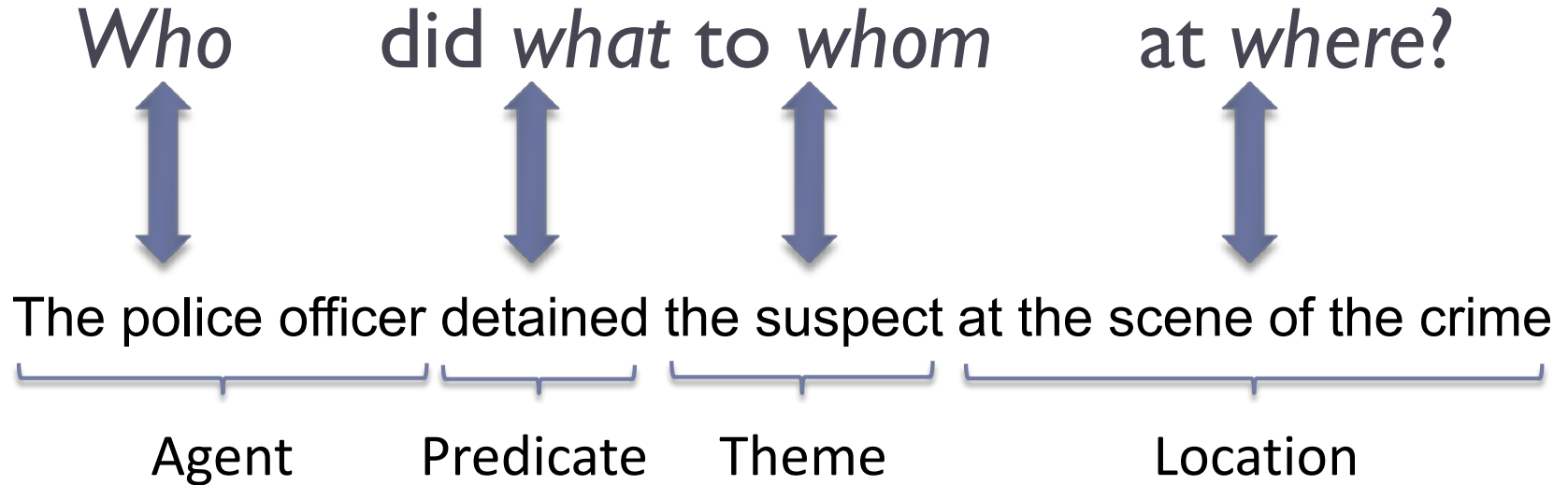


Semantic Role Labeling

Introduction

Many slides adapted from Dan Jurafsky

Semantic Role Labeling



Can we figure out that these have the same meaning?

XYZ corporation **bought** the stock.

They **sold** the stock to XYZ corporation.

The stock was **bought** by XYZ corporation.

The **purchase** of the stock by XYZ corporation...

The stock **purchase** by XYZ corporation...

Semantic Role Labeling

Semantic Roles

Getting to semantic roles

Neo-Davidsonian event representation:

Sasha broke the window

$$\exists e, x, y \text{ Breaking}(e) \wedge \text{Breaker}(e, \text{Sasha}) \\ \wedge \text{BrokenThing}(e, y) \wedge \text{Window}(y)$$

Pat opened the door

$$\exists e, x, y \text{ Opening}(e) \wedge \text{Opener}(e, \text{Pat}) \\ \wedge \text{OpenedThing}(e, y) \wedge \text{Door}(y)$$

Subjects of break and open: **Breaker** and **Opener**

Deep roles specific to each event (breaking, opening)

Hard to reason about them for NLU applications like QA

Thematic roles

- **Breaker** and **Opener** have something in common!
 - Volitional actors
 - Often animate
 - Direct causal responsibility for their events
- Thematic roles are a way to capture this semantic commonality between *Breakers* and *Eaters*.
- They are both AGENTS.
- The *BrokenThing* and *OpenedThing*, are THEMES.
 - prototypically inanimate objects affected in some way by the action

Thematic roles

- One of the oldest linguistic models
 - Indian grammarian Panini between the 7th and 4th centuries BCE
- Modern formulation from Fillmore (1966,1968), Gruber (1965)
 - Fillmore influenced by Lucien Tesnière's (1959) *Éléments de Syntaxe Structurale*, the book that introduced dependency grammar
 - Fillmore first referred to roles as *actants* (Fillmore, 1966) but switched to the term *case*

Thematic roles

- A typical set:

Thematic Role	Definition	Example
AGENT	The volitional causer of an event	<i>The waiter</i> spilled the soup.
EXPERIENCER	The experiencer of an event	<i>John</i> has a headache.
FORCE	The non-volitional causer of the event	<i>The wind</i> blows debris from the mall into our yards.
THEME	The participant most directly affected by an event	Only after Benjamin Franklin broke <i>the ice</i> ...
RESULT	The end product of an event	The city built a <i>regulation-size baseball diamond</i> ...
CONTENT	The proposition or content of a propositional event	Mona asked “ <i>You met Mary Ann at a supermarket?</i> ”
INSTRUMENT	An instrument used in an event	He poached catfish, stunning them <i>with a shocking device</i> ...
BENEFICIARY	The beneficiary of an event	Whenever Ann Callahan makes hotel reservations <i>for her boss</i> ...
SOURCE	The origin of the object of a transfer event	I flew in <i>from Boston</i> .
GOAL	The destination of an object of a transfer event	I drove <i>to Portland</i> .

Thematic grid, case frame, θ -grid

Example usages of “break”

John broke the window.

AGENT THEME

John broke the window with a rock.

AGENT THEME INSTRUMENT

The rock broke the window.

INSTRUMENT THEME

The window broke.

THEME

The window was broken by John.

THEME AGENT

thematic grid, case frame, θ -grid

Break:

AGENT, THEME, INSTRUMENT.

Some realizations:

AGENT/Subject, THEME/Object

AGENT/Subject, THEME/Object, INSTRUMENT/PP_{with}

INSTRUMENT/Subject, THEME/Object

THEME/Subject

Diathesis alternations (or verb alternation)

Doris gave the book to Cary.

AGENT THEME BENEFICIARY

Break: AGENT, INSTRUMENT, or THEME as subject

Doris gave Cary the book.

AGENT BENEFICIARY THEME

Give: THEME and BENEFICIARY in either order

Dative alternation: particular semantic classes of verbs, “verbs of future having” (*advance, allocate, offer, owe*), “send verbs” (*forward, hand, mail*), “verbs of throwing” (*kick, pass, throw*), etc.

Levin (1993): 47 semantic classes (“**Levin classes**”) for 3100 English verbs and alternations. In online resource VerbNet.

Problems with Thematic Roles

Hard to create standard set of roles or formally define them
Often roles need to be fragmented to be defined.

Levin and Rappaport Hovav (2015): two kinds of INSTRUMENTS
intermediary instruments that can appear as subjects

The cook opened the jar with the new gadget.

The new gadget opened the jar.

enabling instruments that cannot

Shelly ate the sliced banana with a fork.

*The fork ate the sliced banana.

Alternatives to thematic roles

- 1. Fewer roles:** generalized semantic roles, defined as prototypes (Dowty 1991)
PROTO-AGENT
PROTO-PATIENT
[PropBank](#)
- 2. More roles:** Define roles specific to a group of predicates
[FrameNet](#)

Semantic Role Labeling

The Proposition Bank
(PropBank)

PropBank

- Palmer, Martha, Daniel Gildea, and Paul Kingsbury. 2005. The Proposition Bank: An Annotated Corpus of Semantic Roles. *Computational Linguistics*, 31(1):71–106

PropBank Roles

Following Dowty 1991

Proto-Agent

- Volitional involvement in event or state
- Sentience (and/or perception)
- Causes an event or change of state in another participant
- Movement (relative to position of another participant)

Proto-Patient

- Undergoes change of state
- Causally affected by another participant
- Stationary relative to movement of another participant

PropBank Roles

- Following Dowty 1991
 - Role definitions determined verb by verb, with respect to the other roles
 - Semantic roles in PropBank are thus verb-sense specific.
- Each verb sense has numbered argument: Arg0, Arg1, Arg2,...

Arg0: PROTO-AGENT

Arg1: PROTO-PATIENT

Arg2: usually: benefactive, instrument, attribute, or end state

Arg3: usually: start point, benefactive, instrument, or attribute

Arg4 the end point

PropBank Frame Files

agree.01

Arg0: Agreeer

Arg1: Proposition

Arg2: Other entity agreeing

Ex1: [Arg0 The group] *agreed* [Arg1 it wouldn't make an offer].

Ex2: [ArgM-TMP Usually] [Arg0 John] *agrees* [Arg2 with Mary]
[Arg1 on everything].

fall.01

Arg1: Logical subject, patient, thing falling

Arg2: Extent, amount fallen

Arg3: start point

Arg4: end point, end state of arg1

Ex1: [Arg1 Sales] *fell* [Arg4 to \$25 million] [Arg3 from \$27 million].

Ex2: [Arg1 The average junk bond] *fell* [Arg2 by 4.2%].

Modifiers or adjuncts of the predicate:

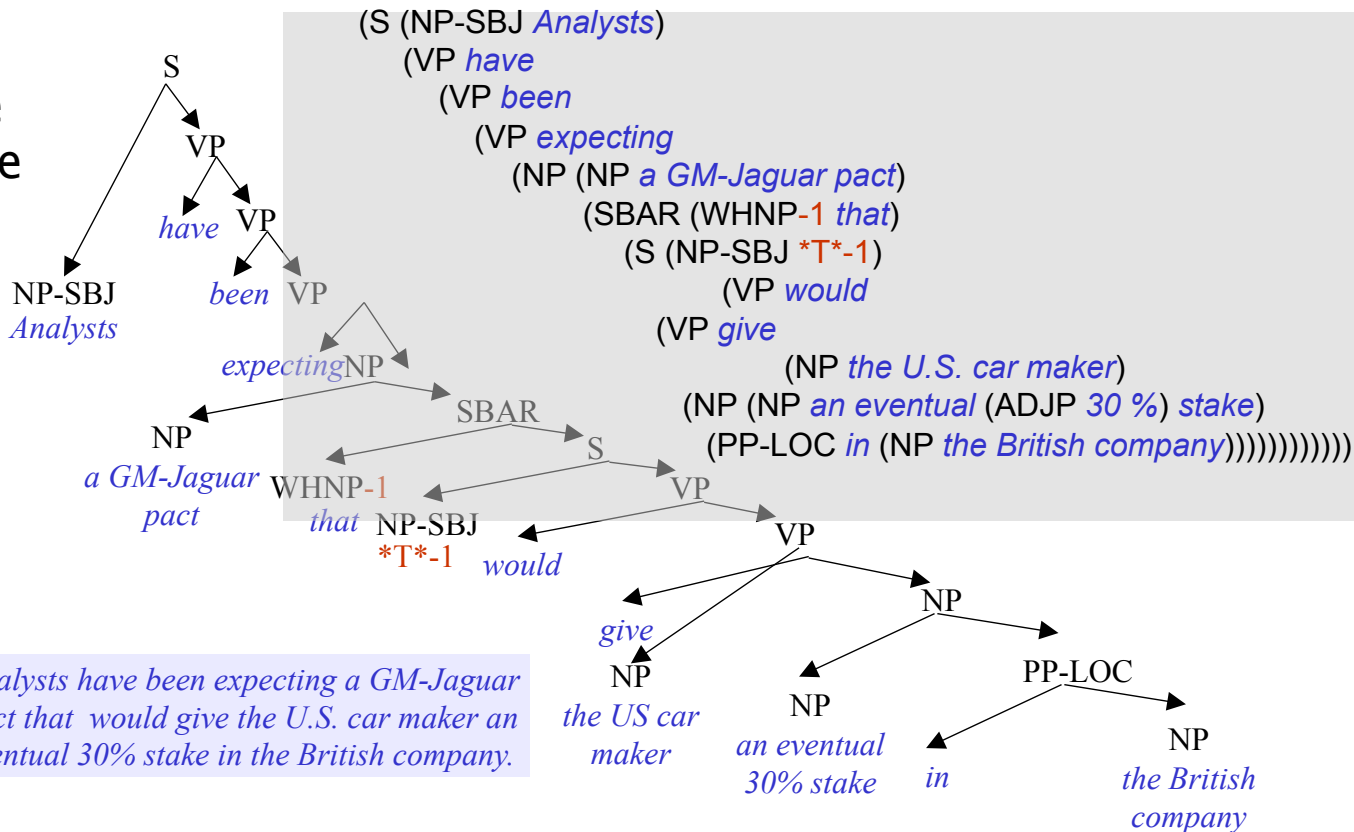
Arg-M

ArgM-TMP	when?	yesterday evening, now
LOC	where?	at the museum, in San Francisco
DIR	where to/from?	down, to Bangkok
MNR	how?	clearly, with much enthusiasm
PRP/CAU	why?	because ... , in response to the ruling
REC		themselves, each other
ADV	miscellaneous	
PRD	secondary predication	...ate the meat raw

PropBanking a Sentence

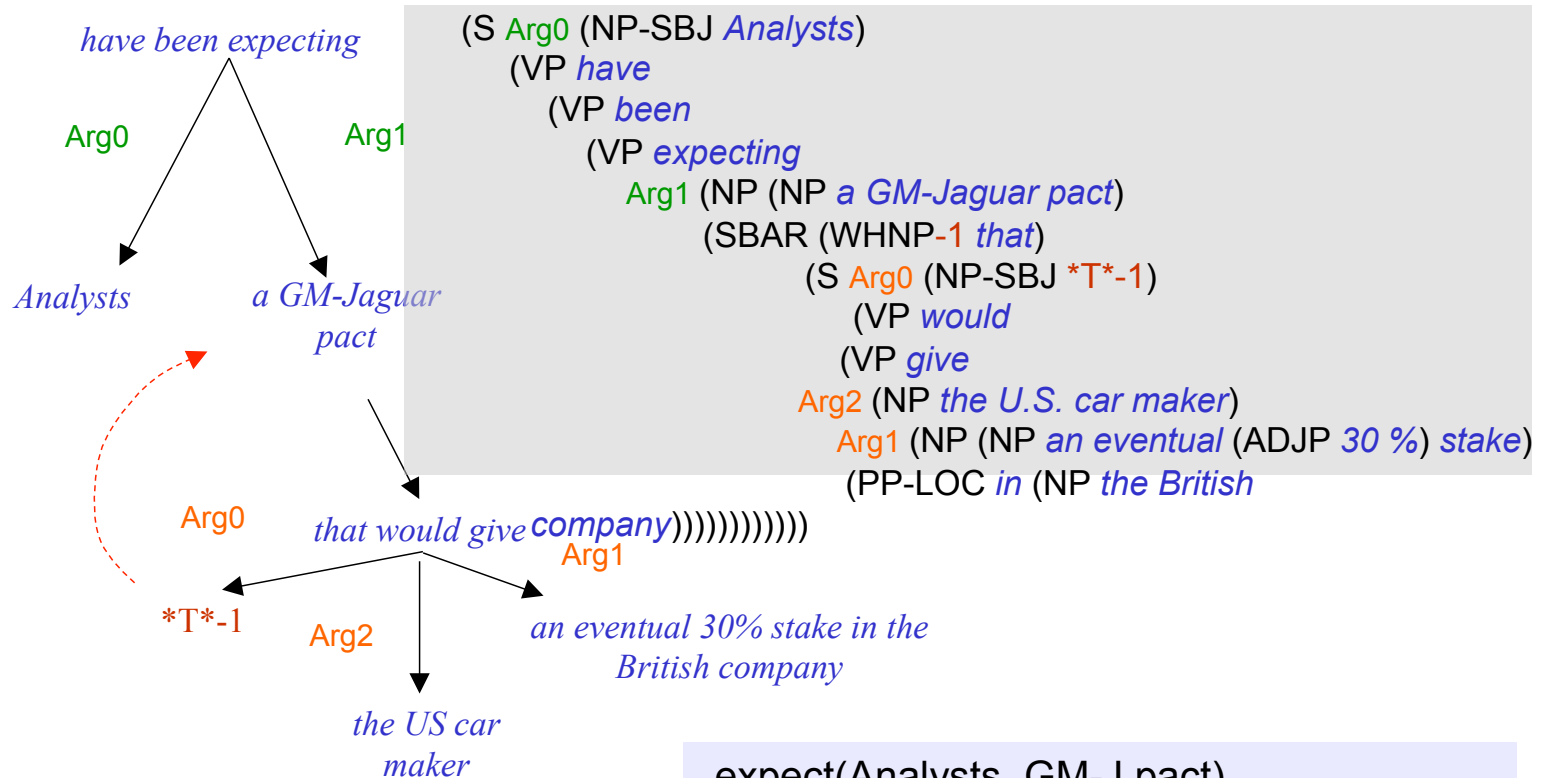
Martha Palmer 2013

A sample
parse tree



The same parse tree PropBanked

Martha Palmer 2013



```

(S Arg0 (NP-SBJ Analysts)
 (VP have
 (VP been
 (VP expecting
 Arg1 (NP (NP a GM-Jaguar pact)
 (SBAR (WHNP-1 that)
 (S Arg0 (NP-SBJ *T*-1)
 (VP would
 (VP give
 Arg2 (NP the U.S. car maker)
 Arg1 (NP (NP an eventual (ADJP 30 %) stake)
 (PP-LOC in (NP the British

```

```

expect(Analysts, GM-J pact)
give(GM-J pact, US car maker, 30% stake)

```

Annotated PropBank Data

- Penn English TreeBank, OntoNotes 5.0.
 - Total ~2 million words
- Penn Chinese TreeBank
- Hindi/Urdu PropBank
- Arabic PropBank

2013 Verb Frames Coverage
Count of word sense (lexical units)

<i>Language</i>	<i>Final Count</i>
English	10,615*
Chinese	24,642
Arabic	7,015

Plus nouns and light verbs

Example Noun: *Decision*

▶ Roleset: Arg0: decider, Arg1: decision...

▶ “[...**[your_{ARG0}]** **[decision_{REL}]**
[to say look I don't want to go through this anymore_{ARG1}]”

Example within an LVC: *Make a decision*

▶ “[...**[the President_{ARG0}]** **[made_{REL-LVB}]**
the **[fundamentally correct_{ARGM-ADJ}]**
[decision_{REL}] **[to get on offense_{ARG1}]**”

Semantic Role Labeling

Semantic Role Labeling
Algorithm

Semantic role labeling (SRL)

- The task of finding the semantic roles of each argument of each predicate in a sentence.
- FrameNet versus PropBank:

[You] can't [blame] [the program] [for being unable to identify it]
COGNIZER TARGET EVALUEE REASON

[The San Francisco Examiner] issued [a special edition] [yesterday]
ARG0 TARGET ARG1 ARGM-TMP

History

- Semantic roles as a intermediate semantics, used early in
 - machine translation (Wilks, 1973)
 - question-answering (Hendrix et al., 1973)
 - spoken-language understanding (Nash-Webber, 1975)
 - dialogue systems (Bobrow et al., 1977)
- Early SRL systems
 - Simmons 1973, Marcus 1980:
 - parser followed by hand-written rules for each verb
 - dictionaries with verb-specific case frames (Levin 1977)

Why Semantic Role Labeling

- A useful shallow semantic representation
- Improves NLP tasks like:
 - question answering
Shen and Lapata 2007, Surdeanu et al. 2011
 - machine translation
Liu and Gildea 2010, Lo et al. 2013

A simple modern algorithm

```
function SEMANTICROLELABEL(words) returns labeled tree
```

```
  parse ← PARSE(words)
```

```
  for each predicate in parse do
```

```
    for each node in parse do
```

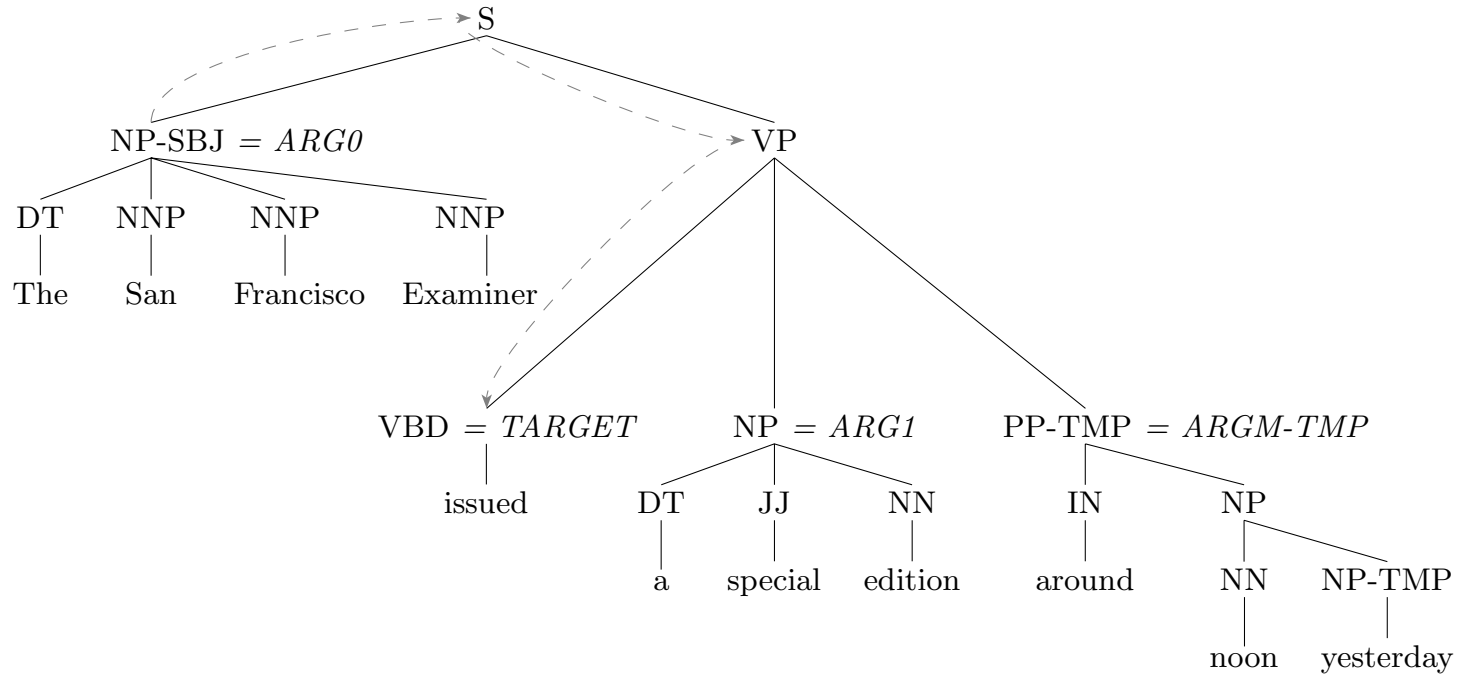
```
      featurevector ← EXTRACTFEATURES(node, predicate, parse)
```

```
      CLASSIFYNODE(node, featurevector, parse)
```

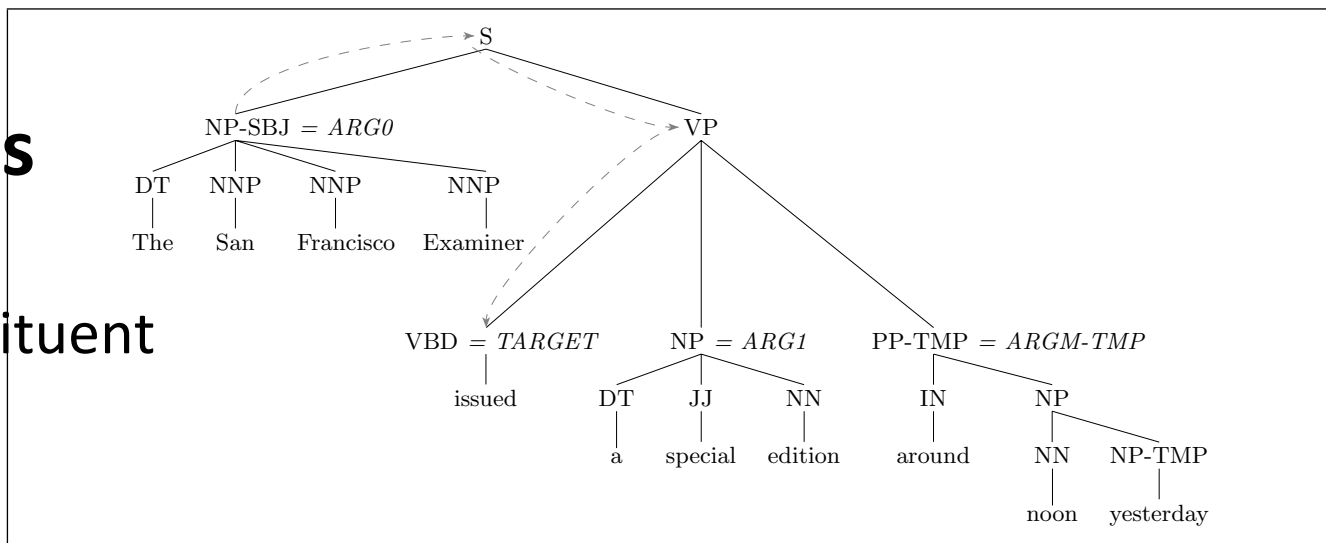
How do we decide what is a predicate

- If we're just doing PropBank verbs
 - Choose all verbs
 - Possibly removing light verbs (from a list)
- If we're doing FrameNet (verbs, nouns, adjectives)
 - Choose every word that was labeled as a target in training data

Semantic Role Labeling



Features



Headword of constituent

Examiner

Headword POS

NNP

Voice of the clause

Active

Subcategorization of pred

VP -> VBD NP PP

Named Entity type of constit

ORGANIZATION

First and last words of constit

The, Examiner

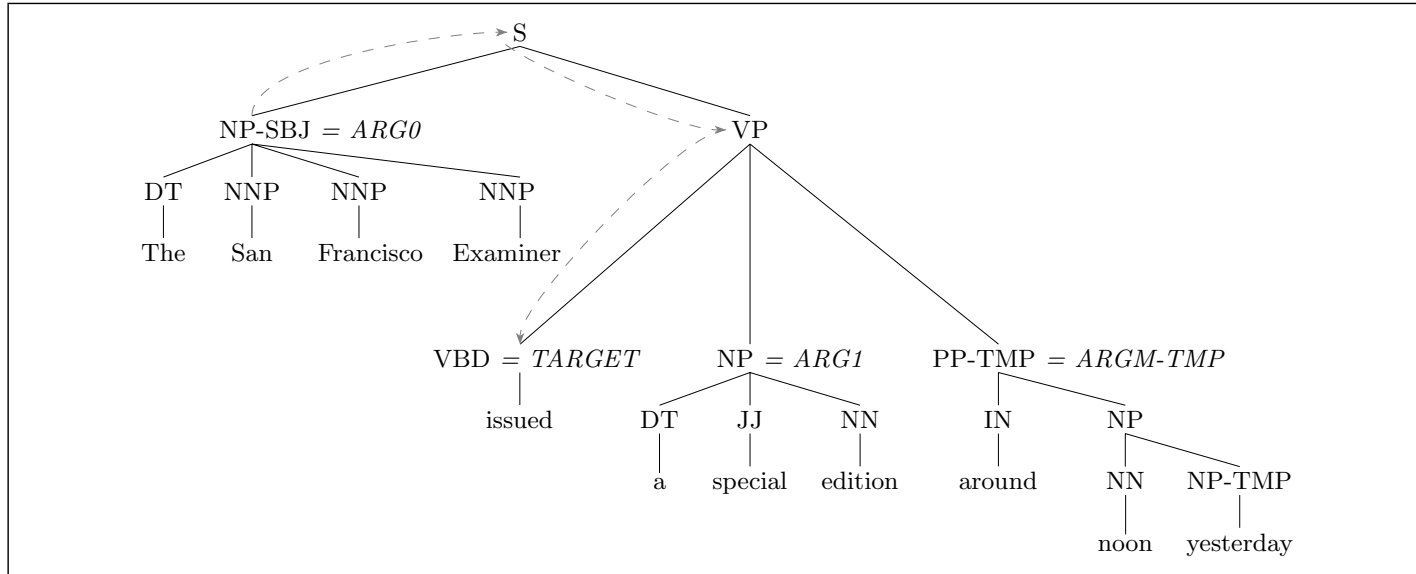
Linear position, clause re: predicate

before

Path Features

Path in the parse tree from the constituent to the predicate

NP↑**S**↓**VP**↓**VBD**



A common final stage: joint inference

- The algorithm so far classifies everything **locally** – each decision about a constituent is made independently of all others
- But this can't be right: Lots of **global** or **joint** interactions between arguments
 - Constituents in FrameNet and PropBank must be non-overlapping.
 - A local system may incorrectly label two overlapping constituents as arguments
 - PropBank does not allow multiple identical arguments
 - labeling one constituent ARG0
 - Thus should increase the probability of another being ARG1

How to do joint inference

- Reranking
 - The first stage SRL system produces multiple possible labels for each constituent
 - The second stage classifier the best **global** label for all constituents
 - Often a classifier that takes all the inputs along with other features (sequences of labels)

Semantic Role Labeling

Conclusion

Semantic Role Labeling

- A level of shallow semantics for representing events and their participants
 - Intermediate between parses and full semantics
- Two common architectures, for various languages
 - FrameNet: frame-specific roles
 - PropBank: Proto-roles
- Current systems extract by
 - parsing sentence
 - Finding predicates in the sentence
 - For each one, classify each parse tree constituent