Using Off-the-Shelf Exception Support Components in C++ Verification

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DIVINE – Verification of C++ Programs

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Contribution of this Work

- full support for C++ exceptions
- with minimal changes to the verification core of DIVINE
- re-using existing implementation of exception matching

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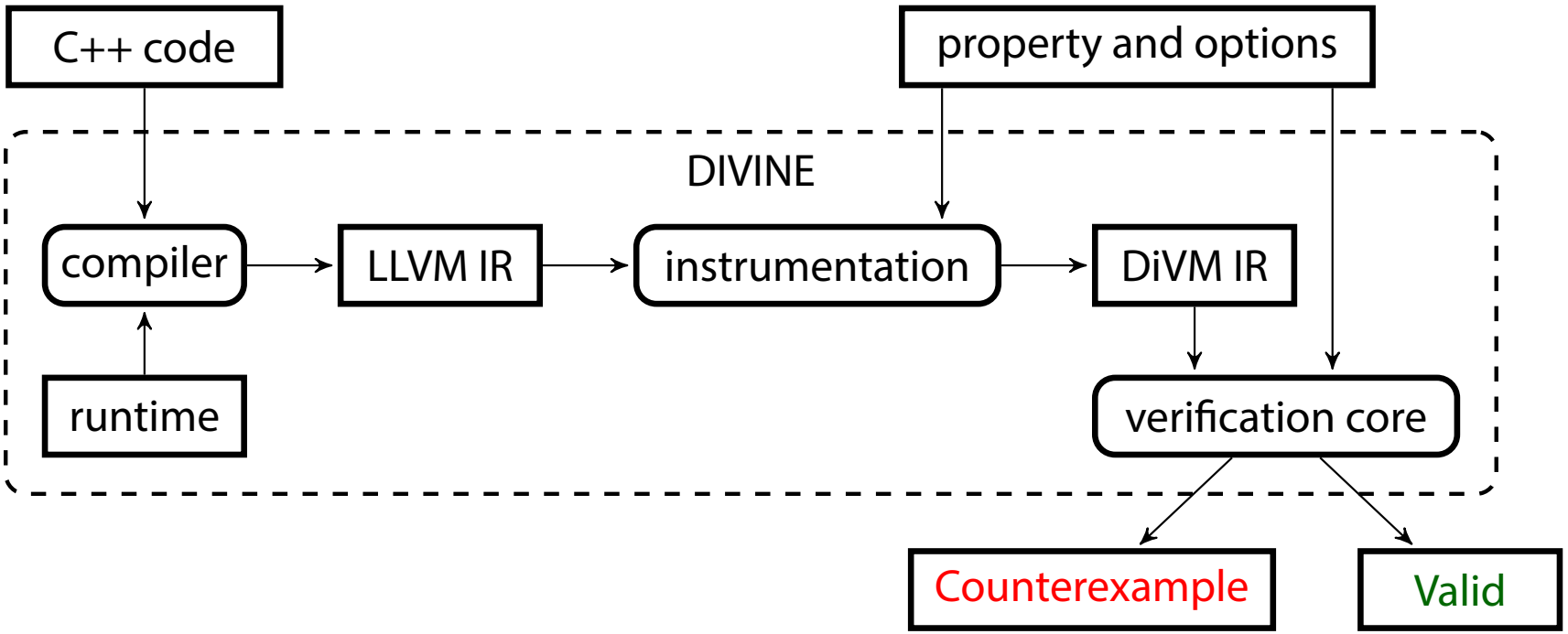

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- exceptions support is complex
- re-implementation would risk imprecisions, would be large, or require changes to the verification core

How Exceptions Work

```
1  X::~X() { }
2  void g() {
3    throw std::exception();
4  }
5  void f() {
6    X x;
7    g();
8  }
9
10 int main() {
11   try {
12     f();   <-------------------------
13   } catch ( ... ) {
14     /* ... */
15   }
16 }
```

main:12

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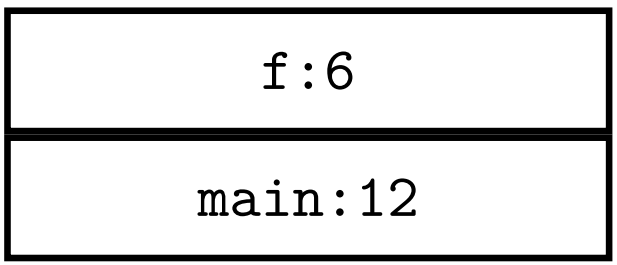

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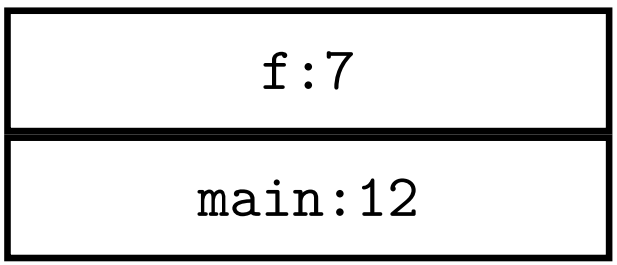

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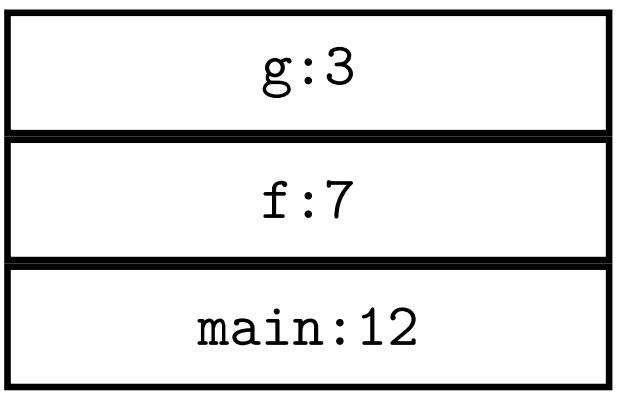

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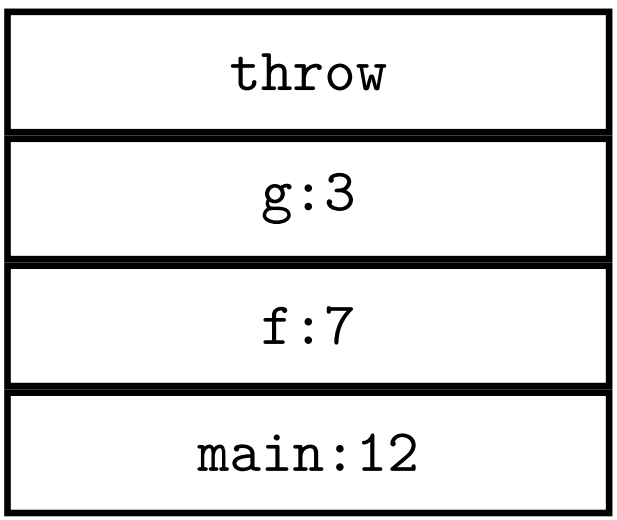
unwinding



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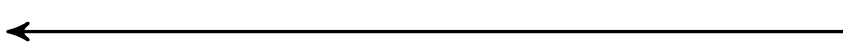

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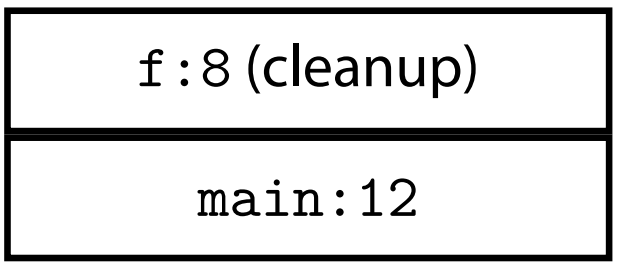

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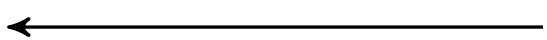

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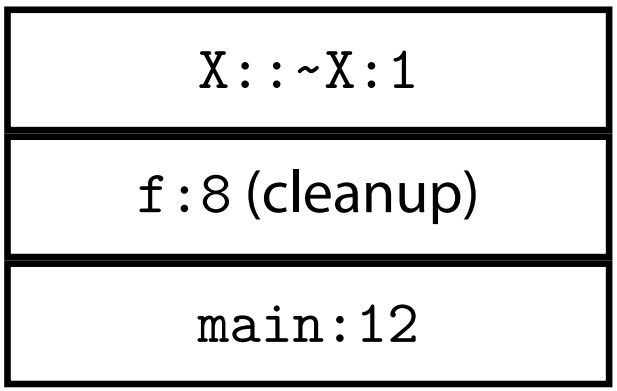

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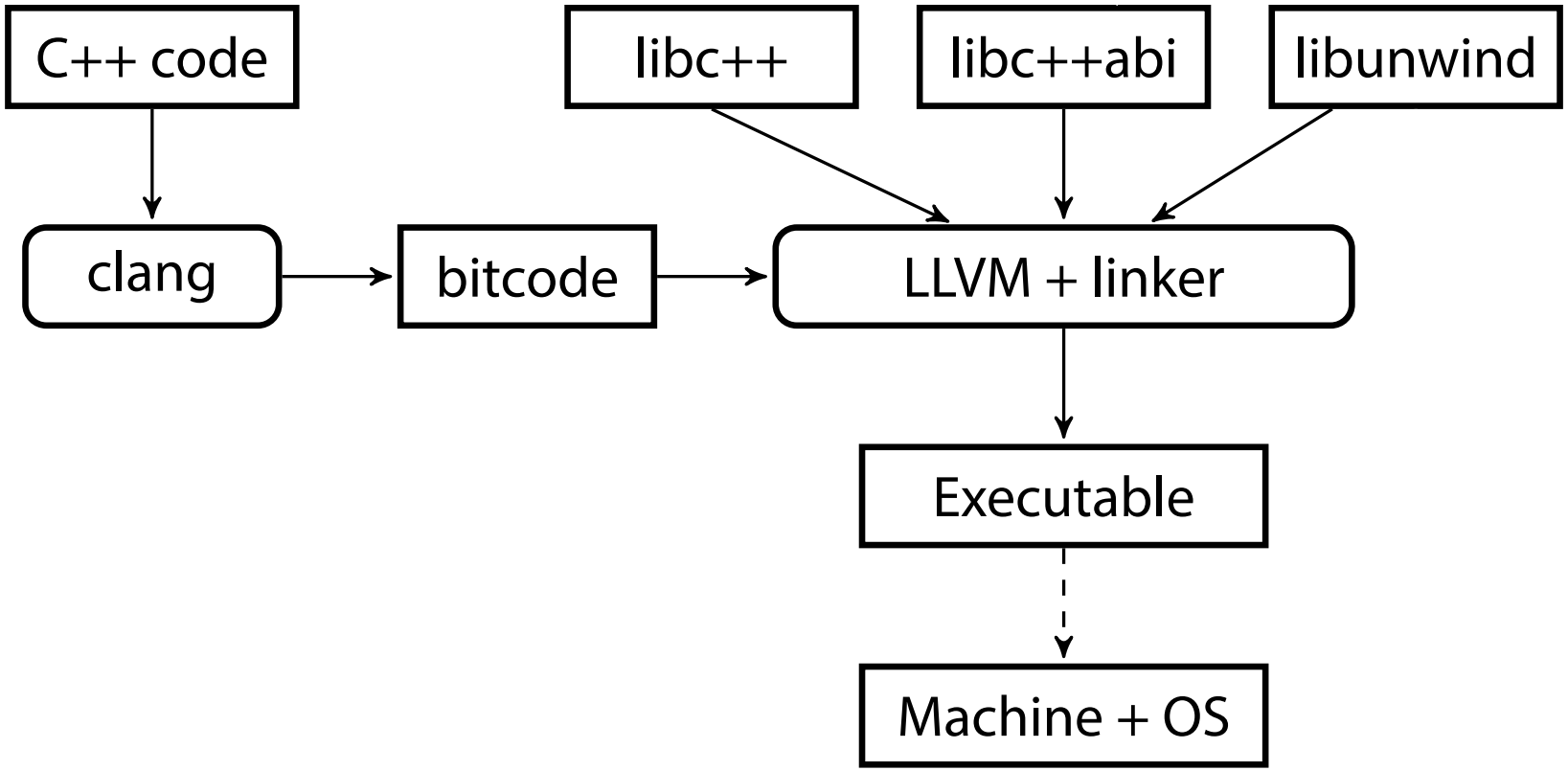

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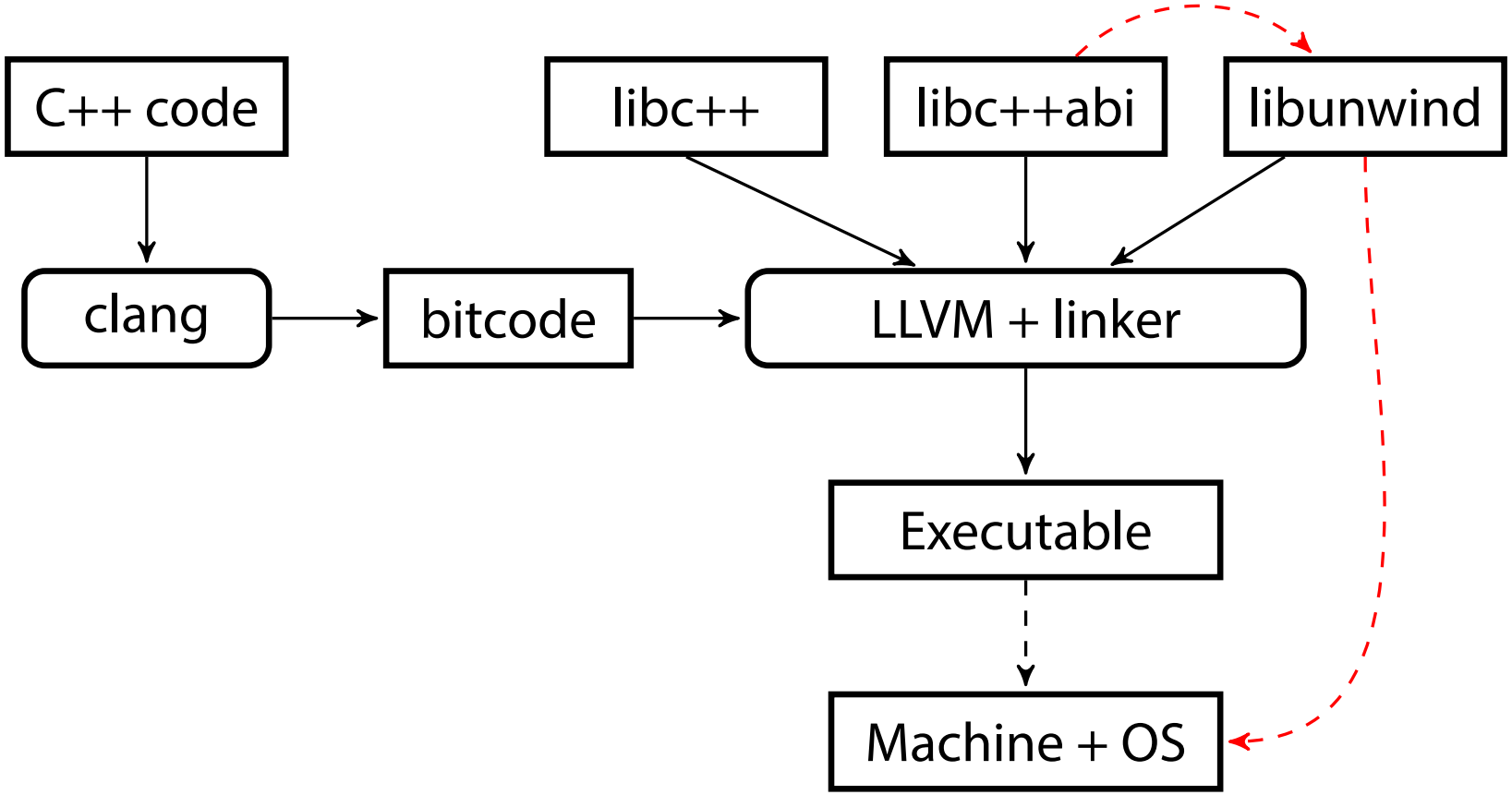

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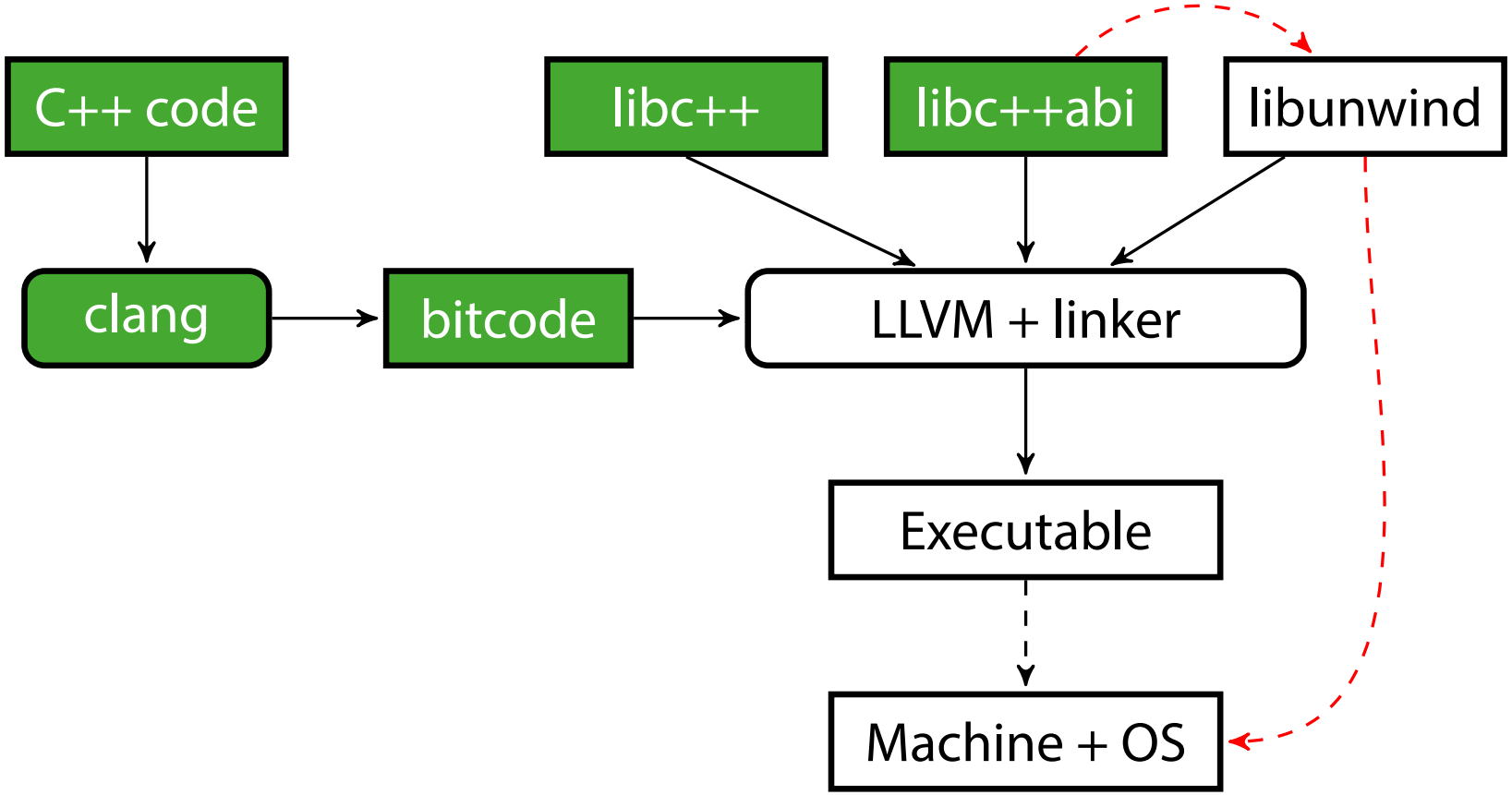
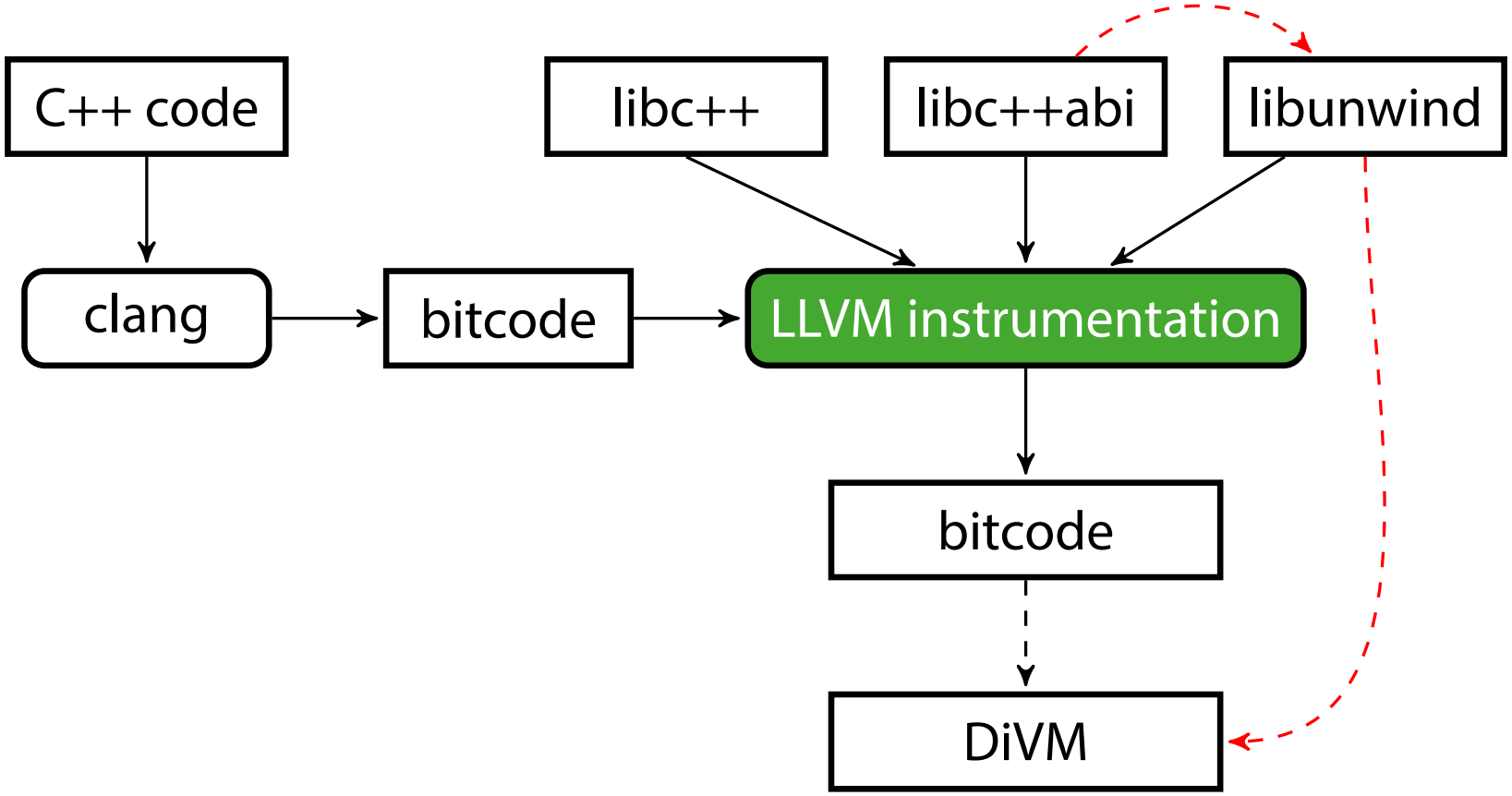


- the code is compiled and linked to the standard library (`libc++`), runtime library (`libc++abi`), and the unwinder (`libunwind`)
- the runtime library depends on the unwinder which depend on the machine and OS
- **green** components are re-used in DIVINE

Analyzing C++ Program with DIVINE



DIVINE/DiVM-specific components

- LLVM-based preprocessing

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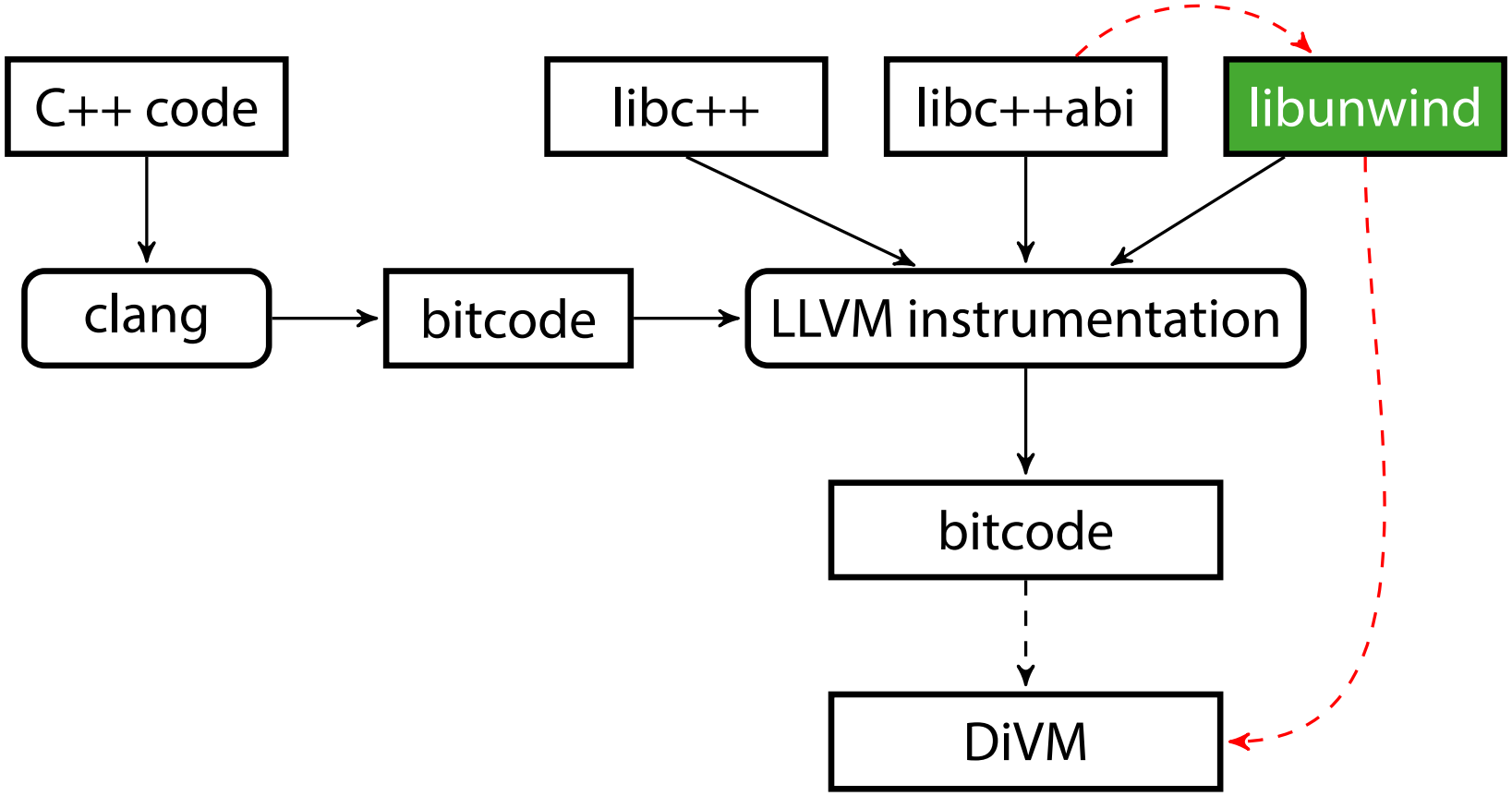

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- DiVM-based implementation of `libunwind`

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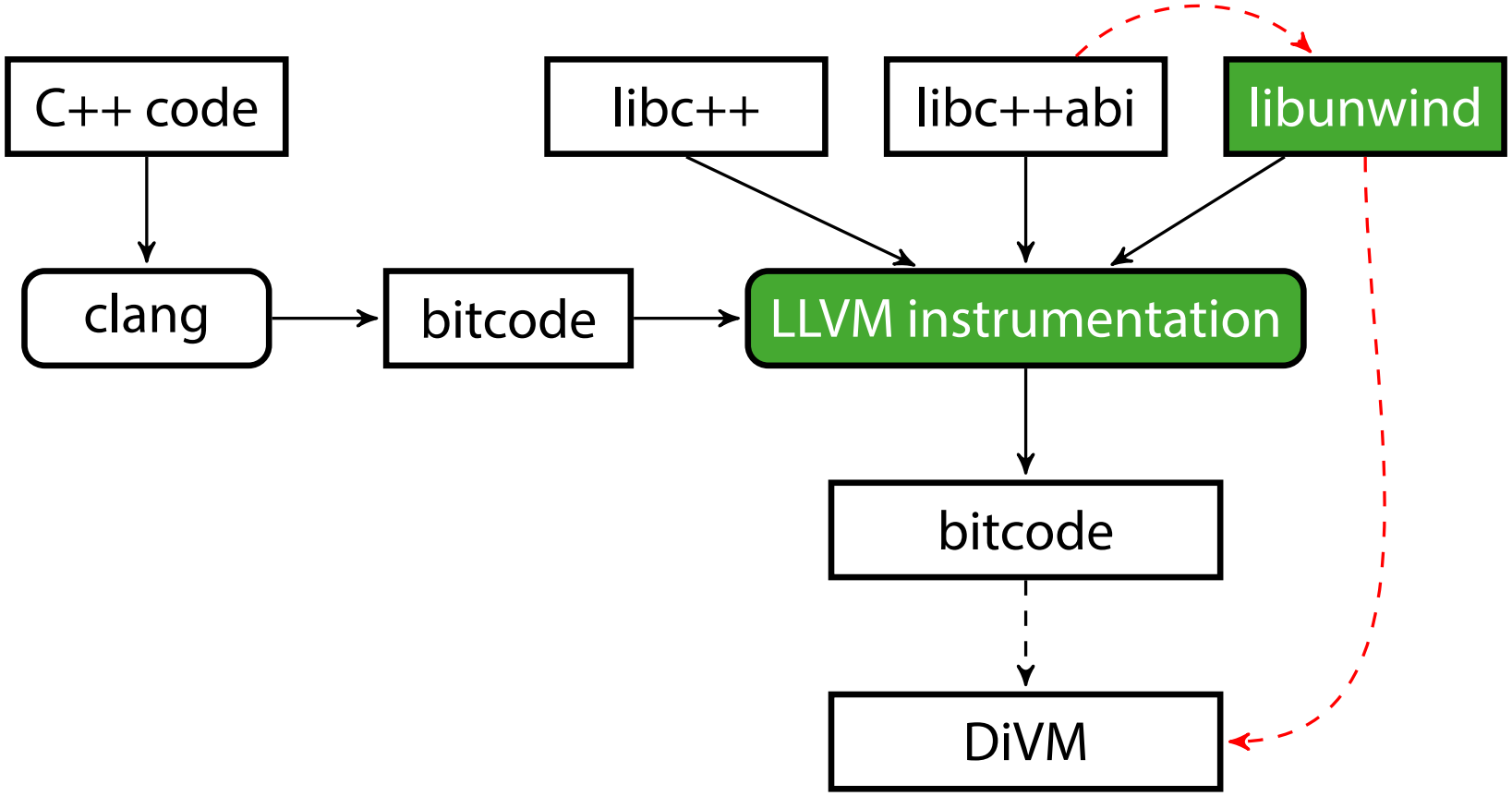

DIVINE/DiVM-specific components

- LLVM-based preprocessing
- DiVM-based implementation of `libunwind`
- approximately 700 lines of new modular C++ code

LLVM Transformation

- exceptions require metadata about stack frames, catch blocks and cleanups for destructors
  - normally describe the machine code
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  - normally describe the machine code
  - DIVINE needs metadata for LLVM bitcode
- metadata format depends on the implementation of the C++ runtime library
- output of the transformation is LLVM bitcode with additional metadata stored in global constants
- C++ specific encoding of catch and cleanup locations

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- implements the same interface as platform unwinder
- would also work with other languages

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- reusing C++ runtime library means full support for C++ exceptions
- exception search and type matching fully reused
- substantial improvement in verification fidelity
- minimal investment: ~ 700 lines of code
- minimal overhead: 2.6 % time overhead compared to an older style of implementation which required changes to the verification core

`divine.fi.muni.cz`
`paradise-fi/divine` on GitHub

more data & code:
`divine.fi.muni.cz/2017/exceptions`