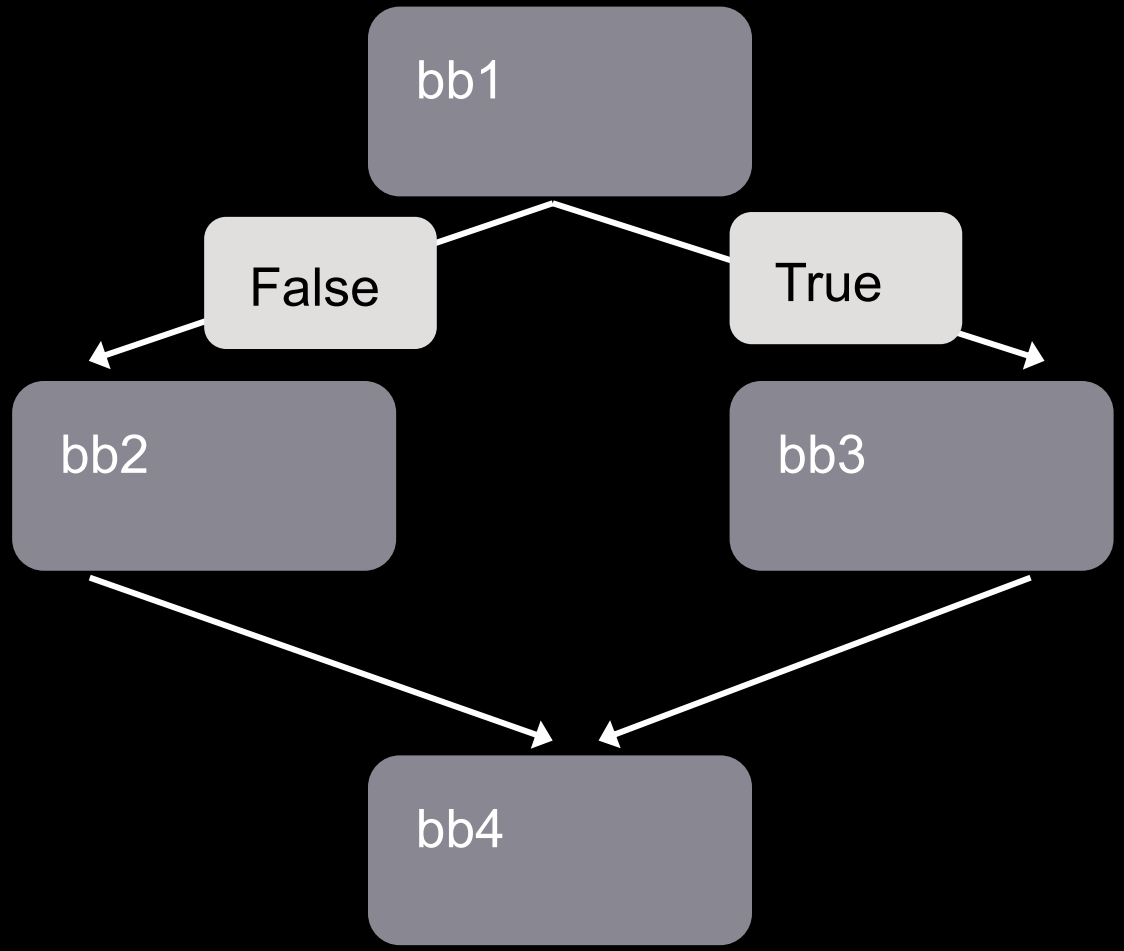

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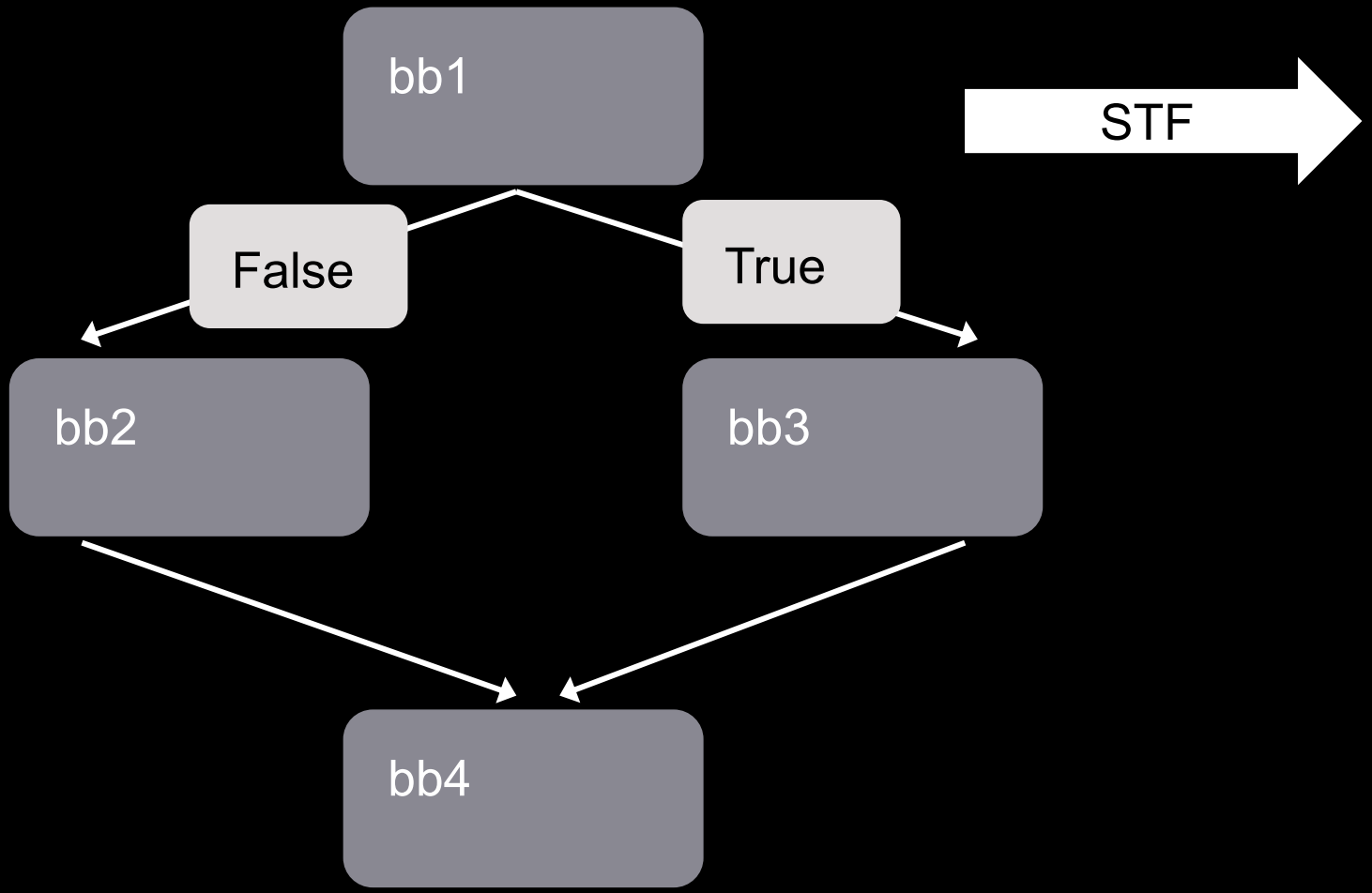

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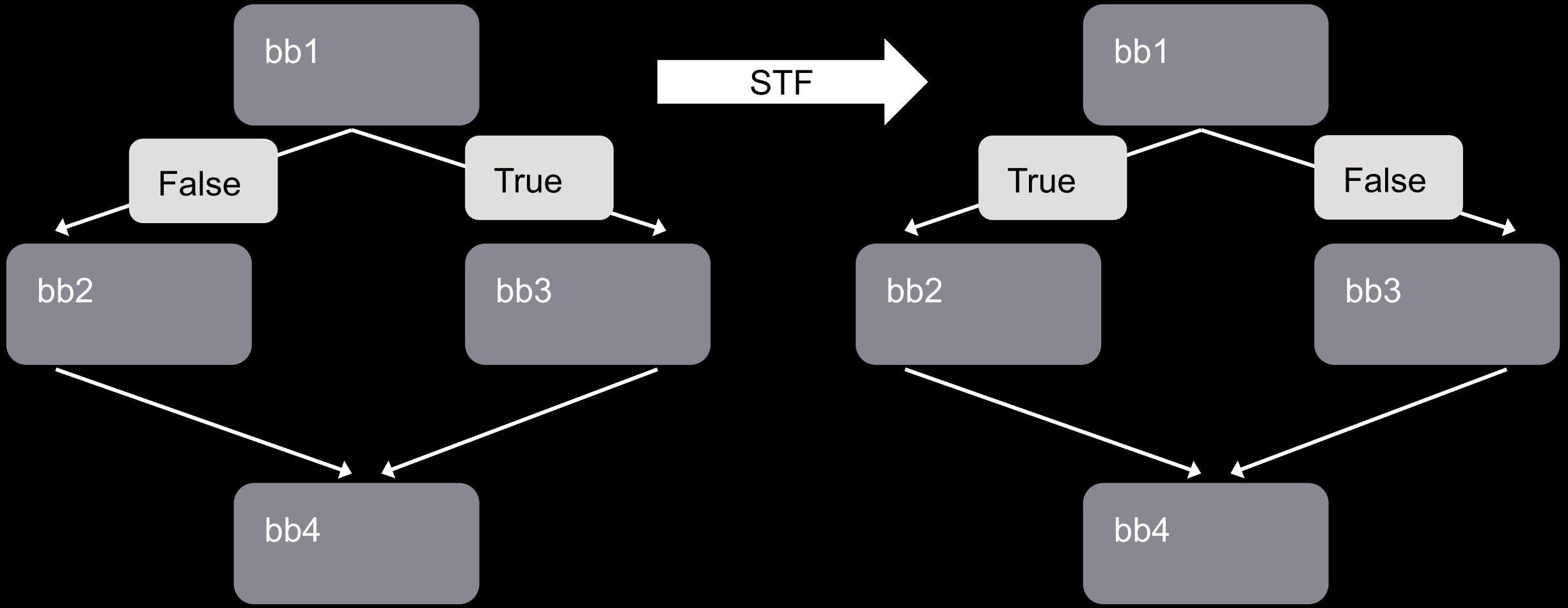

Case study: SwapTrueFalse (STF)

We can use a mutation to differentially test an analysis that does not react to it

STF does not change the structure of the control-flow graph so can be used for analysis that are independent of CFG

Source of bug

The bug in any fundamental analysis will only be caused by itself

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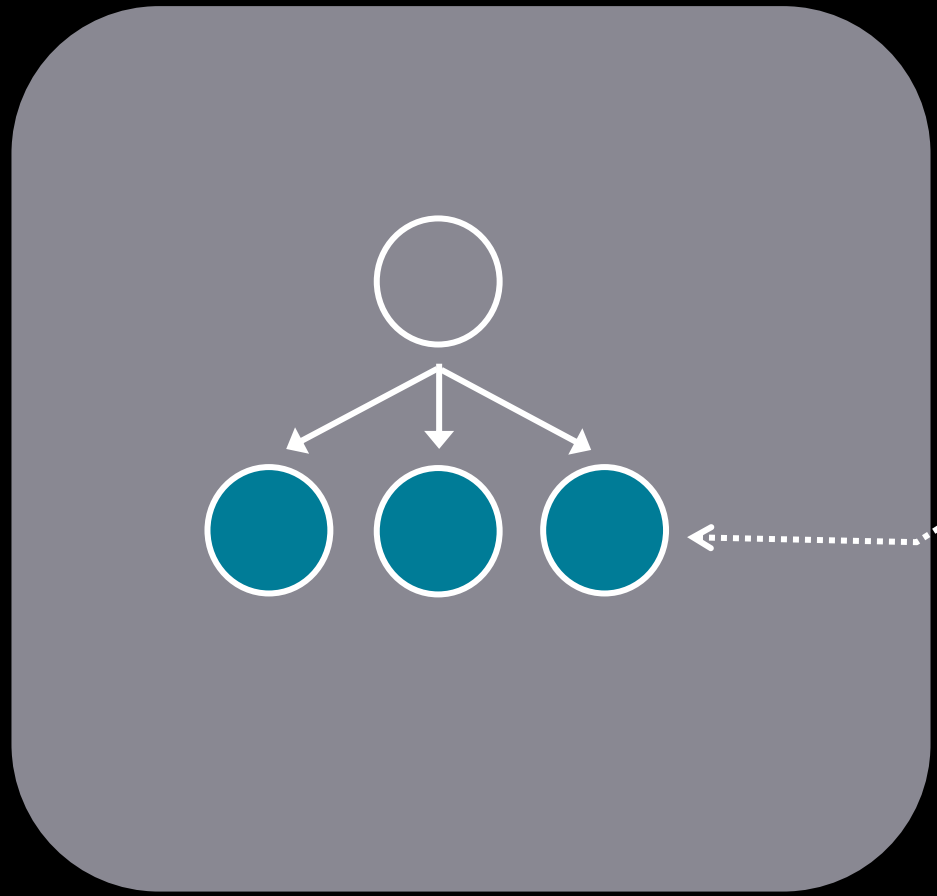

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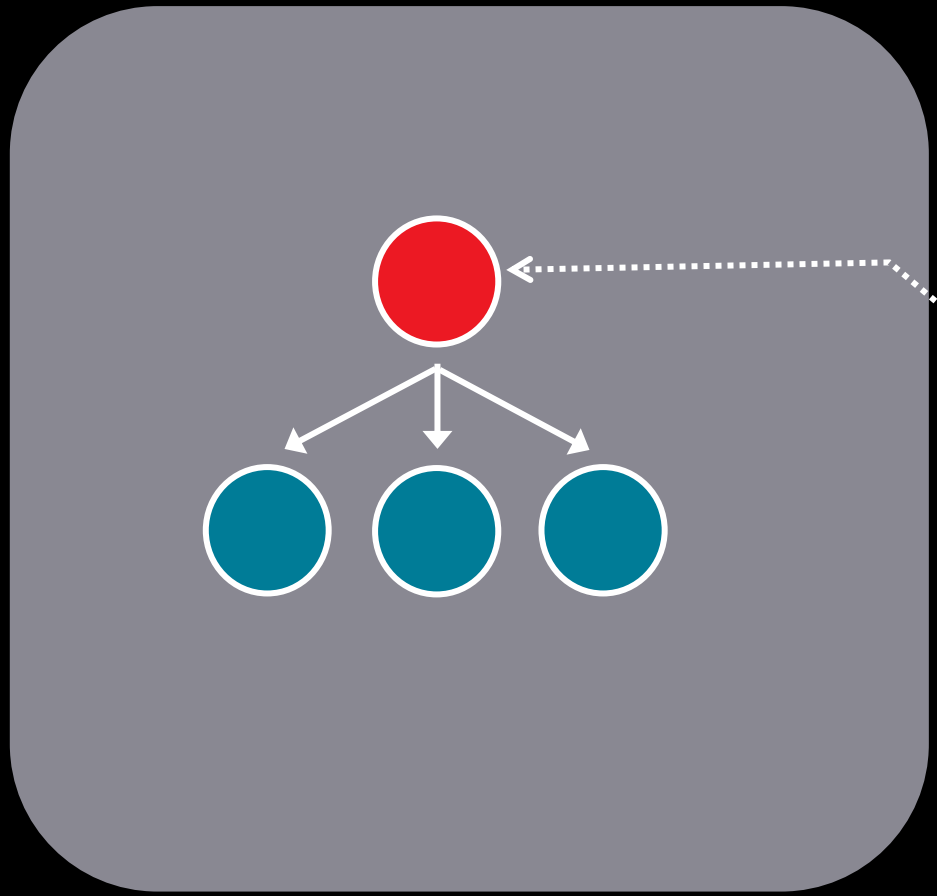
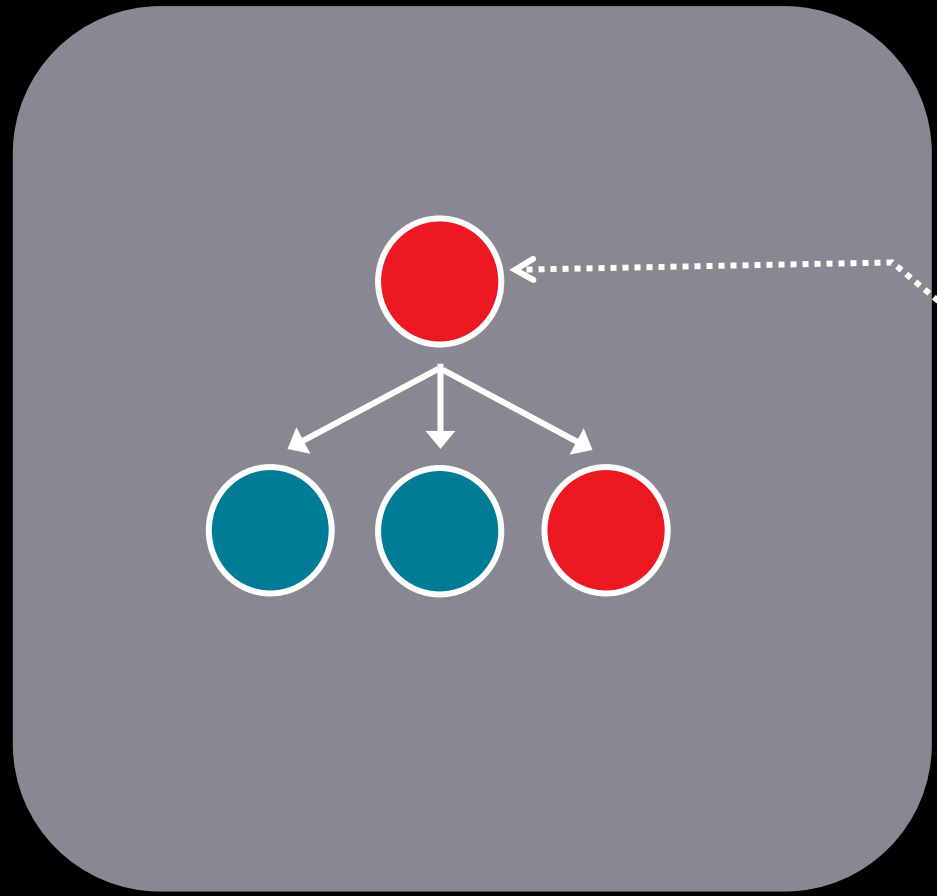


This analysis depends on the results from other analyses

Source of bug

The bug in any derived analysis can be caused by any dependent analysis



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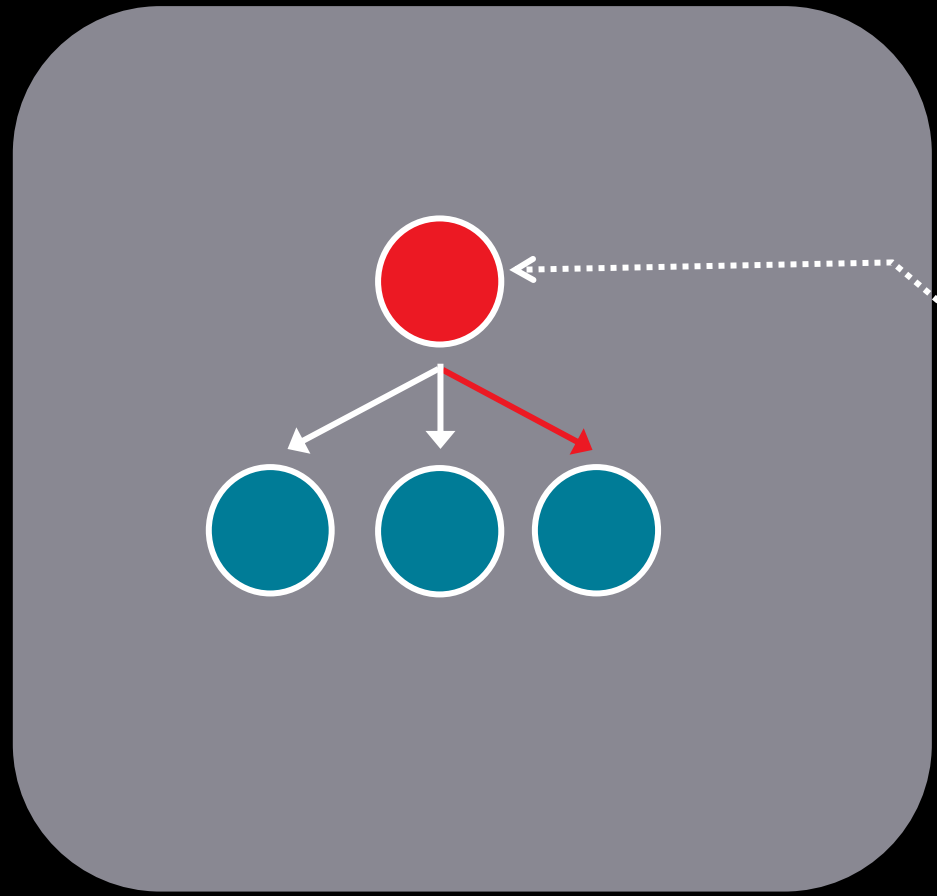
Source of bug

The bug in any derived analysis can be caused by the interaction between the analyses



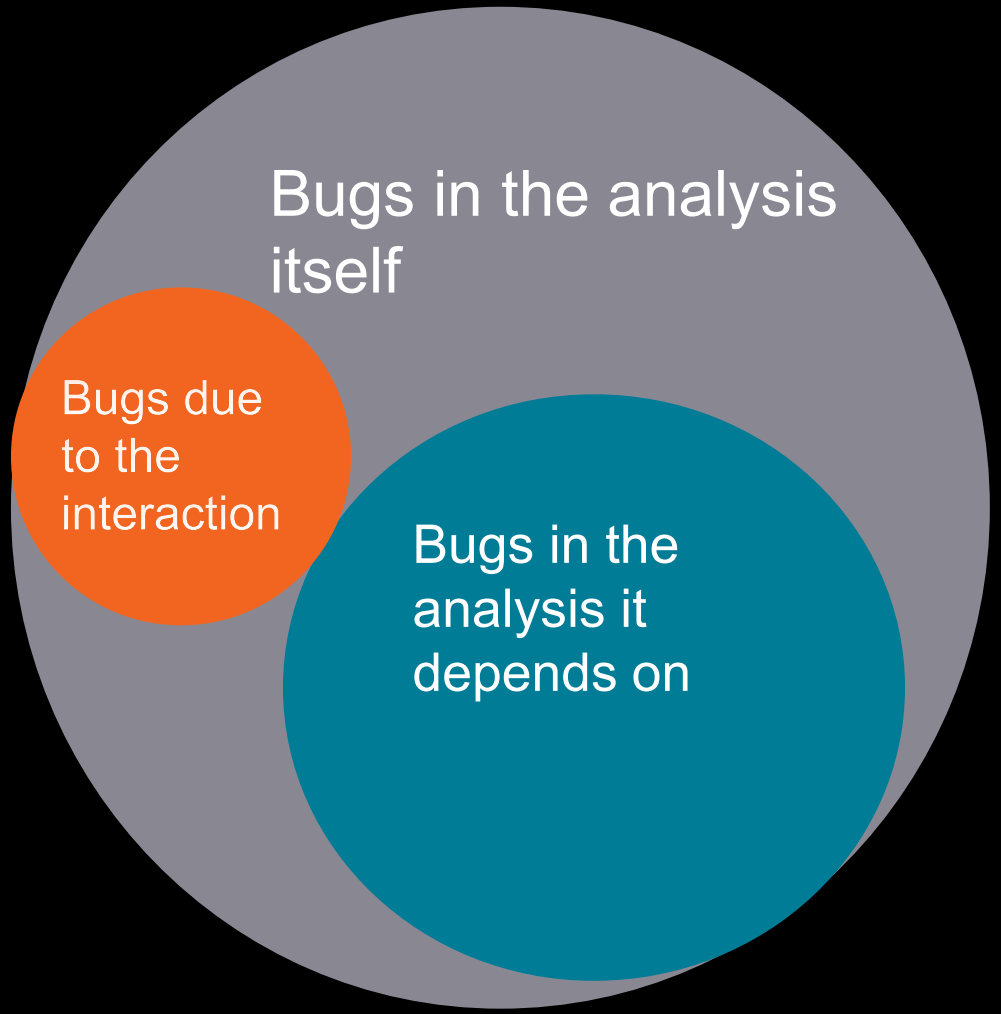
This analysis depends on the results from other analyses

Source of bug

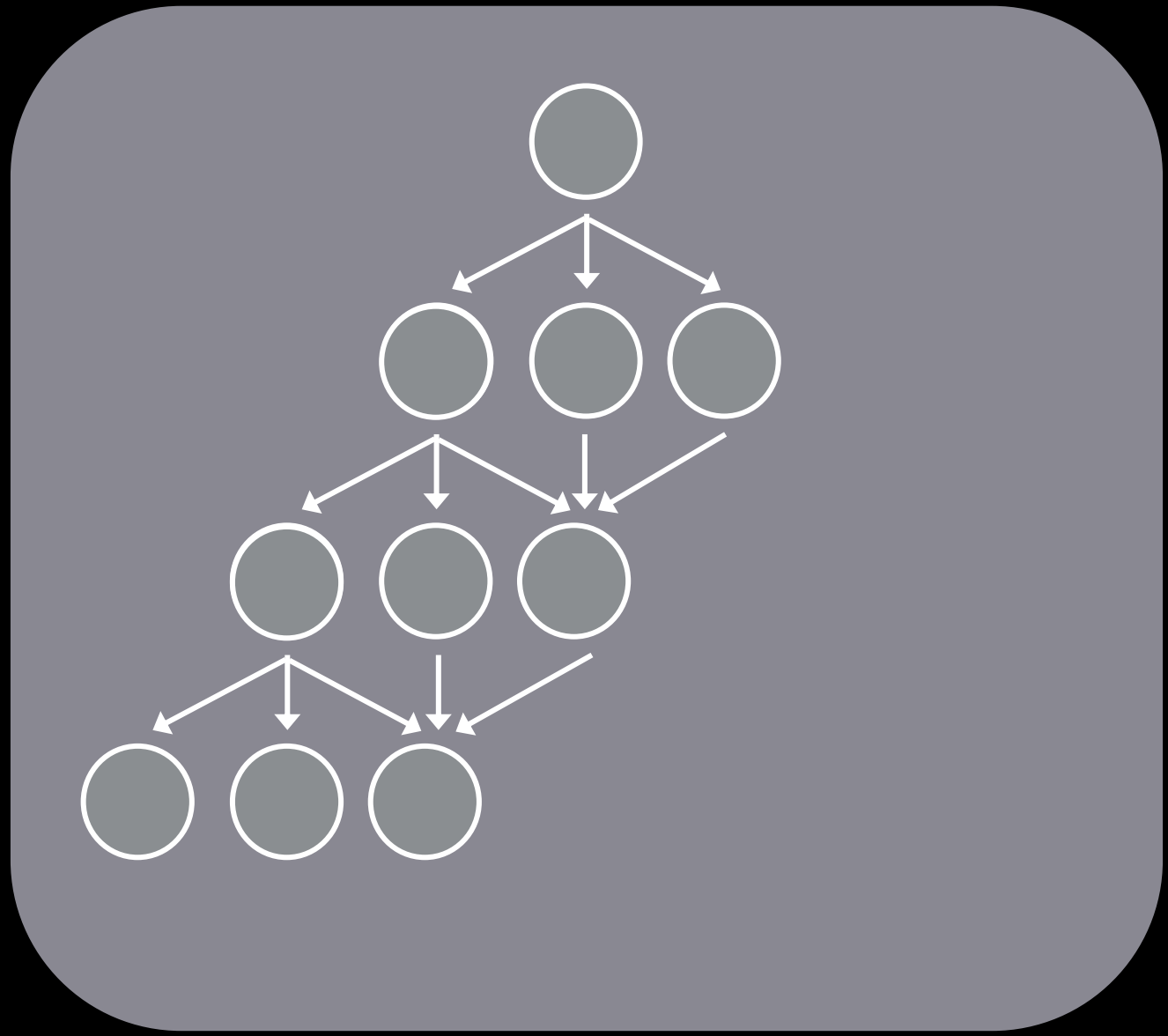
The bug in any derived analysis can be caused by the following,

- Can be caused by itself
- Can be caused by any other analysis it depends on
- Can be caused by the interaction between the analyses

Source of bug



Source of trust



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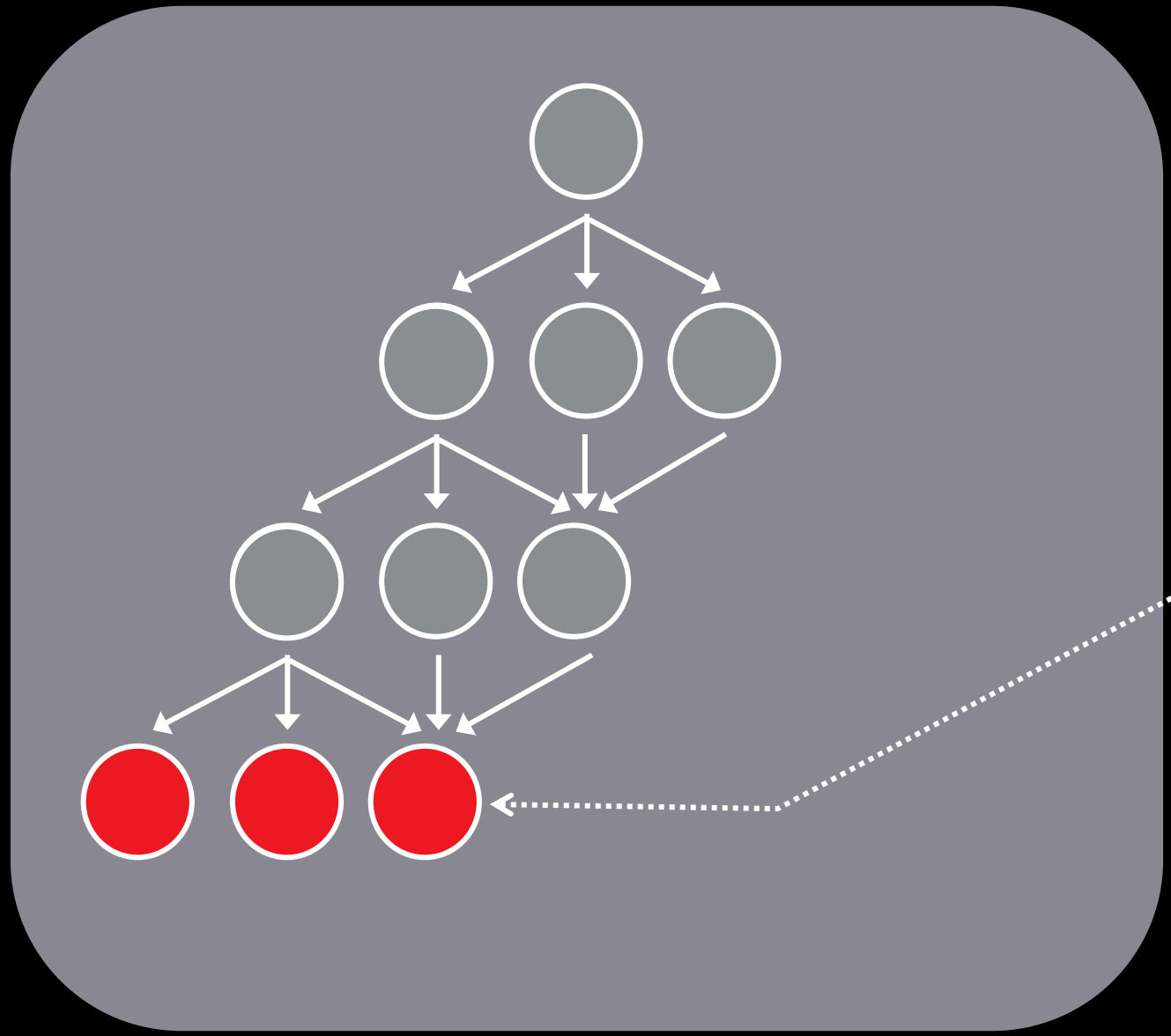

Fundamental analysis are the easiest to reason about

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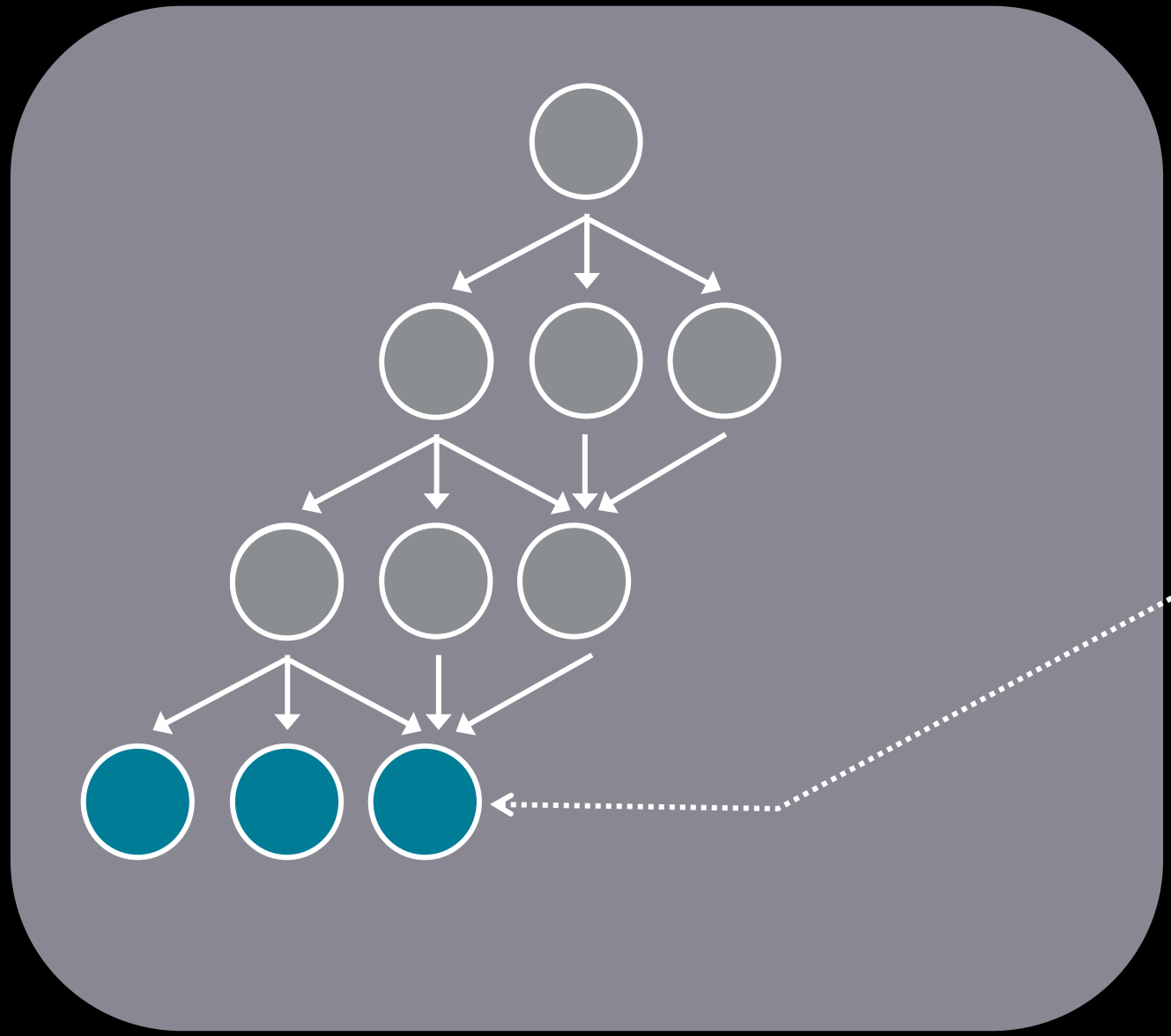

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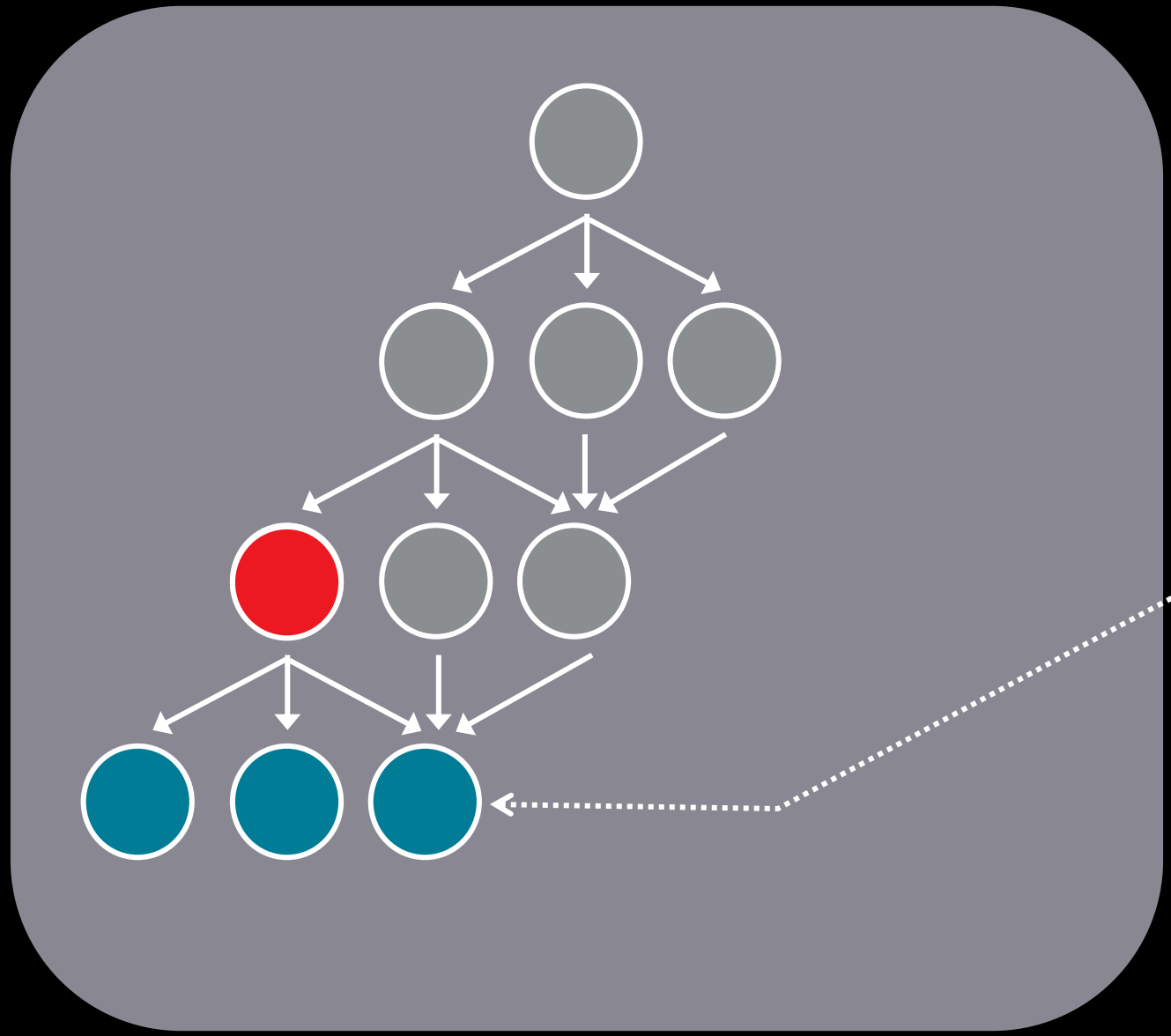

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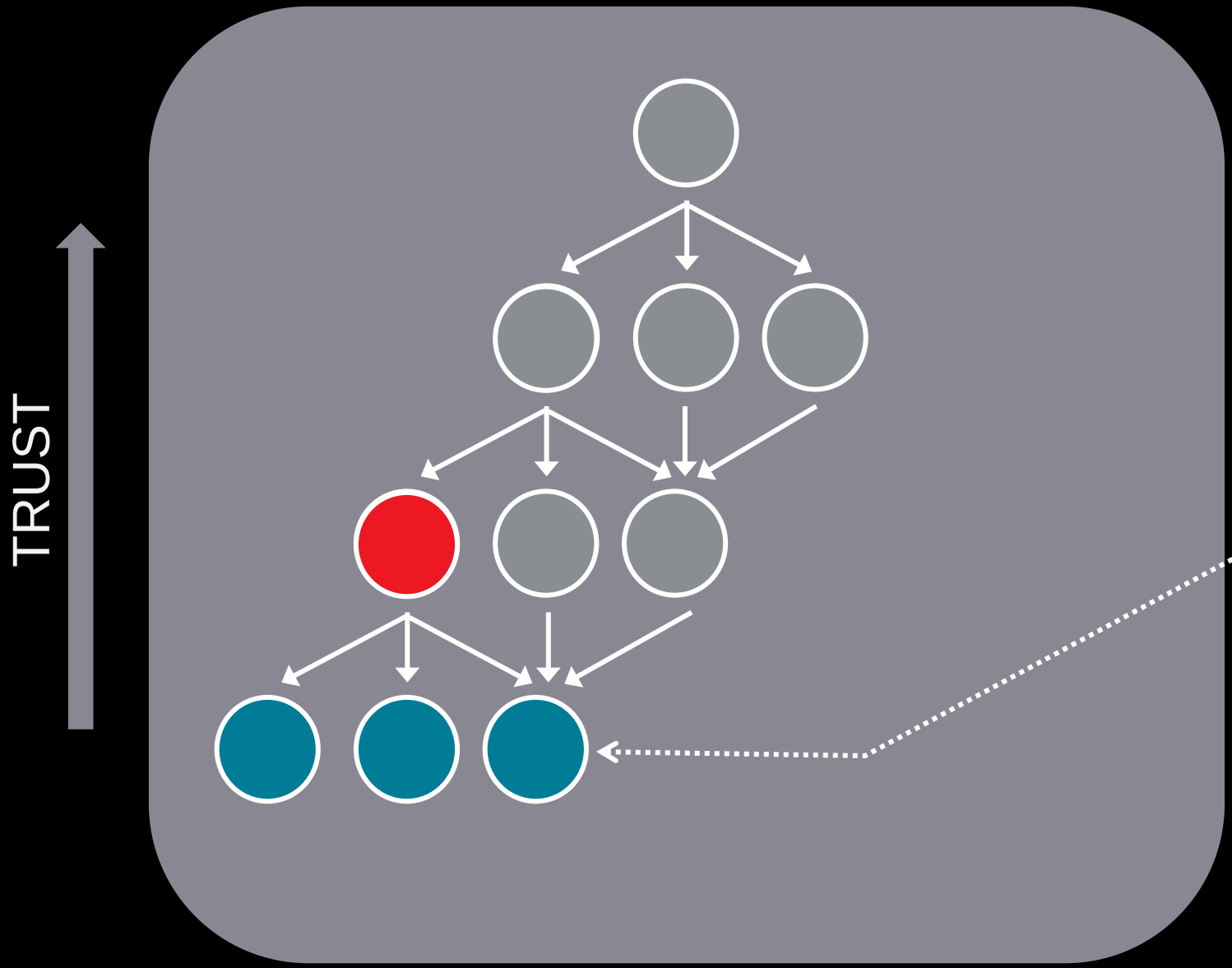

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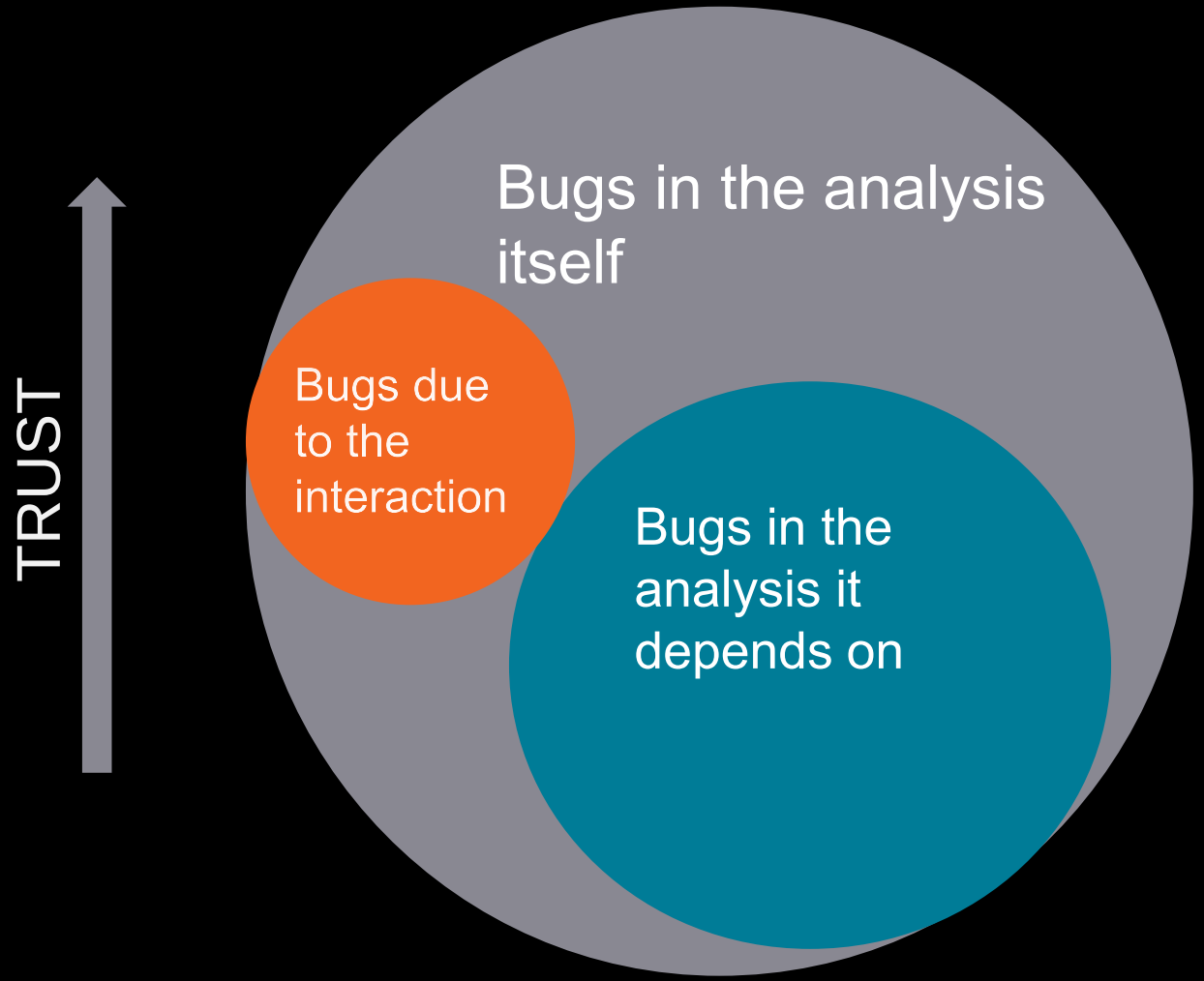

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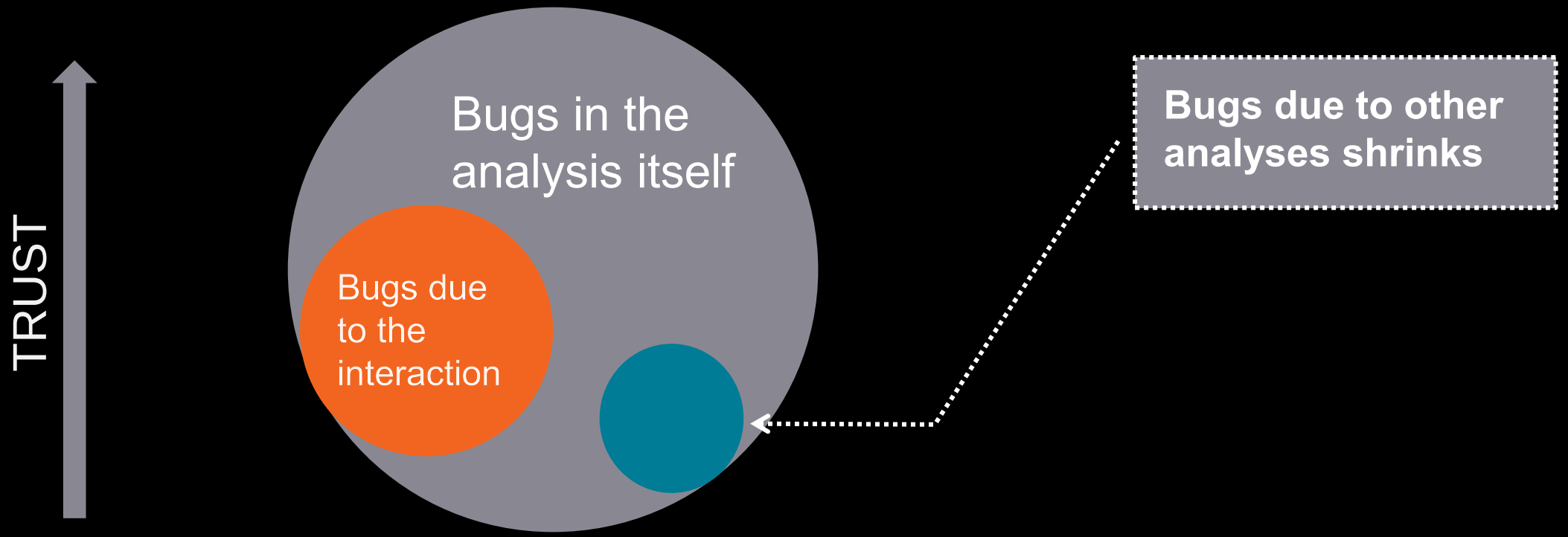

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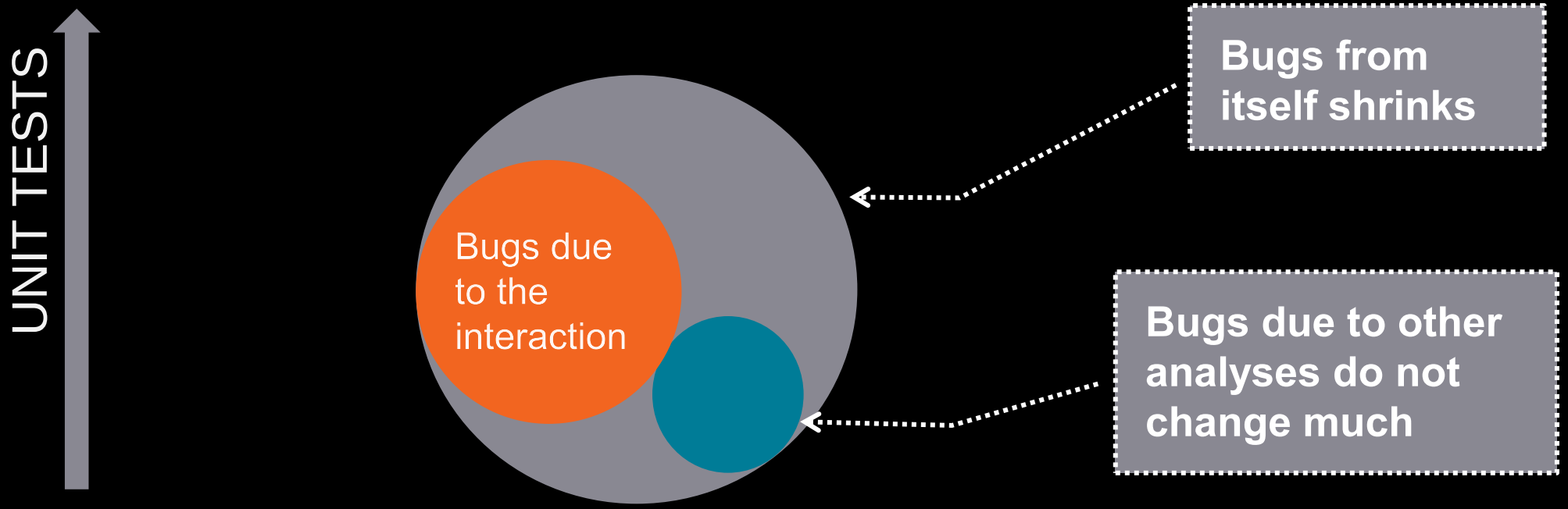

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If we choose mutations which are inert to the analysis in question and the analyses it uses

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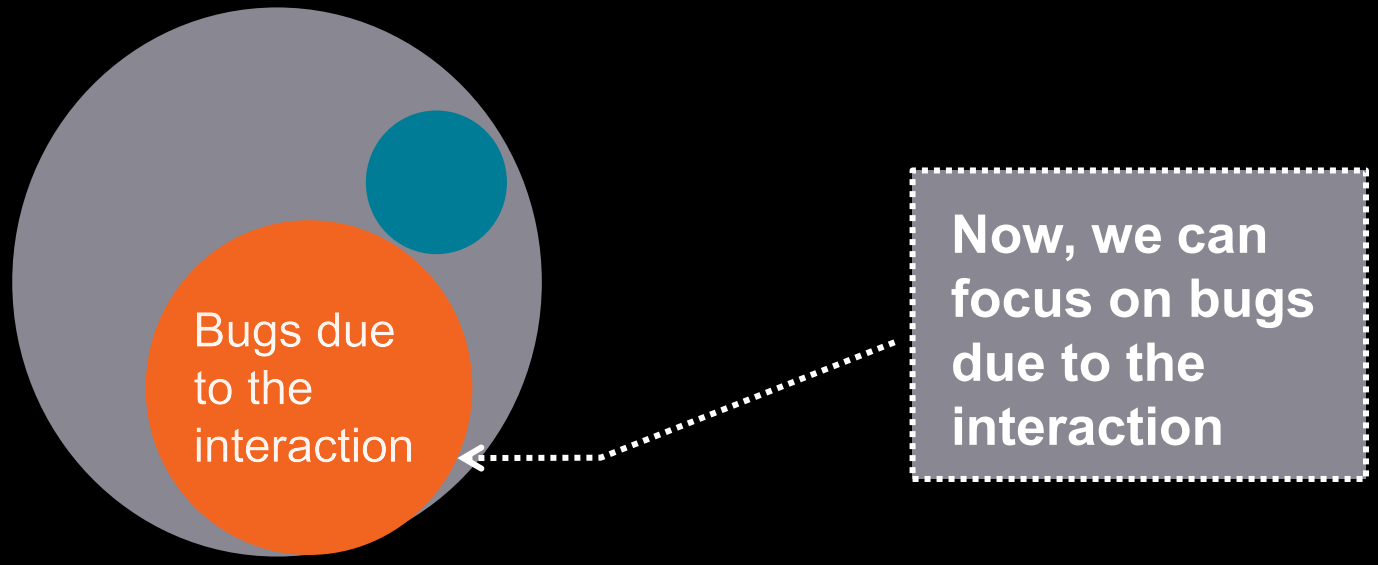
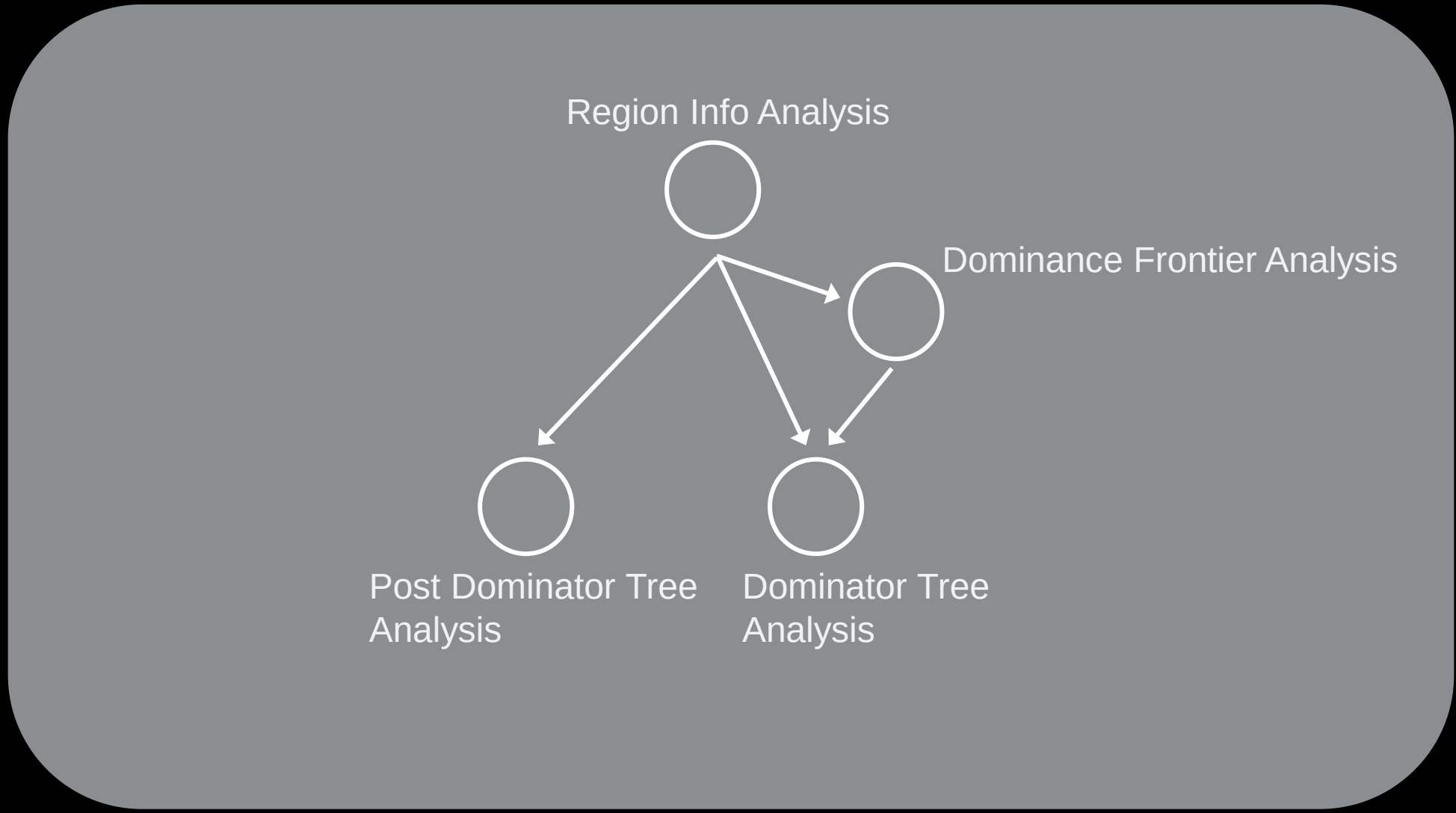
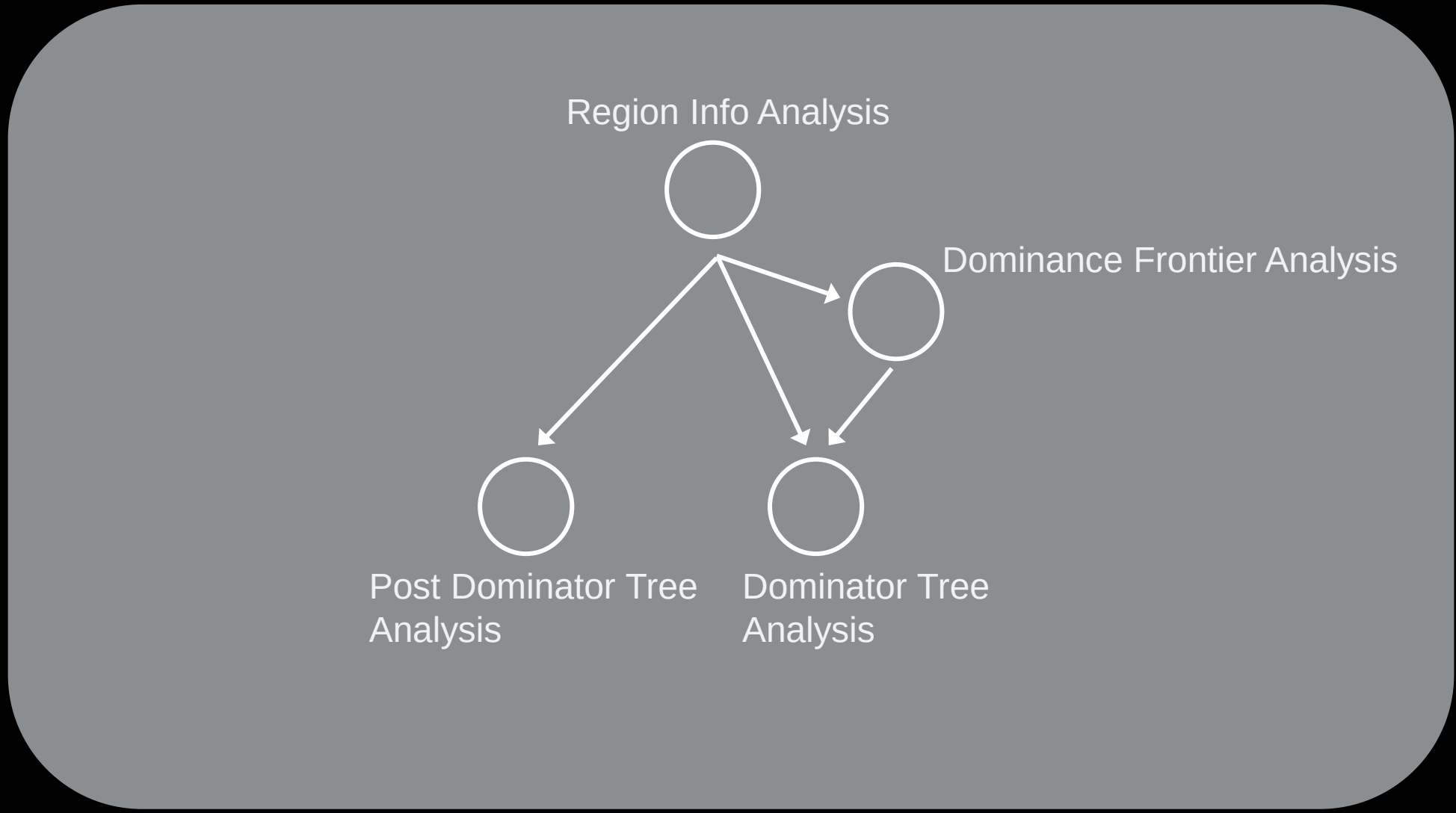


Example: Region Info Analysis



Mutation: SwapTrueFalse (STF)



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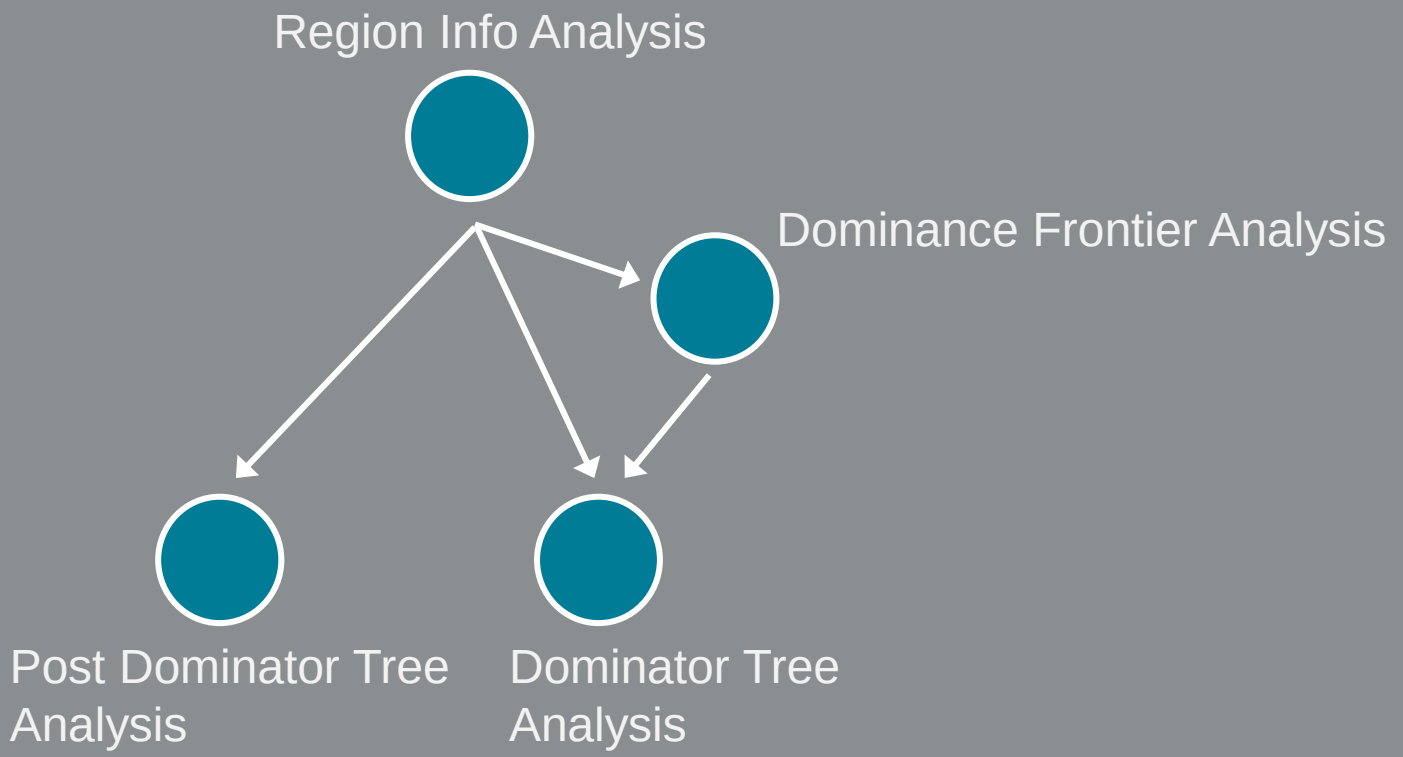
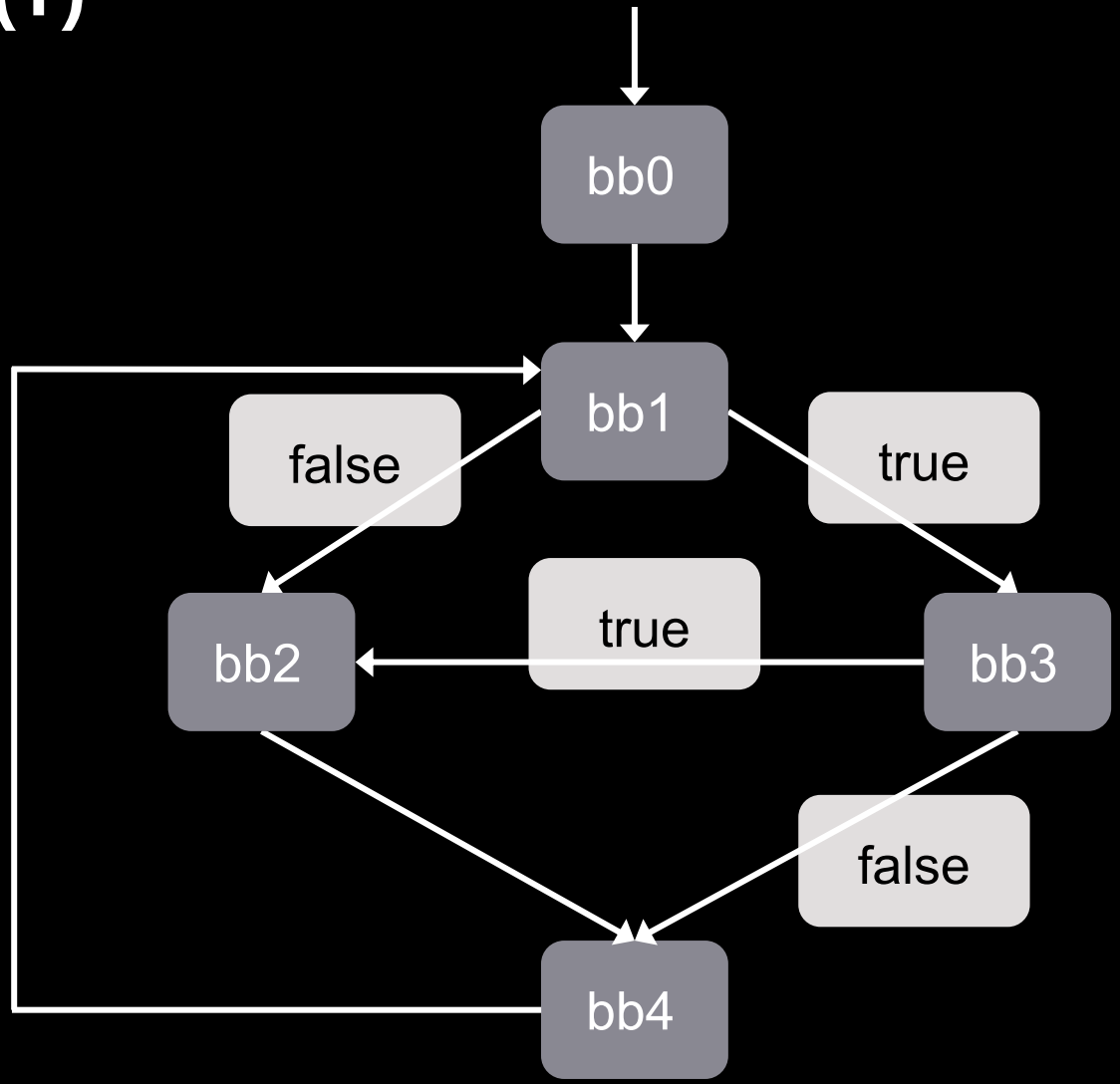
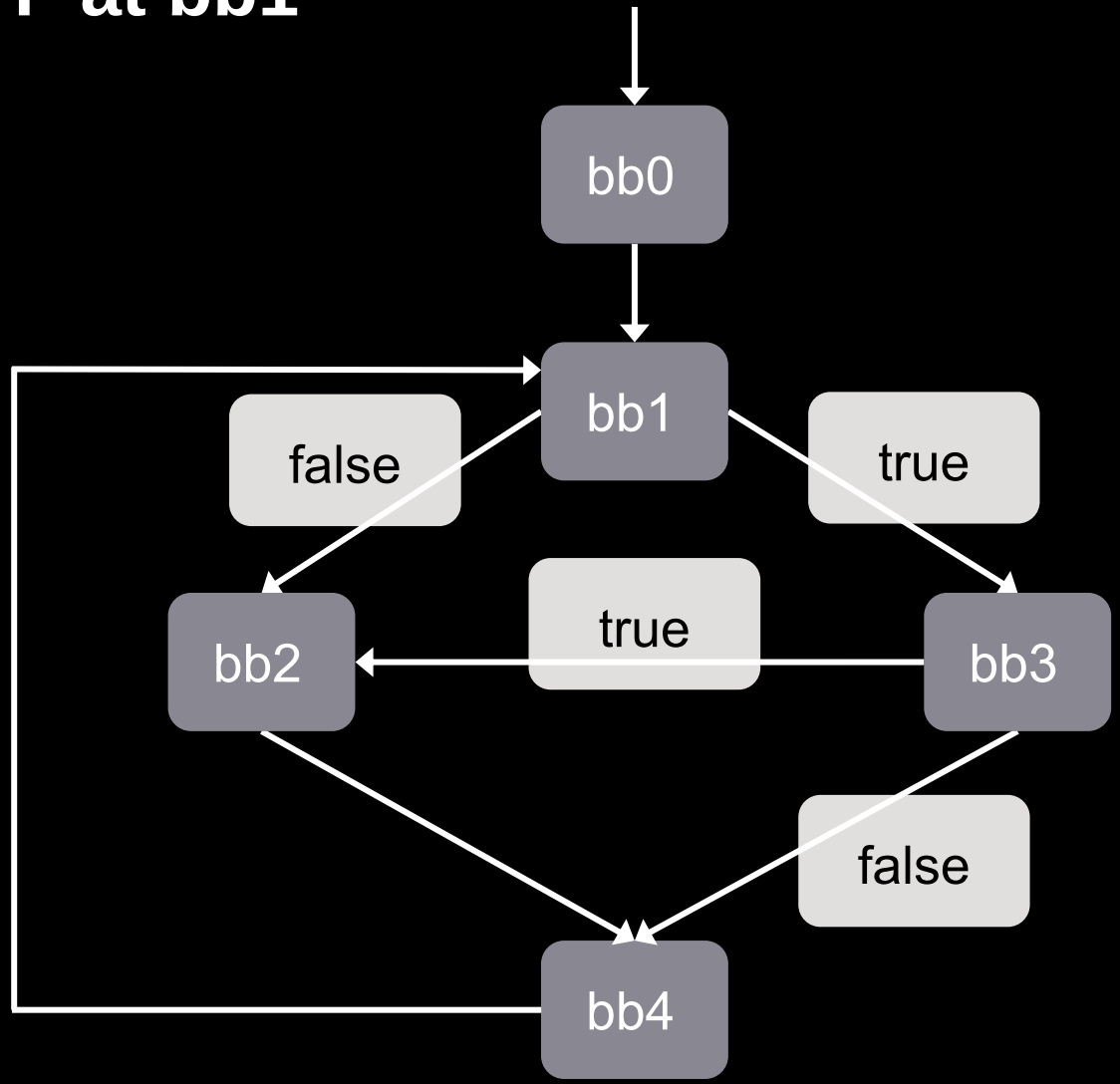


A test case (T)



Applying STF at bb1



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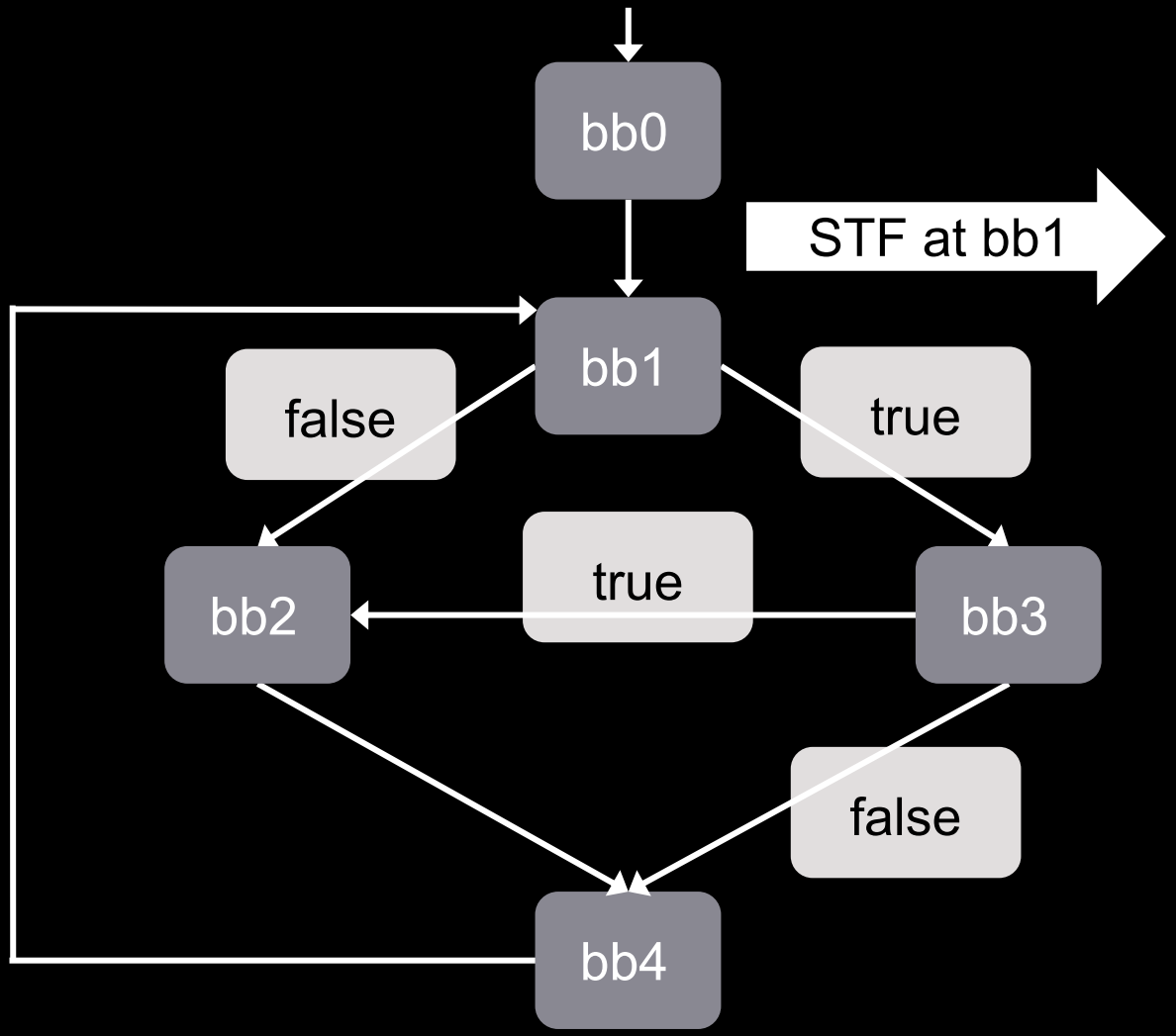

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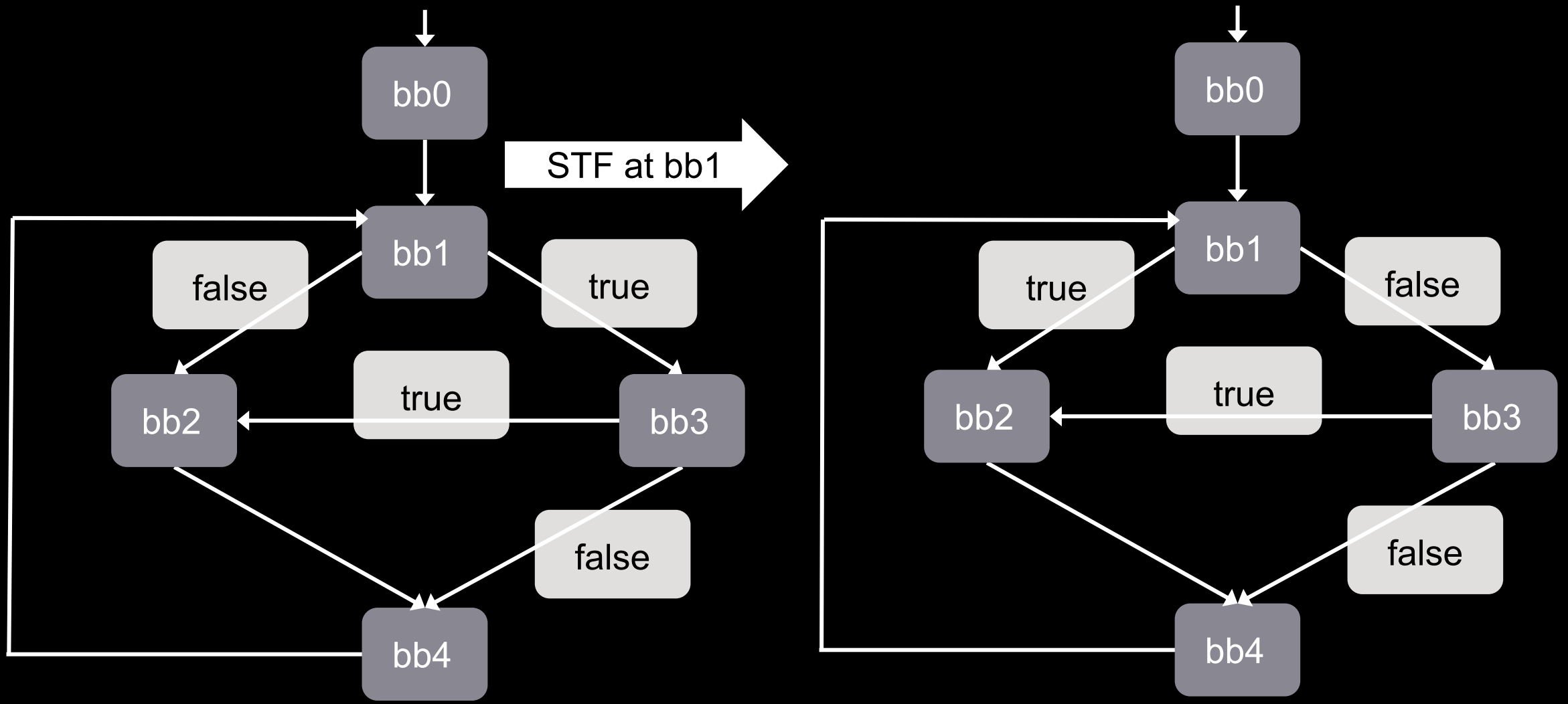
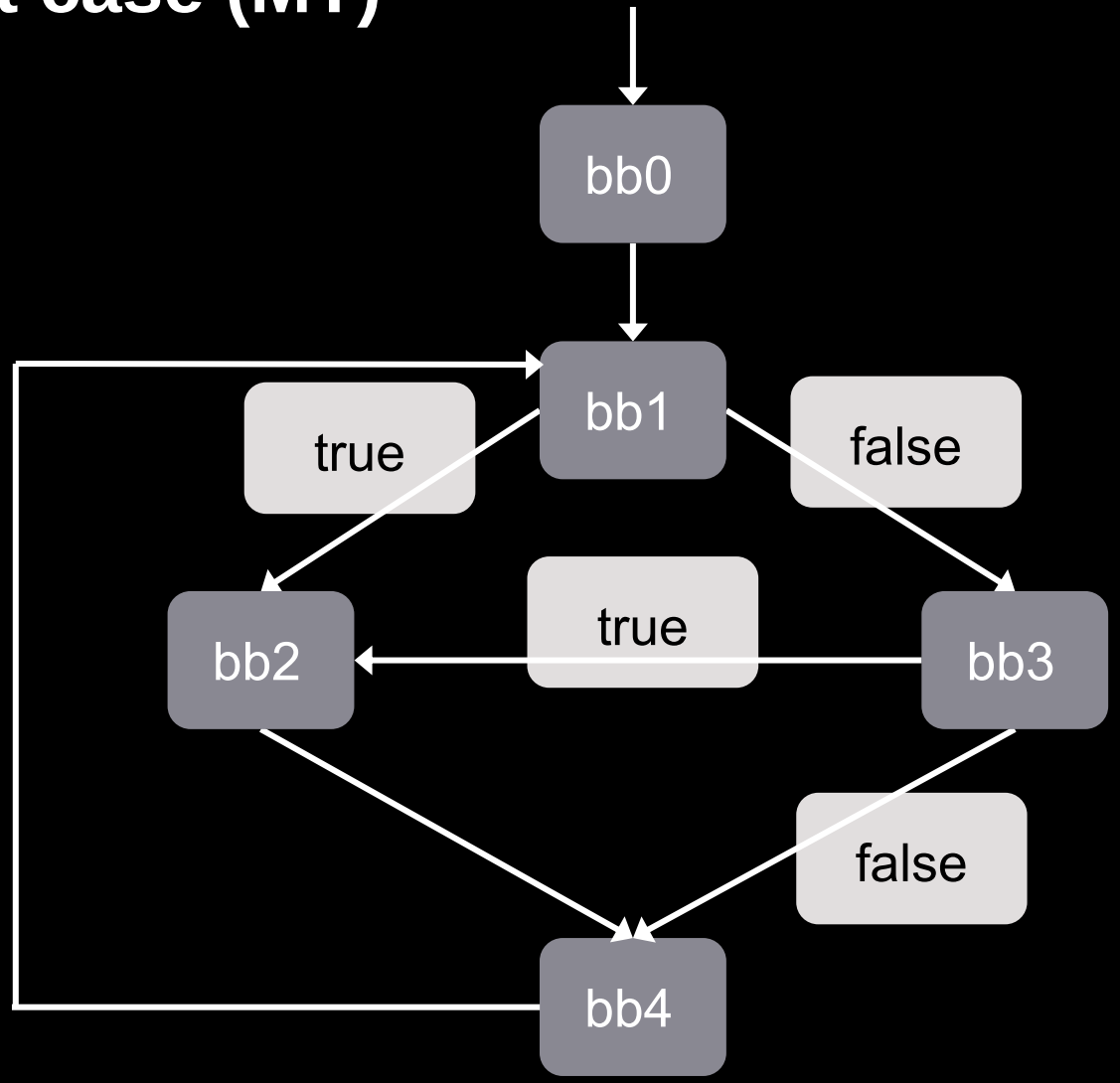


Mutated test case (MT)



Region Info Analysis

A Region is a connected subgraph of a control flow graph that has exactly two connections to the remaining graph

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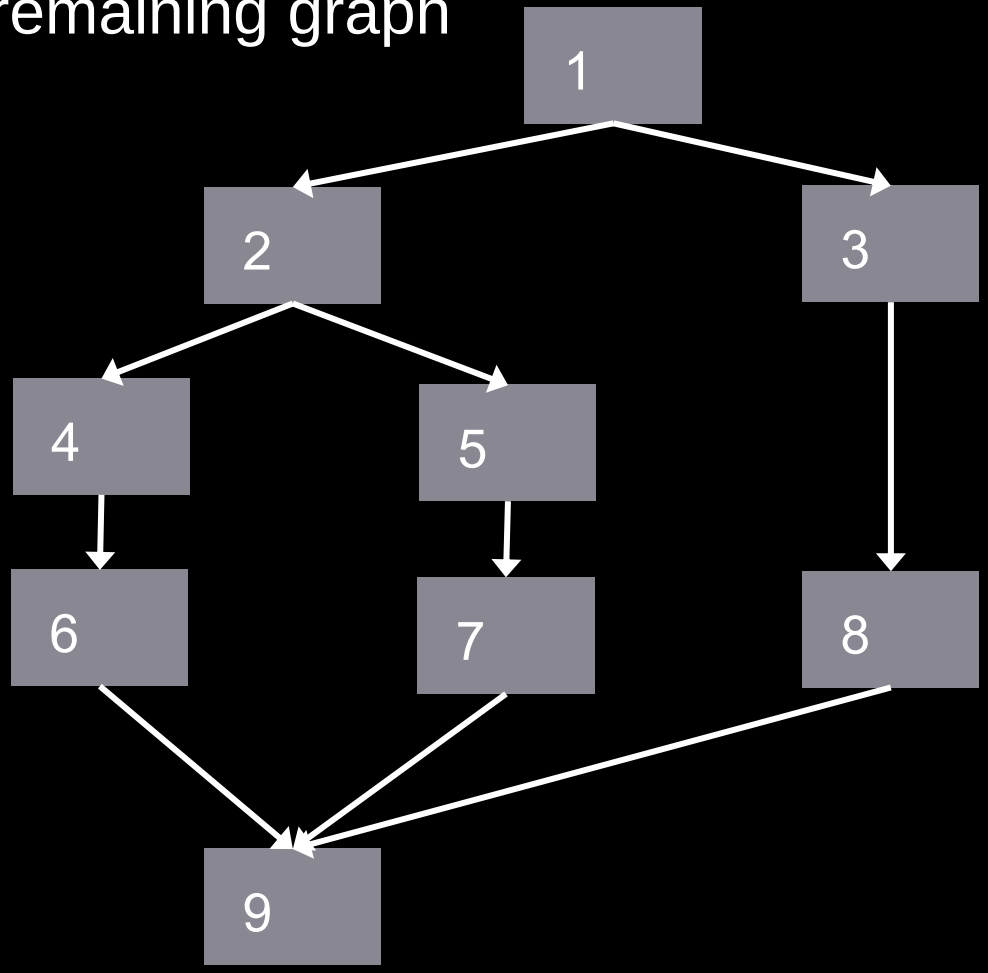

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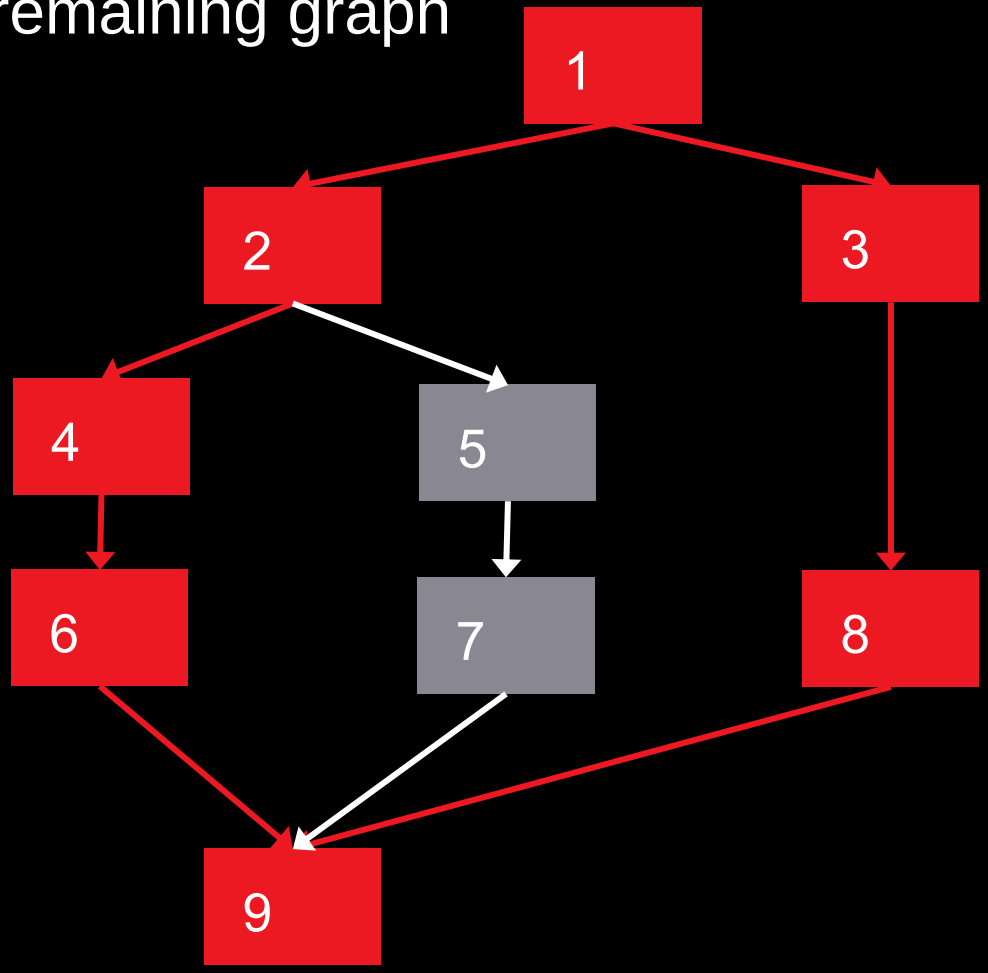
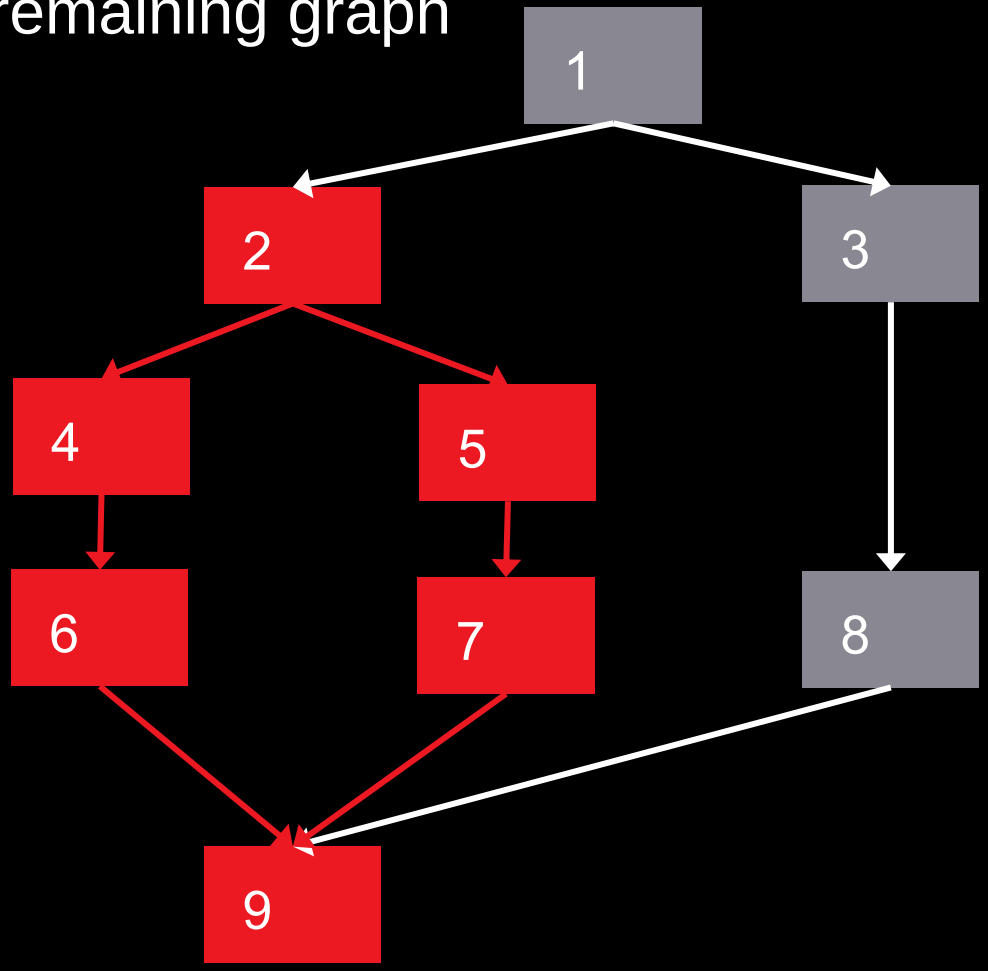
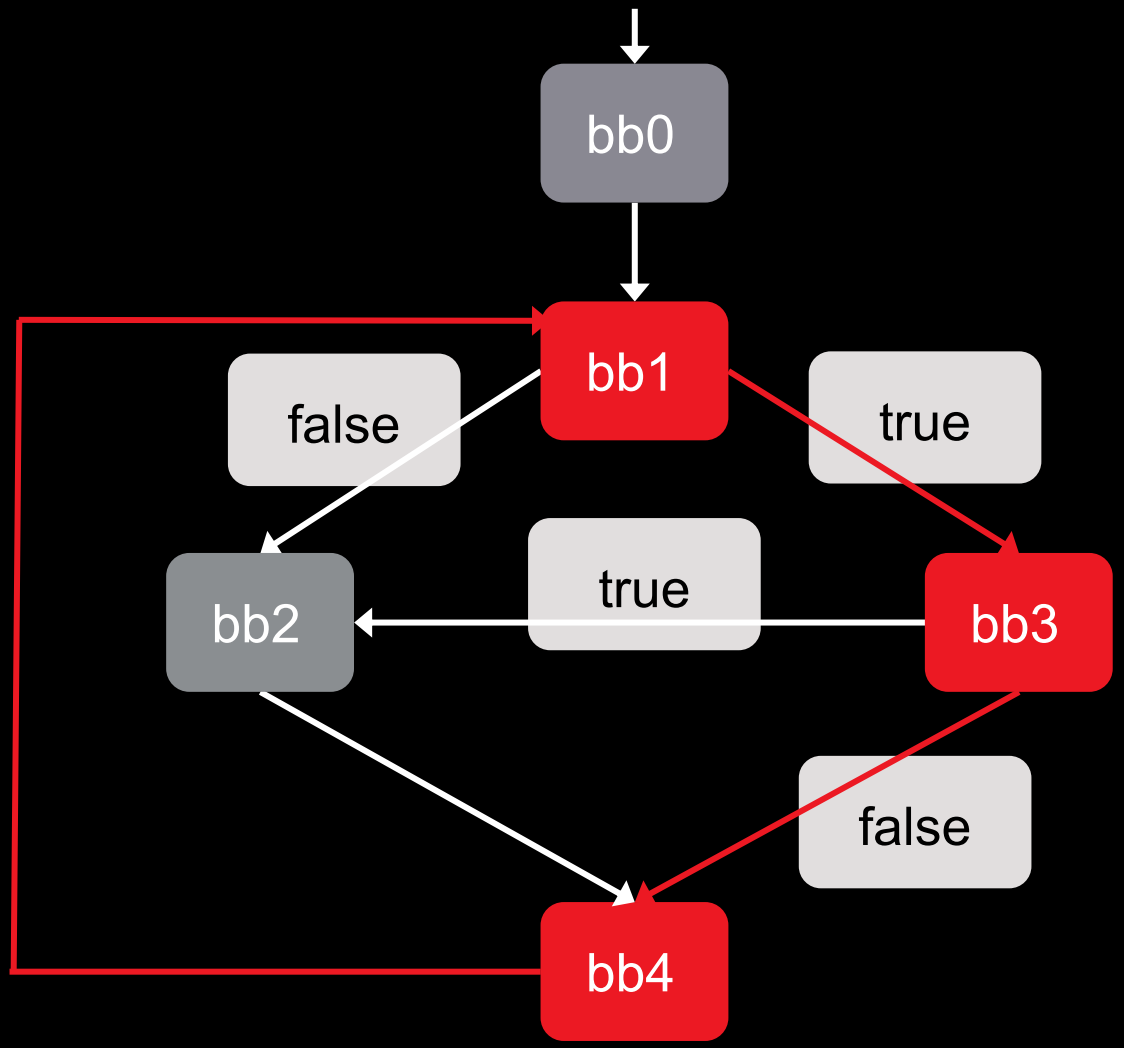
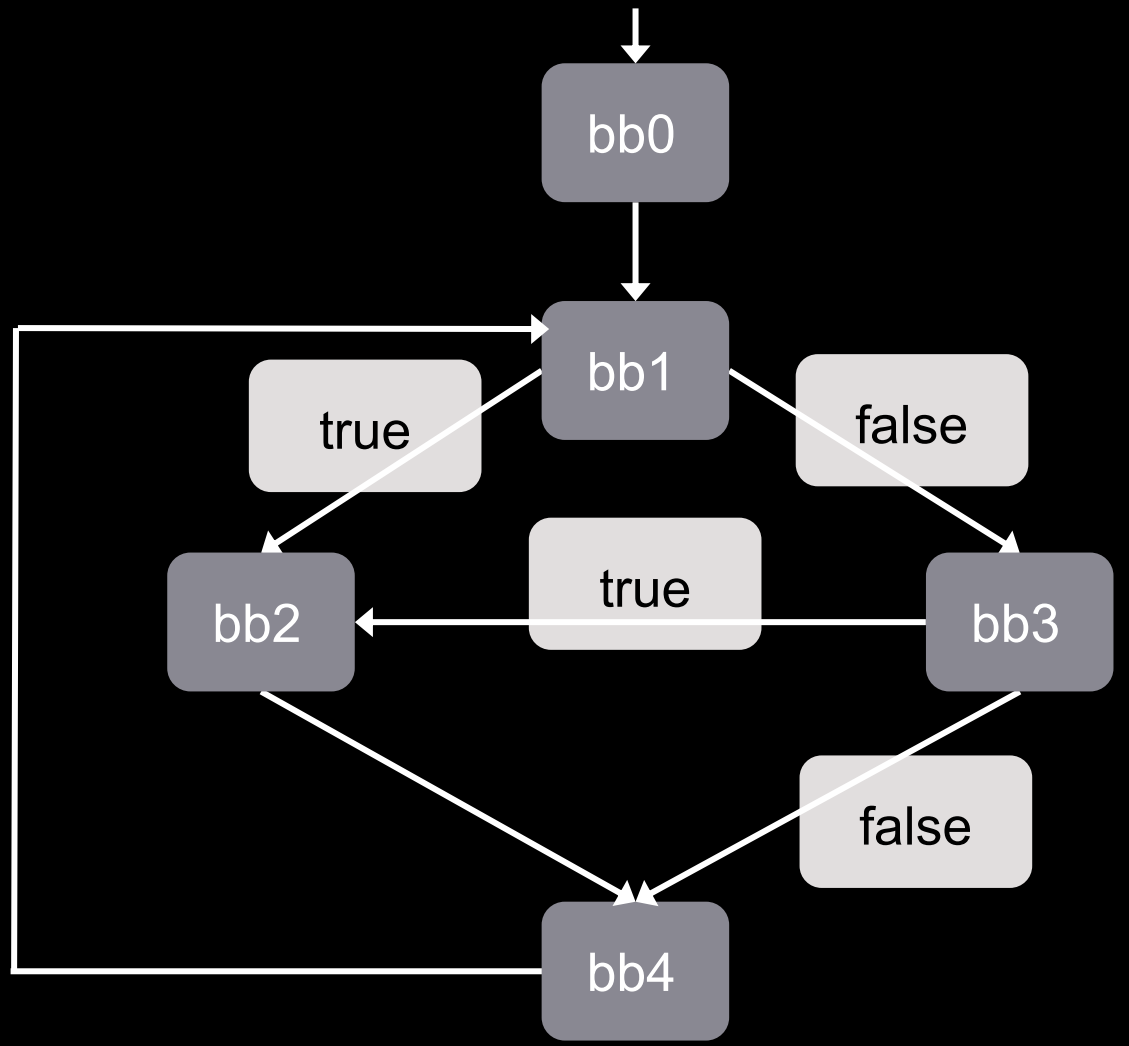


Region Info Analysis

A Region is a connected subgraph of a control flow graph that has exactly two connections to the remaining graph




bb0
bb1
false
true
bb2
true
bb3
false
bb4


bb0
bb1
true
false
bb2
true
bb3
false
bb4

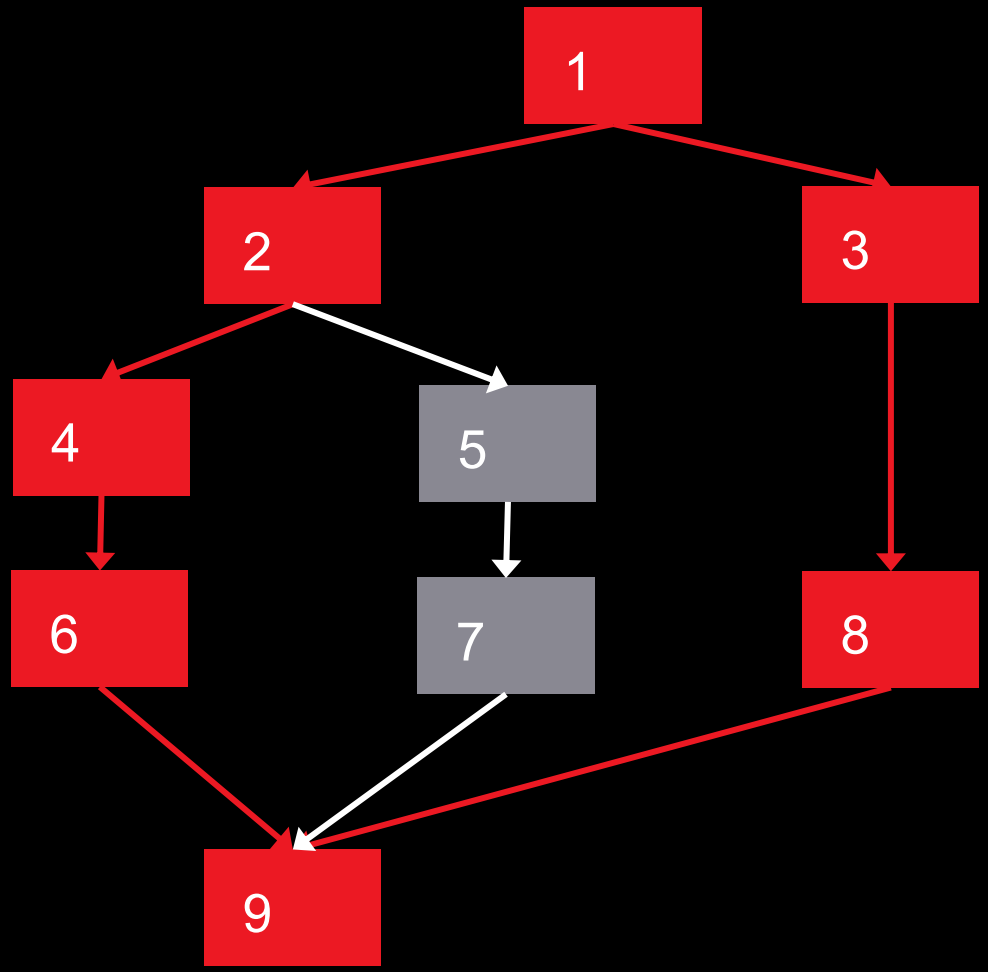
How bad is missing a region?

There is a region pass in the legacy pass manager

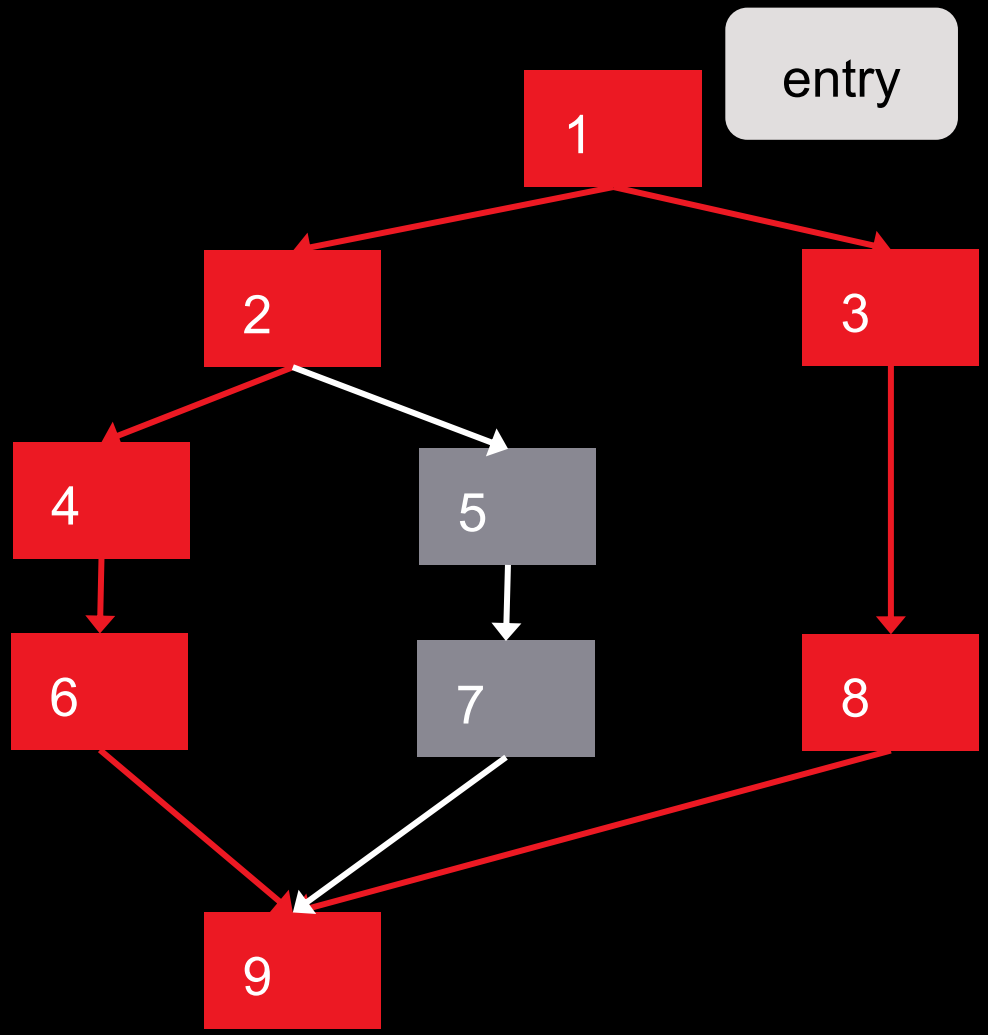
Was it really an interaction bug?

How does region info analysis works

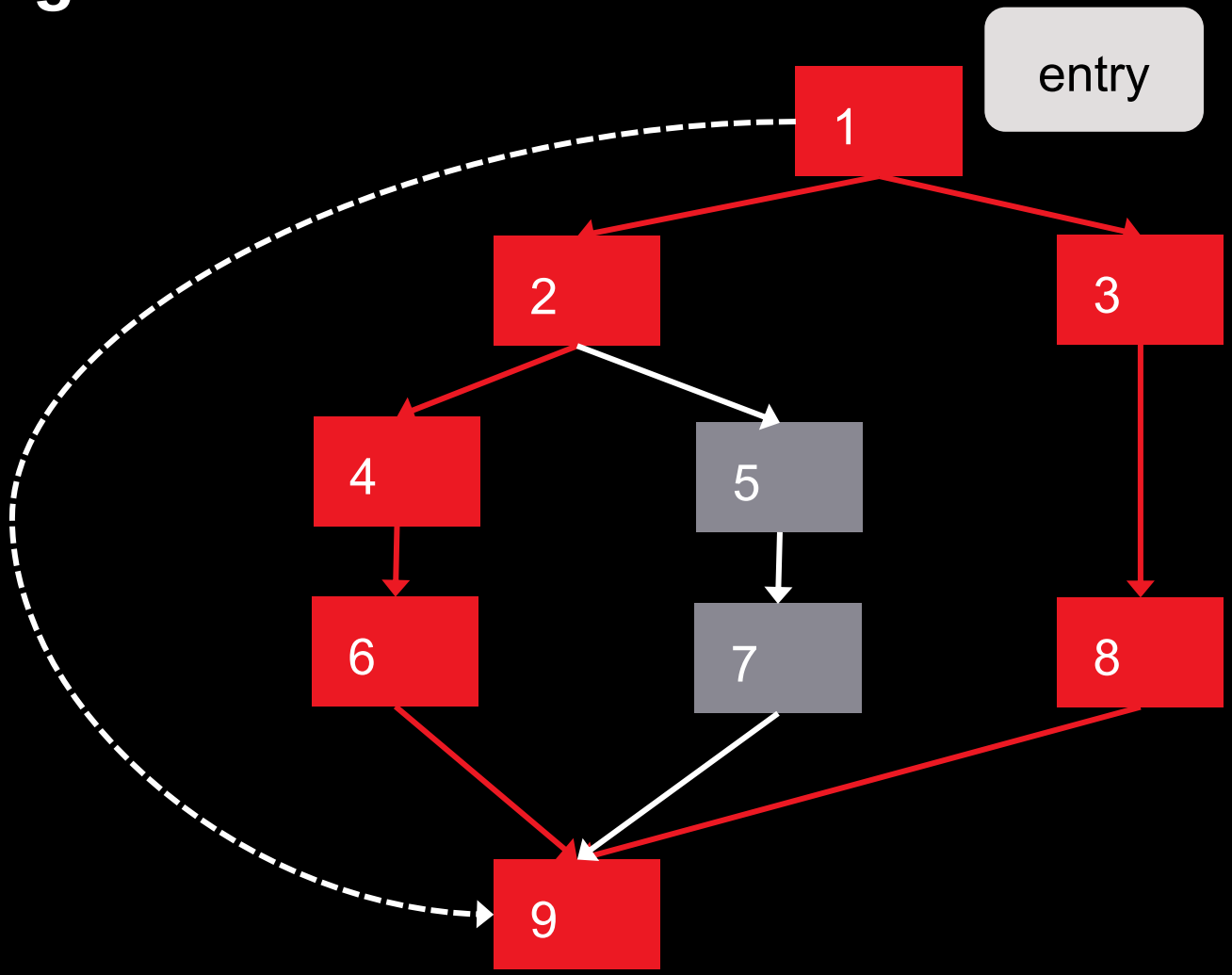
Is it a region?



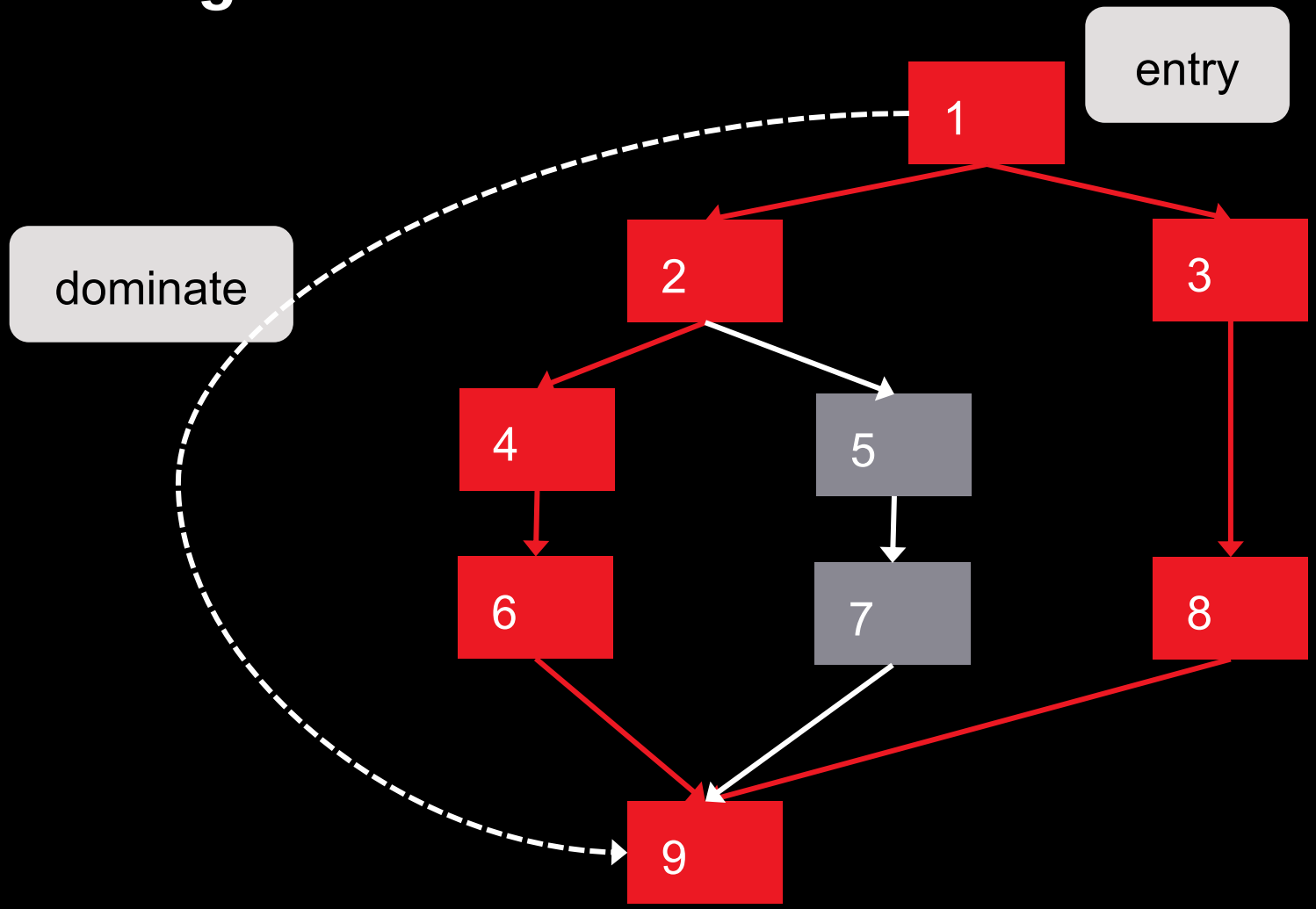
Is it a region?



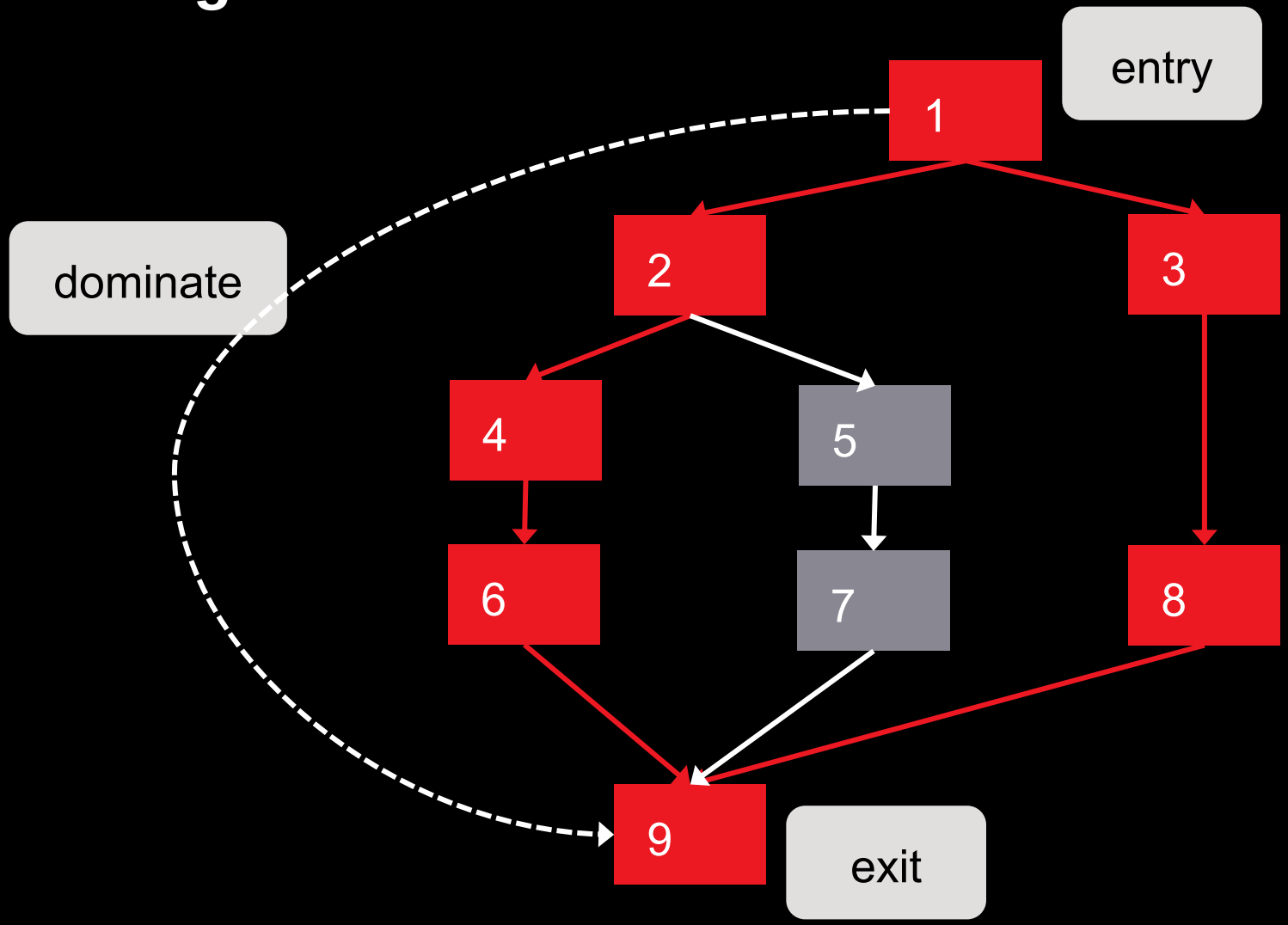
Is it a region?



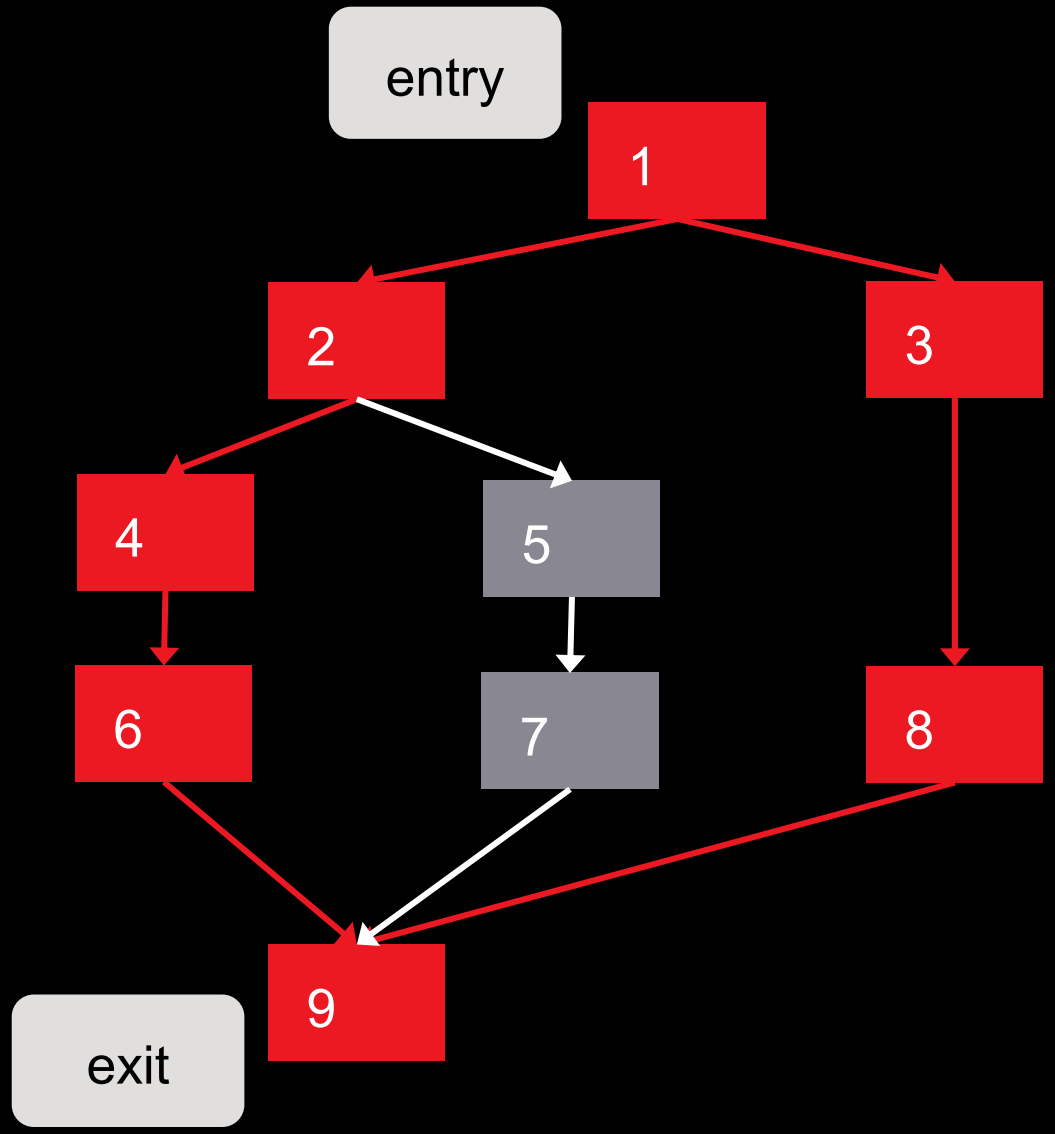
Is it a region?



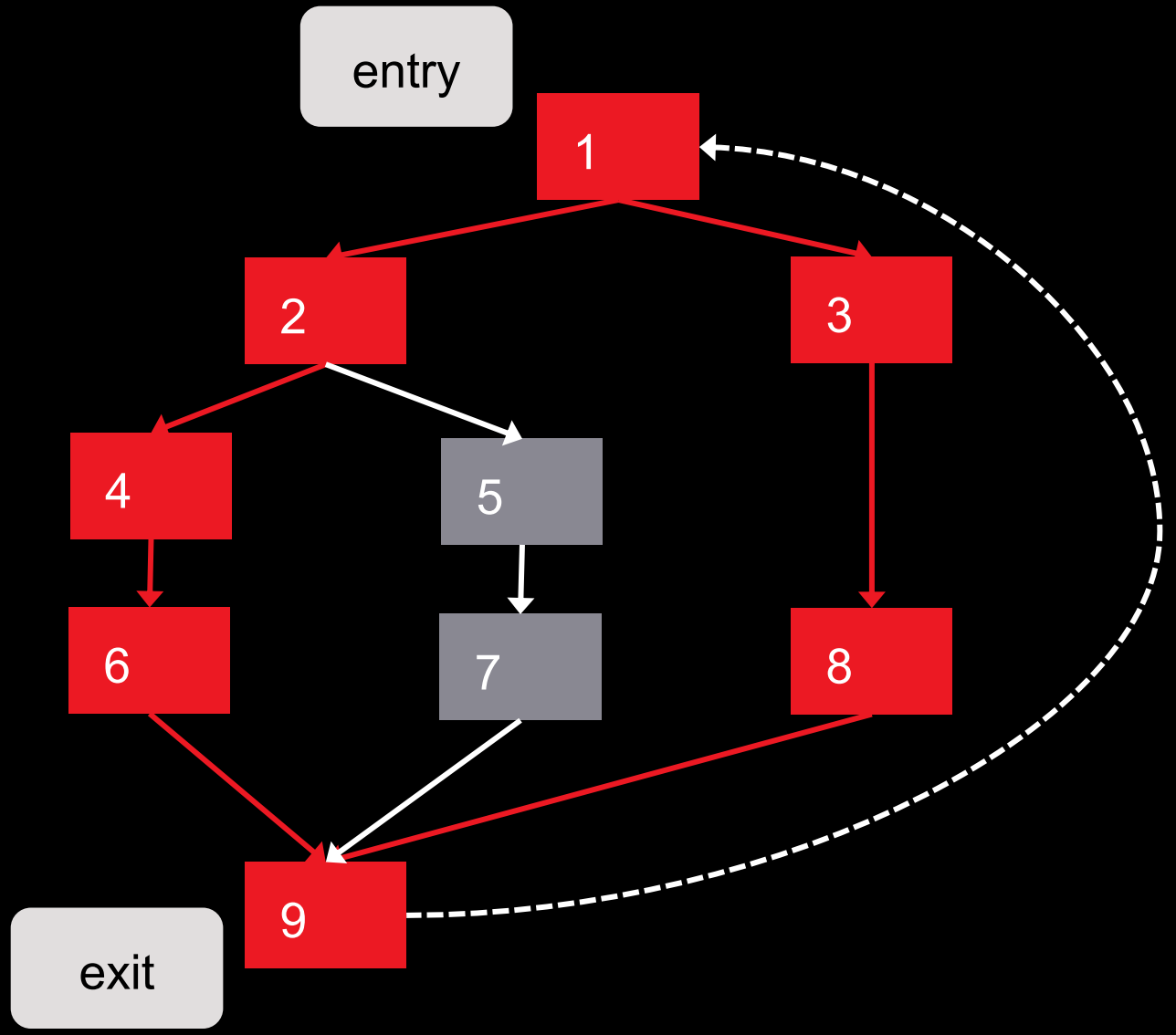
Is it a region?



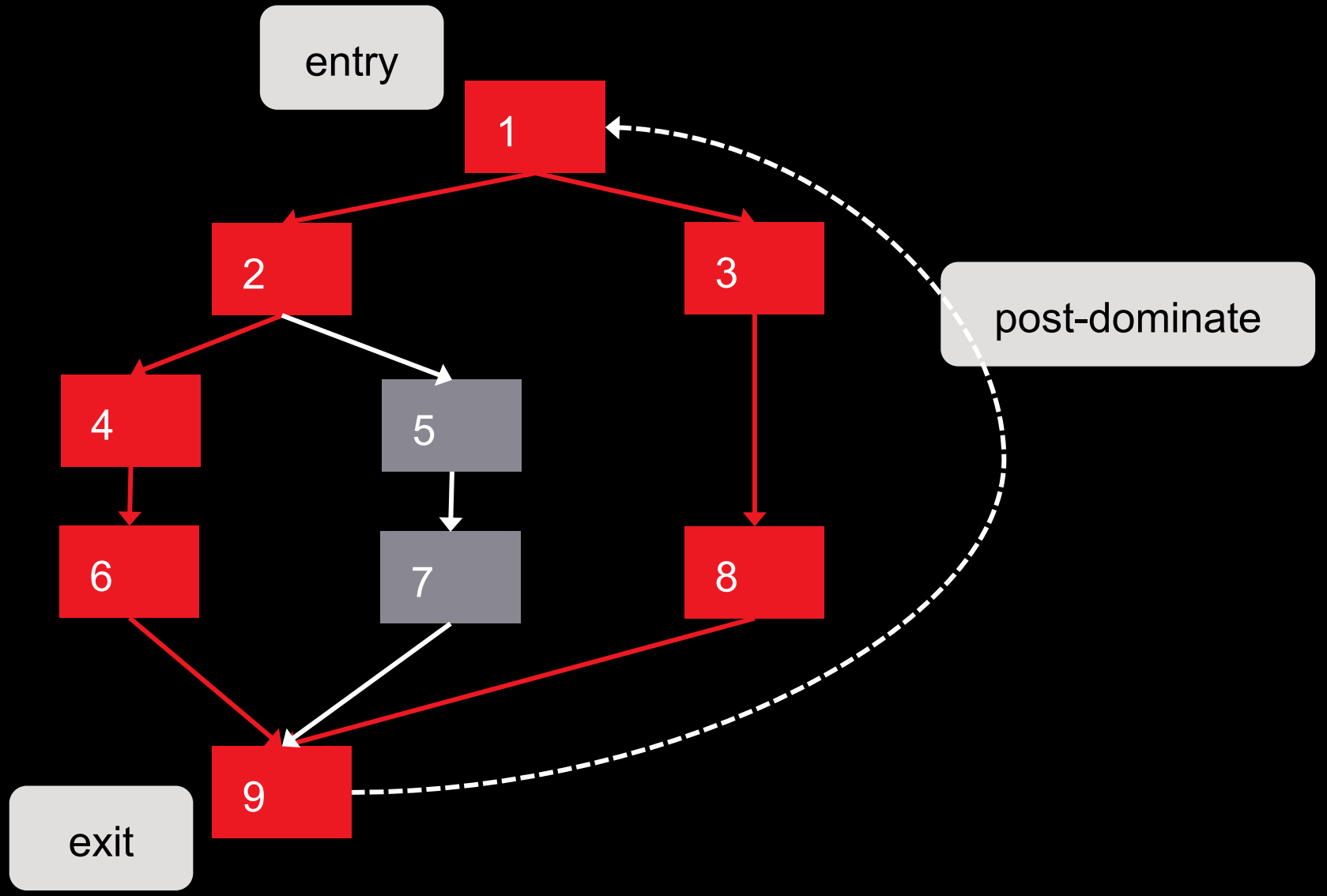
Is it a region?



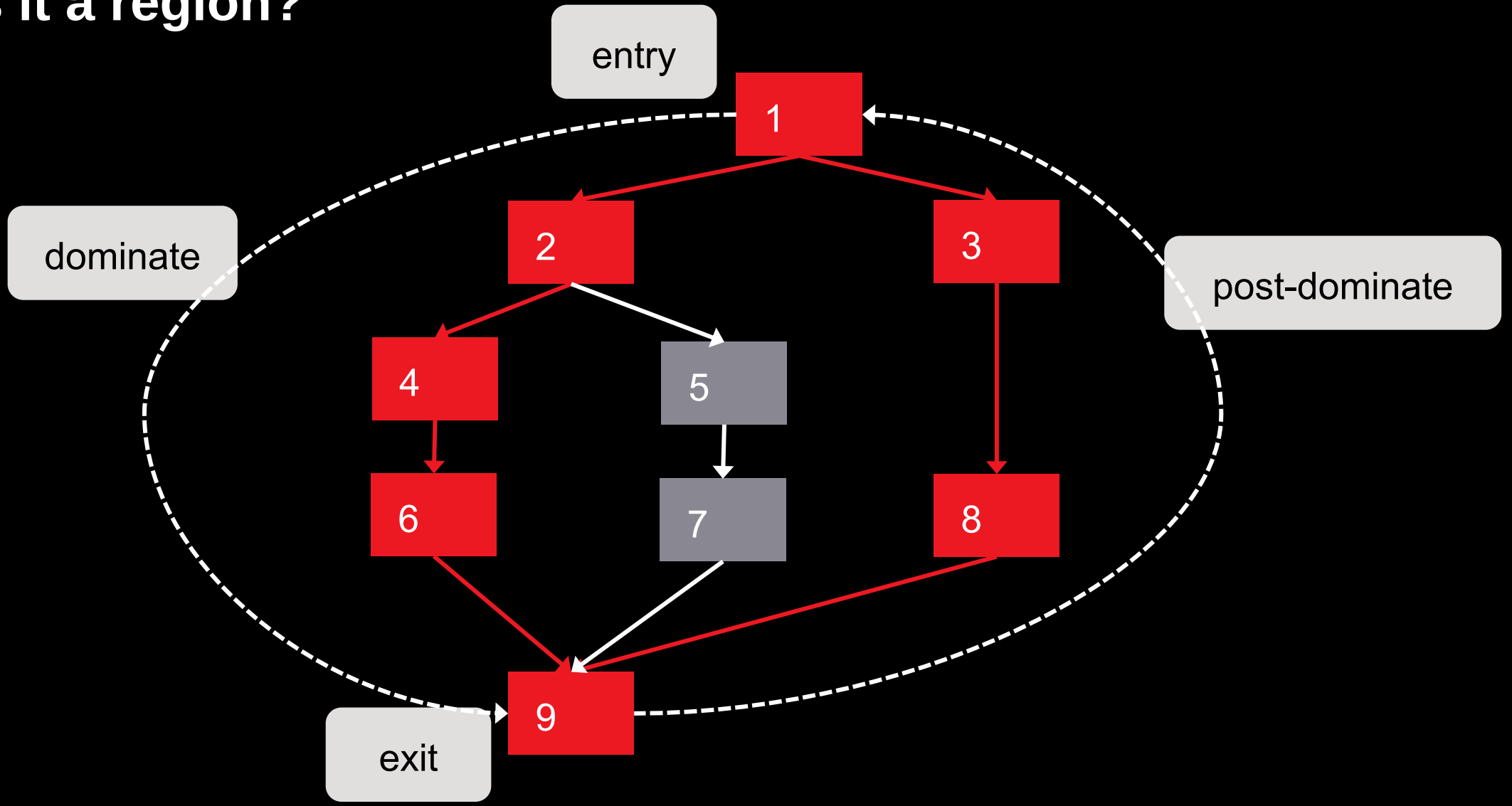
Is it a region?



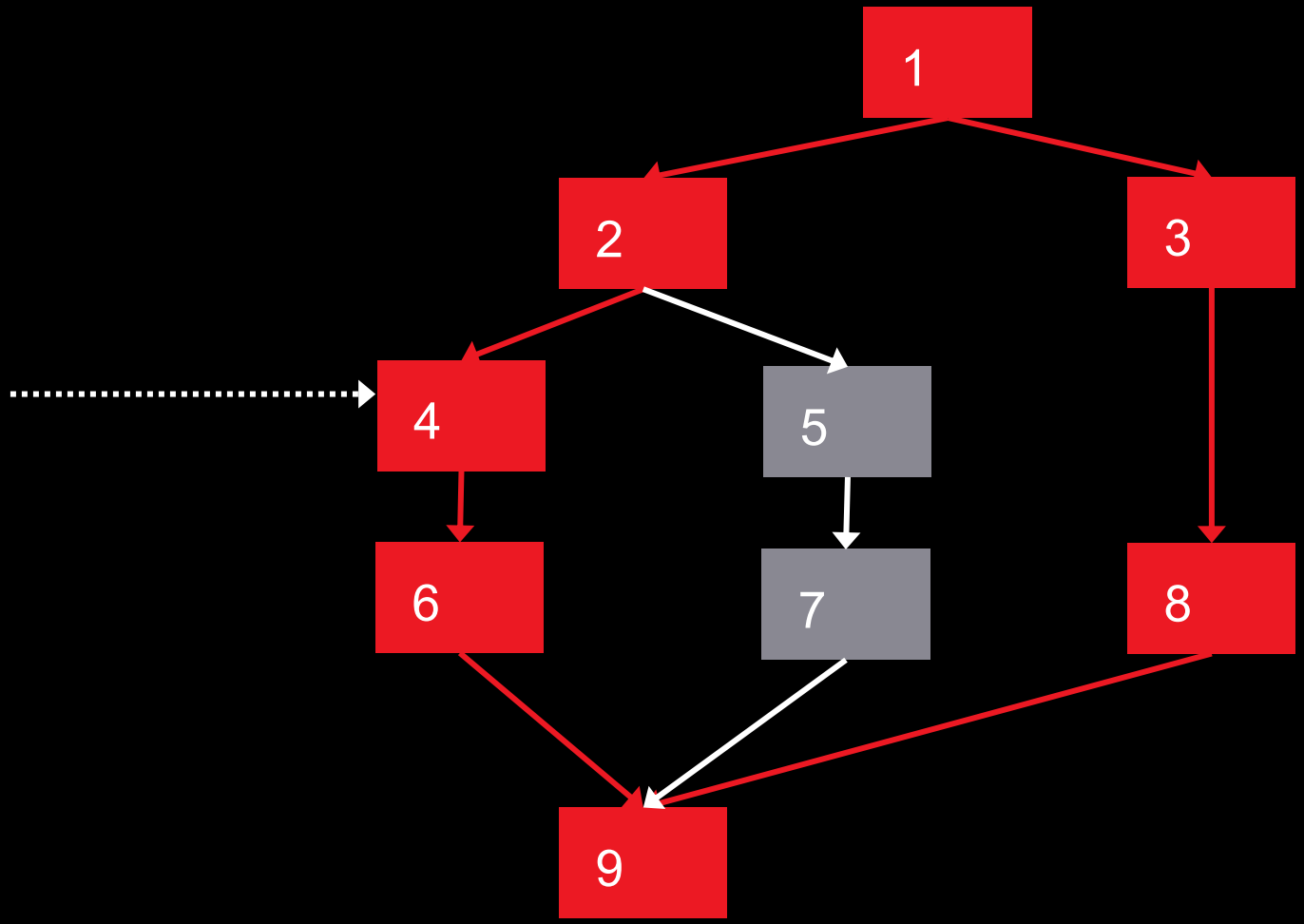
Is it a region?



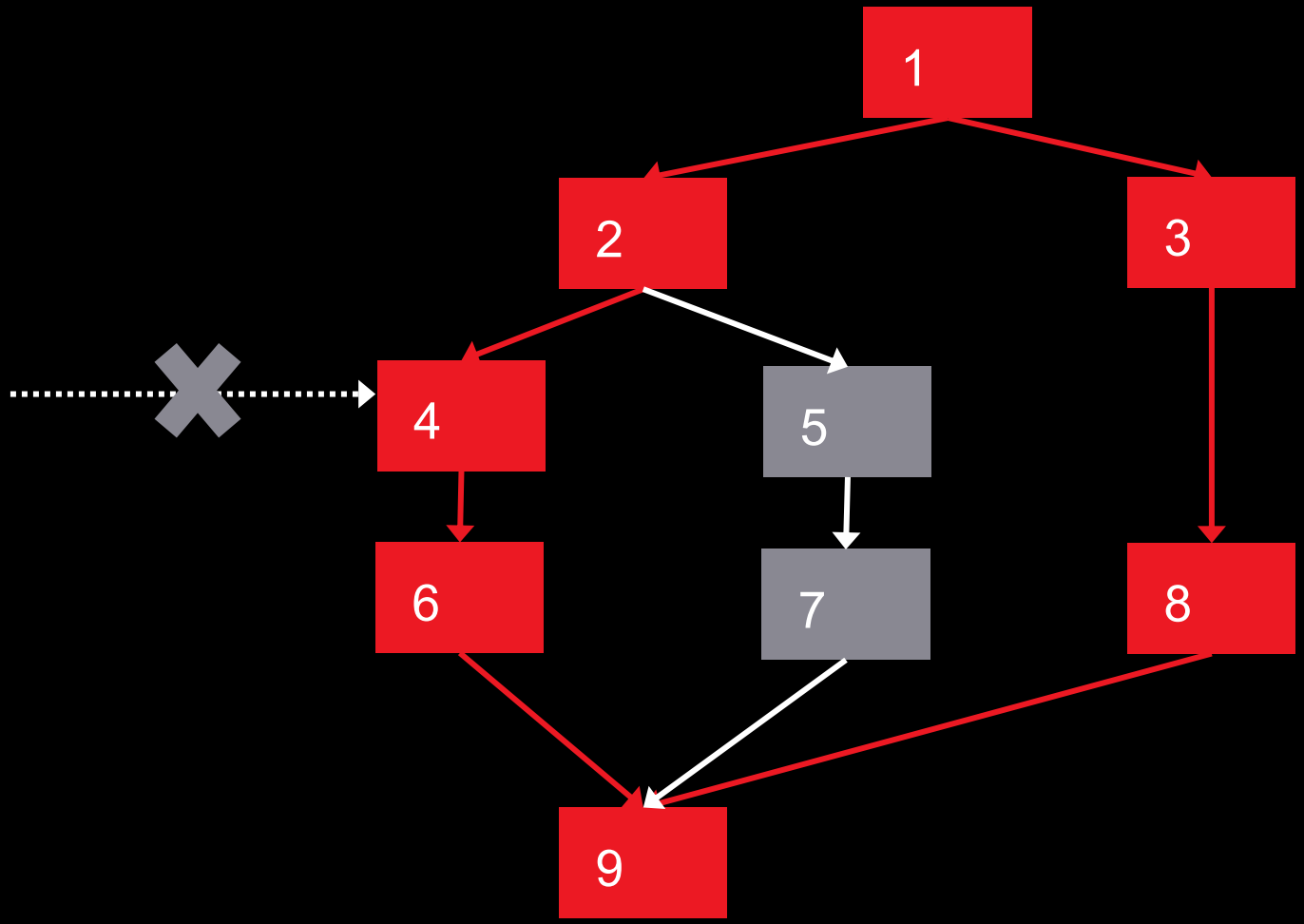
Is it a region?



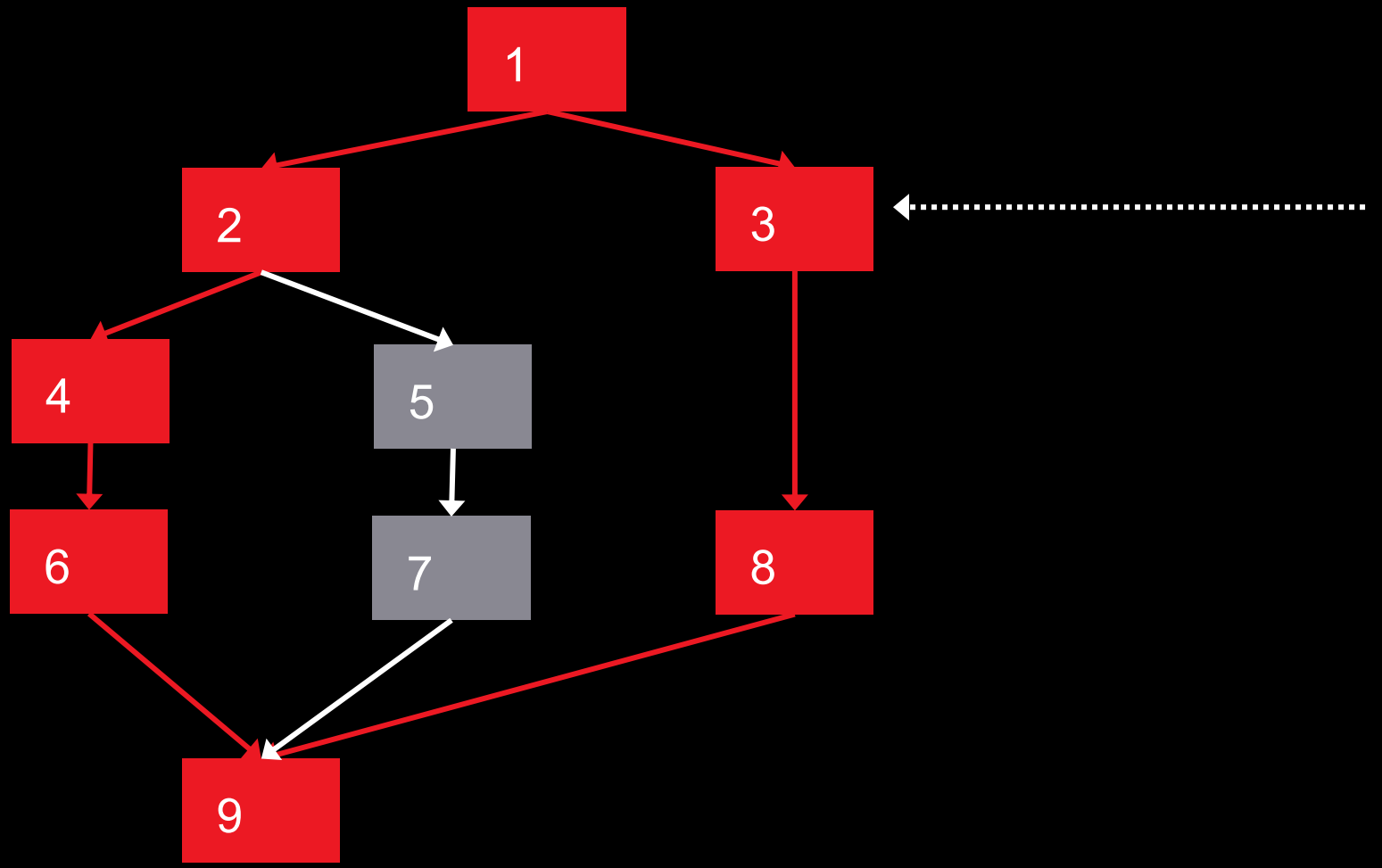
Is it a region?



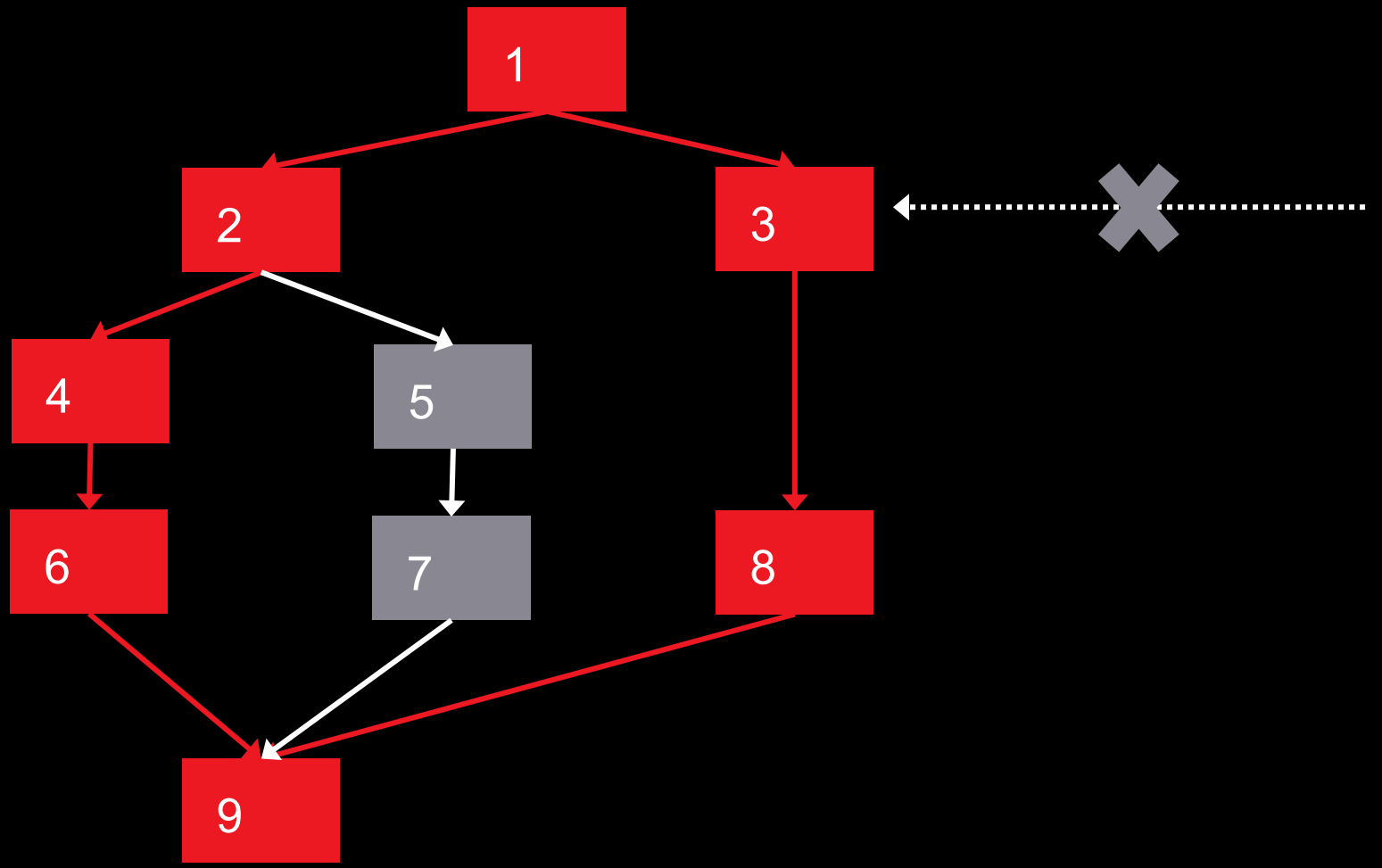
Is it a region?



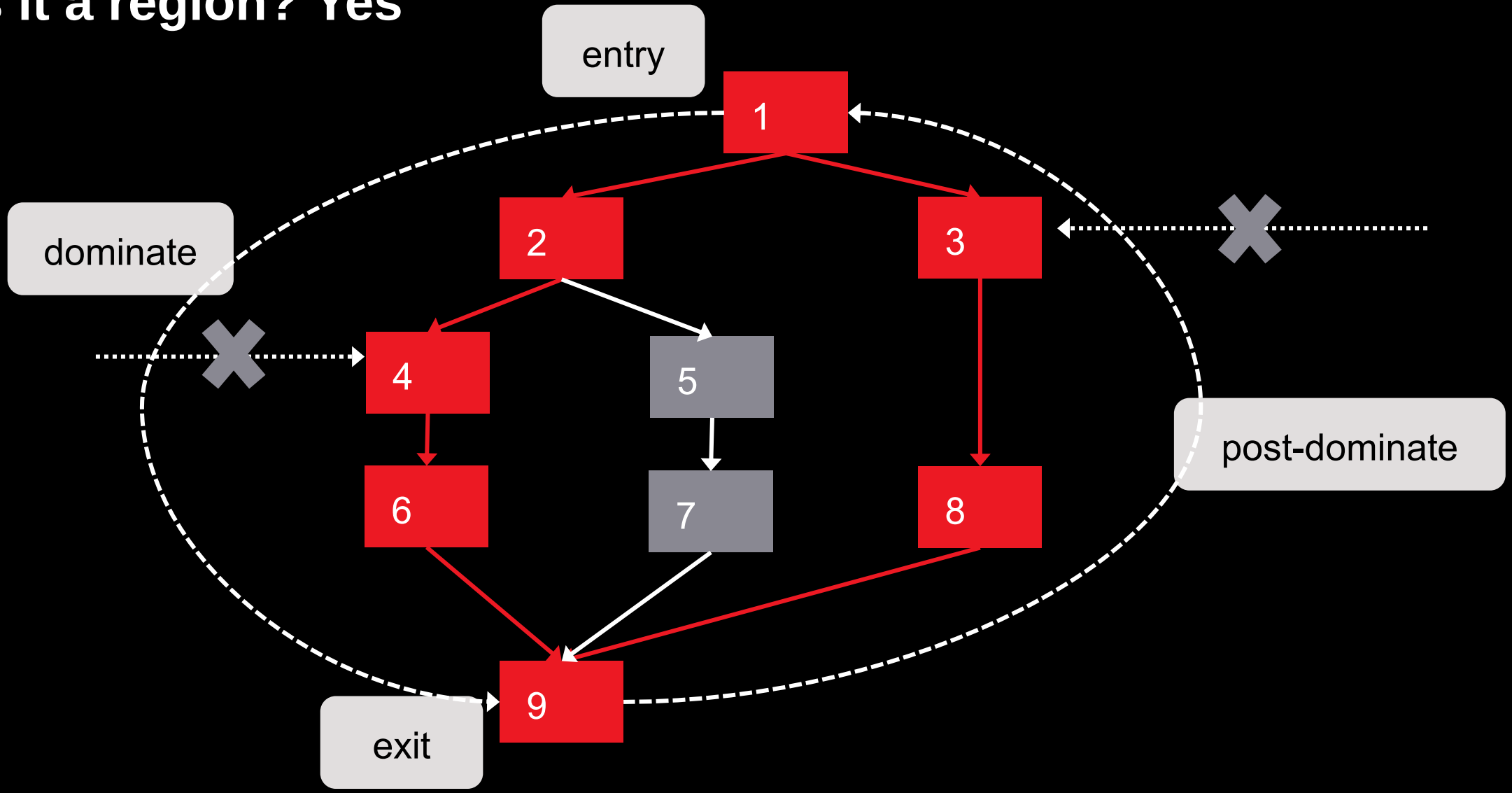
Is it a region?



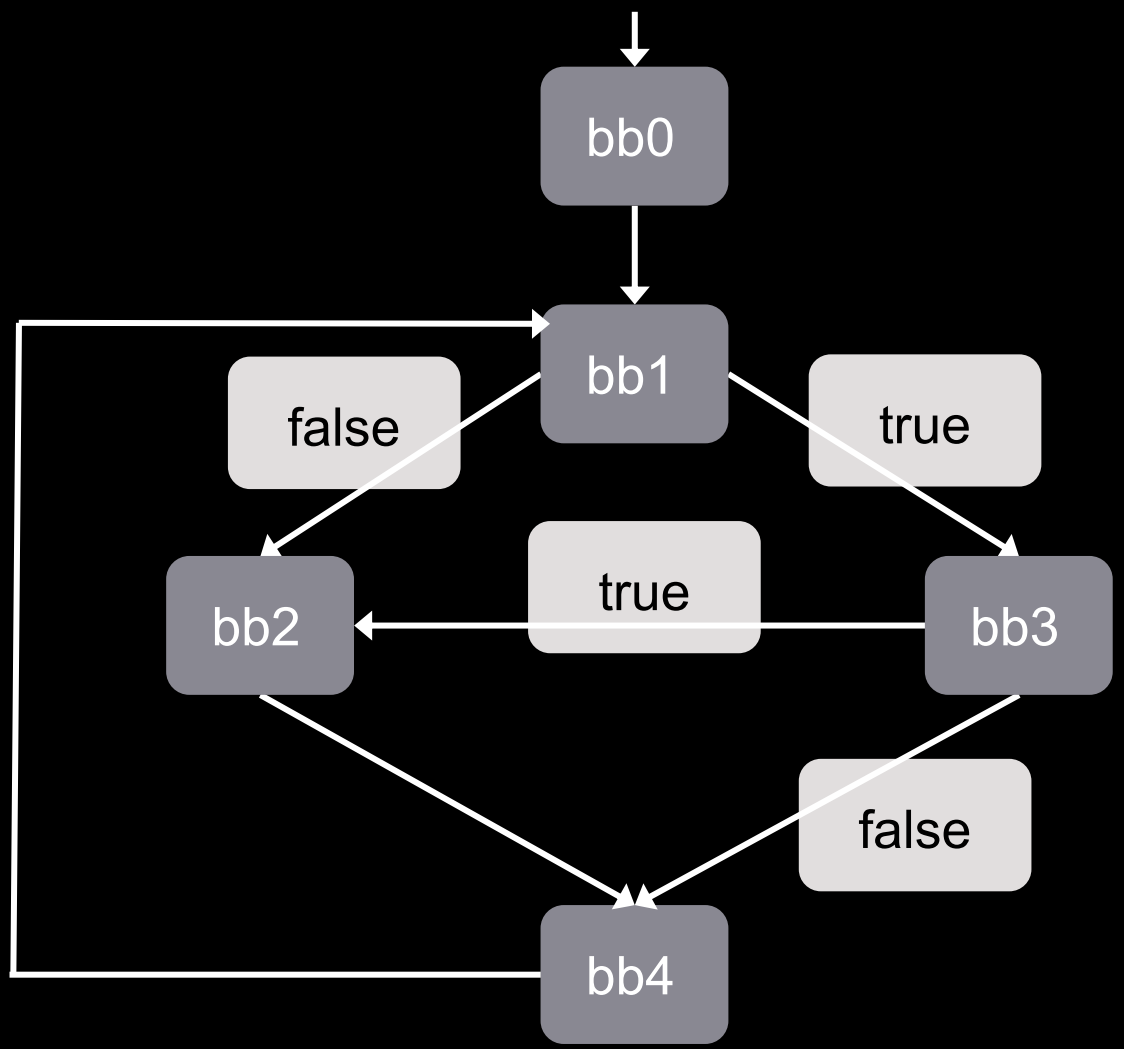
Is it a region?

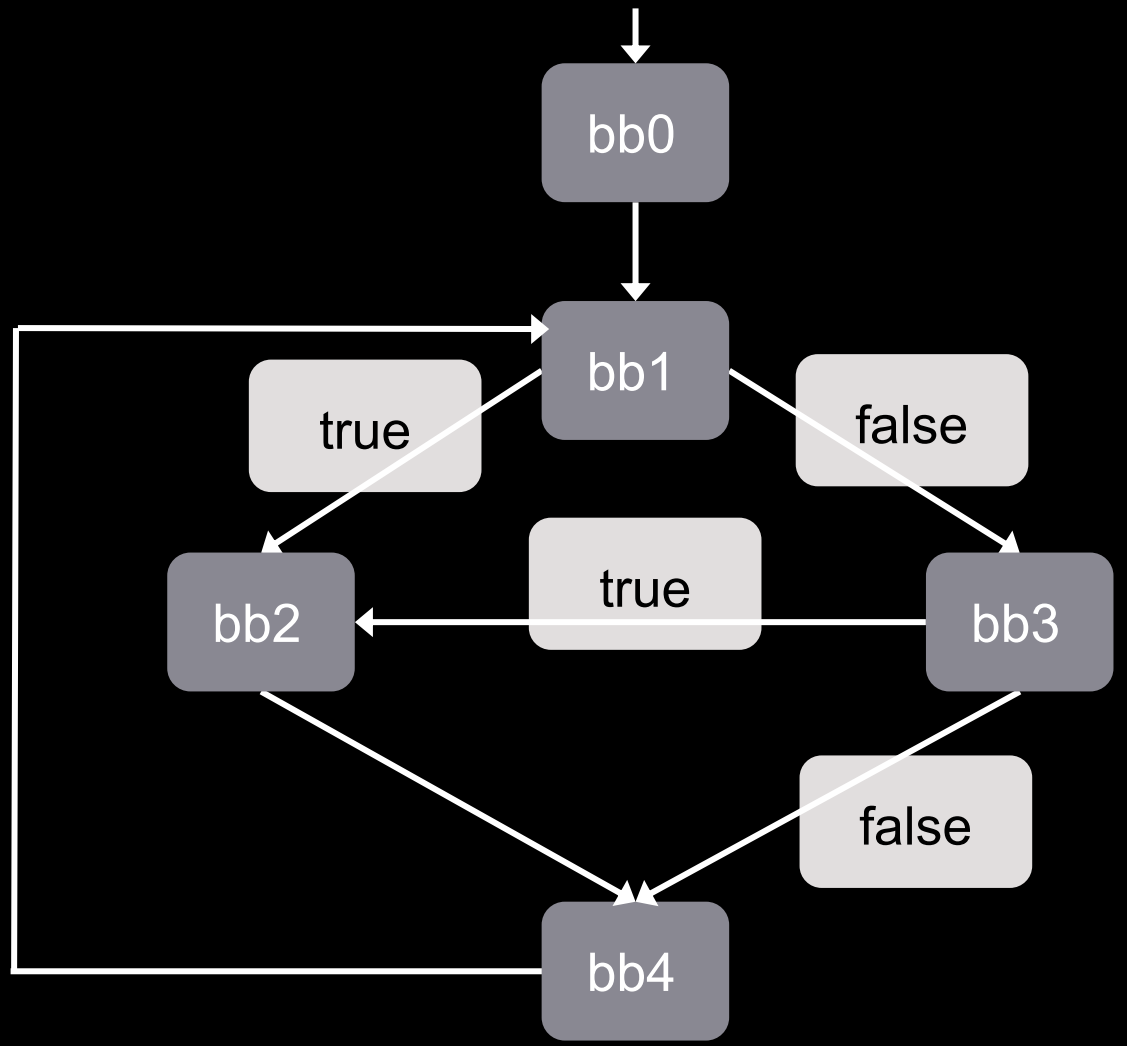


Is it a region? Yes

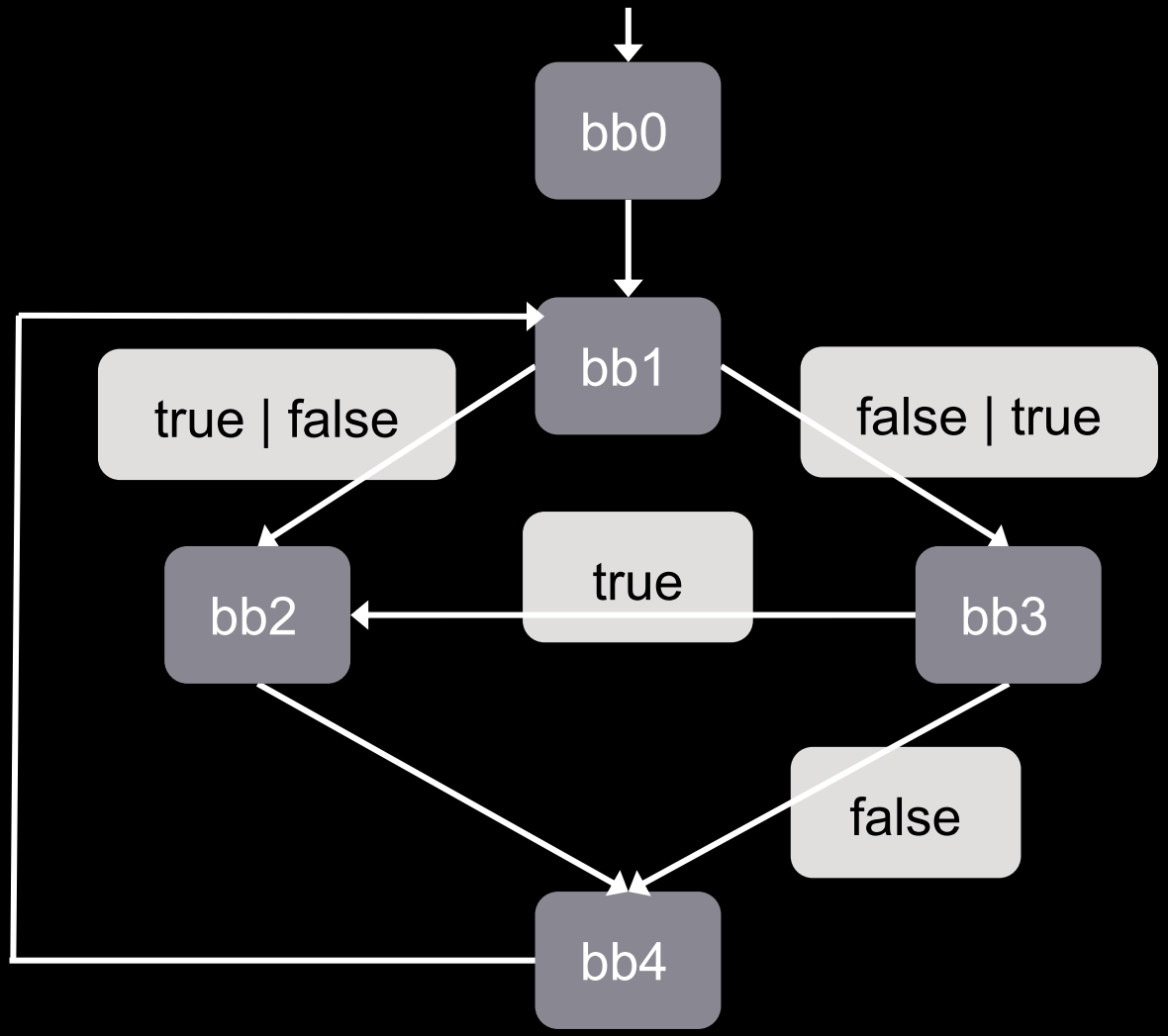


The test case and the analyses results

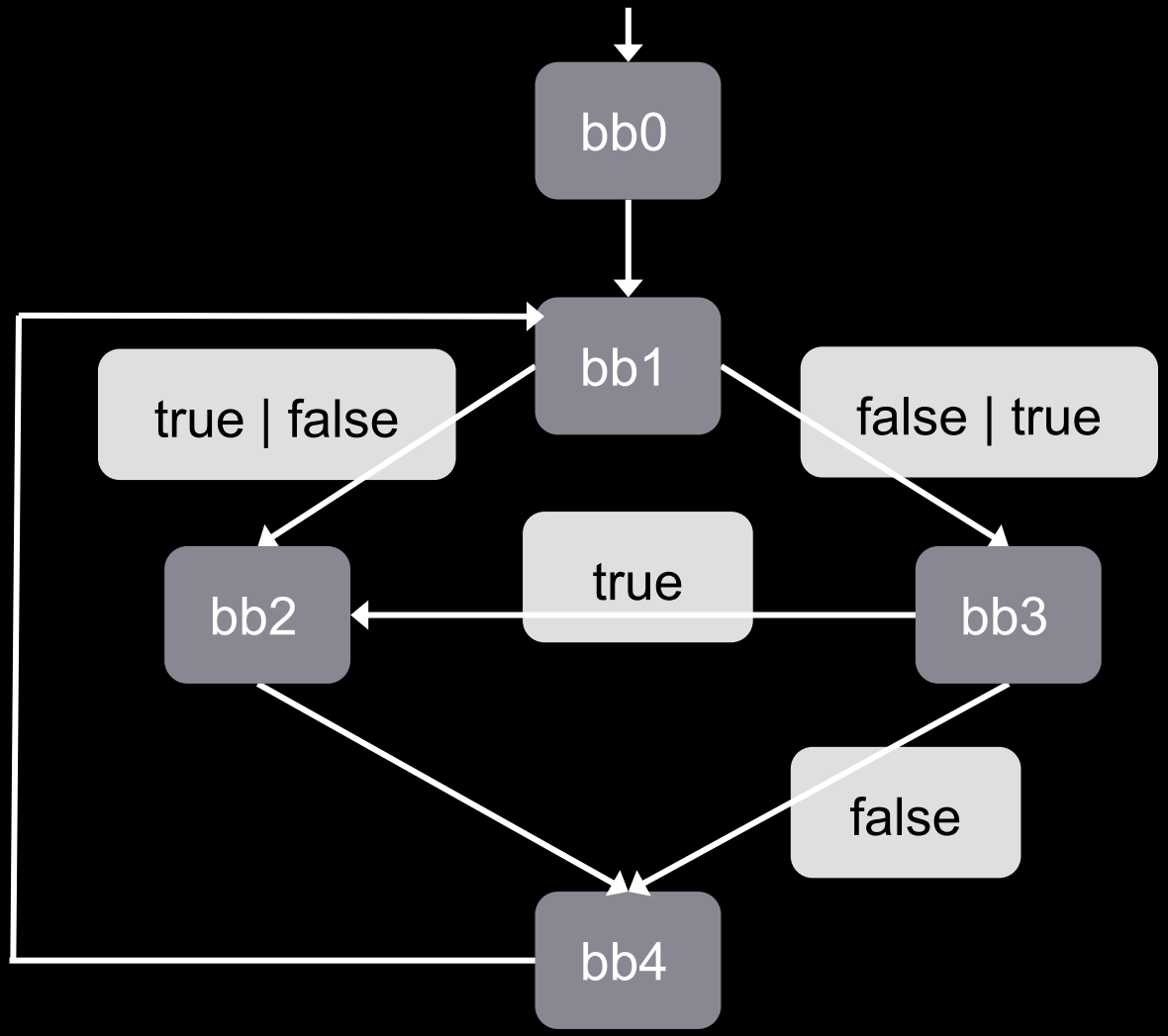




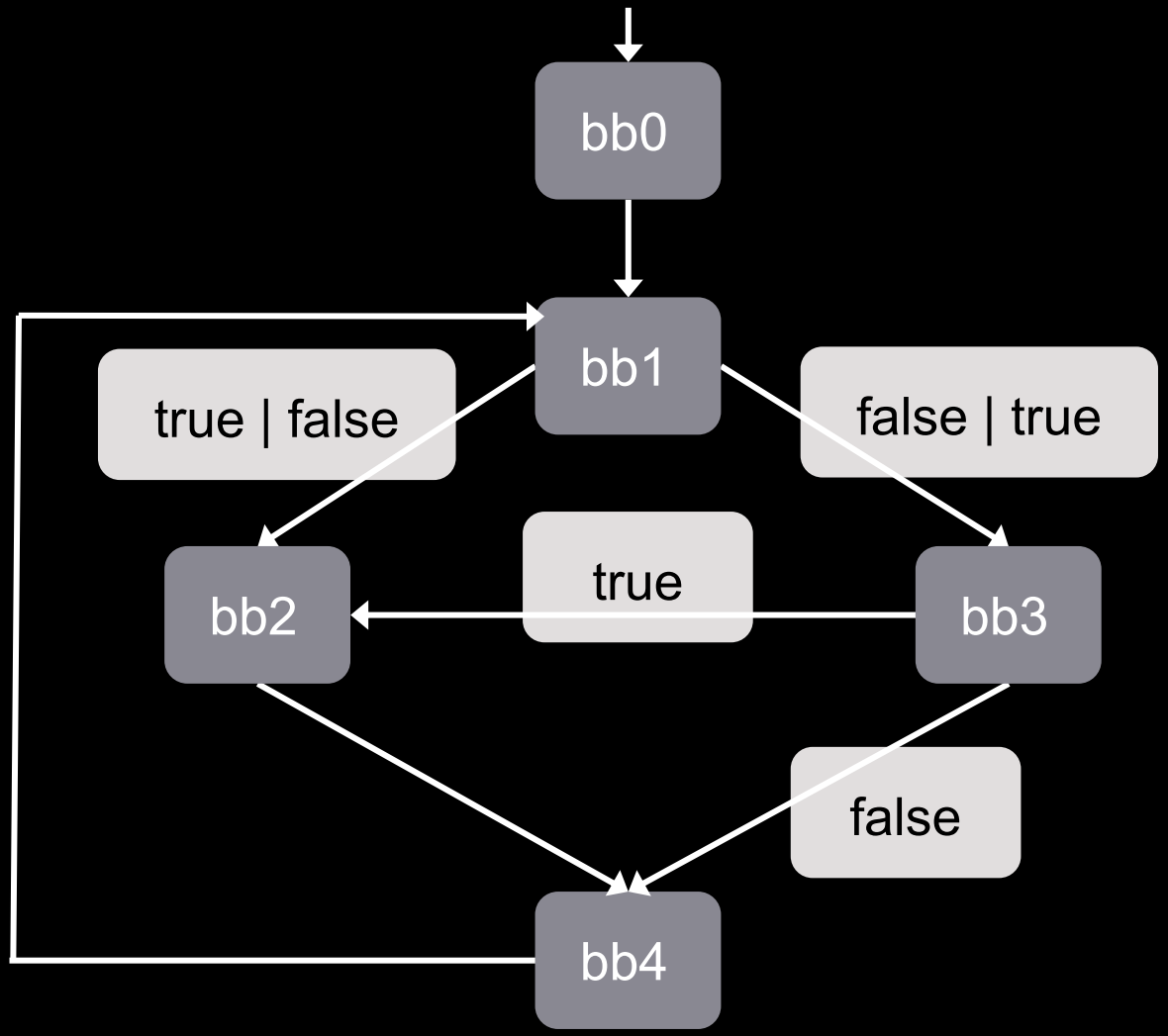
The test case and the analyses results

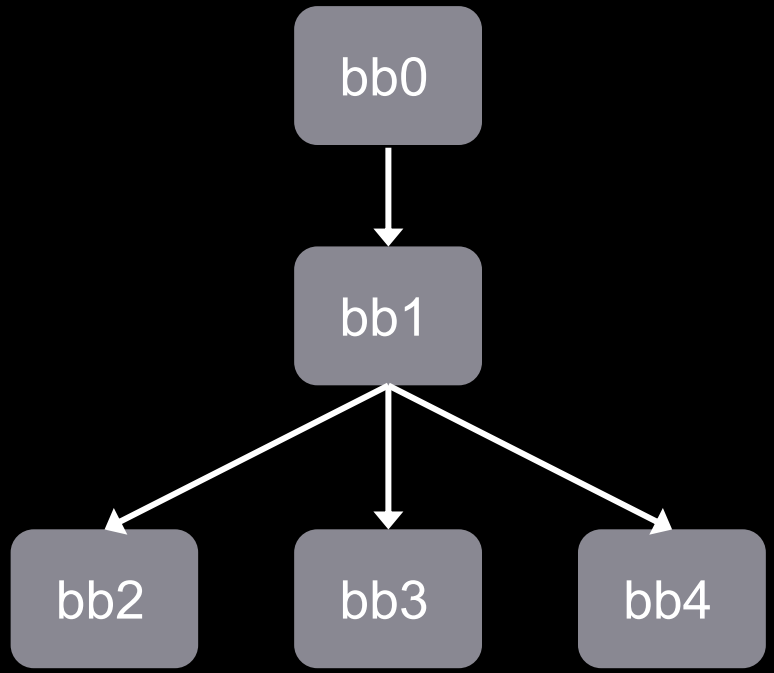


The test case and the dominator tree

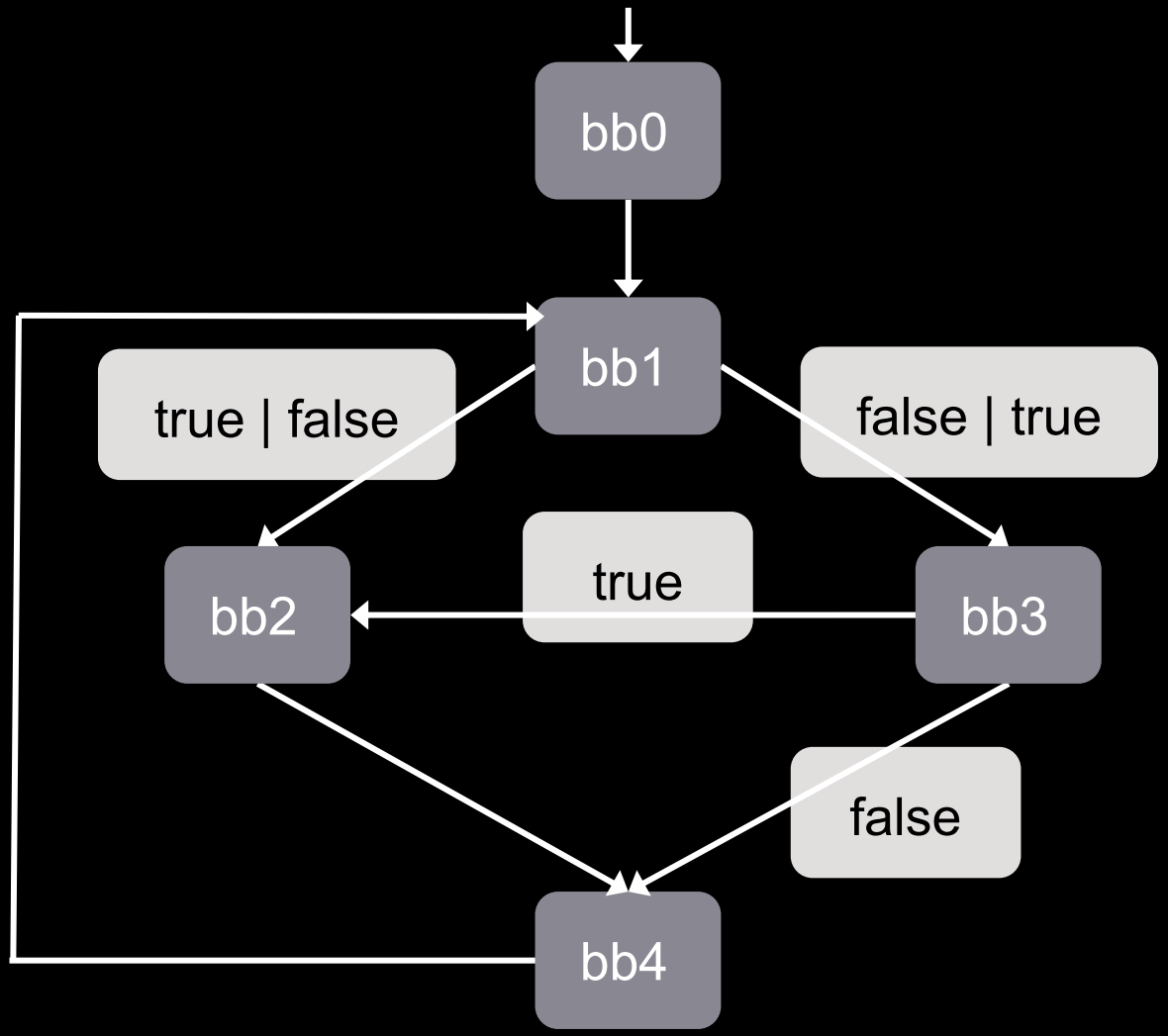


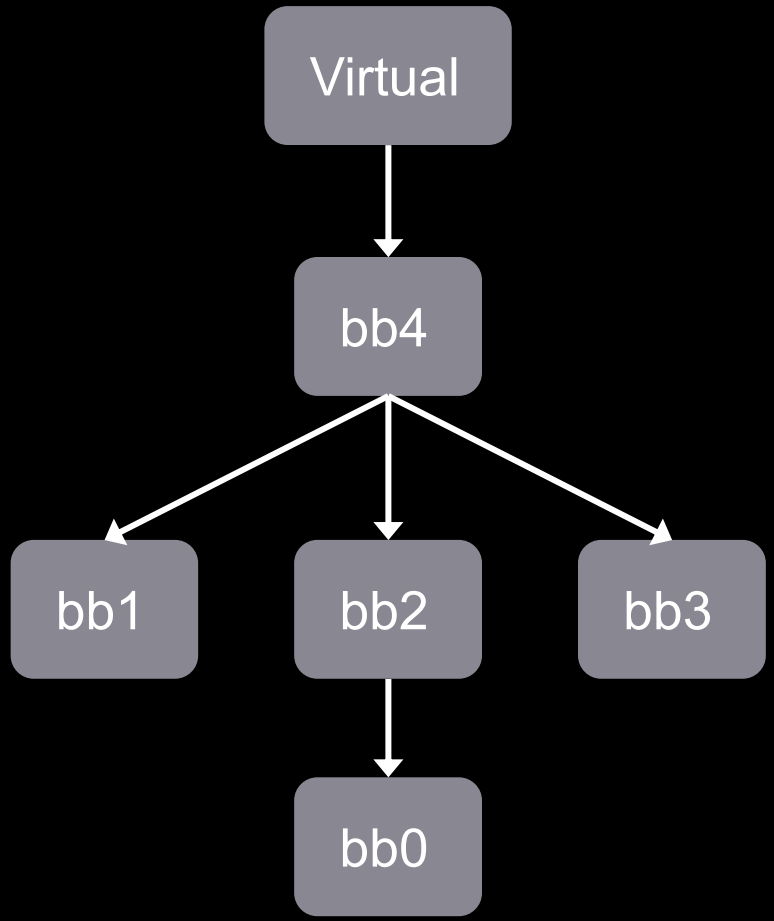
The test case and the dominator tree



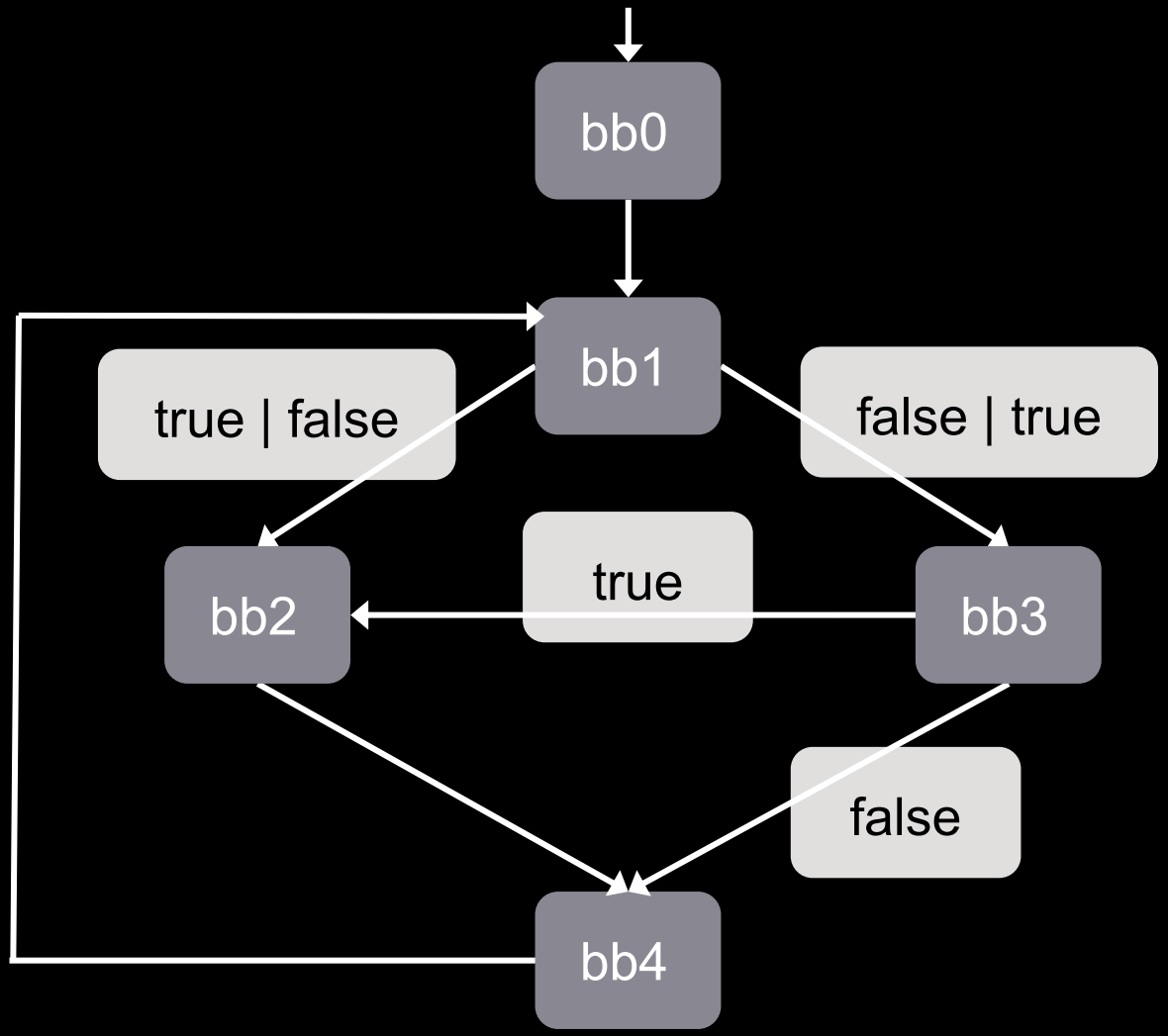


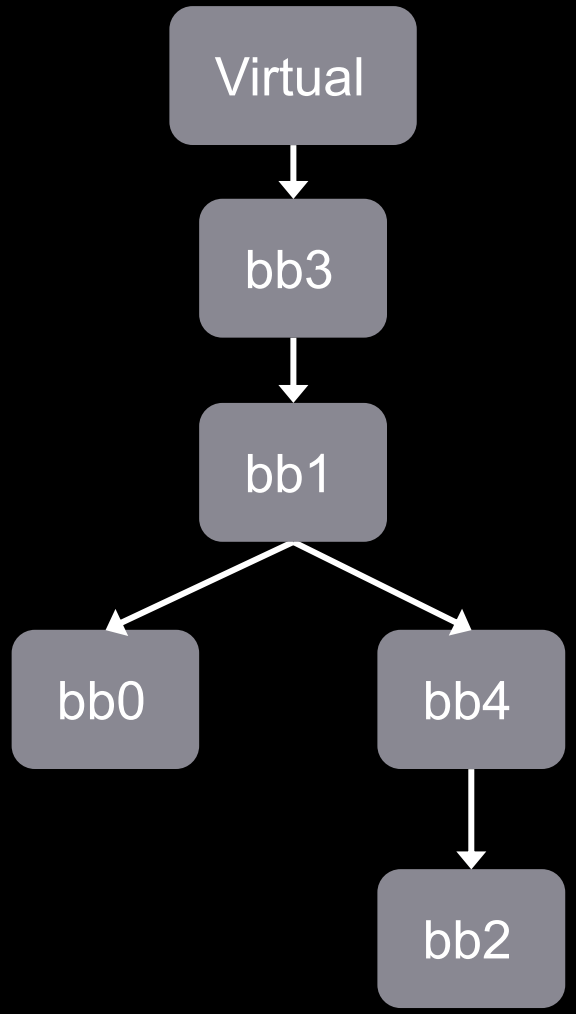
The test case and the post dominator tree



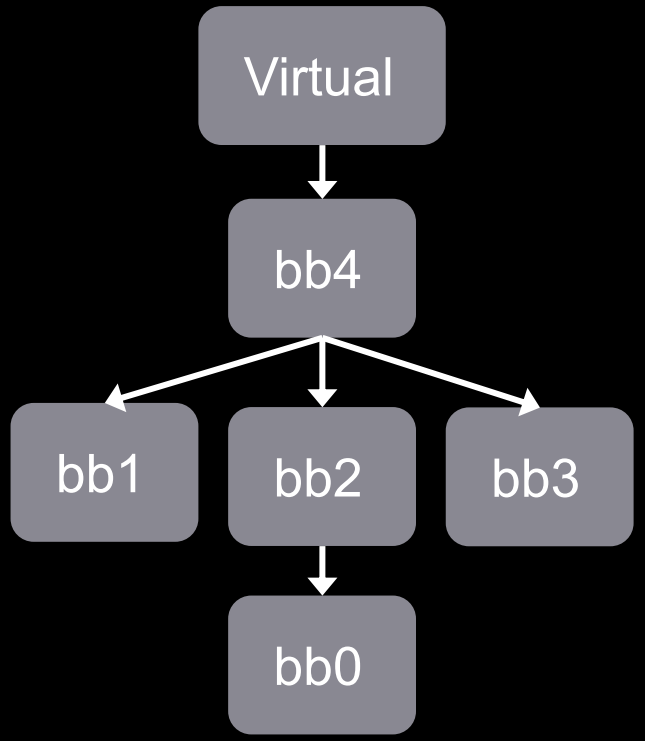


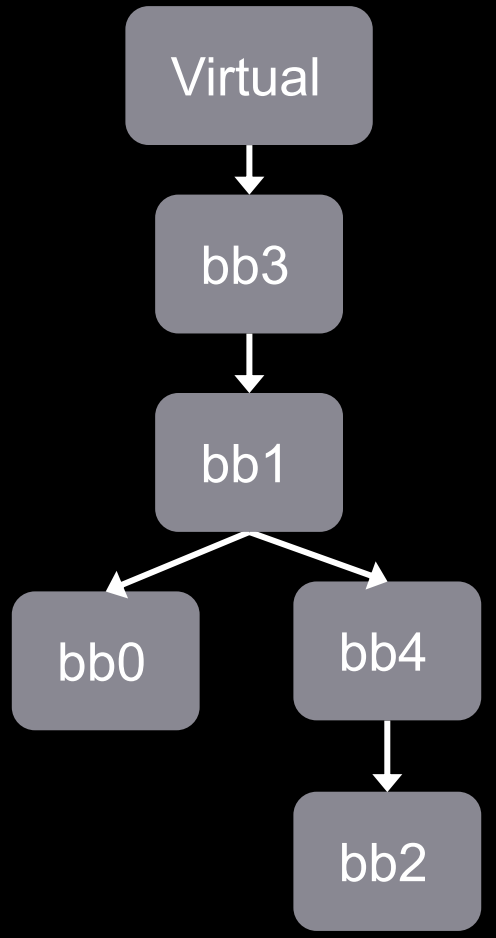
The test case and the post dominator tree (again)



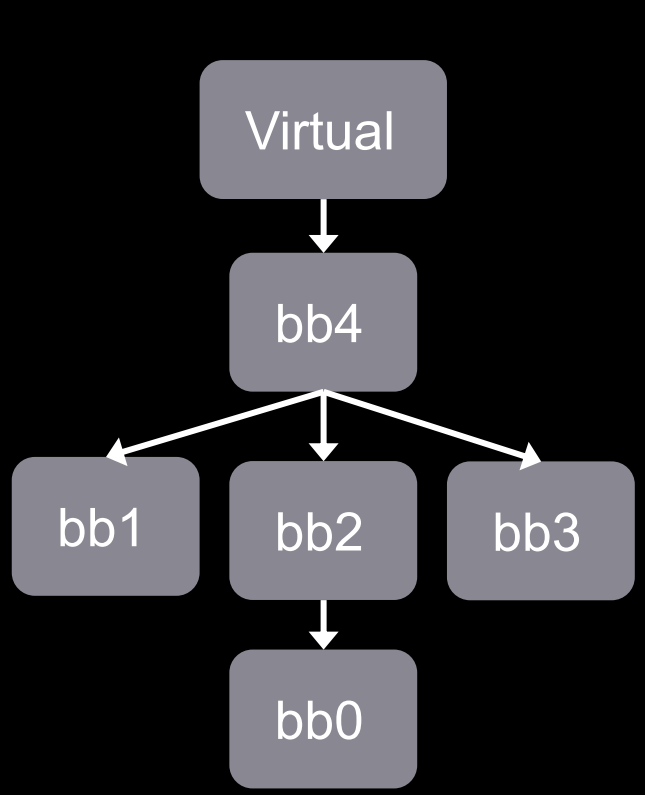


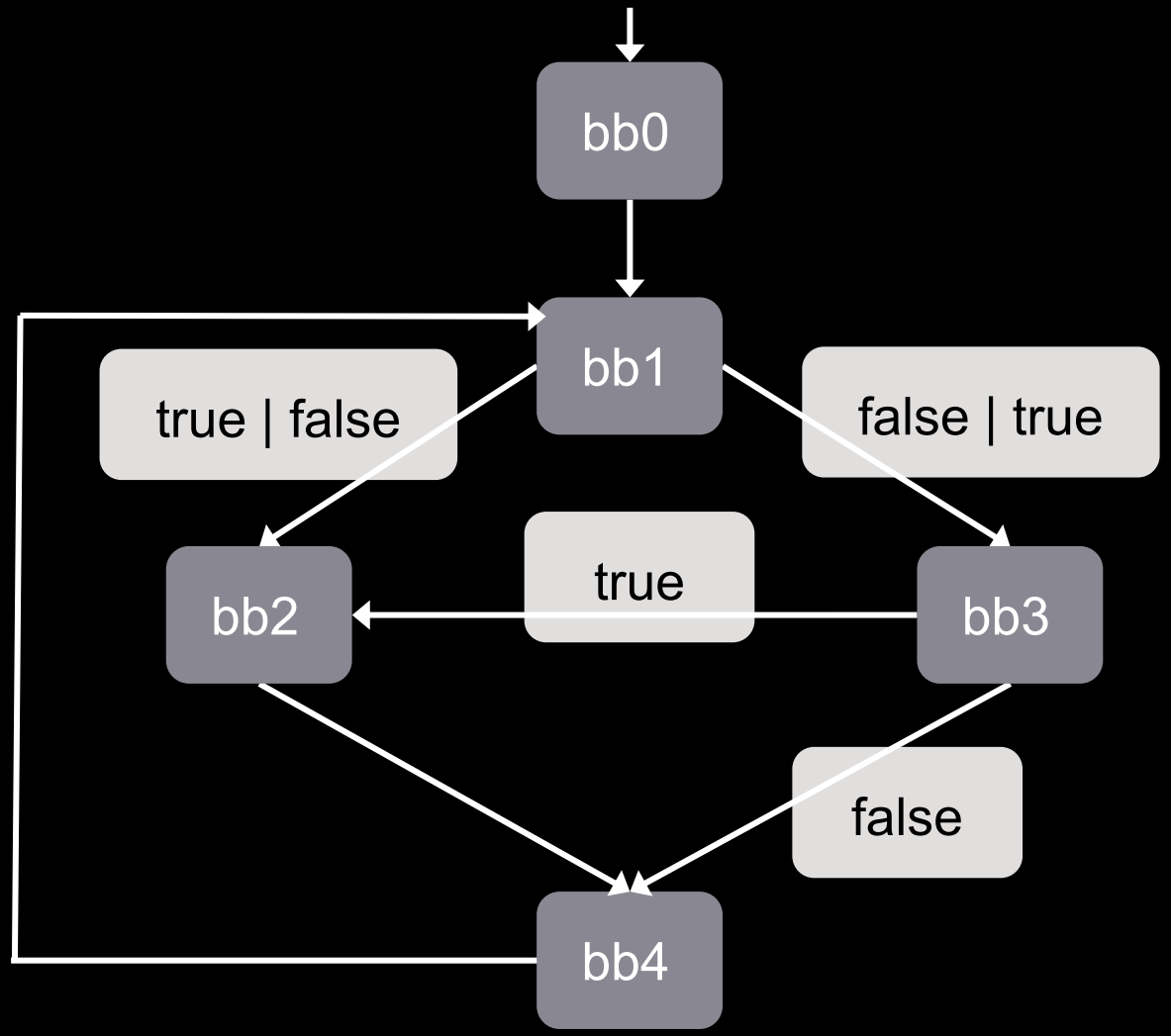
Two legal post dominator trees

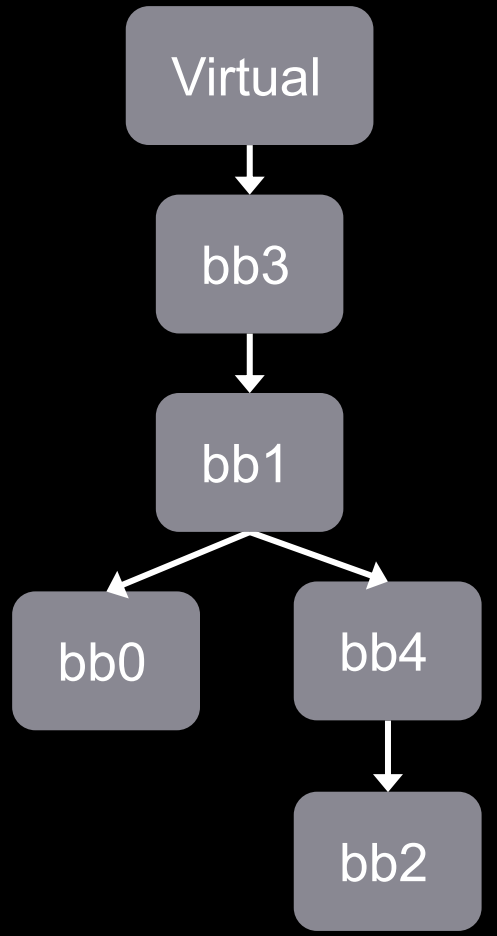




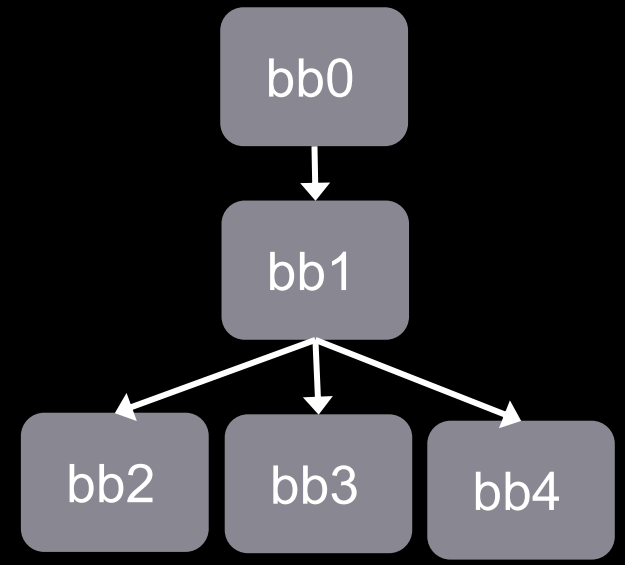
Two legal post dominator trees



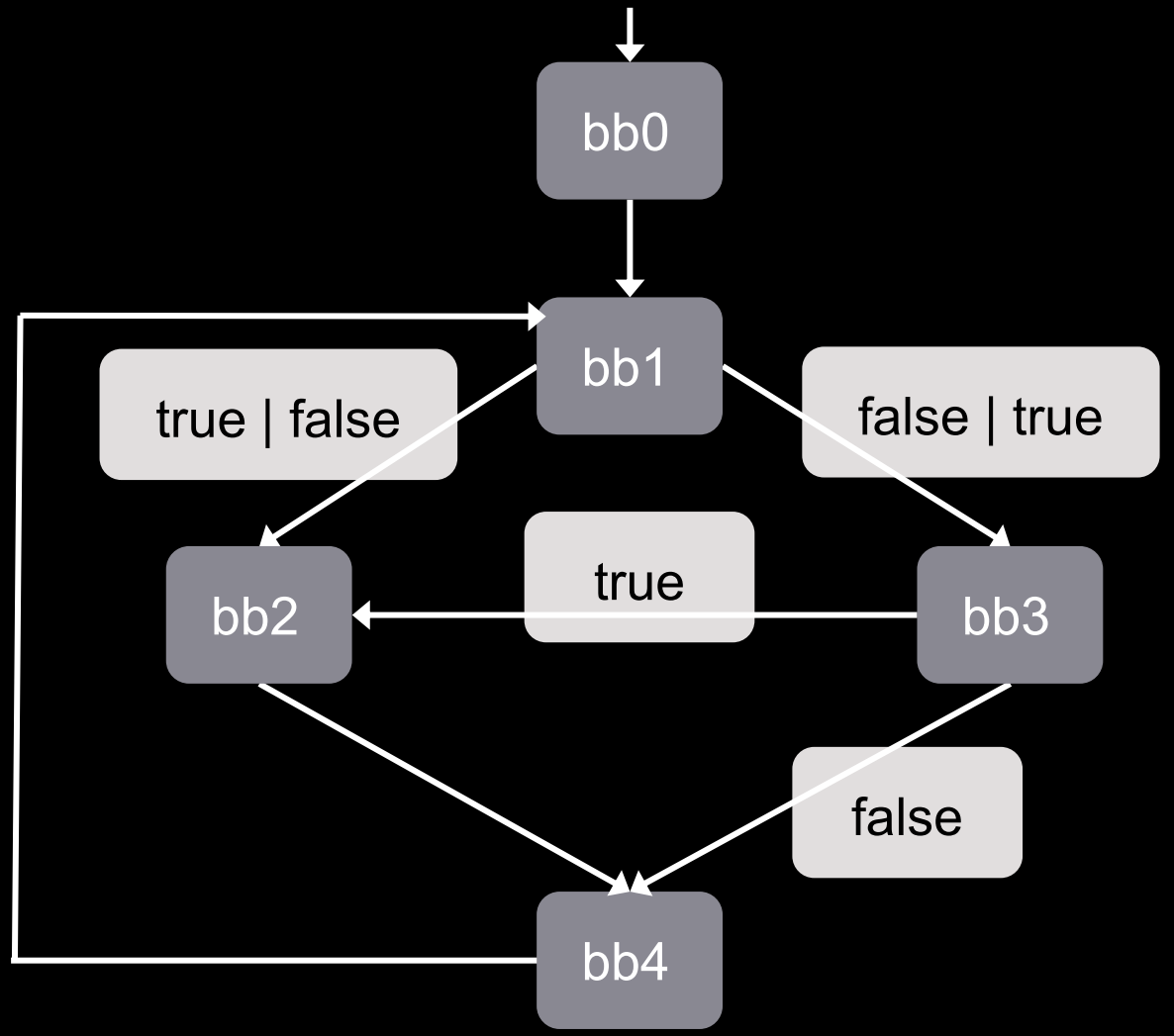


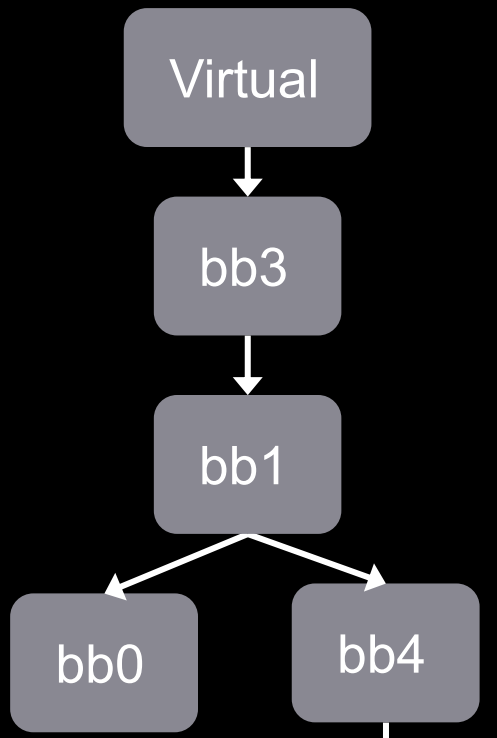


Test cases and analyses



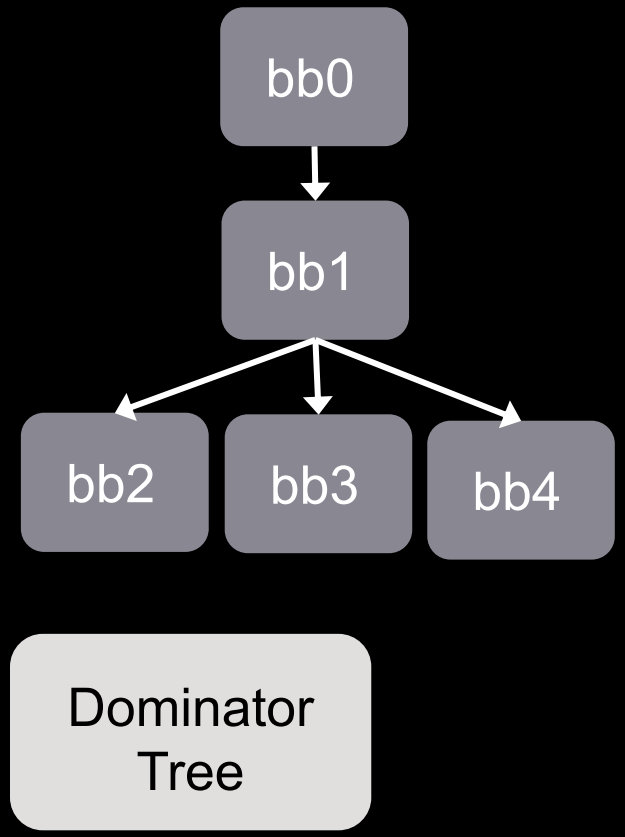
Dominator Tree

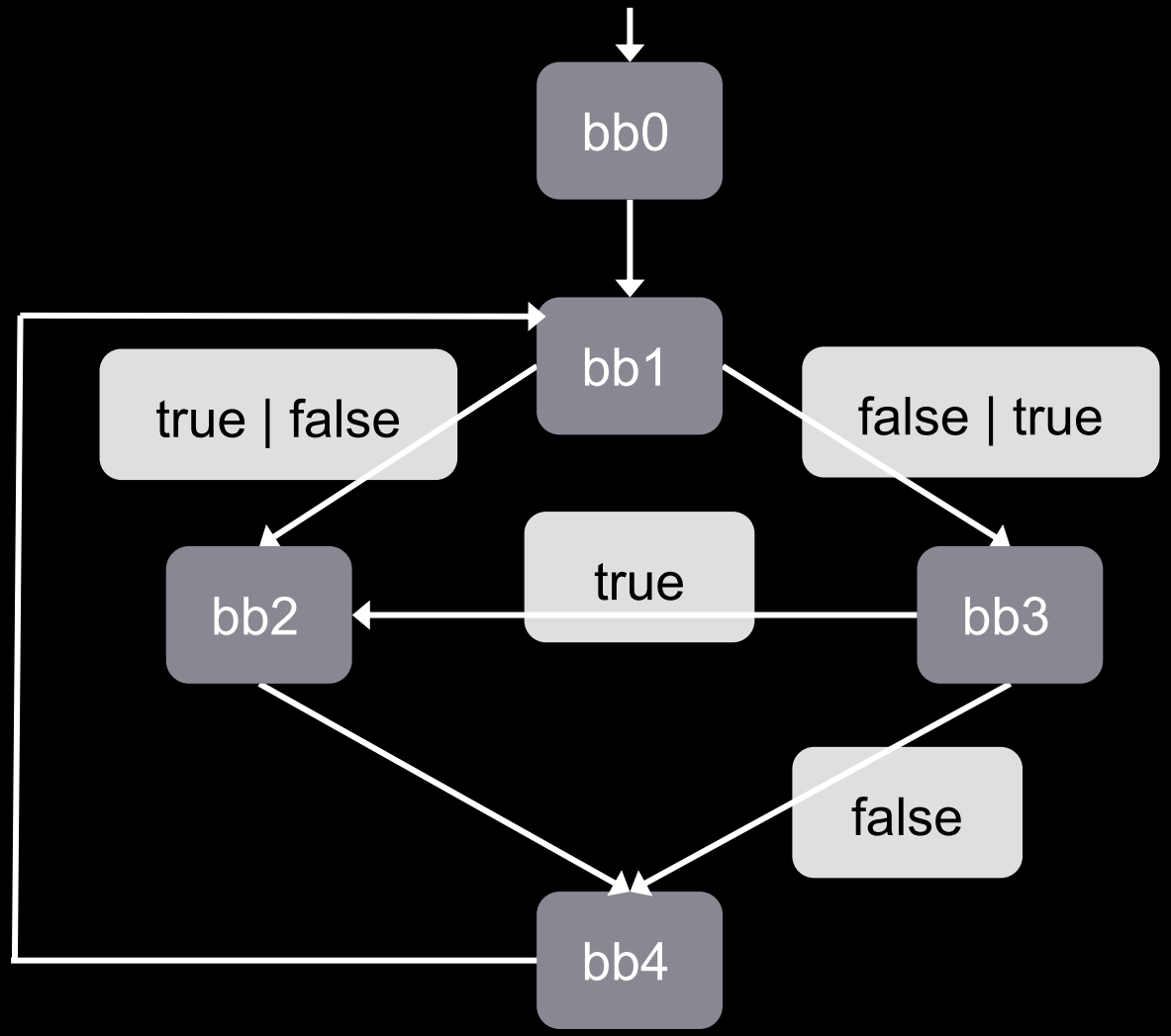


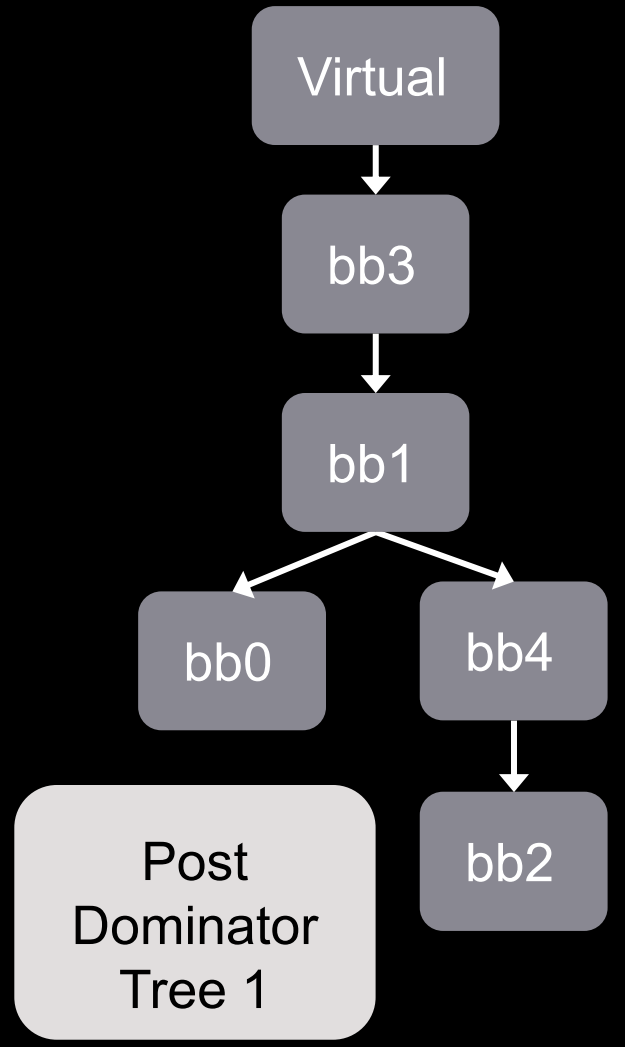


Post Dominator Tree 1

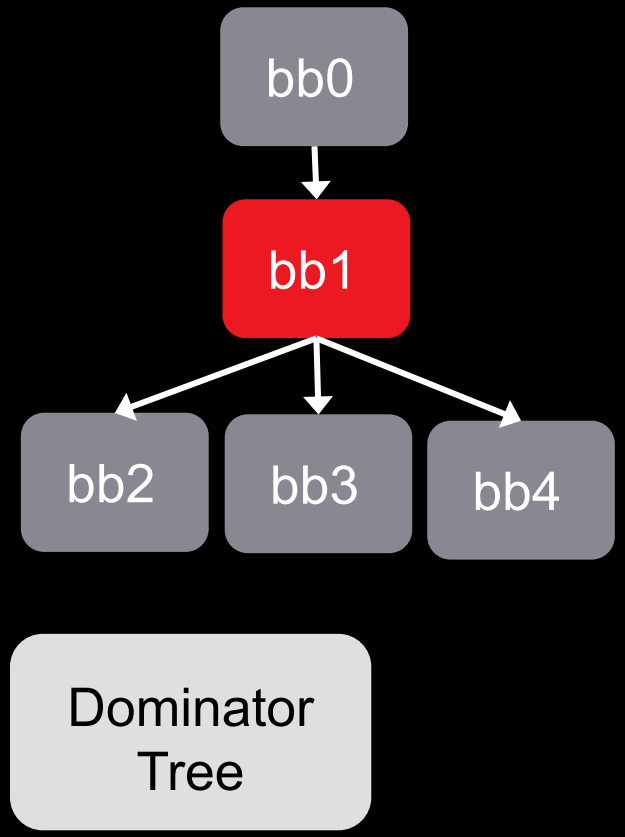
Let’s find regions

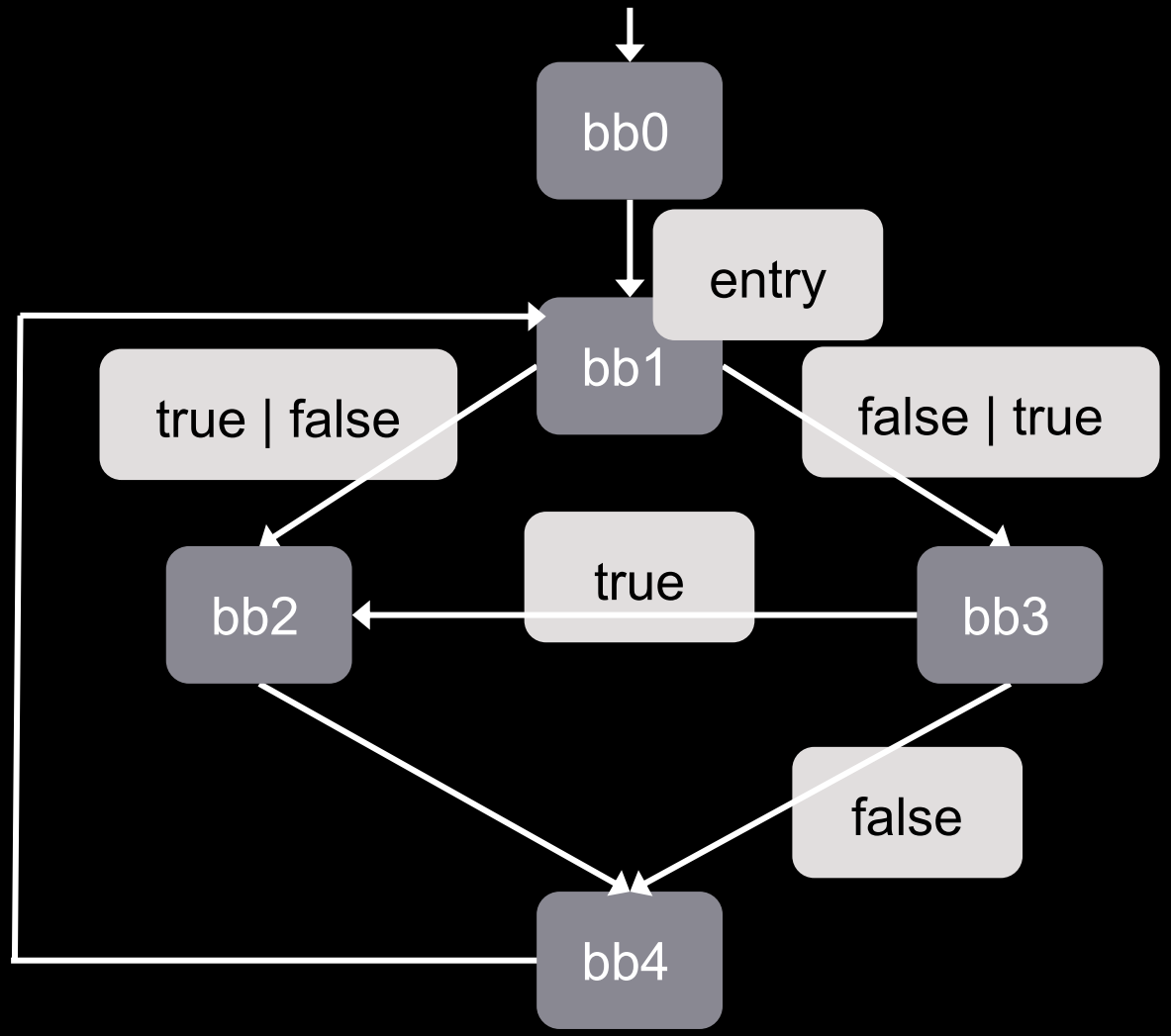


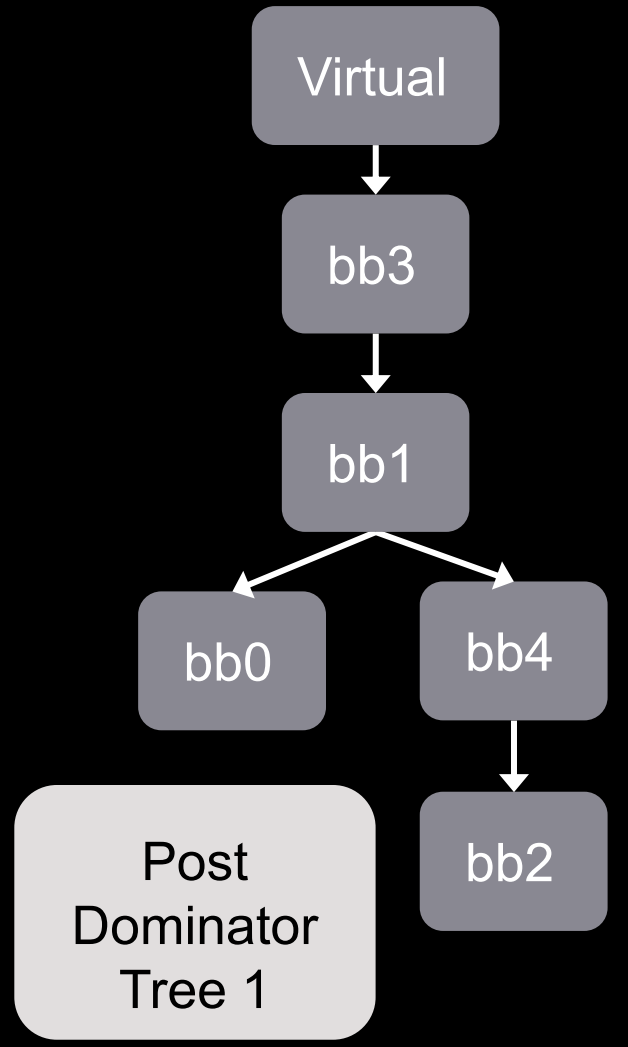




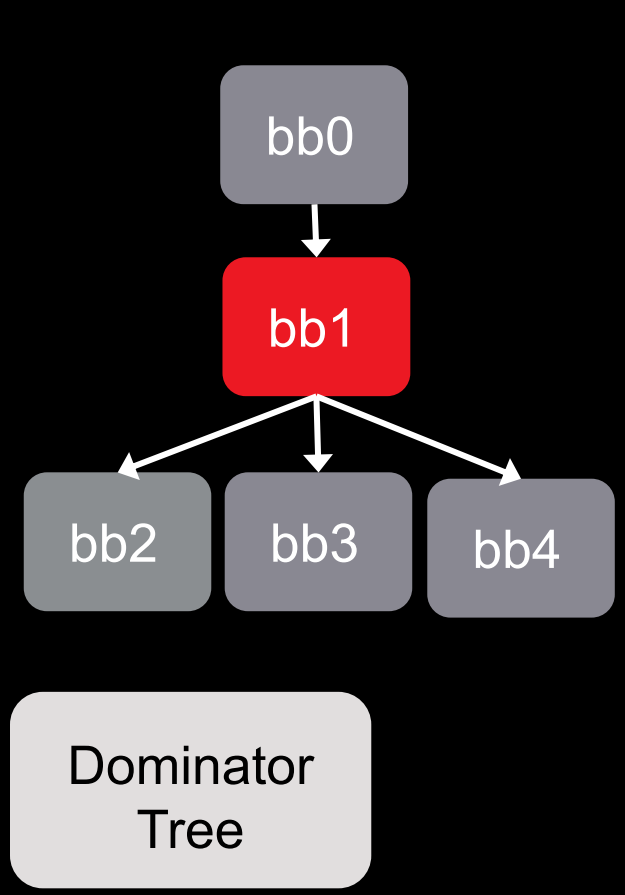
Let’s find regions

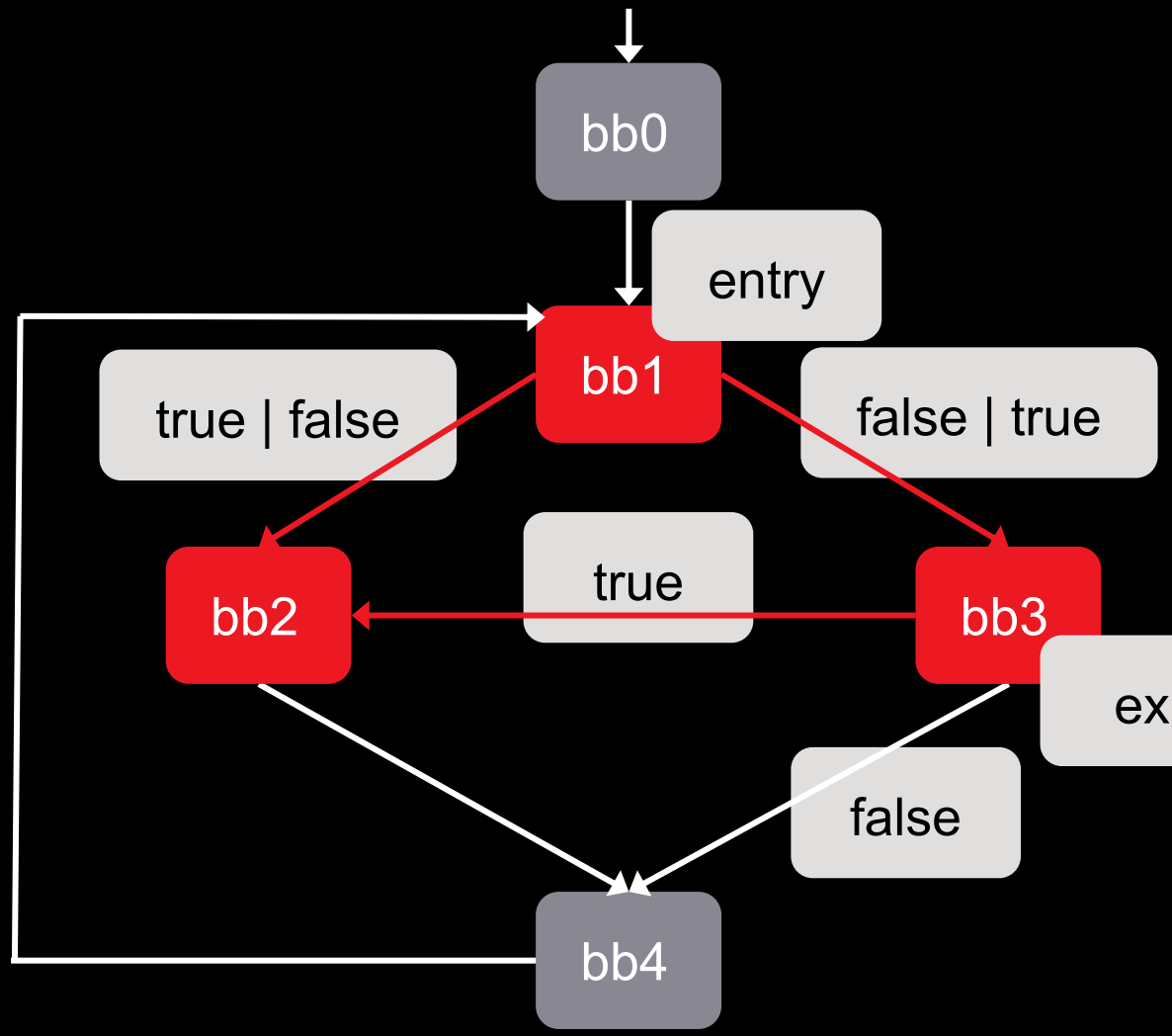


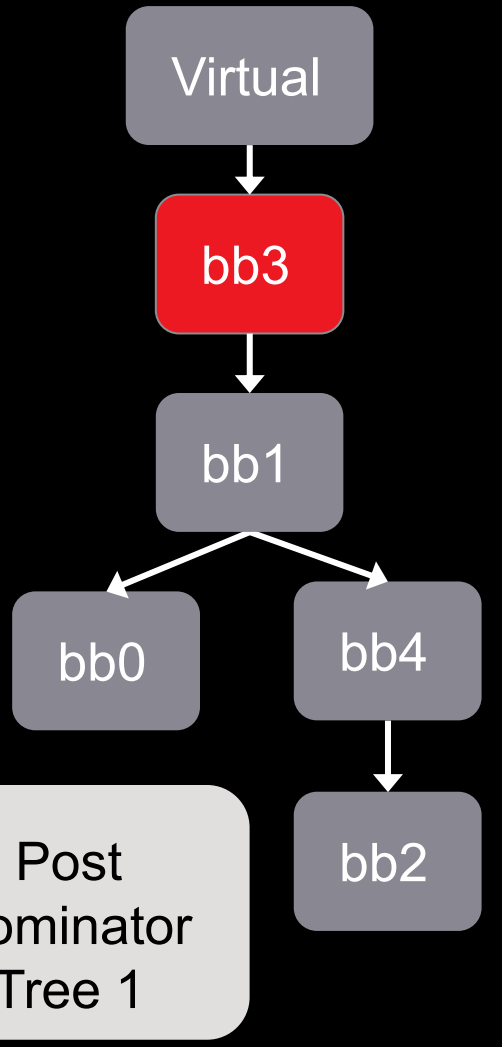




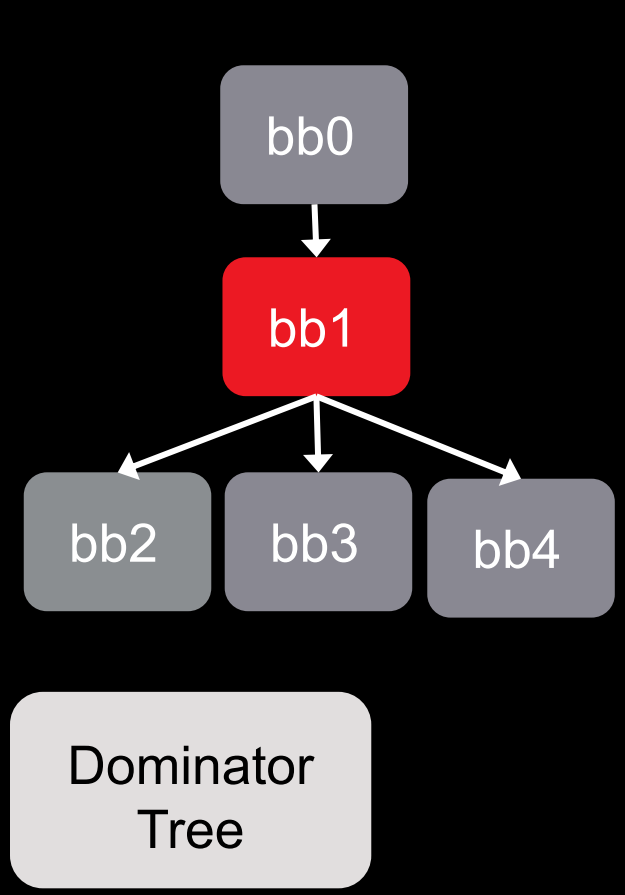
Let’s find regions

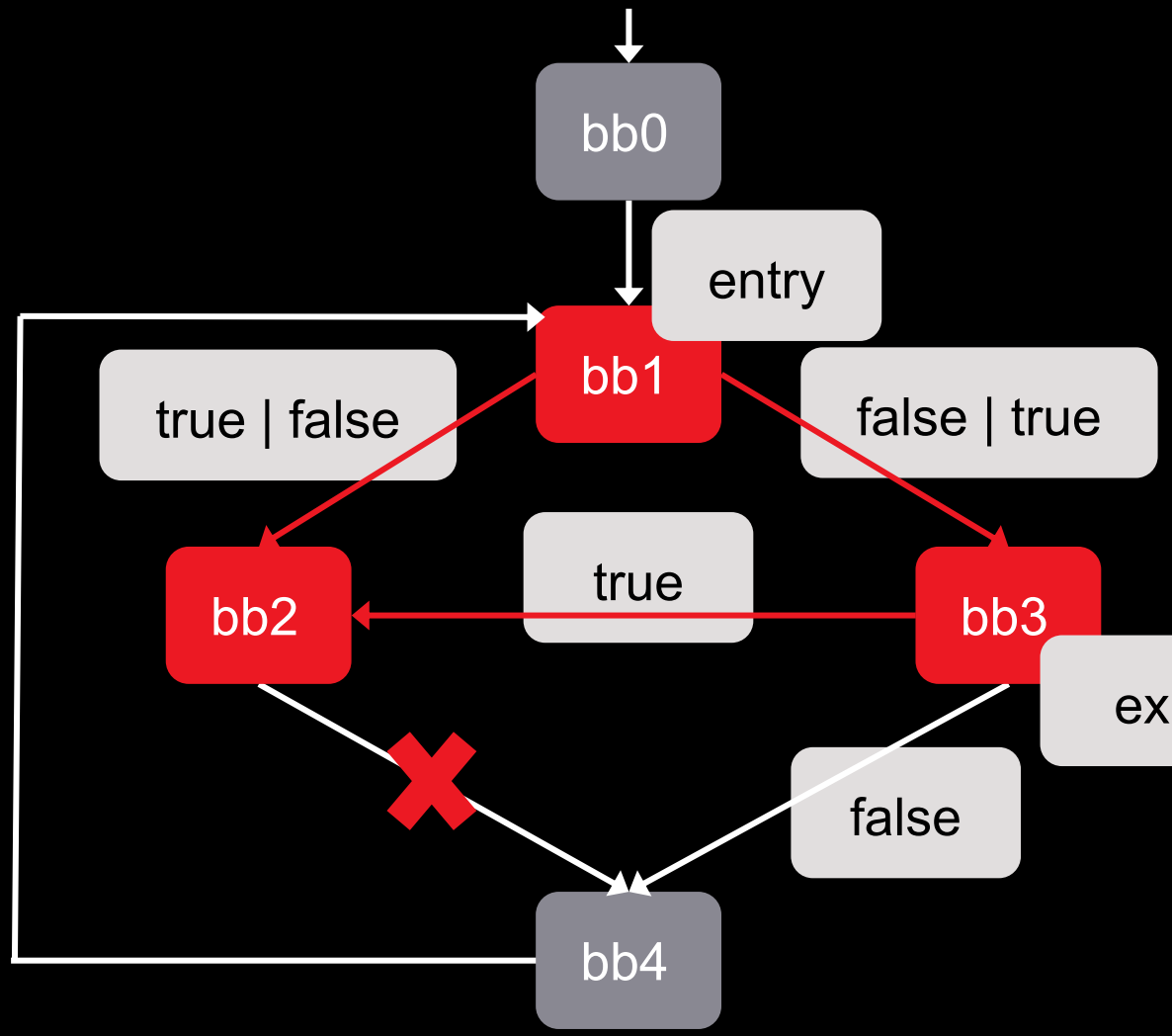


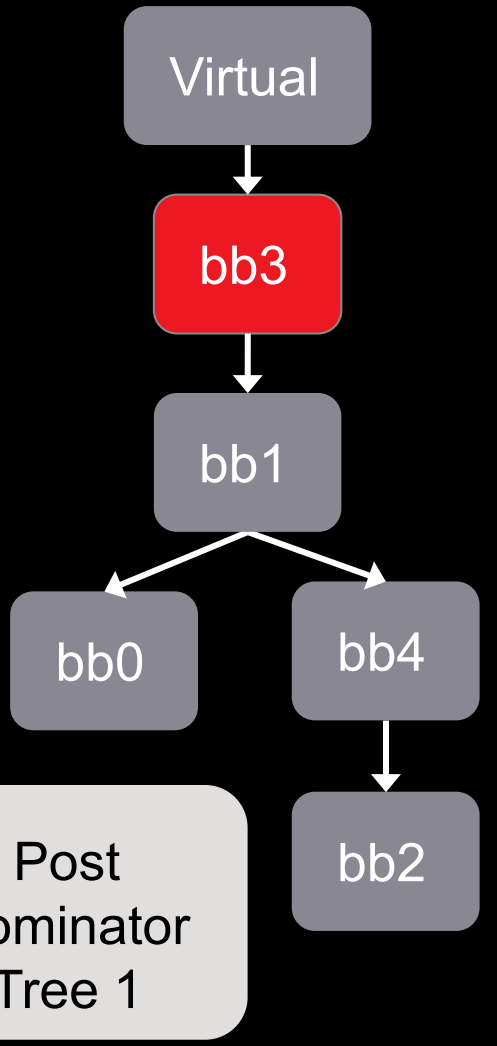




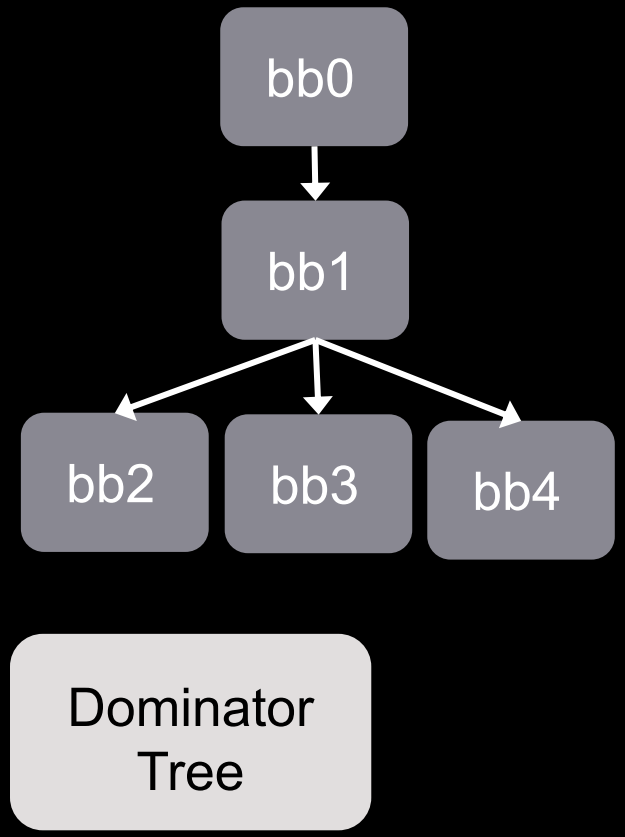
Let’s find regions

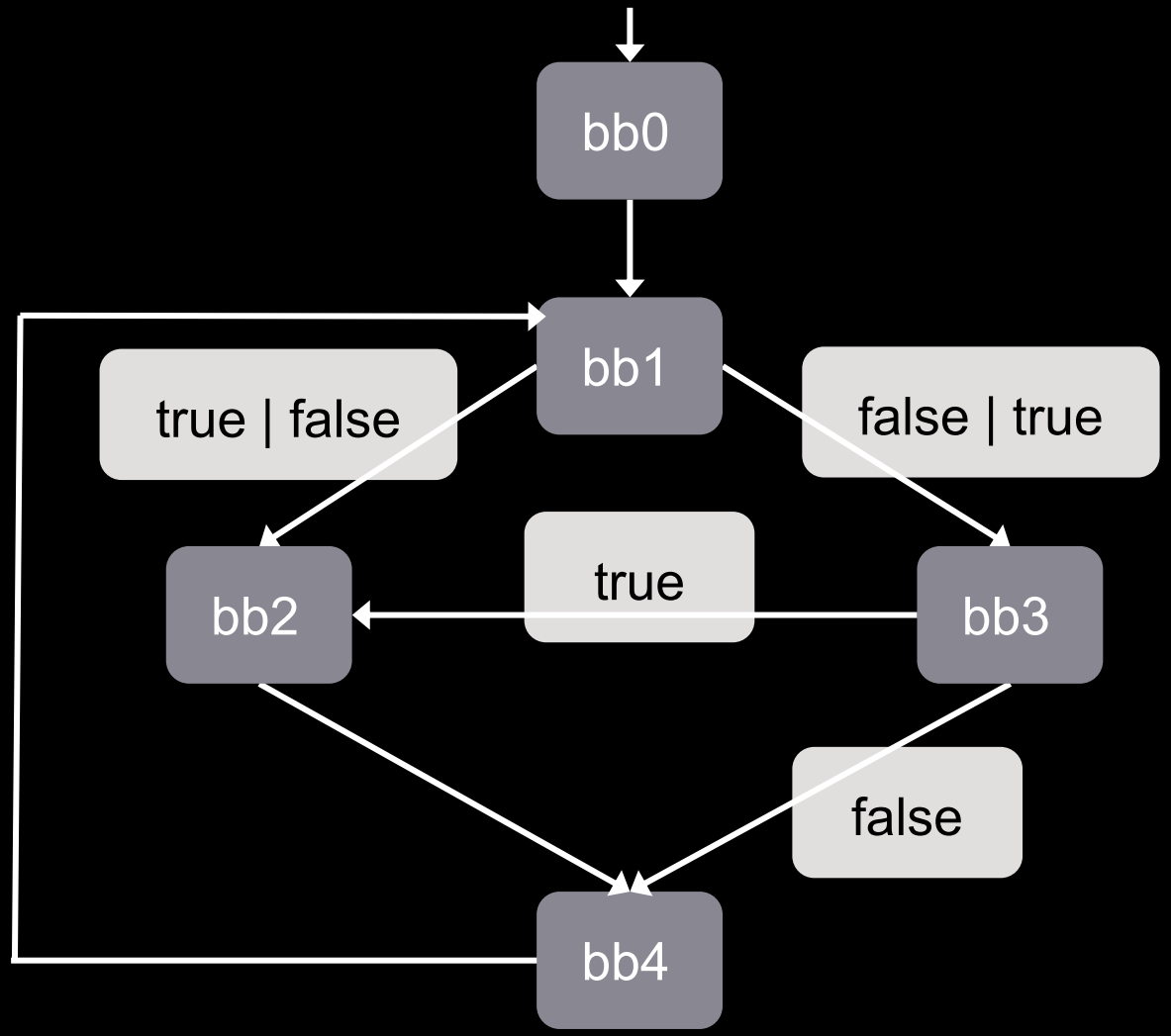


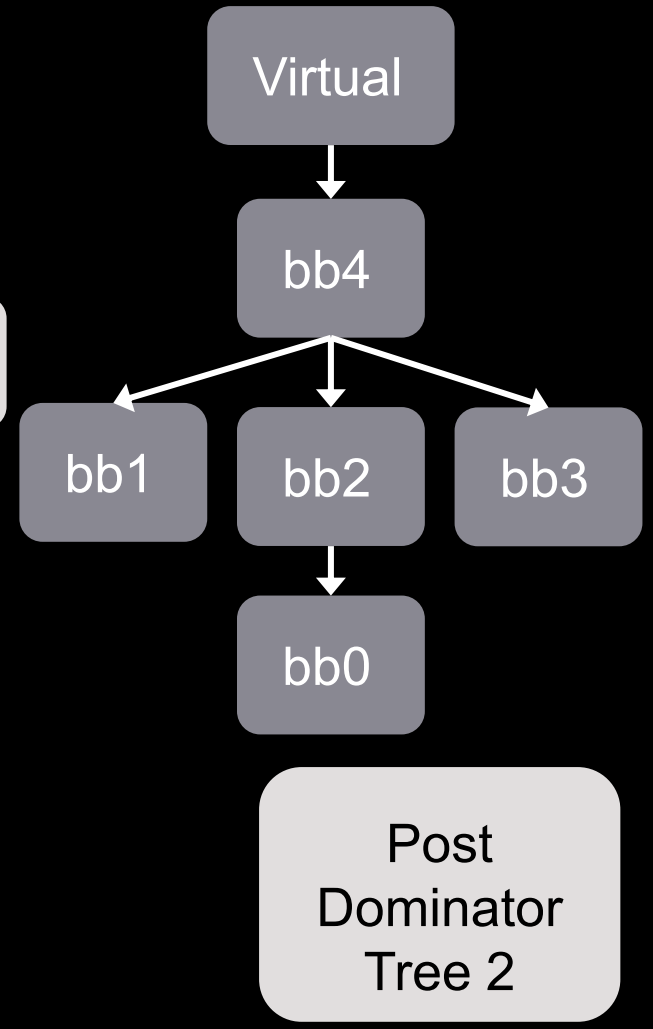




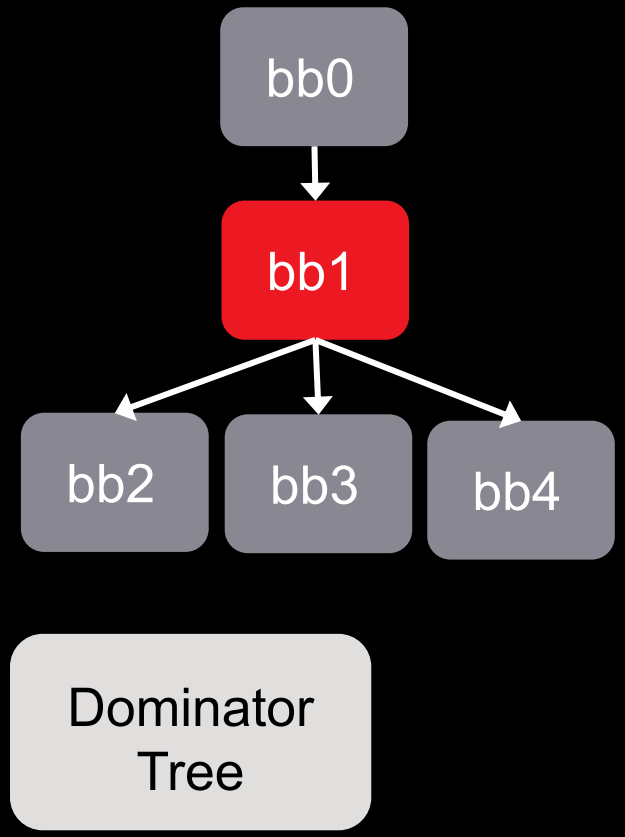
Let’s find regions

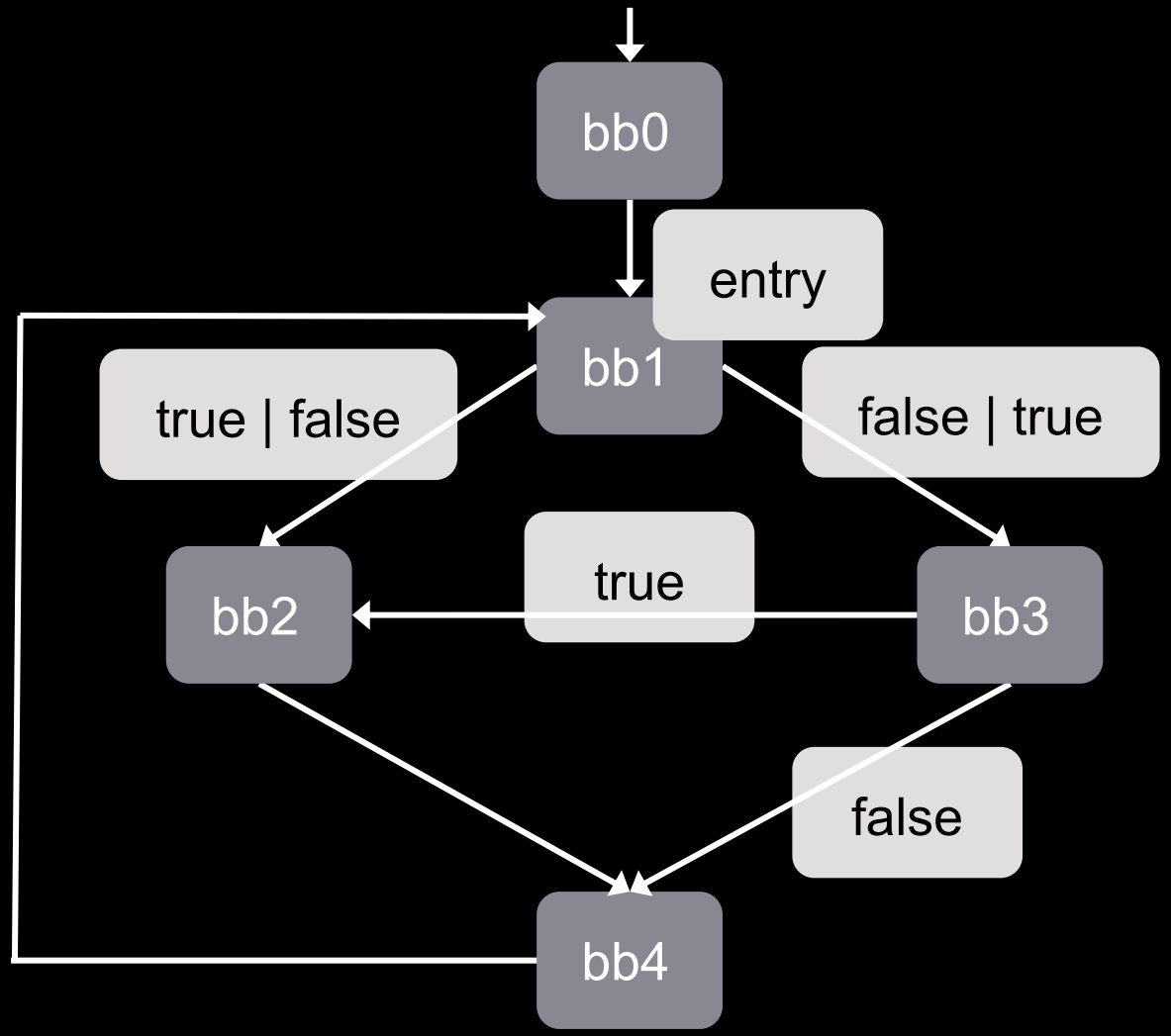


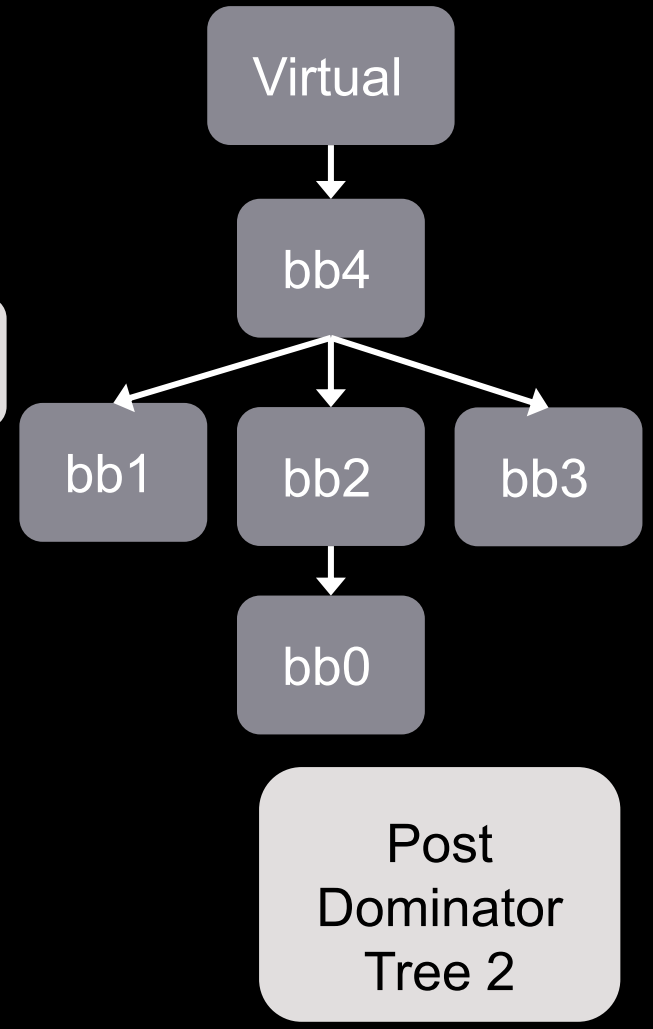




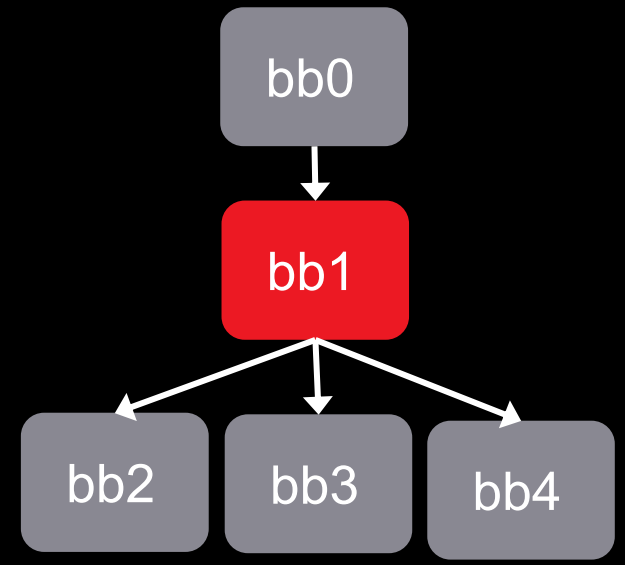
Let’s find regions



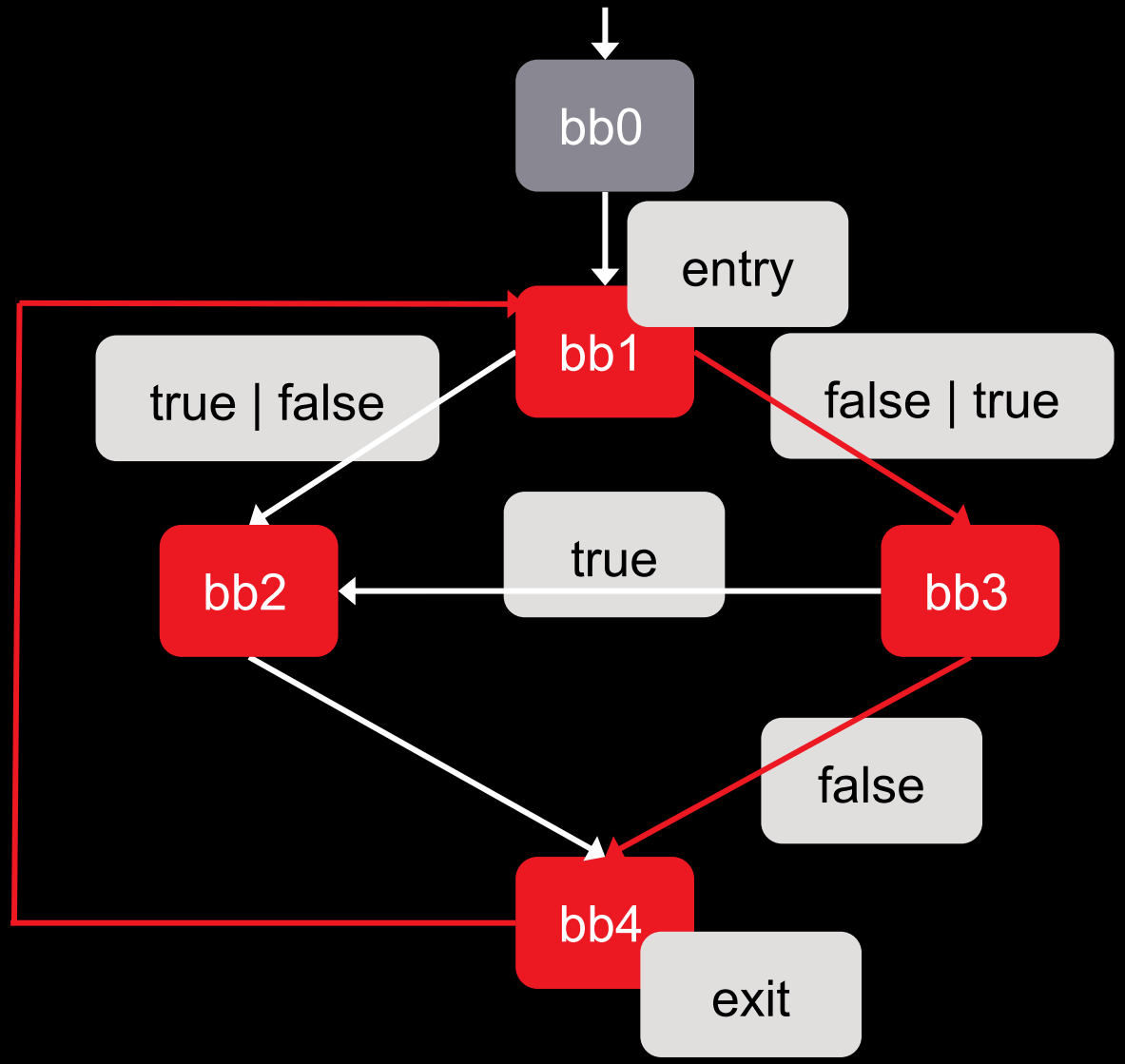


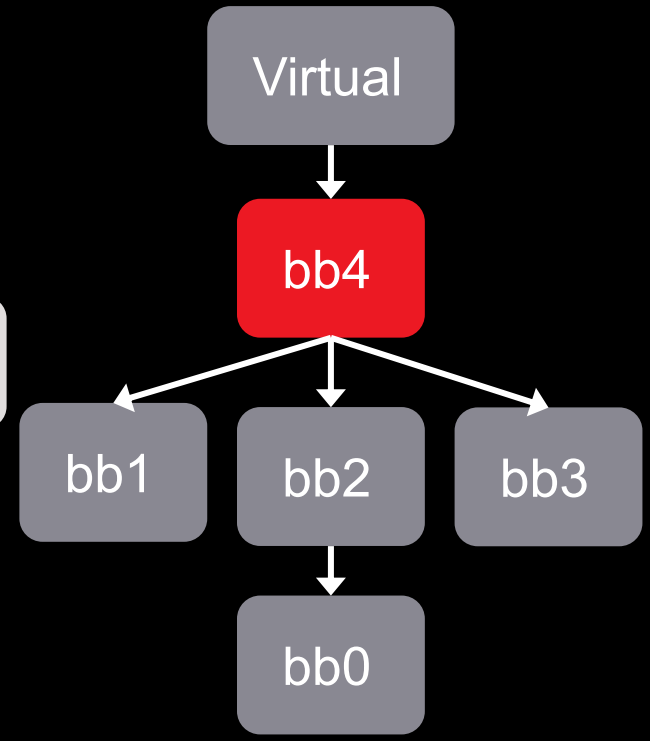


Let’s find regions



Dominator Tree





Post Dominator Tree 2

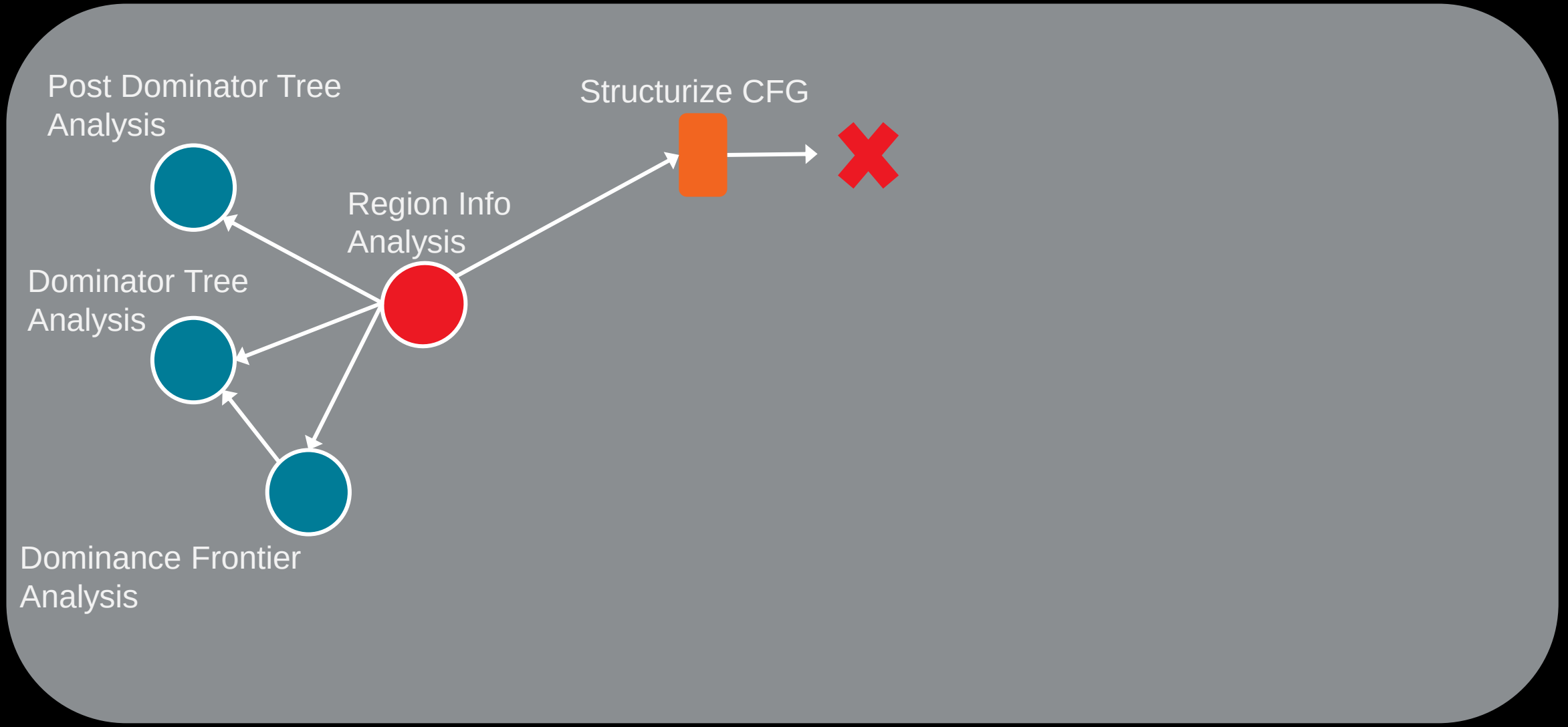
AMD

What went wrong?

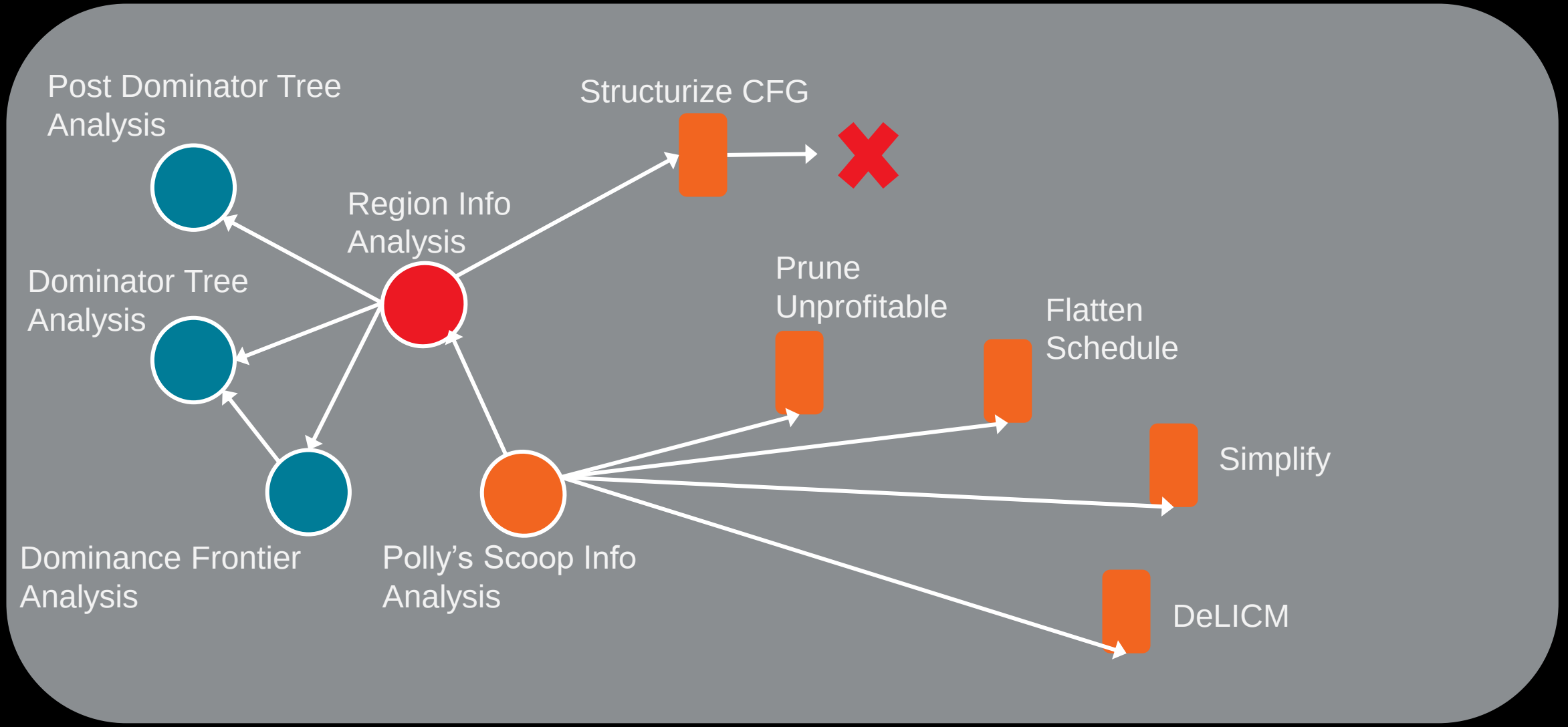
Region analysis did the right thing at its end

Post dominator analysis also did the right thing at its end

How bad is missing a region?



How bad is missing a region?



Conclusion

Compilers are complex ☺

Conclusion

Compilers are complex ☺

Special cases for each analysis should be kept in mind while using them

New techniques to suggest tests based on interaction between the analyses

Thank You!

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