Generating Quantifiers and Negation to Explain Homework Testing

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June 5, 2010

Slides available at
`http://paul.rutgers.edu/~jasperry/gqn_bea.pdf`

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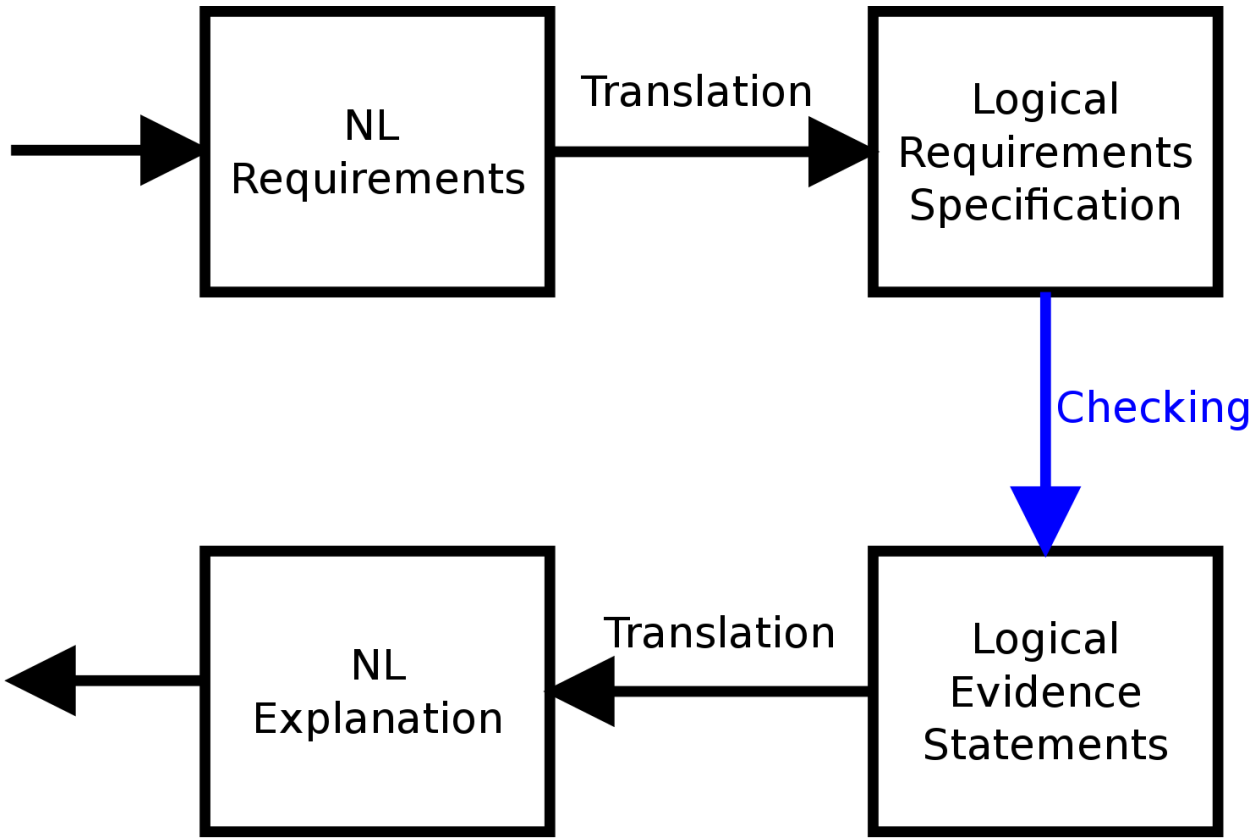
- Student automatically receives feedback:
  "Credit was lost because 'foo.c' doesn't compile and 'Readme.txt' doesn't mention 'bar.c'."

Goals

- Workable automated checking of basic programming assignment requirements with a natural language interface.
- A study of quantifiers and negation in NL generation, within an end-to-end NLP framework.

Prograder NLP System Architecture Overview



Semantics of a Requirements Statement

- Each requirement specification is a sentence, whose truth value is determined by checking a single student's programming assignment.
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- Checking of quantified statements is done through iteration over the domain (submitted files).

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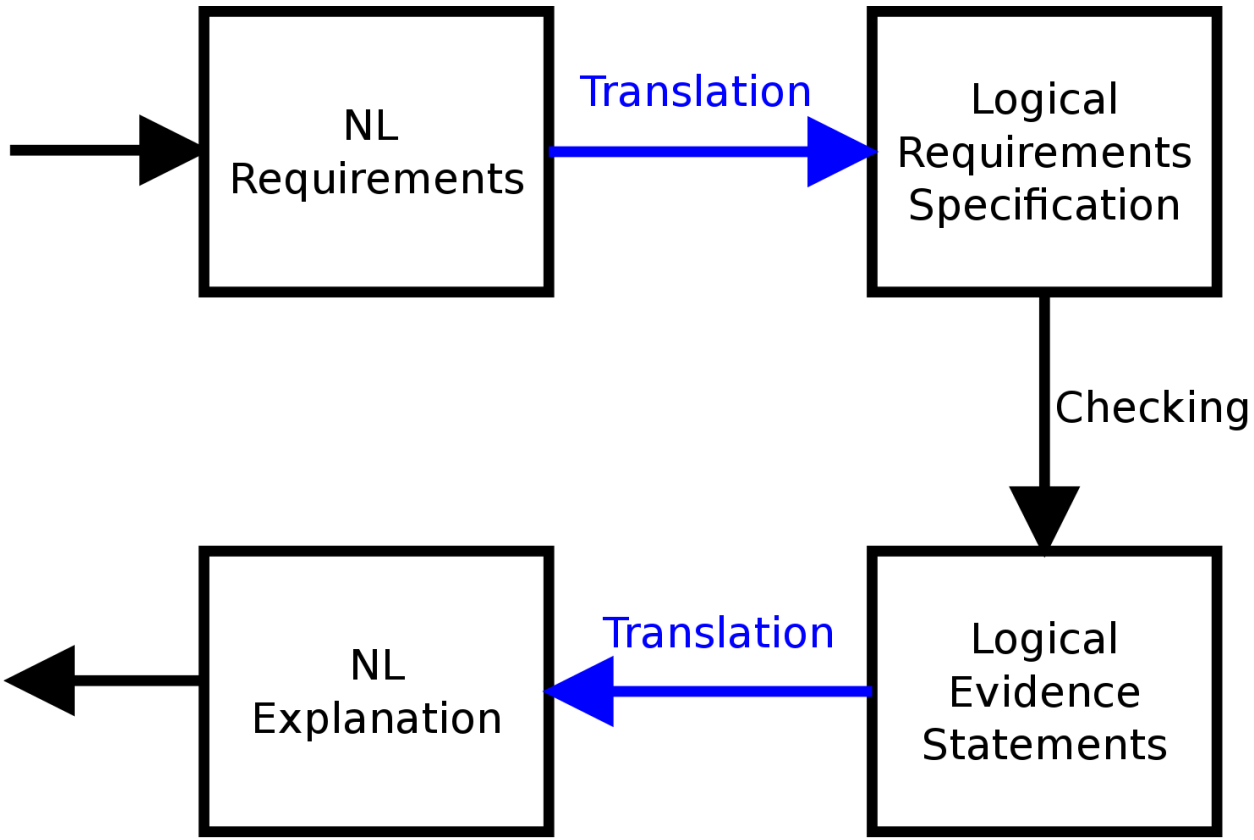
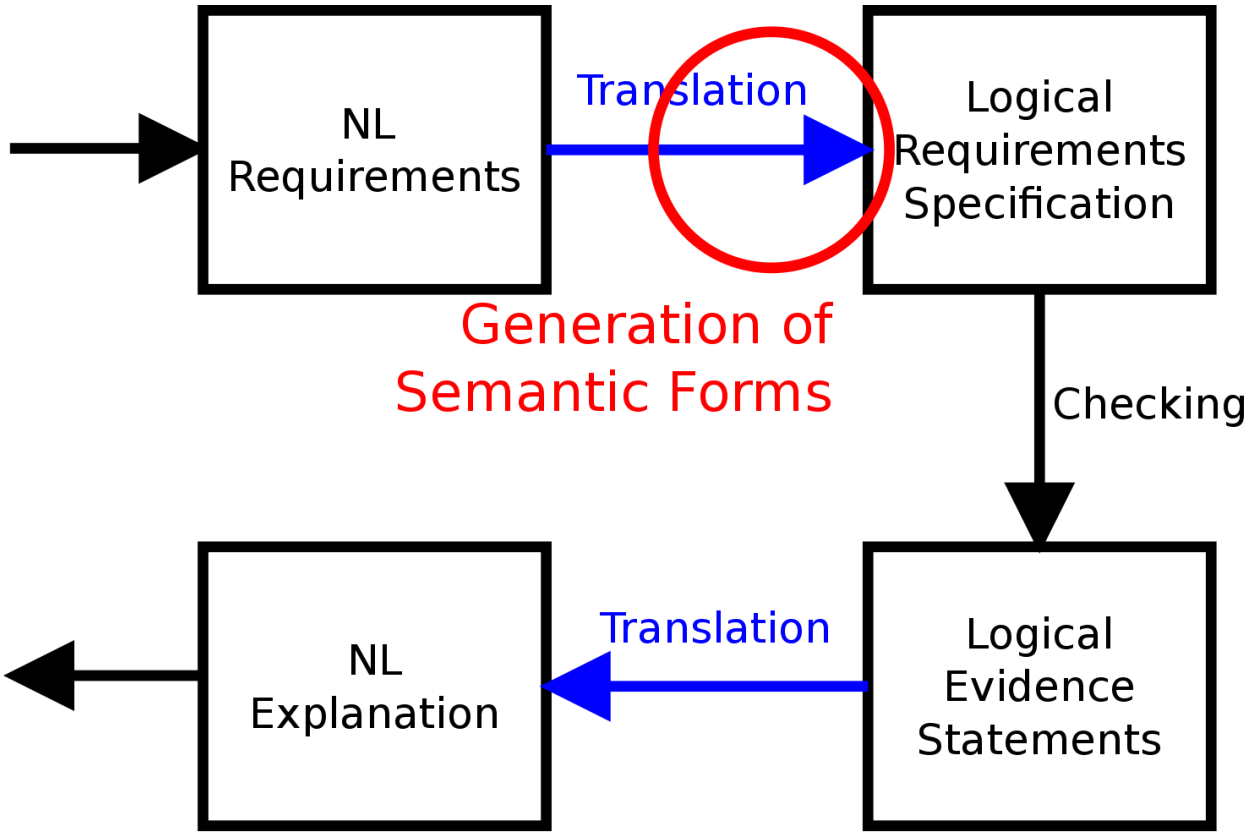
- Expand the type definition of truth value: instead of just a boolean, use a *(boolean, explanation)* pair.
- Summarization by grouping/quantifying over evidence statements

Prograder NLP System Architecture



Prograder Architecture - the Hard Part



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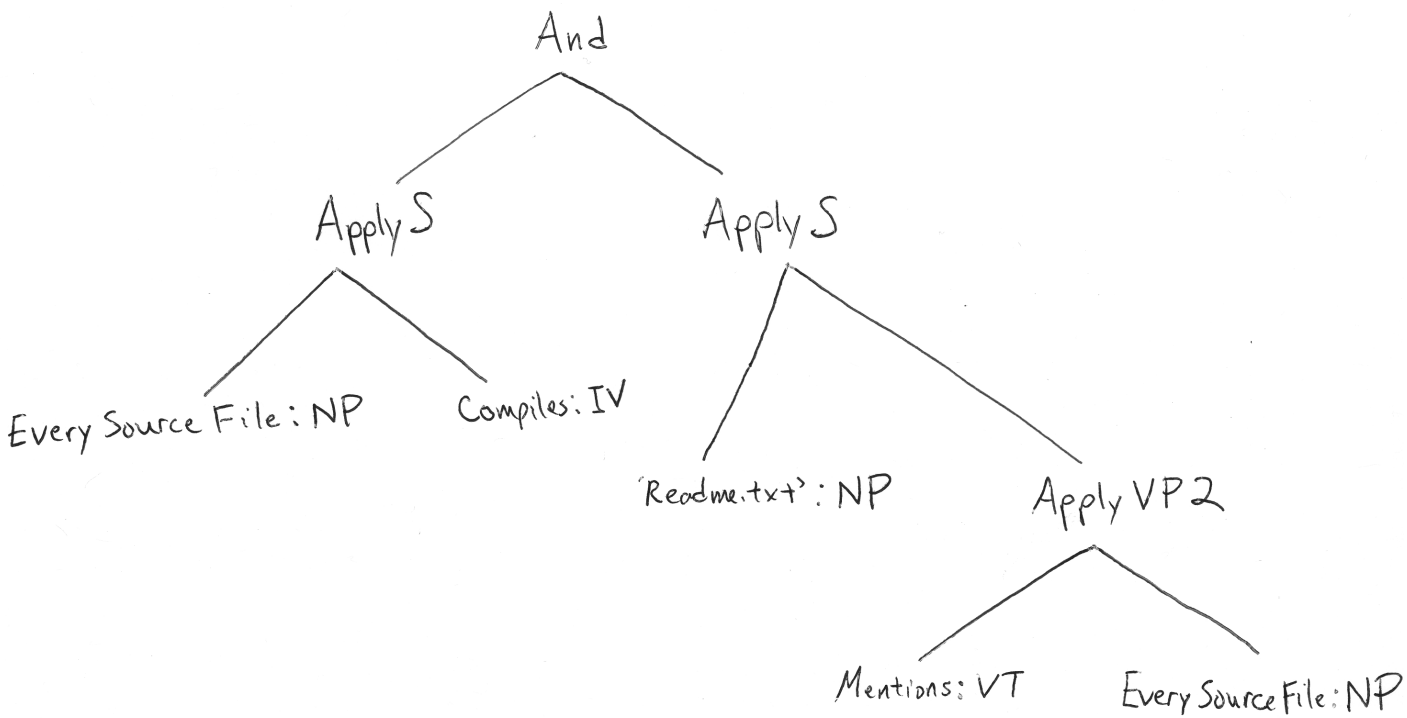
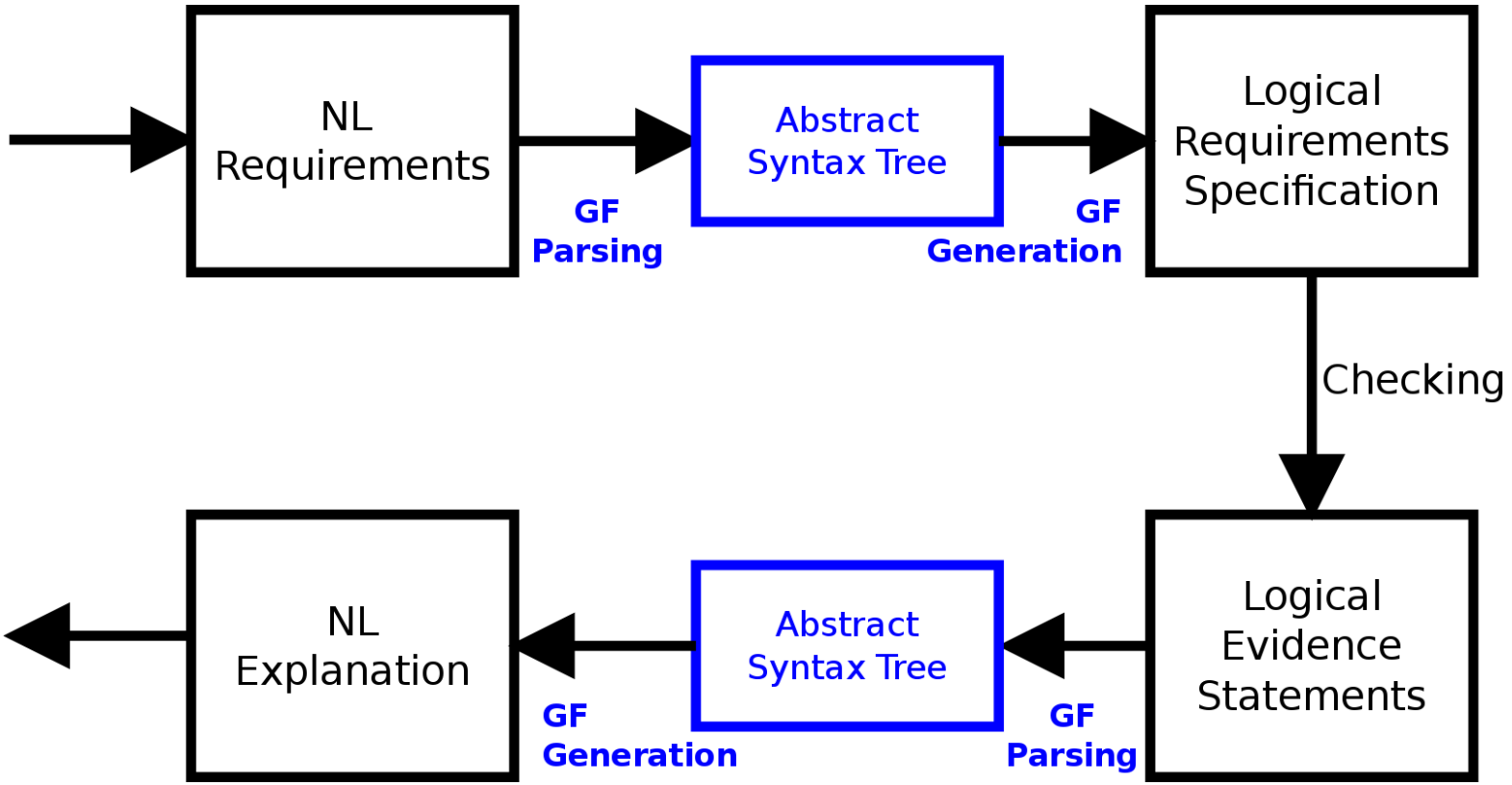
  - Parse using one concrete grammar, generate using the other, and vice-versa
- Abstract grammar is functional, concrete grammar uses string concatenation with record structures for efficiency (context-free+)
- **Prograder uses one concrete grammar for parsing/generating English, another for the Python logical form.**

Parsing Requirements to Abstract Syntax



- Non-phrase-structure aspects such such as agreement are handled in the (English) concrete grammar.
- Quantified NPs are not distinguished from syntactic NPs in the abstract syntax.

Prograder NLP Architecture Revisited



Produce a logical semantic representation from the syntax tree *using GF's generation capability*.

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What kind of expressions/application rules implement scoping?

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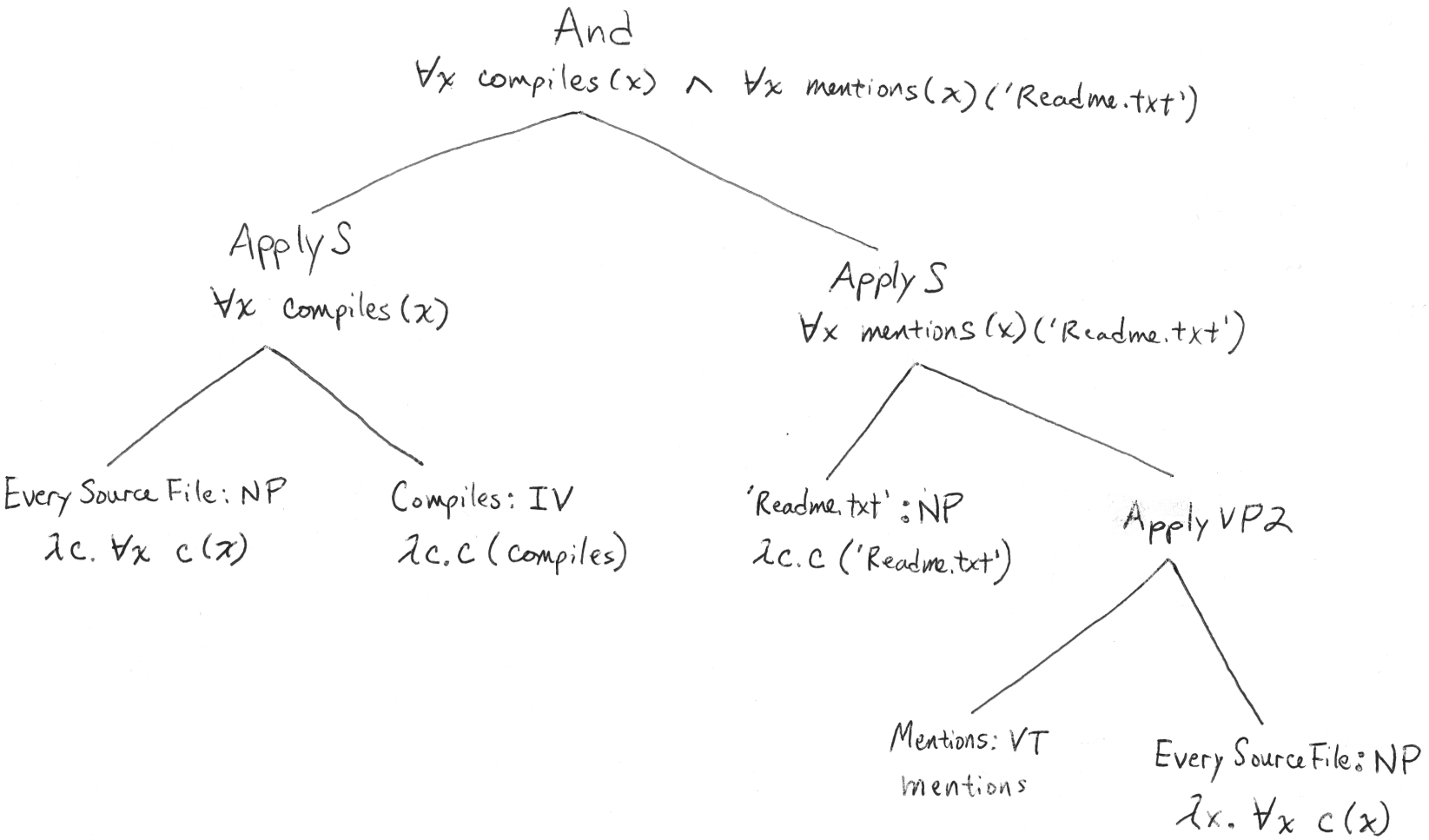
- Represents surface scope: NP can take scope over VP

Abstract Syntax Tree with Semantic Attachments



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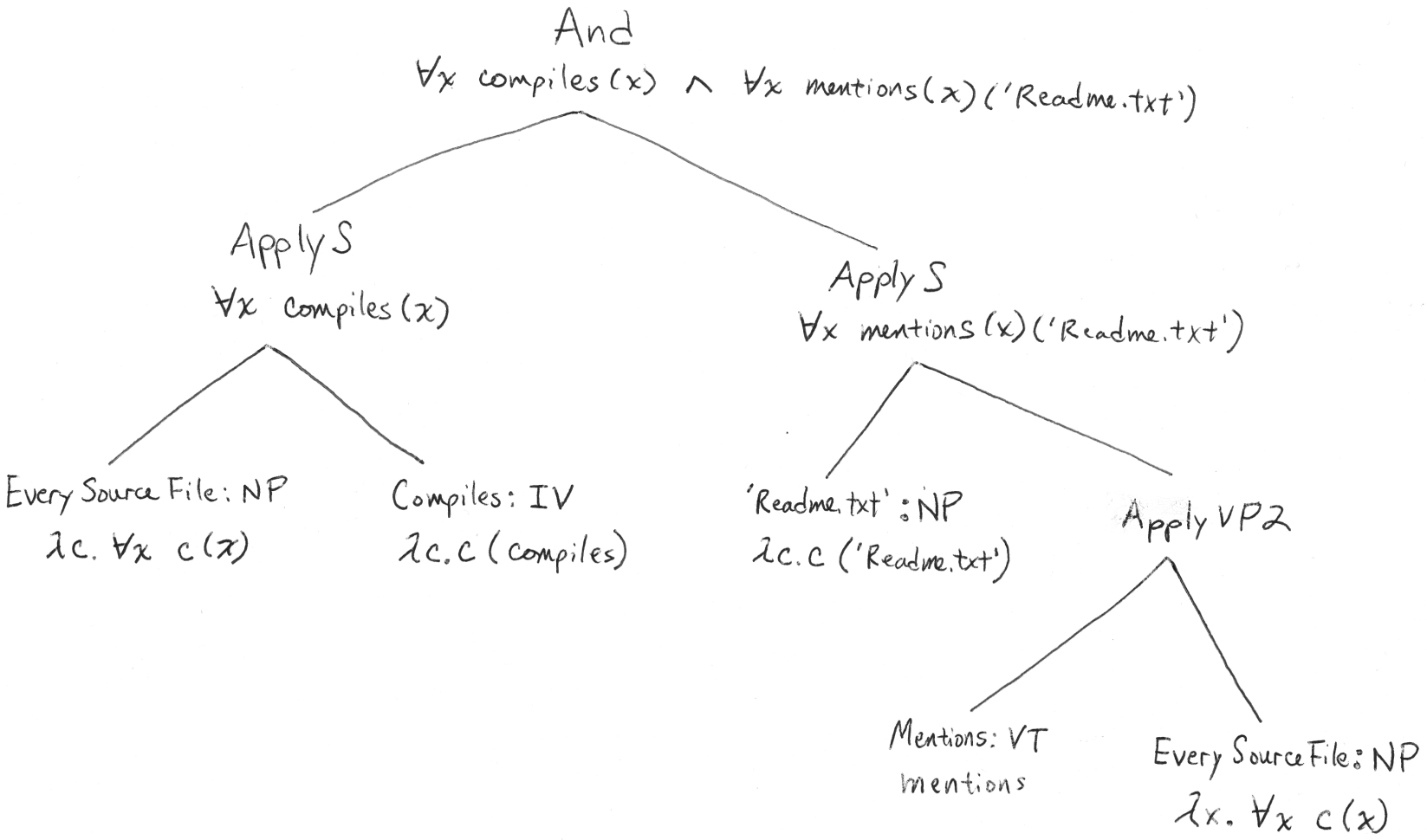

Can we generate/combine such representations using GF?

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- But GF's linearization is limited to string concatenation - no higher-order functions allowed.

Solution: simulate higher-order functions with interleaved record fields.

Simulating Bounded-depth Continuations with String Concatenation

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    { "", "'foo.c'", "" }
lin everysourcefile =
    { "everysourcefile(lambda x:", "x", ")" }
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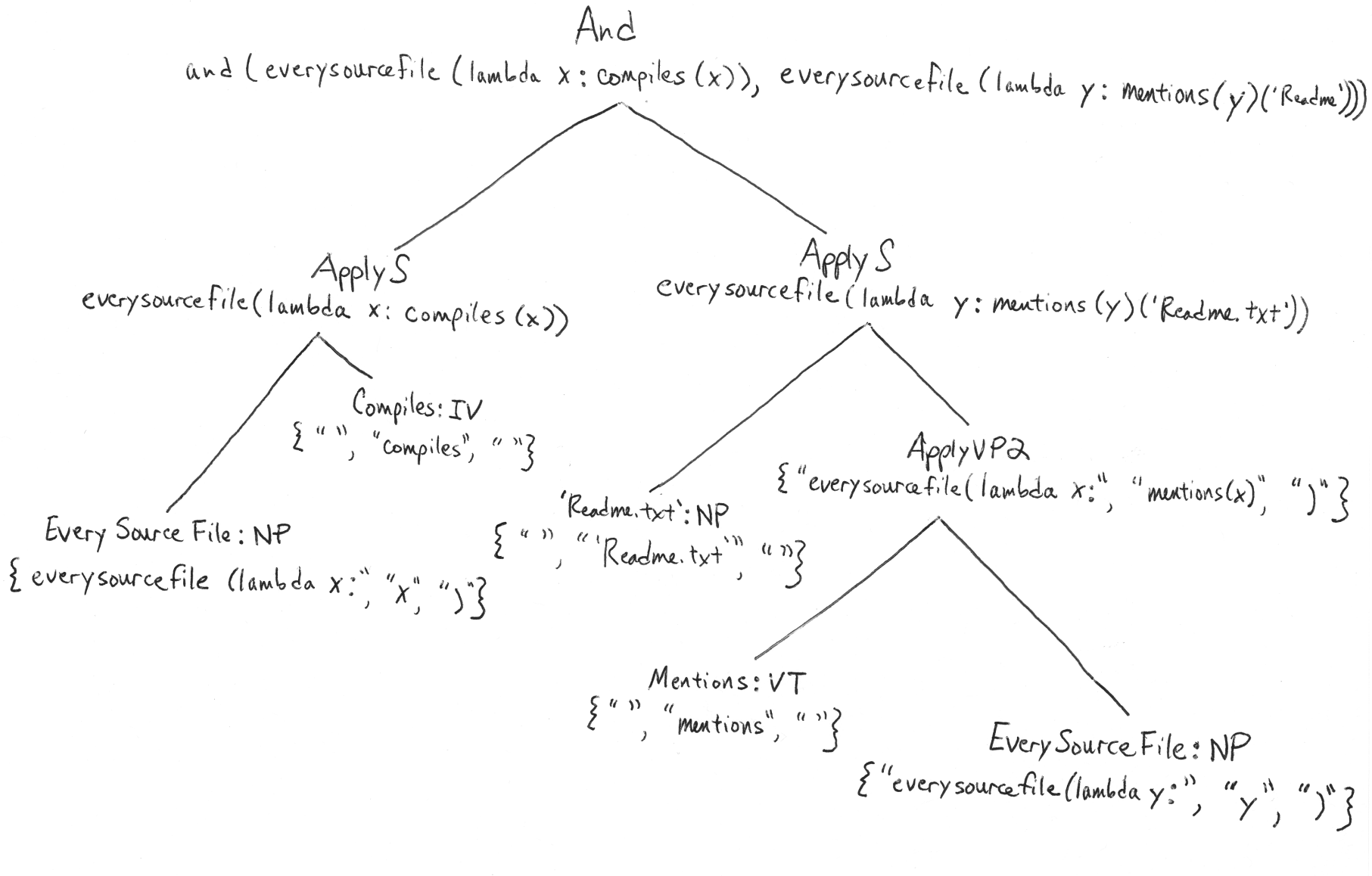
GF Generations as Semantic Attachments



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  "No source file compiles"

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```
noteverysourcefile (not (not (compiles)))

"not every source file compiles"
```

Sample Output

```
$ ./runPrograder.py assn 'every source file compiles and
        "README" mentions every source file'
*****************************
RESULT: False, because:
a source file doesn't compile and "README" doesn't mention
        every source file
"nowork2.c" doesn't compile
"nowork.c" doesn't compile
"README" doesn't mention "nowork2.c"
"README" doesn't mention "hello.c"
"README" doesn't mention "work1.c"
```

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- Grad students don't have to write as many scripts, professors don't have to learn a new system.

Continuing Work

- Testing with actual professors and students, expanding the vocabulary
- Finish the general formulation of the continuation-rule-to-record mapping, including higher-order quantifiers e.g. 'some'
- Further investigation of summarization within the type-theoretic framework

The End

Thank you!