

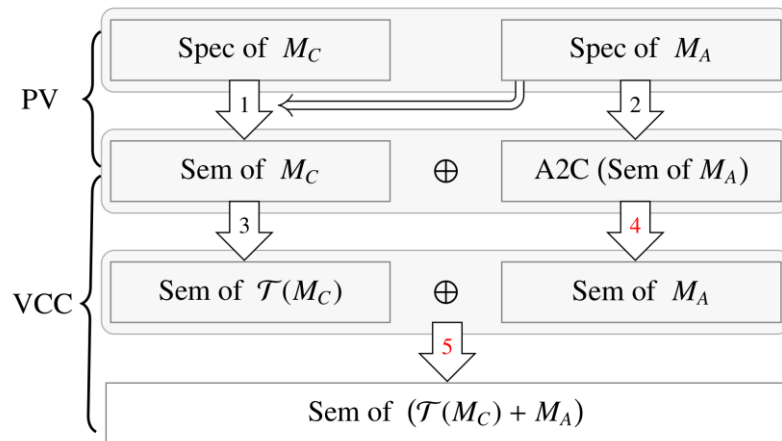
Linking C and Assembly for Denotation-Based Verified Compositional Compilation

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Problems & Ideas

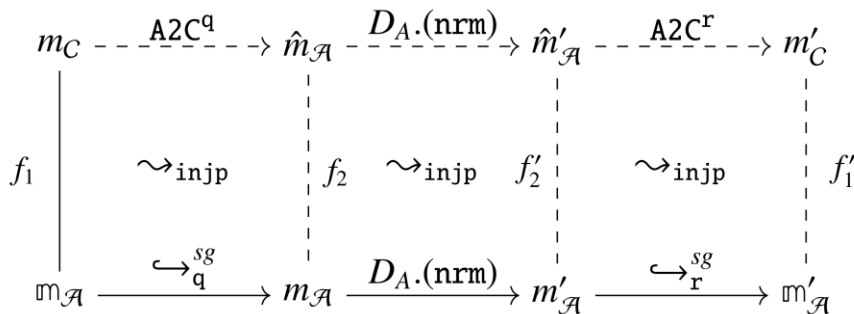
- Problems of linking C and assembly:
 - Mixed C and assembly systems (e.g., GMP, OpenSSL) require semantic linking that supports verified compositional compilation (VCC).
 - Prior approaches either require identical language interfaces, break the bridge to syntactic linking, or lack scalability.
- Ideas: Introduce a denotation-based VCC framework that transforms assembly semantics to C-level denotations via an A2C operator, enabling unified composition with C semantics.



Abstraction layers bridged by program verification (PV) and verified compositional compilation (VCC), where M_C is an open C module, M_A a closed assembly module, and $\mathcal{T}(M_C)$ the compiled assembly module from M_C . The diagram has four layers: (i) top-level specifications, (ii) C-level semantics, (iii) assembly-level semantics, and (iv) physical semantics. Notation \oplus denotes semantic linking and $+$ denotes syntactic linking. The five arrows denote: 1/2 program correctness, 3/4 compiler correctness (**with Arrow 4 being the central focus of our approach**), and 5 semantic adequacy.

Main Contributions

- Contributions:
 - Formalize a denotation-based VCC framework featuring a novel semantic translator A2C, and a procedure-level assembly semantics;
 - Prove the soundness of A2C: the derived C-level semantics is preserved by assembly denotational semantics;
 - Apply the framework to address the problem of verifying mixed compilation of C and x86 assembly in CompCert;
 - All definitions and results are formalized in Coq.



Key proof steps for the soundness of A2C

Portion	Definitions	Proofs
Signature property	269	770
Memory property	454	861
Semantics (§3.2 and §3.3)	18	195
Behavior consistency (§4.2)	317	1270
Compositionality (§5)	76	207
Total	1134	3303

The significant lines of our Coq development.