CS 4248
Natural Language Processing

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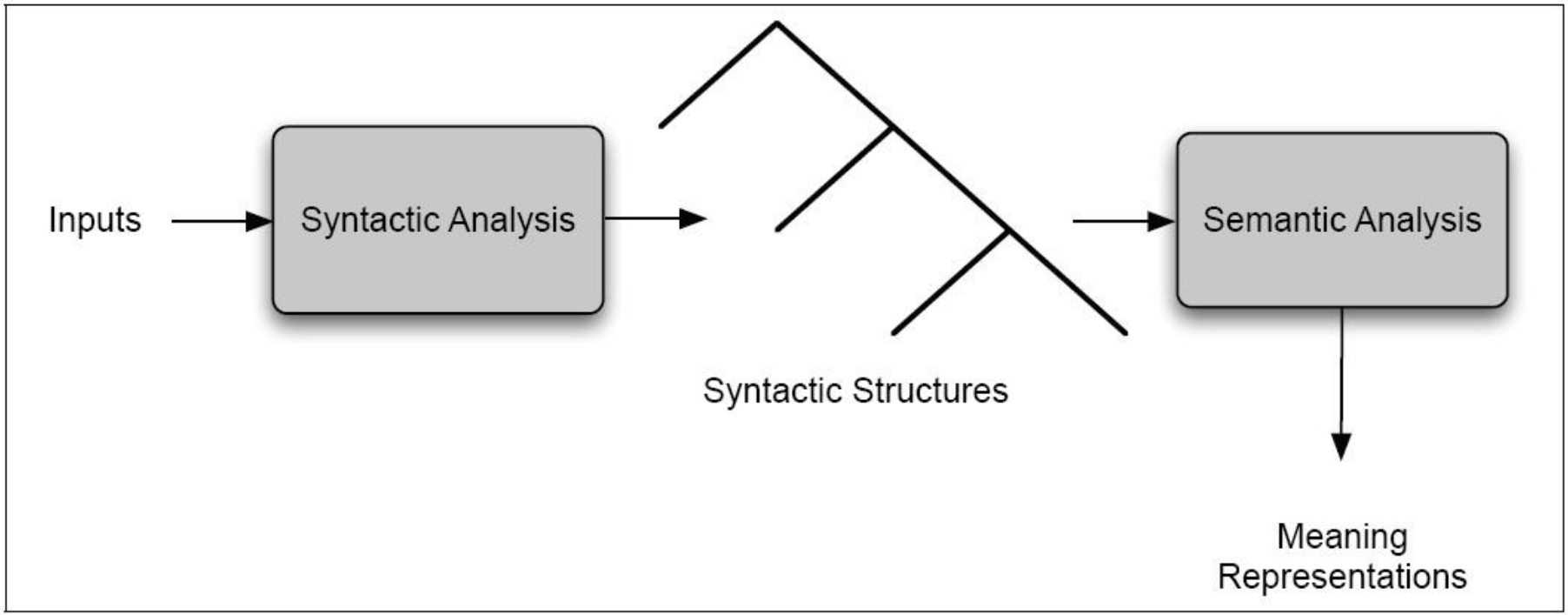
Chapter 18: Computational Semantics

- Syntax-Driven Semantic Analysis

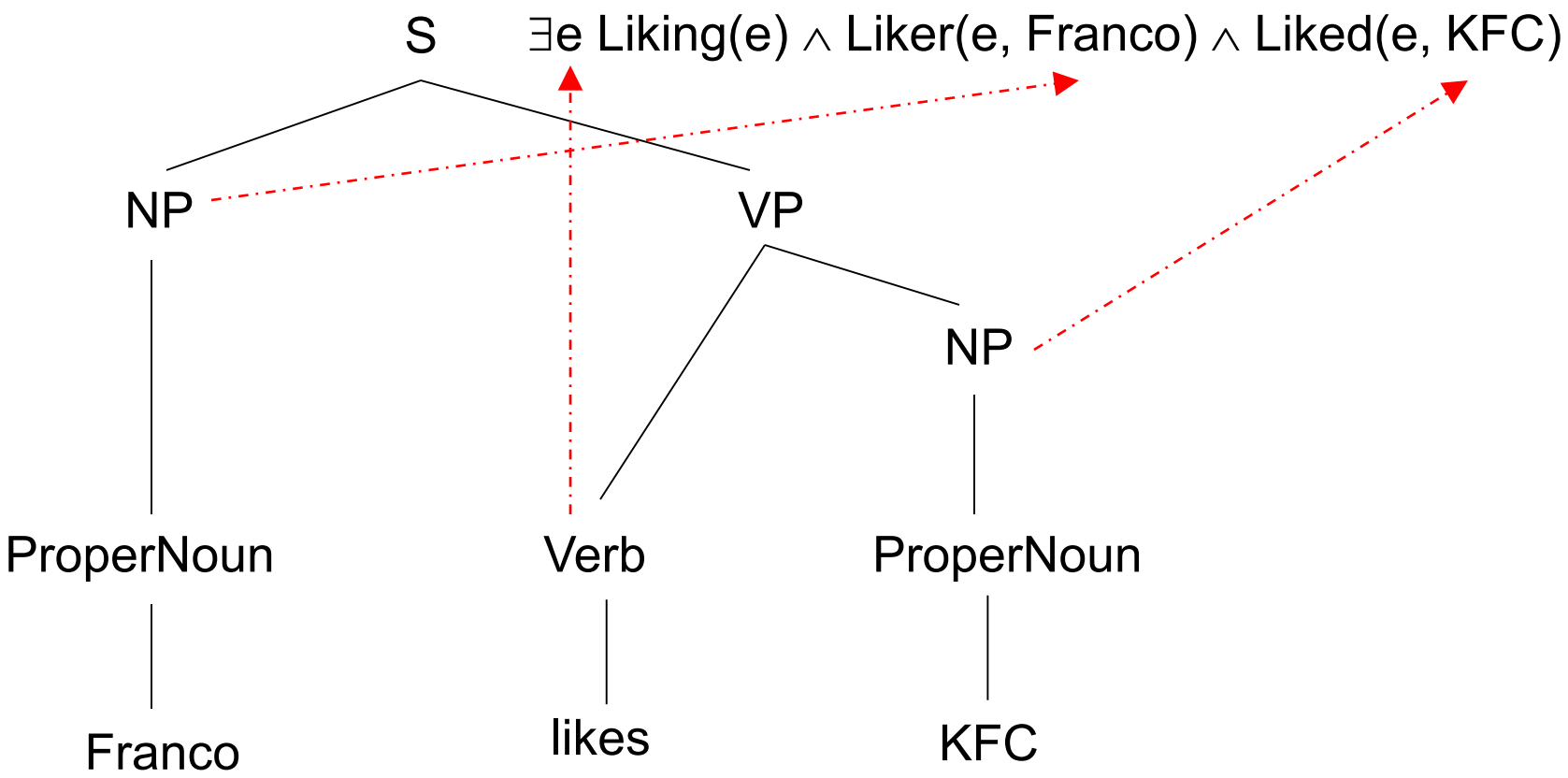
Syntax-Driven Semantic Analysis

- Principle of compositionality
  - The meaning of a sentence can be composed from the meanings of its parts
- The meaning of a sentence is dependent on the ordering, grouping, and relations among the words in the sentence (i.e., its syntactic structure)

Syntax-Driven Semantic Analysis



Syntax-Driven Semantic Analysis



Semantic Attachments

- Augment CFG rules with semantic attachments

  $A \rightarrow \alpha_1 \ldots \alpha_n \quad \{ f(\alpha_j.sem, \ldots, \alpha_k.sem) \}$
- A semantic attachment describes how to compute the meaning representation of the LHS constituent (A.sem) using the meaning representations of the RHS constituents (α_i.sem)

Semantic Attachments

Grammar Rule	Semantic Attachment
$S \rightarrow NP\ VP$	$\{NP.sem(VP.sem)\}$
$NP \rightarrow Det\ Nominal$	$\{Det.sem(Nominal.sem)\}$
$NP \rightarrow ProperNoun$	$\{ProperNoun.sem\}$
$Nominal \rightarrow Noun$	$\{Noun.sem\}$
$VP \rightarrow Verb$	$\{Verb.sem\}$
$VP \rightarrow Verb\ NP$	$\{Verb.sem(NP.sem)\}$
$Det \rightarrow every$	$\{\lambda P.\lambda Q.\forall x P(x) \Rightarrow Q(x)\}$
$Det \rightarrow a$	$\{\lambda P.\lambda Q.\exists x P(x) \wedge Q(x)\}$
$Noun \rightarrow restaurant$	$\{\lambda r.Restaurant(r)\}$
$ProperNoun \rightarrow Matthew$	$\{\lambda m.m(Matthew)\}$
$ProperNoun \rightarrow Franco$	$\{\lambda f.f(Franco)\}$
$ProperNoun \rightarrow Frasca$	$\{\lambda f.f(Frasca)\}$
$Verb \rightarrow closed$	$\{\lambda x.\exists e Closed(e) \wedge ClosedThing(e,x)\}$
$Verb \rightarrow opened$	$\{\lambda w.\lambda z.w(\lambda x.\exists e Opened(e) \wedge Opener(e,z) \wedge \sout{Opened}(e,x))\}$

OpenedThing

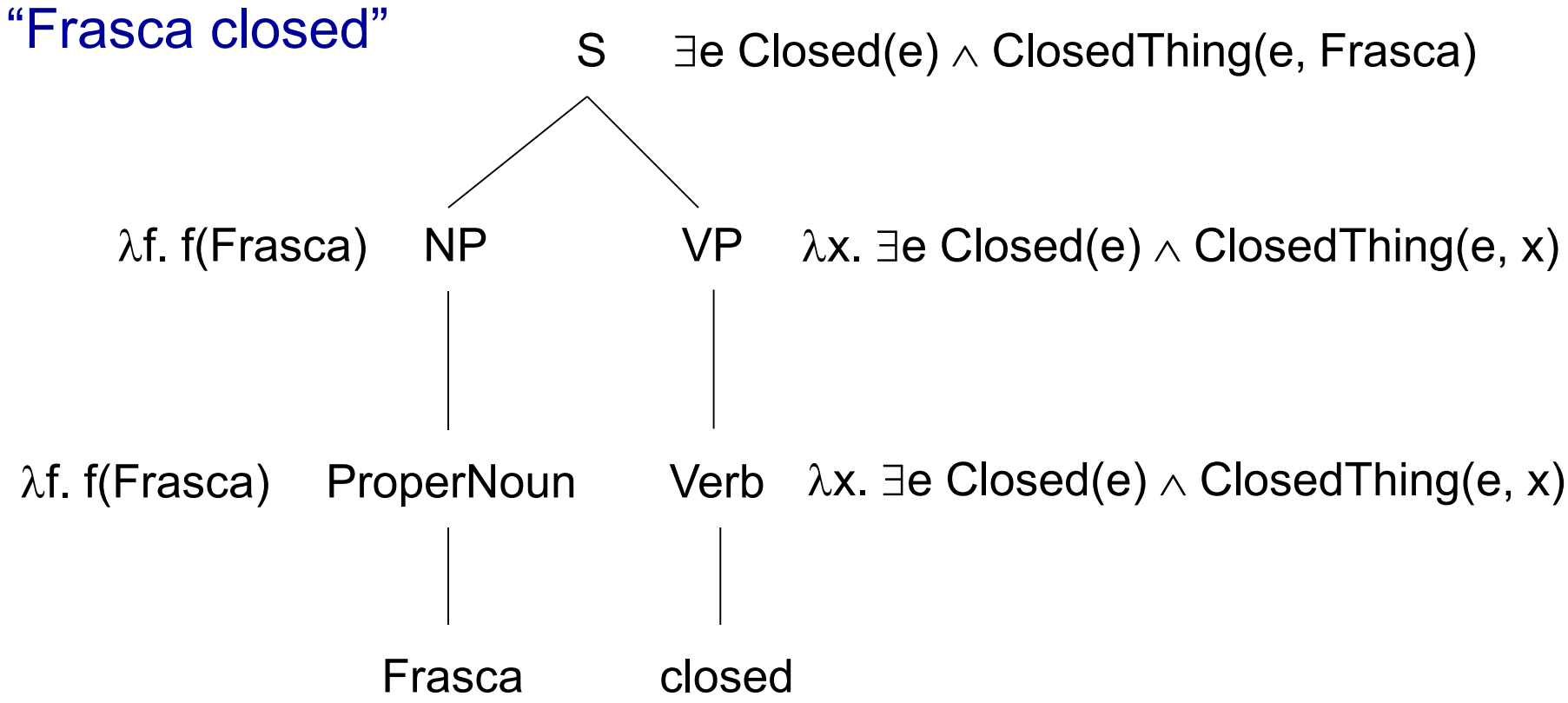
Semantic Attachments

- Associating complex, function-like λ-expressions with lexical items
- Copying of semantic values from children to parents in non-branching rules
- Function-like application of the semantics of one of the children of a rule to the semantics of the other children of the rule via λ-reduction

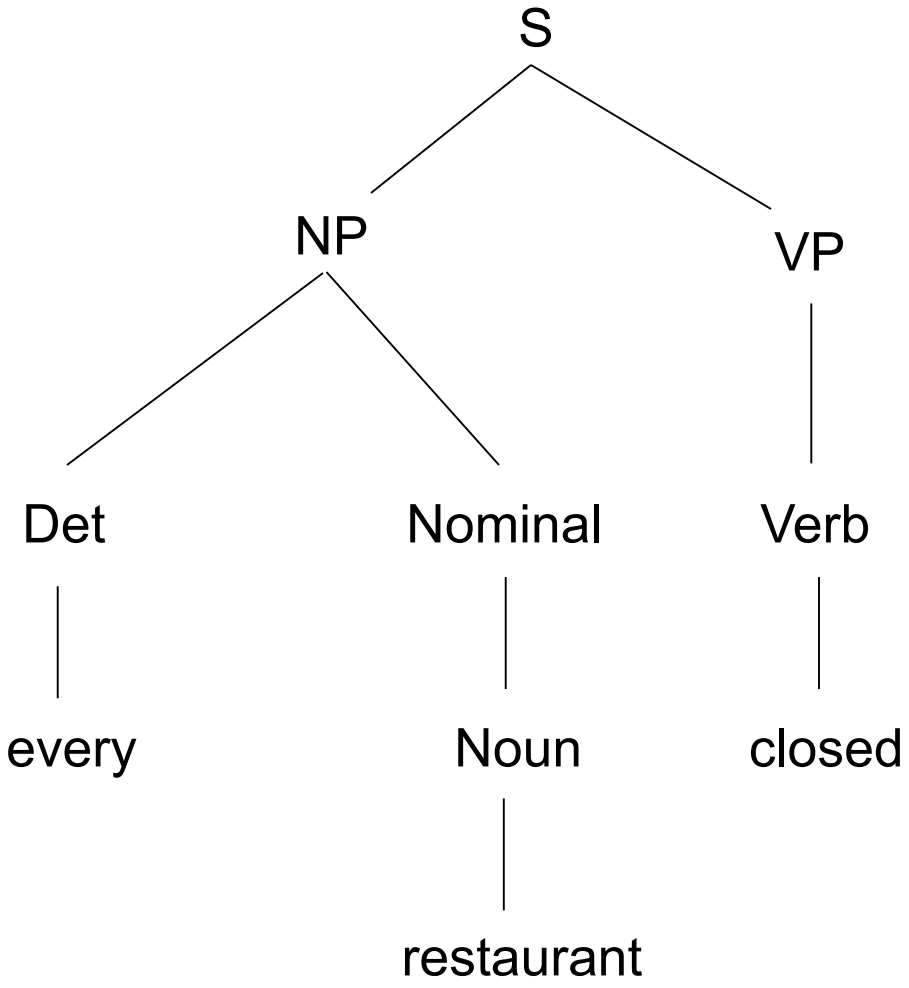
Semantic Attachments

- Lambda expression: λx P(x)
- λ-reduction: apply a lambda expression to a term
  - Replace the λ variable by the term, then remove λx
- Examples:
  - λx P(x)(A) gives P(A)
  - λxλy Near(x,y)(NUS) gives λy Near(NUS,y)
  - λy Near(NUS,y)(AYE) gives Near(NUS, AYE)

Semantic Attachments



Semantic Attachments



$\forall x$ Restaurant(x) $\Rightarrow$
$\exists e$ Closed(e) $\wedge$ ClosedThing(e, x)

"every restaurant closed"

Idioms and Compositionality

- Idioms violate the assumption of compositionality
- “The SEC’s allegations are only the tip of the iceberg.”

  NP $\rightarrow$ the tip of the iceberg { Beginning }
- “These comments describe only the tip of a 1,000-page iceberg.”
- “The 10 employees represent the merest tip of the iceberg.”

  NP $\rightarrow$ TipNP of IcebergNP { Beginning }