Toward a Verified, Secure, General-Purpose Microkernel

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Quick Review

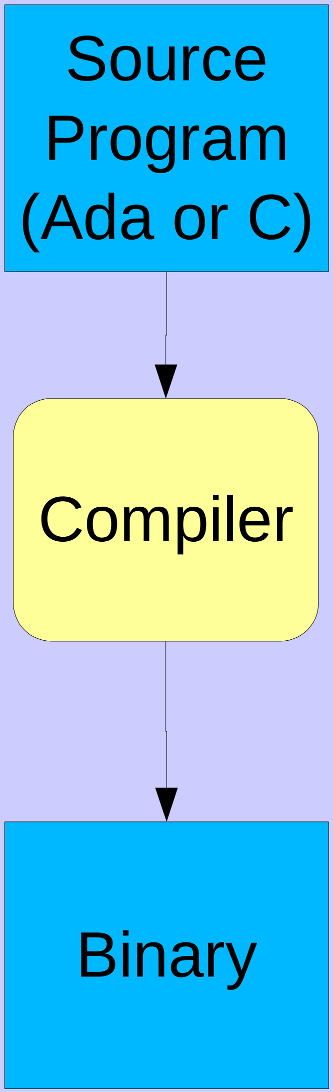
- You have:
  - A set of security, isolation requirements
  - A model of a system
- You want to know:
  - Does the system you built meet the requirements?
- Approach:
  - Verify that the operational semantics of the *model* satisfies the requirements (*Shapiro&Weber, 2000)*
    - Must formalize requirements (goals)
    - Must formalize model
  - Verify correspondence: does implementation match the model.

Sufficient rigor is moderately hard, but tractable.

Complications

- Sufficient rigor is hard.
- Need an implementation language that you can reason about formally.
  - Usually assumed that aliasing needs to be restricted
    - no general pointers!
  - We found an alternative
- From a practical standpoint, need to use a standardized language
  - That leaves Ada
- But after you hire *all* of the surviving ADA programmers...

Traditional Approach



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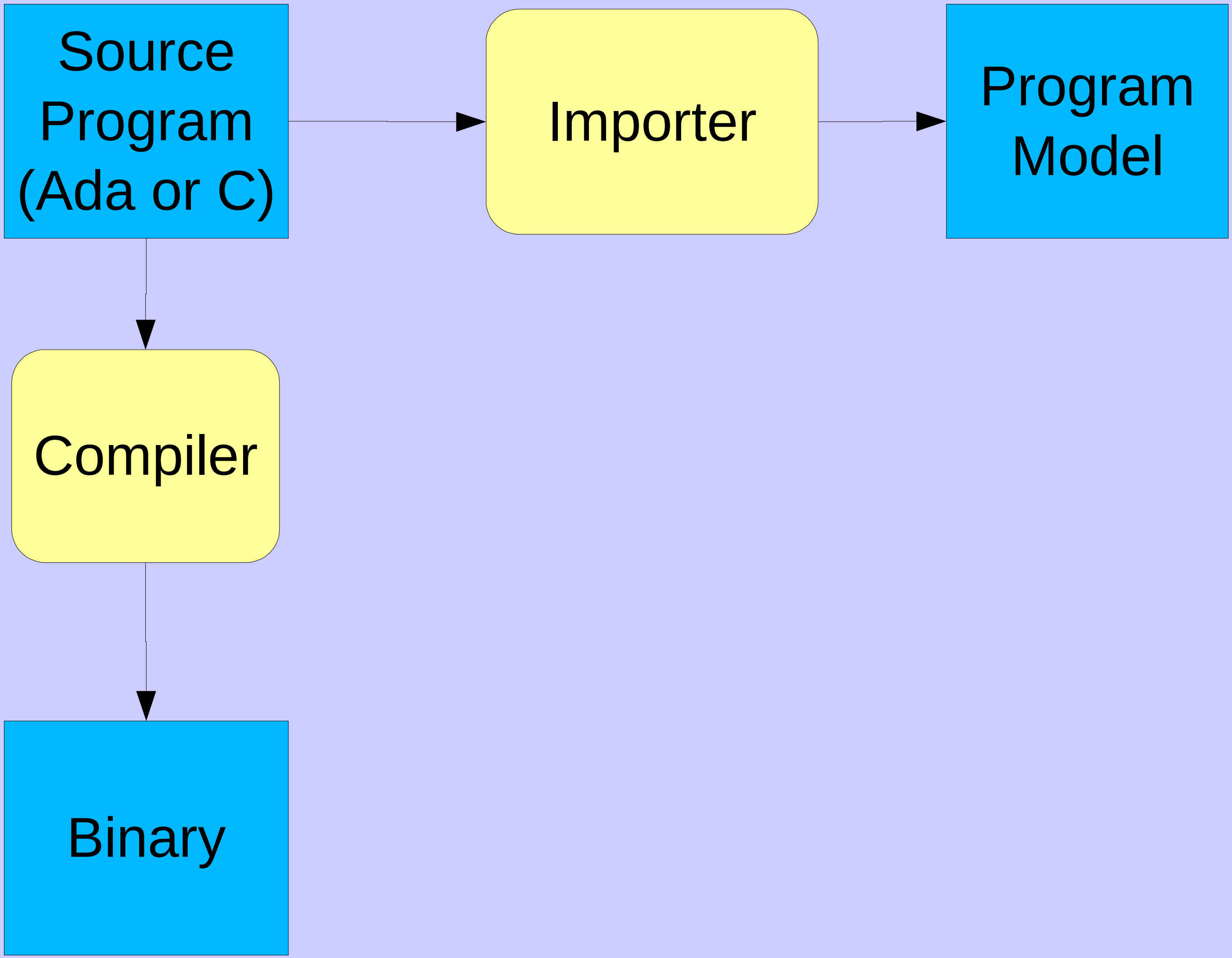

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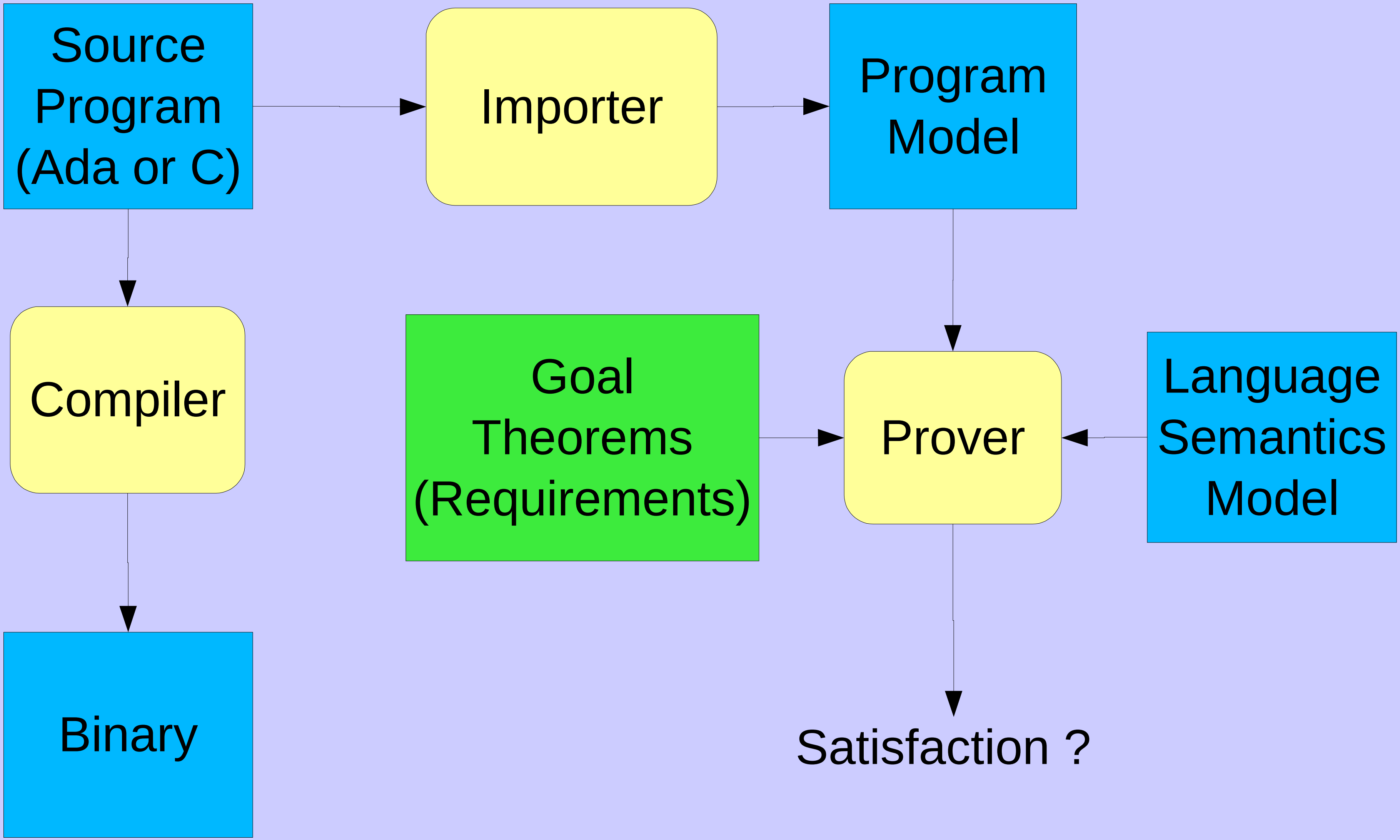

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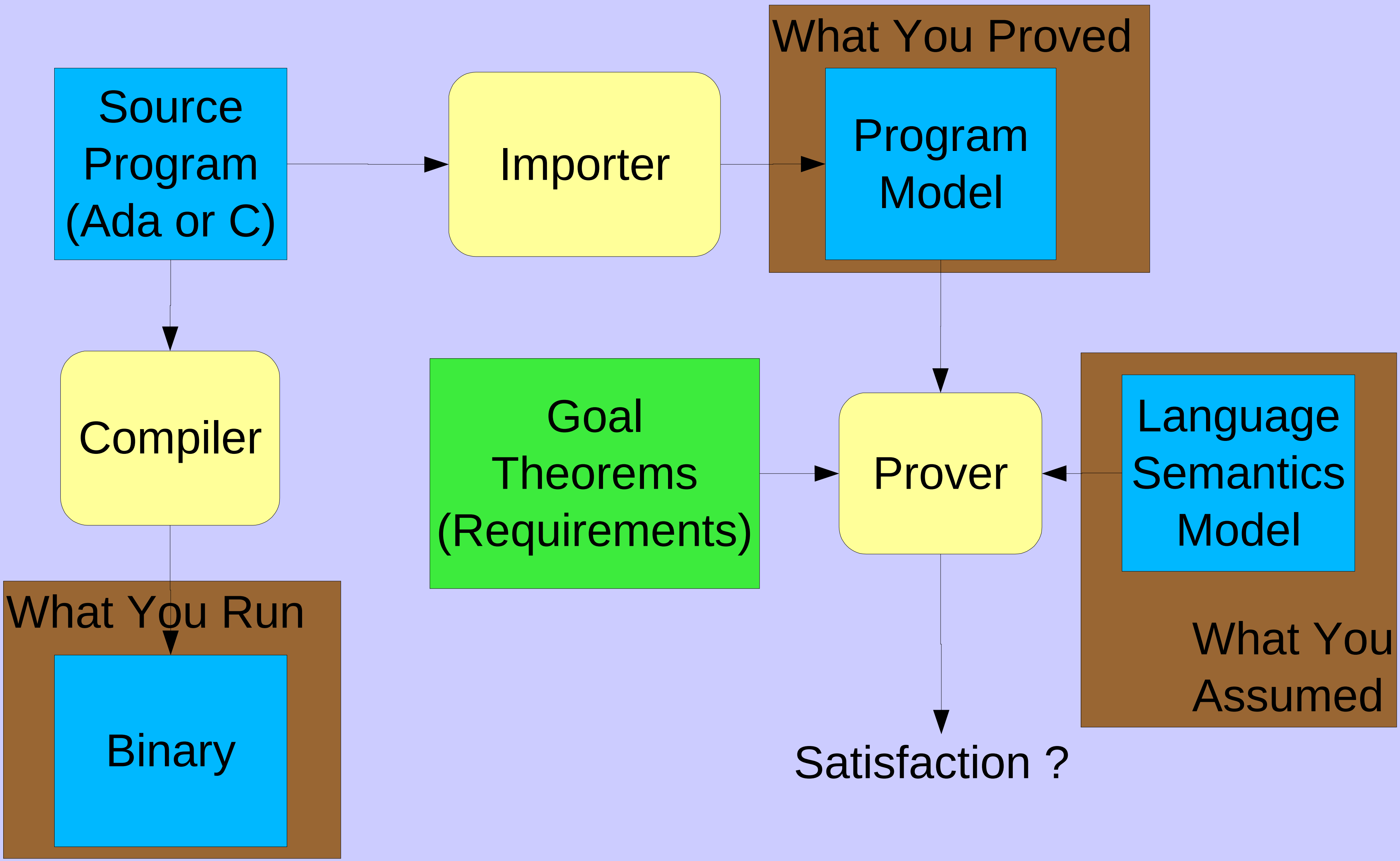

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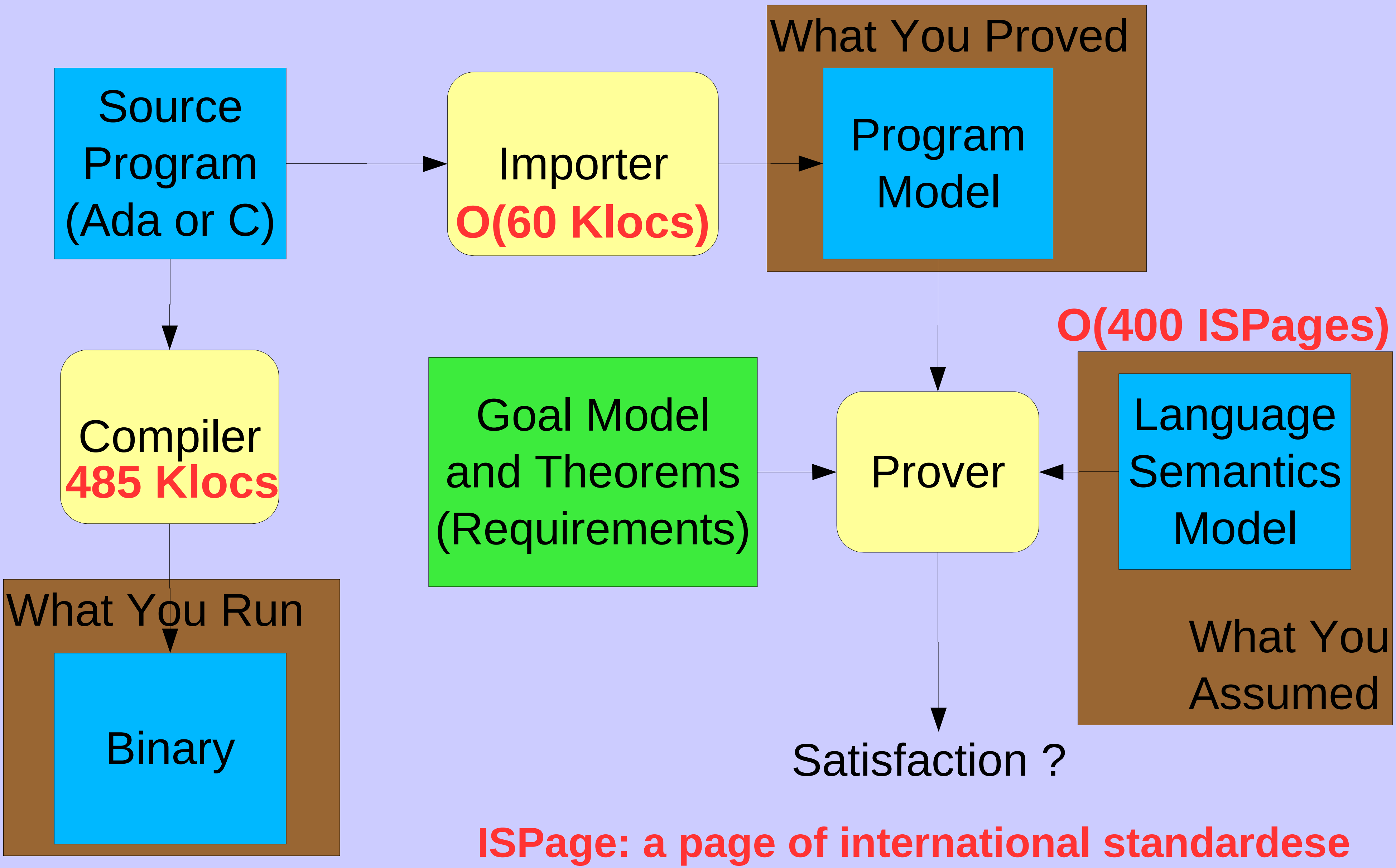
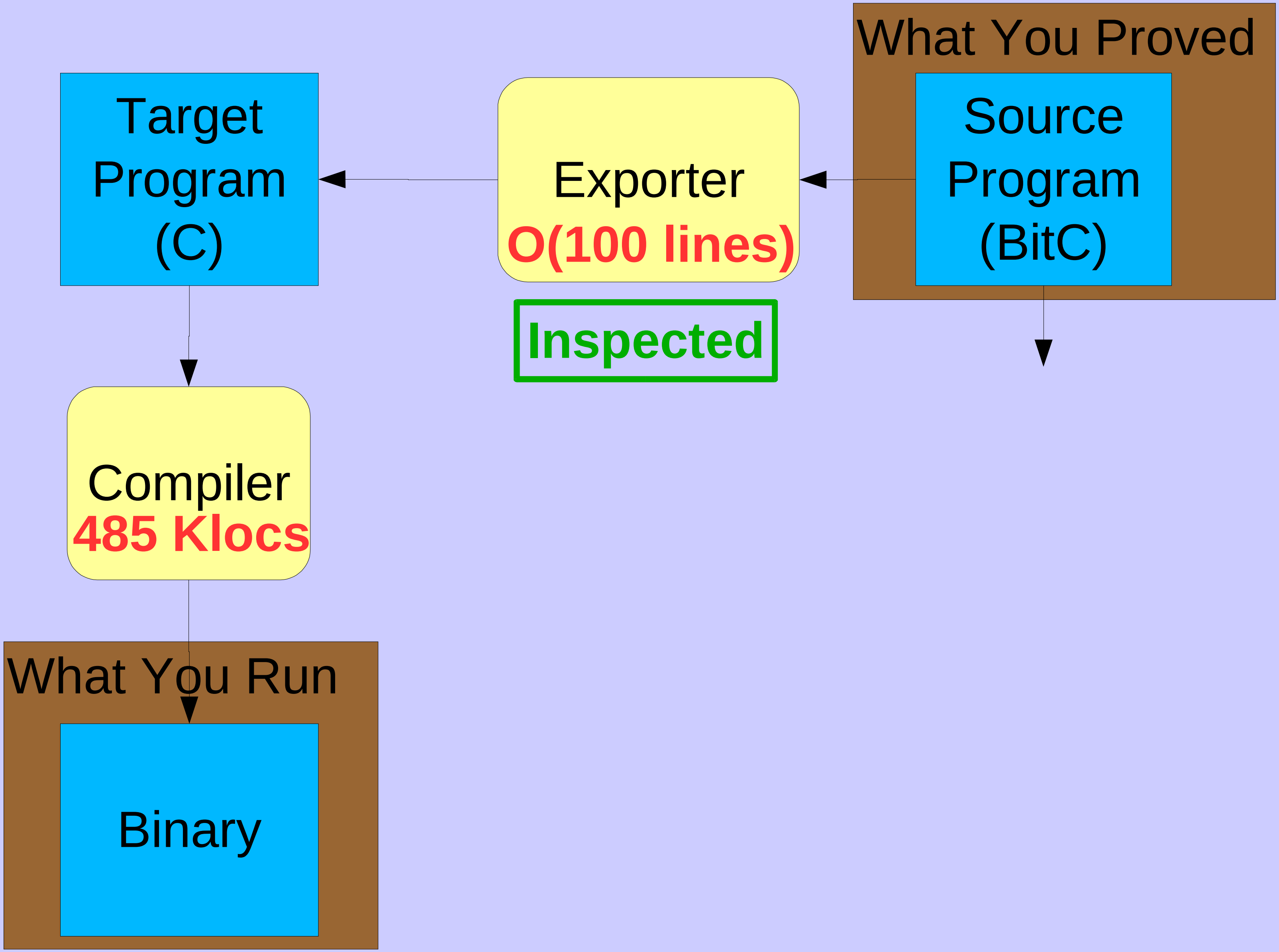


ISPage: a page of international standardese

BitC Approach (Interim)



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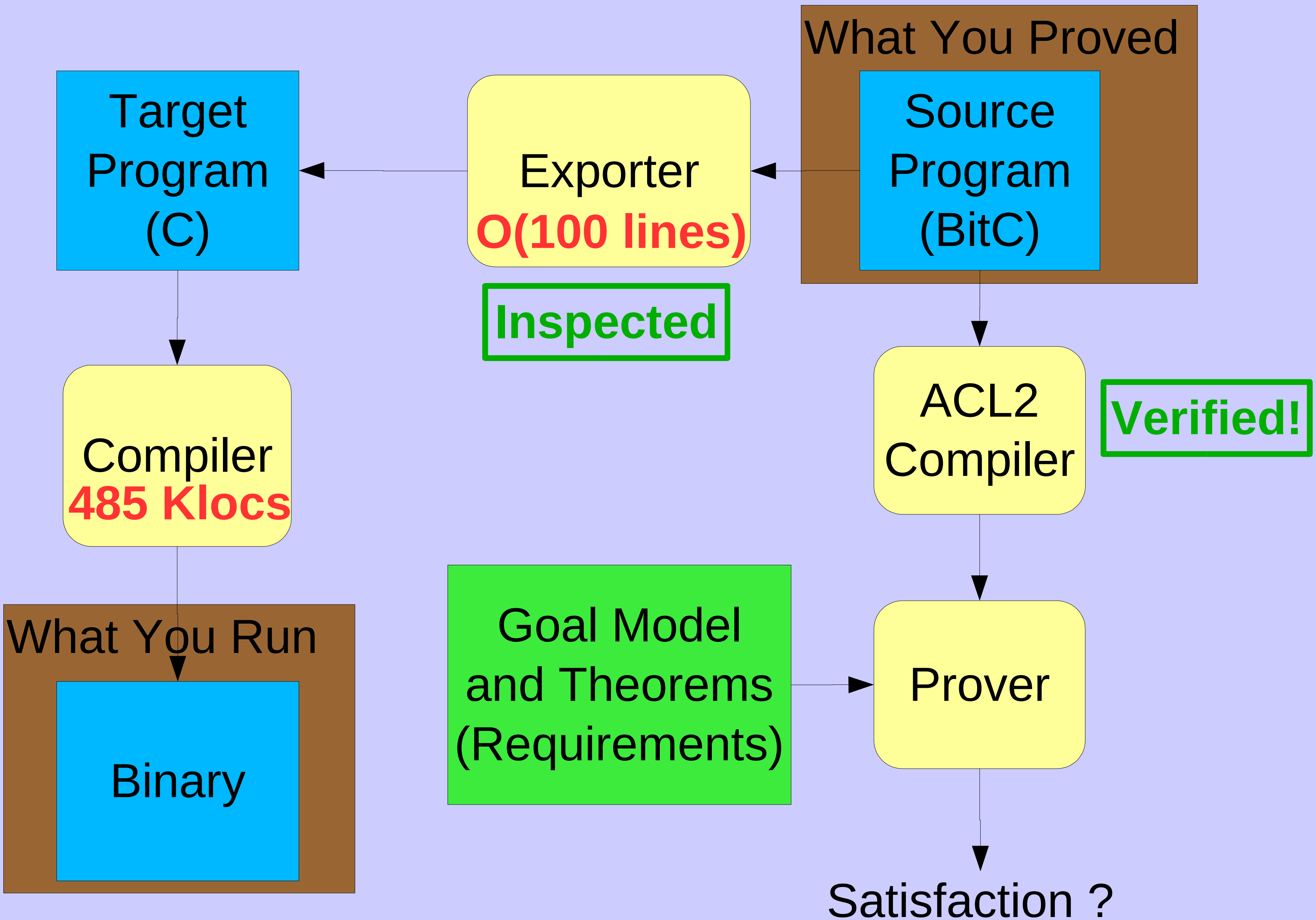
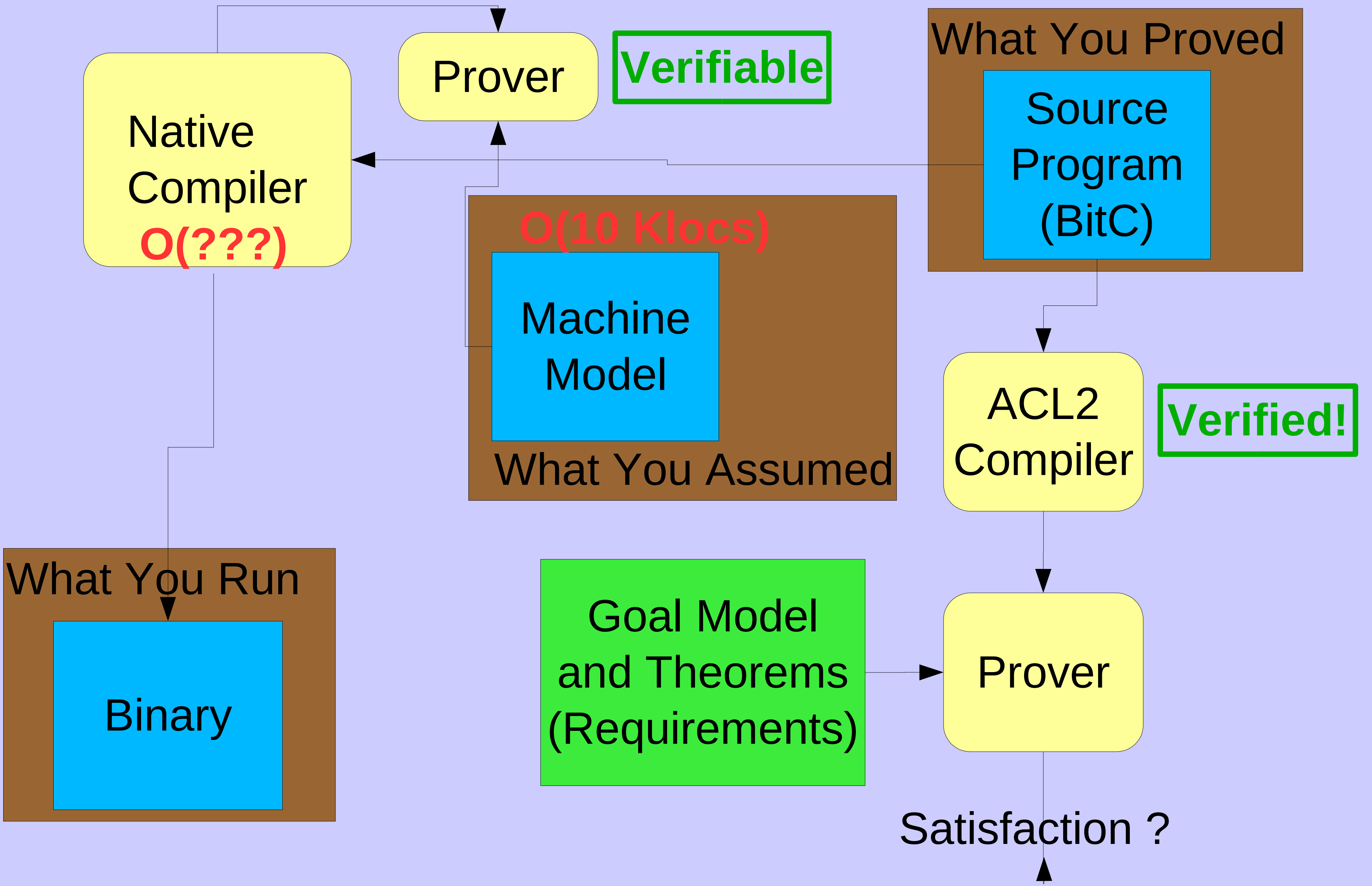


BitC Approach (Eventual)



The Good News

- EROS is pretty easy to specify.
  - Atomic units of operation: it's really just a big state machine
  - The externally visible abstractions are relatively easy to formalize (address spaces, processes)
- We can duck the aliasing issue because the implementation can (and does) restart system calls when it gets into a corner.
- From prior work, we think we know what properties we are trying to prove.
- EROS-NG is much simpler and faster than EROS

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Secret Sauce!

Things We Know How to Verify (We Think)

- *All* required access checks actually happen.
- *No* TOCTOU errors
- Every kernel path terminates in bounded time.
- Correctness of address translation and page table invalidation.
- Correctness of states (e.g. stopped process cannot receive)
- Correctness of dependency invariants
- Enforcement of confinement preconditions
- Correspondence to the abstract operational semantics (as revised).
- *(BitC is inherently memory safe)*

End Result

- First general-purpose, fully verified security kernel
- And oh yes:
  - Still fast
  - Still real-time
  - Still embeddable
  - Still runs on commodity hardware
    - Subject to secure boot assumptions
- But also:
  - First generally available verification infrastructure for systems programmers
  - Identification of a class of important programs that we can actually verify things about (atomic transactional).