

Semantic Roles

Different phrases in the same syntactic position can serve in different semantic roles.

John broke the window with the hammer.

The hammer broke the window.

The window broke.

Rover smelled.

Elvis smelled Rover.

I ate the spaghetti with a fork.

I ate the spaghetti with a friend.

I ate the spaghetti with tomato sauce.

I ate the spaghetti with glee.

Common Thematic Roles

- Agent
- Theme
- Instrument
- Recipient
- Experiencer
- Beneficiary
- Cause
- Location
- Path

Thematic Roles

- **Thematic roles** (or **thematic relations**) represent the role that a noun phrase plays with respect to an action or state, usually expressed by a verb.
- Thematic roles are related to Charles Fillmore's theory of case grammars and case roles.
- A relatively small set of thematic roles are commonly used, although there is no single definitive set.
- Key Idea: abstract away from syntax to represent the conceptual role that a phrase plays with respect to an action or state.

Different syntactic realizations of the same sentence should be represented with the same set of semantic roles!

The Agent Role

- An **agent** is responsible for an action. Often (though not always) this implies intentionality.
- The agent is usually ANIMATE. Forces of nature (e.g., *tornado*) may be permissible agents if there is no **cause** role.

John broke the window.

John intentionally broke the window.

The hammer broke the window.

The hammer intentionally broke the window. ()*

- A **co-agent** is another entity that also performed the action.

John painted the wall with Mary.

The Theme Role

- The **theme** (or **patient**) is the object/concept being affected or acted upon.
- The theme is usually the answer to the question: “What was verb-ed?”

Rover smelled.

John smelled Rover.

John gave Rover a bath.

- A **co-theme** is another object/concept that is affected or acted upon.

John washed Rover along with Snoopy.

Recipient, Possessor, Beneficiary

- The **recipient** role is assigned to an entity that receives something.
 - *John gave a birthday present to Mary.*
 - *John gave Mary a birthday present.*
- The **possessor** role represents the original possessor when there is a change of possession.
 - *John threw a ball to Mary.*
- The **beneficiary** role is assigned to an entity that benefits from an action (without receiving anything).
 - *John sang a song for Mary.*
 - *John sang Mary a song.*

The Instrument Role

An **instrument** represents a tool, material, or force that is used to perform an action.

An instrument does not have to be a physical object. It can be anything used to accomplish an action.

The hammer broke the window.

I ate spaghetti with a fork.

I saw Elvis with binoculars.

He paid for the repair using his credit card.

He used a telescope to see Elvis.

John broke the door down with his weight.

The Experiencer and Cause Roles

- Some verbs express internal beliefs, emotions, or states. The **experiencer** role represents an entity who is experiencing something.
 - *Mary believes that Elvis is still alive.*
 - *The boy fears spiders.*
- A **cause** role is sometimes used for events or situations that produce an effect.
 - *The economic recession led to many corporate layoffs.*
 - *The tornado damaged thousands of homes.*

Locations, Times, Measurements

Location, Time, and Measurement roles may be subdivided into subroles representing different types of state changes.

AT State: *Yosemite is in California.* → AT-LOC
I woke up at 7am. → AT-TIME
I have 20 dollars. → AT-VALUE

FROM/TO Change:
I drove from Utah to California. → FROM-LOC (Origin/Source)
TO-LOC (Destination)
The party starts at 8pm and ends at midnight. → FROM-TIME
TO-TIME

PATH: a trajectory
She swam across the channel. → PATH-LOC

Case Frame Representations

Case frames can be defined manually with mappings between syntactic and semantic roles. For example:

GAVE
Agent = subject
Theme = direct object
Recipient = indirect object

John gave Mary a book.

GAVE
Agent = *John*
Theme = *a book*
Recipient = *Mary*

Semantic Frames

- A **semantic frame** (or **case frame**) is a conceptual structure that represents the semantic arguments of a word (usually a verb). They originated from Charles Fillmore's theory of **frame semantics**.
- A frame represents semantic knowledge about an activity or state that captures its meaning.
- In semantics, predicates take **arguments**, which are necessary to represent the meaning of an activity or state described in text. (They are similar to **complements** in syntax.)
Examples: *agents, themes, recipients*
- In contrast, **adjuncts** are attributes that may be present but are not necessary. If omitted, the rest of the meaning is the same.
Examples: *dates, locations, manner*

Selectional Restrictions

Semantic constraints called **selectional restrictions** can be assigned to semantic roles for disambiguation.

GAVE
Agent = subject [ANIMATE]
Theme = direct object [PHYSOBJ]
Recipient = indirect object [ANIMATE]

John gave Mary a book.

GAVE
Agent = *John*
Theme = *a book*
Recipient = *Mary*

Disambiguation Example

KILLED(Passive)

Theme = subject [ANIMATE]
Agent = PP(by) [ANIMATE]
Instrument = PP(by) [WEAPON]
Instrument = PP(with) [WEAPON]
Co-Theme = PP(with) [ANIMATE]

John was killed by Mary.

KILLED
Theme = *John*
Agent = *Mary*

John was killed with Mary by a man with a bomb.

GAVE
Theme = *John*
Co-Theme = *Mary*
Agent = *a man*
Instrument = *a bomb*

John was killed by a bomb.

KILLED
Theme = *John*
Instrument = *a bomb*

Semantic Role Labeling

- **Semantic Role Labeling (SRL)** is a NLP task that involves automatically assigning semantic roles to the words and phrases in a sentence.
- Semantic roles are always relative to a **target** word, which is usually a verb. A phrase can sometimes serve in multiple semantic roles for different target words in the same sentence.
- SRL systems typically use machine learning to automatically produce semantic role assignments.
- Framenet and PropBank are two SRL resources that used different frame definitions and semantic role representations. They include manually annotated data sets that are widely used for training and evaluation.

FrameNet

- The Berkeley FrameNet project is an effort to create **frame-semantic descriptions** for English terms.
- A **frame** is a conceptual structure describing the argument structure for lexical items, and **frame elements** (FEs) are the semantic roles for a frame.
- FrameNet includes a lexical resource that consists of a frame database that defines frames and their conceptual structure, a dictionary of semantic frames associated with words (lexical units), and annotated example sentences.

Frame Examples

```
frame(TRANSPORTATION)
  frame_elements(MOVER, MEANS, PATH)
  scene(MOVER move along PATH by MEANS)
```

```
frame(DRIVING)
  inherit(TRANSPORTATION)
  frame_elements(DRIVER (=MOVER), VEHICLE(=MEANS), RIDER (=MOVER),
                CARGO (=MOVER))
  scenes(DRIVER starts VEHICLE, DRIVER controls VEHICLE, DRIVER stops
         VEHICLE)
```

```
frame(RIDING)
  inherit(TRANSPORTATION)
  frame_elements(VEHICLE(=MEANS), RIDER (=MOVER))
  scenes(RIDER enters VEHICLE, VEHICLE carries RIDER along PATH, RIDER leaves
         VEHICLE)
```

Frame Element Annotations

- Kate_{DRIVER} **drove** home_{PATH} in a stupor.
- A woman **fell** into the path of [a car]_{VEHICLE} driven by [her uncle]_{DRIVER}.
- And that is why Tom_{DRIVER} **drove** [eastwards along Lake Geneva]_{PATH}.
- [John Smith]_{DRIVER} was **driving** [his guest]_{RIDER} [back to the station]_{PATH}.
- Susan_{DRIVER} **drove** [her Honda]_{VEHICLE} at high speed [around the streets of Utah]_{PATH}.
- We_{DRIVER} **drive** [home along miles of empty freeway]_{PATH}.

Framenet Lexicon

- Framenet's Index defines a set of conceptual frame structures.
- Framenet's dictionary contains frames indexed with **lexical units (LUs)** that can evoke the frames, **frame elements (FEs)**, and exemplar sentences.
- In a sentence, the word or phrase that evokes a frame is called a **target**.
- Framenet also contains a rich categorization of lexical units, especially verbs.

More Examples

- Pat **replaced** [the curtains]_{OLD} with [wooden blinds]_{NEW}.
- **Boil** [the rice]_{FOOD} [for 3 minutes]_{DURATION} [in water]_{MEDIUM}, then drain.
- [Four activists]_{AGENT} **chained** [themselves]_{ITEM} [to an oil drilling rig being towed to the Bering Sea]_{GOAL}.
- She_{JUDGE} **blames** [the government]_{EVALUEE} [for not doing enough]_{REASON}.
- The government claims that ranchers_{JUDGE} misrepresent their livestock losses and **blame** everything_{REASON} [on coyotes]_{EVALUEE}.

sell.v

Frame: Commerce_sell

Definition:

COD: hand over in exchange for money.

Frame Elements and Their Syntactic Realizations

Frame Element	Number Annotated	Realization(s)
Buyer	(98)	DNL-- (3) INL-- (60) NP.Obj (8) PPintol.Dep (1) PPtol.Dep (20) VPto.Dep (4)
Goods	(100)	NP.Obj (50) DNL-- (3) INL-- (1) NP.Ext (38) NP.Dep (8)
Manner	(8)	PPatl.Dep (1) AVP.Dep (3) PPbyl.Dep (2) PPlikel.Dep (1) PPinl.Dep (1)
Money	(16)	PPatl.Dep (2) PPforl.Dep (14)
Place	(5)	AVP.Dep (2) PPinl.Dep (1) PPatl.Dep (2)
Purpose	(1)	VPto.Dep (1)
Purpose of Goods	(1)	PPforl.Dep (1)
Rate	(2)	PPatl.Dep (1) PPforl.Dep (1)
Relay	(2)	PPonl.Dep (2)
Result	(2)	PPforl.Dep (1) PPintol.Dep (1)
Seller	(99)	NP.Ext (60) CNL-- (35) PPbyl.Dep (4)

Commerce_sell

[Lexical Unit Index](#)

Definition:

These are words describing basic commercial transactions involving a buyer and a seller exchanging money and goods, taking the perspective of the seller. The words vary individually in the patterns of frame element realization they allow. For example, the typical patterns for SELL: SELLER sells GOODS to BUYER for MONEY.

Robin **SOLD** a car to Abby for \$5,000.

FEs:

Core:

Buyer [Byr]

The **Buyer** has the **Money** and wants the **Goods**.
Lee **SOLD** a textbook to Abby.

Goods [Gds]

The FE Goods is anything (including labor or time, for example) which is exchanged for Money in a transaction.
Kim **SOLD** the sweater.

Seller [Slr]

The **Seller** has possession of the **Goods** and exchanges them for **Money** from a **Buyer**.
So far, **my company** has **SOLD** more than three million copies.

Non-Core:

Manner [I]

Semantic Type: Manner

Any description of the selling event which is not covered by more specific FEs, including secondary effects (quietly, loudly), and general descriptions comparing events (the same way). It may also indicate salient characteristics of the **Seller** that affect the action (presumptuously, coldly, deliberately, eagerly, carefully).
Stuart **reluctantly SOLD** her his last rock.

Means [Mns]

Semantic Type: State_of_affairs

The means by which a commercial transaction occurs.
Abby **SOLD** the car **for cash**.

Money [Mny]

Money is the thing given in exchange for Goods in a transaction.
Sam **SOLD** the car **for \$12,000**.

Period_of_iteration [Iter]

The length of time from when the commerce event began to be repeated to when it stopped.
I have been **SELLING** materials to the factories **for over 5 years**.

Place [Place]

Semantic Type: Locative_relation

Where the event takes place.

Purpose [Purp]

Semantic Type: State_of_affairs

The purpose for which an intentional act is performed.

Purpose_of_Goods [POG]

The **Buyer's** intended purpose for the **Goods**.
He **SOLD** the filing robot to me **for filing all my legal documents**.

Lexical Units:

auction.n, auction.v, retail.v, retailer.n, sale.n, sell.v, seller.n, vend.v, vendor.n

Created by 243 on 07/12/2001 01:11:04 PDT Thu

Frame-frame Relations:

Inherits from: [Giving](#)

Is Inherited by: [Renting_out](#)

Perspective on: [Commerce_goods_transfer](#)

Is Perspectivized in:

Uses:

Is Used by: [Carry_goods](#), [Exporting](#)

Subframe of:

Has Subframe(s):

Precedes:

Is Preceded by:

Is Inchoative of:

Is Causative of:

Lexical Unit	LU Status	Lexical Entry Report	Annotation Report	Annotator ID
auction.n	Created	Lexical entry	Annotation	597
auction.v	Add_Annotation	Lexical entry	Annotation	361
retail.v	Finished_Initial	Lexical entry	Annotation	296
retailer.n	Finished_Initial	Lexical entry	Annotation	296
sale.n	Created	Lexical entry	Annotation	664
sell.v	Finished_Initial	Lexical entry	Annotation	296
seller.n	Finished_Initial	Lexical entry	Annotation	143
vend.v	Finished_Initial	Lexical entry	Annotation	296
vendor.n	Finished_Initial	Lexical entry	Annotation	296

PropBank

- The **PropBank** project produced semantic role annotations on the Wall Street Journal portion of the Penn Treebank (which already had parse tree annotations).
- PropBank defines predicate-argument structures for verbs with semantic role assignments for each verb's arguments.
- The predicate is labeled as REL (for relation) and is either a verb or a verb + particle (e.g., "keep up").
- PropBank's semantic role arguments are not named, but indicated as Arg0, Arg1, Arg2, etc. The meaning is specific to one verb sense! They do not have the same meaning for different verbs or different senses of the same verb.

PropBank Definitions

PropBank provides *Frames files* which defines a set of roles (*roleset*) for verb senses from VerbNet. There are two types of roles: numbered arguments and adjuncts.

Numbered Arguments: A0-A5

- Arg0 *usually* refers to the verb's agent.
- Arg1 *usually* refers to the verb's patient/theme (if it has one)
- All other arguments vary from verb to verb.

Adjuncts: optional, general arguments that any verb can take

AM-ADV : general-purpose	AM-MOD : modal verb
AM-CAU : cause	AM-NEG : negation marker
AM-DIR : direction	AM-PNC : purpose
AM-DIS : discourse marker	AM-PRD : predication
AM-EXT : extent	AM-REC : reciprocal
AM-LOC : location	AM-TMP : temporal
AM-MNR : manner	

PropBank Framesets

Different senses of a verb may have different semantic roles. In this case, framesets are used to define the semantic roles for each verb sense.

Example for the verb "left":

Frameset leave.01 "move away from":

Arg0: entity leaving

Arg1: place left

Frameset leave.02 "give":

Arg0: giver

Arg1: thing given

Arg2: beneficiary

PropBank Frame File Example

Frame File for the verb 'expect':

Roles:

Arg0: expecter

Arg1: thing expected

Example: Transitive, active:

Portfolio managers expect further declines in interest rates.

Arg0: Portfolio managers

REL: expect

Arg1: further declines in interest rates

PropBank Examples

- [John]_{ARG0} **broke** [the window]_{ARG1}.
- [The window]_{ARG1} **broke**.
- [John]_{ARG0} **opened** [the door]_{ARG1} [with his foot]_{ARG2}.
- [John]_{ARG0} tried to **kick** [the football]_{ARG1}.
- [He]_{ARG0} **expects** [Ford to meet the deadline easily]_{ARG1}.
- [Mr. Bush]_{ARG0} **met** [him]_{ARG1} [privately]_{ARGM-MNR} [in the White House]_{ARGM-LOC} , [on Thursday]_{ARGM-TMP} .
- [Sales]_{ARG1} **fell** [to \$50 million]_{ARG4} [from \$80 million]_{ARG3} .

Summary

- Semantic Role Labeling is essential to understand the *meaning* of text, a deeper representation than syntax.
- Case frame representations can be used to represent predicates and their arguments, providing a mapping between semantic (thematic) and syntactic roles.
- Framenet provides a *conceptually rich* organization of lexical items, case frame definitions, and thematic roles.
- PropBank provides semantic role definitions for both arguments and adjuncts for *verb* predicates, and a tighter coupling with syntactic representations.