DIVINE: Verification of Real-World Software

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April 20, 2017

The Problem Introduction

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- using formal methods
- these methods have to be actually usable
  - minimal investment from the developers' perspective
  - gives useful answers most of the time

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- static analysis
  - good for finding common problems directly from the source (without execution)
  - compiler warnings, linters, ...

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- symbolic execution
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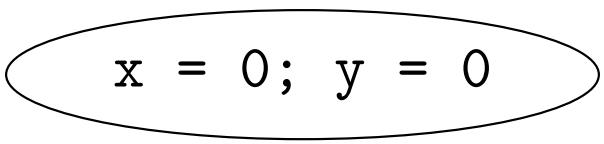

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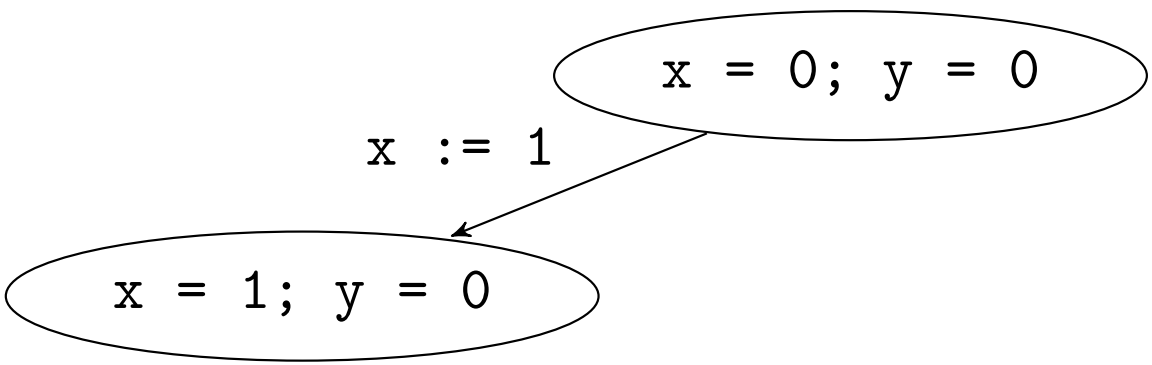

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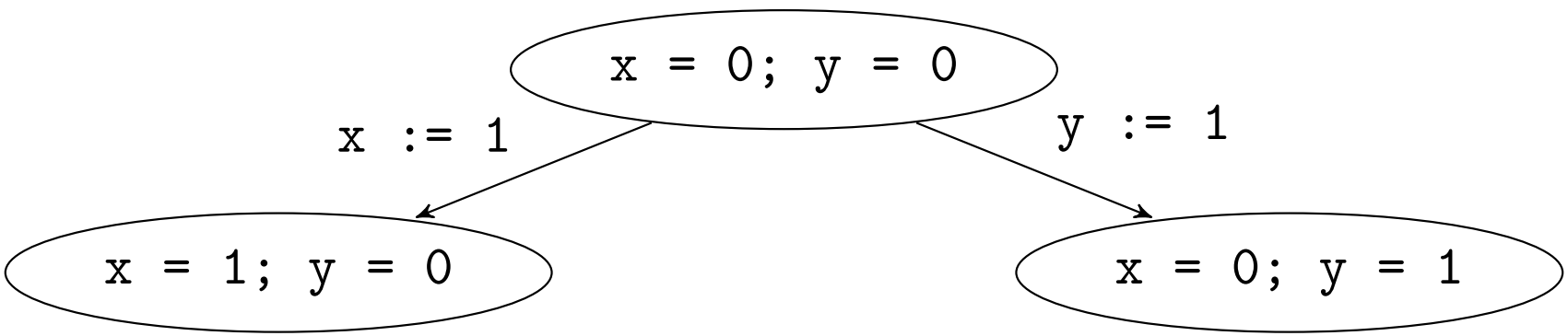

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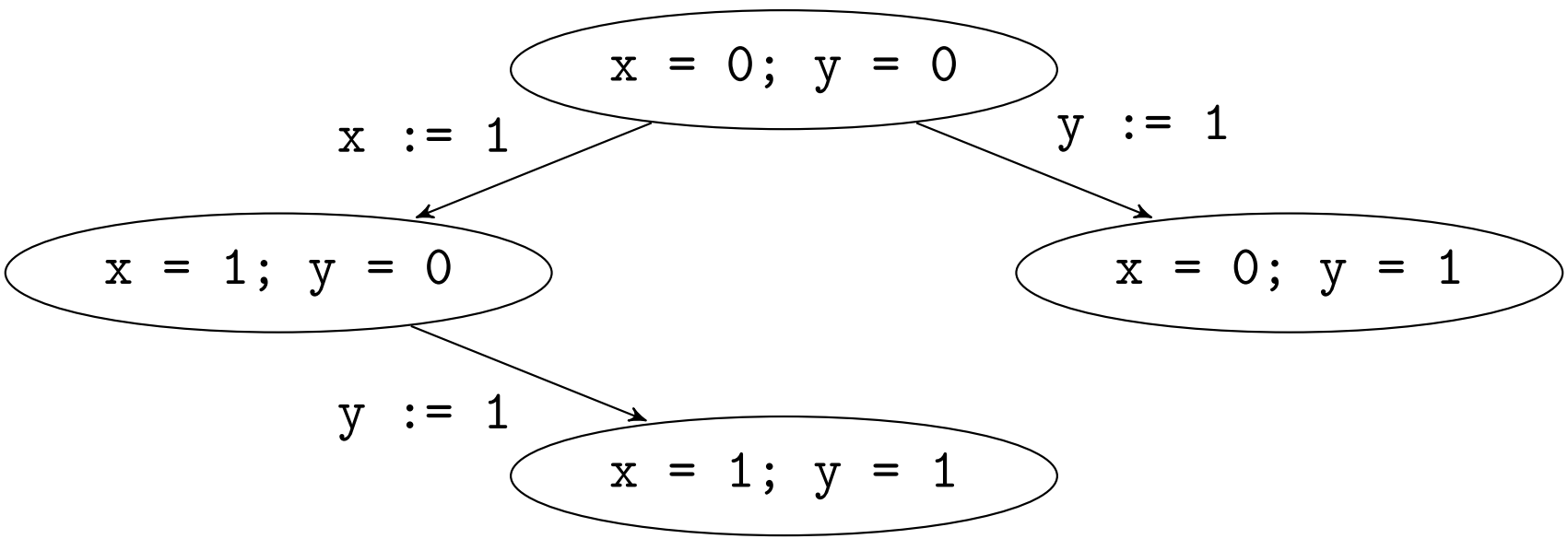

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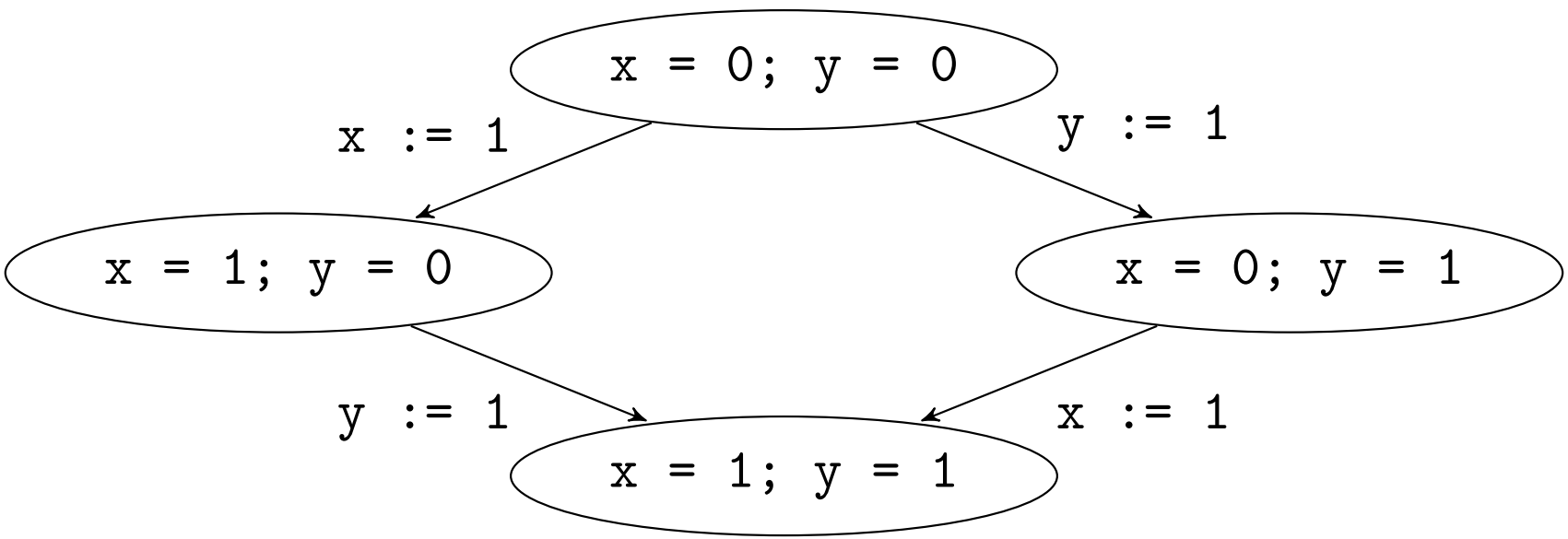

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  - efficient storage of program state
  - efficient exploration of important parts of the state space
  - general usability without expertise in program analysis

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- C and C++ can be translated to LLVM IR using clang compiler
- all parts of the program, including the libraries it uses, need to be translated to LLVM IR
  - DIVINE handles the translation of user's program and links it to pre-translated libraries
  - C and C++ standard libraries + `pthreads` are supported

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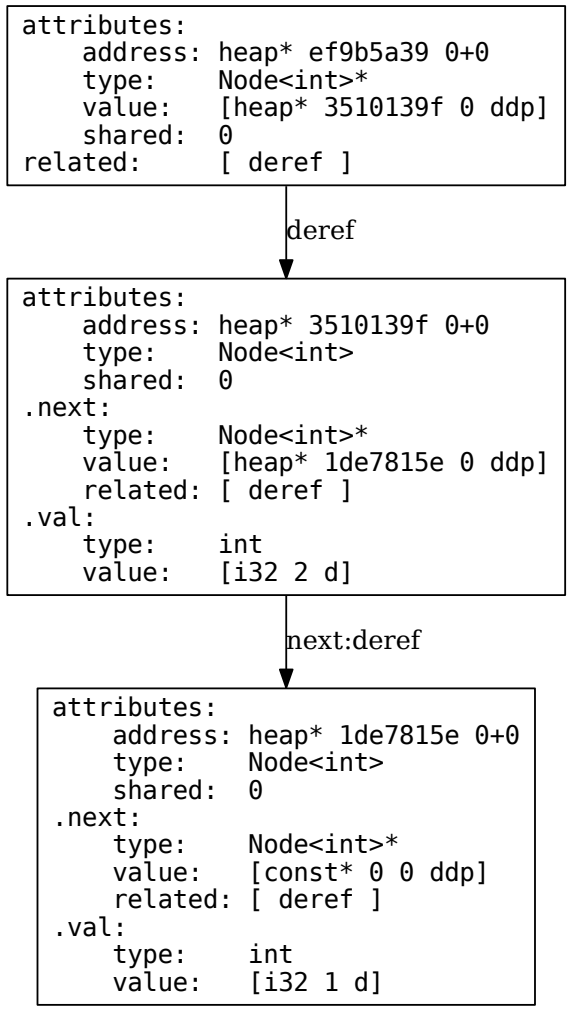
```
template< typename T >
struct Node {
    Node(T val, Node *n = nullptr) :
        val(val), next(n)
    {}
    Node *next = nullptr;
    T val;
};
int main() {
    Node<int> *n1 = new Node<int>(1);
    Node<int> *n2 = new Node<int>(2, n1);
}
```



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- there is also possibility of optimizing the program in a way so that the state representation is smaller
  - detecting unchanging global variables
  - slicing-out provably unused variables
  - relaxing static single assignment form of LLVM in the internal representation
  - ...

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  - that does not interact with *globally visible* memory
  - that interacts with globally visible memory *that is nevertheless only accessed by one thread*

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  - many interleavings can have the same results because threads do not actually interact
- it should be possible to combine *(dynamic) partial order reduction* techniques with DIVINE
  - these techniques allow exploration of only a subset of state's successors if this subset is sufficient

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- any optimizations done by DIVINE have to be safe – must not change the verification outcome
  - compiler optimizations are safe only for sequential programs
  - we need optimizations safe for all programs