Predicate Argument Structures

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Predicate Identification

What is a predicate?

A linguistic unit that governs arguments. Cannot complete its meaning without its arguments.

verb-predicate

He bought a car from a dealer for her yesterday.

auxiliary verb

He was going to buy a car.

She threw the car away.

He made a bid for the car.

She ignored his bid to accept the car.

The bid was acceptable to me.

verb-particle

light-verb

noun-predicate

adjective-predicate

auxiliary verb
Predicate Sense Disambiguation

A **predicate** can have multiple **senses** (meanings).

**Take**

- He *took* the book with him.
- He couldn’t *take* the pressure.
- He *took* 5 days to complete the homework.

[http://verbs.colorado.edu/propbank/framesets-english/take-v.html](http://verbs.colorado.edu/propbank/framesets-english/take-v.html)
Argument Identification

What is an argument?

A participant of the predicate.
Complete the meaning of the predicate.

Exercise

He bought a car from a dealer for her yesterday.

She threw the car away.

He made a bid for the car.

The bid was acceptable to me.

She ignored his bid to accept the car.
Argument Labeling

He \textcolor{red}{bought} a car from a dealer \textcolor{red}{for her} yesterday.

She \textcolor{red}{threw} the car away.

He \textcolor{red}{made a bid} for the car.

The bid was acceptable to me.

She ignored his bid to accept the car.
# Semantic Roles

**Underlying relations** between *predicates* and their *arguments*.

<table>
<thead>
<tr>
<th>actor</th>
<th>destination</th>
<th>patient</th>
<th>theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>agent</td>
<td>experiencer</td>
<td>predicate</td>
<td>theme</td>
</tr>
<tr>
<td>asset</td>
<td>extent</td>
<td>product</td>
<td>patient</td>
</tr>
<tr>
<td>attribute</td>
<td>instrument</td>
<td>recipient</td>
<td>time</td>
</tr>
<tr>
<td>beneficiary</td>
<td>location</td>
<td>source</td>
<td>topic</td>
</tr>
<tr>
<td>cause</td>
<td>material</td>
<td>stimulus</td>
<td>proposition</td>
</tr>
</tbody>
</table>

http://verbs.colorado.edu/~mpalmer/projects/verbnet.html
PropBank

A corpus in which **arguments** are annotated with the **semantic roles** they play with respect to their **predicates**.

Each **predicate** encompasses one or more **senses** defining their own predicate **argument structures**.

**Predicate Senses**
- open
  - open.01: **open**
    - ARG0: opener
    - ARG1: thing opened
    - ARG2: instrument
    - ARG3: benefactive
  - open.02: **begin**
    - ARG0: causer of opening
    - ARG1: thing opened
  - open.03: **cause to be not closed**
    - ARG0: opener
    - ARG1: thing opened
    - ARG2: instrument
    - ARG3: benefactive

**Argument Structures**
open

open.01: open
ARG0: opener
ARG1: thing opened
ARG2: instrument
ARG3: benefactive

open.02: begin
ARG0: causer of opening
ARG1: thing opened
ARG2: instrument
ARG3: benefactive

open.03: cause to be not closed
ARG0: opener
ARG1: thing opened
ARG2: instrument
ARG3: benefactive

ARG0
NP
PRP He
VBD opened

ARG1
NP
DT the
NN door
IN with

ARG2
PP
PRP$ his
NN foot
IN at

TMP

VP

PropBank
Numbered Arguments

Arguments frequently co-occurring with their predicates.

ARG0: agent.

ARG1: patient, theme.

ARG2: instrument, benefactive, attribute.

ARG3: starting point.

ARG4: ending point.

ARGA: external causer.

Are numbered arguments required?

How do you determine numbered arguments?
## Modifiers

Arguments whose roles are **independent** from their **predicates**.

<table>
<thead>
<tr>
<th>Modifier</th>
<th>Role</th>
<th>Location</th>
<th>Secondary Predication</th>
<th>Purpose</th>
<th>Reciprocals</th>
<th>Temporal</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADJ</td>
<td>Adjectival</td>
<td>LOC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADV</td>
<td>Adverbial</td>
<td>MNR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAU</td>
<td>Cause</td>
<td>MOD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COM</td>
<td>Comitative</td>
<td>NEG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIS</td>
<td>Discourse</td>
<td>PRD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOL</td>
<td>Goal</td>
<td>REC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXT</td>
<td>Extent</td>
<td>TMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Exercise

• Exercise 2
  - Go to http://verbs.colorado.edu/propbank/framesets-english/.
    • lemma-v: verb, lemma-n: noun, lemma-j: adjective.
  - Annotate all arguments of each predicate.
    • He bought a car from a dealer for her yesterday.
    • She threw the car away because she didn’t like it.
    • He made a bid for the car in my office.
    • She ignored his bid to accept the car.
    • The bid was acceptable to me.
  - Useful modifiers
    • TMP: temporal, LOC: location, CAU: cause, NEG: negation.
Exercise

• He bought a car from a dealer for her yesterday.
  - buy.01, A0: He, A1: a car, A2: from a dealer, A4: for her, TMP: yesterday.

• She threw the car away because she didn’t like it.
  - throwAway.07, A0: She, A1: the car, CAU: because ...
  - like.01, A0: she, A1: it, NEG: negation.

• He made a bid for the car in my office.
  - make.LV.
  - bid.01: A0: He, A1: for the car, LOC: in my office.
Exercise

• She ignored his bid to accept the car.
  - \text{ignore.01}: A0: She, A1: his bid to accept the car.
  - \text{bid.01}: A0: his, A1: to accept the car.
  - \text{accept.01}: A1: the car.

• The bid was acceptable to me.
  - \text{bid.01}.
  - \text{acceptable.01}: A0: The bid, A1: to me.
Argument Candidates

No need to traverse the entire tree for finding the arguments!

Sibling of the predicate.

Dependents of the predicate.
Argument Candidates

**siblings** of the ancestors.

**dependents** of the ancestors.
Argument Candidates

Linguistically motivated rules

Dependents of the predicate.
Dependents of the ancestors.

What if the tree is ill-parsed?

![Bar chart showing comparison between Gold and System for First-order metrics. The Gold metric is significantly higher than the System metric.]
Argument Candidates

Higher-order

Descendents ← Dependents of the predicate.
Dependents of the ancestors.

Gold System

First-order  Higher-order

92 94 96 98 100
## Applications

### Question Answering

He *bought* a car from a dealer for her yesterday.

Who *bought* what from whom for whom when?

<table>
<thead>
<tr>
<th>Predicate</th>
<th>buy.01</th>
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</tr>
</thead>
<tbody>
<tr>
<td>ARG0</td>
<td>He</td>
<td>Who</td>
</tr>
<tr>
<td>ARG1</td>
<td>a car</td>
<td>what</td>
</tr>
<tr>
<td>ARG2</td>
<td>from a dealer</td>
<td>from whom</td>
</tr>
<tr>
<td>ARG4</td>
<td>for her</td>
<td>for whom</td>
</tr>
<tr>
<td>TMP</td>
<td>yesterday</td>
<td>when</td>
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Semantic Frames

Semantic role labeling is sometimes not enough!

He **bought** a car from a dealer.

Who **sold** a car to him?

<table>
<thead>
<tr>
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<th>sell.01</th>
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<tbody>
<tr>
<td>ARG0</td>
<td>He</td>
<td>Who</td>
</tr>
<tr>
<td>ARG1</td>
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<td>the car</td>
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<tr>
<td>ARG2</td>
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Use the **VerbNet** semantic frames.

http://verbs.colorado.edu/verb-index/
VerbNet

VerbNet Semantic Frames

**buy** → **get-13.5.1**

- has\_possession\((\text{start}(E), \text{Source}, \text{Theme})\)
- has\_possession\((\text{end}(E), \text{Agent}, \text{Theme})\)
- transfer\(\text{(during}(E), \text{Theme})\)


**sell** → **give-13.1**

- has\_possession\((\text{start}(E), \text{Agent}, \text{Theme})\)
- has\_possession\((\text{end}(E), \text{Recipient}, \text{Theme})\)
- transfer\(\text{(during}(E), \text{Theme})\)

VerbNet

buy → get-13.5.1

\[
\begin{align*}
\text{has\_possession} & (\text{start}(\text{buy}), \text{a dealer}, \text{a car}) \\
\text{has\_possession} & (\text{end}(\text{buy}), \text{He}, \text{a car}) \\
\text{transfer} & (\text{during}(\text{buy}), \text{a car})
\end{align*}
\]

sell → give-13.1

\[
\begin{align*}
\text{has\_possession} & (\text{start}(\text{sell}), \text{Who}, \text{a car}) \\
\text{has\_possession} & (\text{end}(\text{sell}), \text{him}, \text{a car}) \\
\text{transfer} & (\text{during}(\text{sell}), \text{a car})
\end{align*}
\]

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