Strong Slot-and-Filler Structures

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INTRODUCTION

- The weak slot-and-filler structures (semantic networks and frames) does not describe any hard and fast rules about what kinds of objects and links are good in general for knowledge representation.
- The strong slot-and-filler structures, on the other hand, provides specific notions of what kinds of objects and relations are permitted.
- **Conceptual dependency (CD)** and **Scripts** are two strong slot-and-filler structures.

Conceptual Dependency (CD)

- Conceptual Dependencies is a theory to represent the kind of knowledge about events that is usually contained in the natural language sentences.
- The goals of this theory are:
  - To help in the drawing of inference from sentences.
  - To be independent of the words used in the original input. *For any 2 (or more) sentences that are identical in meaning there should be only one representation of that meaning.*
- The CDs of the following expression will be same:

  John gave Mary a book.

  John gave a book to Mary.

  Mary was given a book by John.

  Mary took a book from John.

  Mary received a book from John.
- **CD representations of a sentence is built out of primitives , which are not words belonging to the language but are conceptual , these primitives are combined to form the meanings of the words.**

BUILDING BLOCKS OF CONCEPTUAL DEPENDENCIES

- The basic building blocks is the set of conceptual categories from which dependency structures can be built.

1) **PP**-- Real world objects. (Picture Producers)
2) **ACT**-- Real world actions. (from set of allowable actions).
3) **PA**-- Attributes of objects. (Picture Aiders). of the form STATE(VALUE). e.g., COLOR(red)
4) **AA**-- Attributes of actions. (Action Aiders). e.g., speed factor in PROPEL
5) Time of the event—
6) Location of the event--

Set of Primitive Actions

A typical set of primitive acts and their descriptions:

- ATRANS: Transfer of abstract relationship (e.g. give)
- PTRANS: Transfer of physical location of object (e.g. go)
- PROPEL: Application of physical force to an object (e.g. push)
- MOVE: Move of body part by its owner (e.g. kick)
- GRASP: Grasping of an object by an actor (e.g. clutch)
- INGEST: Ingestion of an object by an actor (e.g. eat)
- MTRANS: Transfer of mental information (e.g. tell)
- MBUILD: Building new information from old (e.g. decide)
- SPEAK: Production of sound (e.g. say)
- ATTEND: Focus of a sense organ toward a stimulus (e.g. listen)
- EXPEL: Getting rid of an object from body e.g. sweat

Allowable Dependencies

- The basic dependencies that can be described are provided by set of rules. Each dependency rule is themselves a conceptualization and can serve as a component of larger dependency.
- Arrows indicate directions of dependency.
- Double arrow indicates two way link between actor and action.

O- for the object case relation

R- for the recipient case relation

P- for past tense

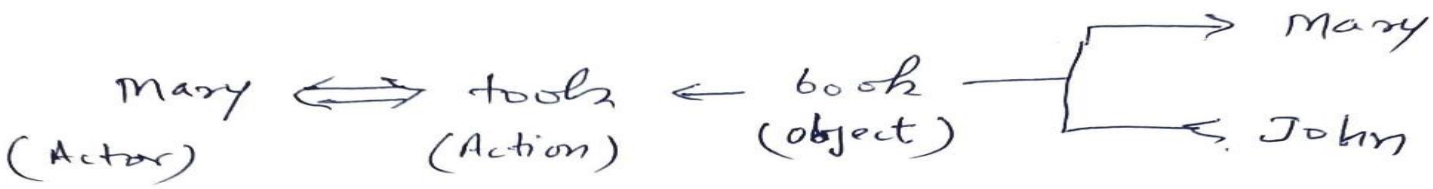
D- destination

I- Instrument

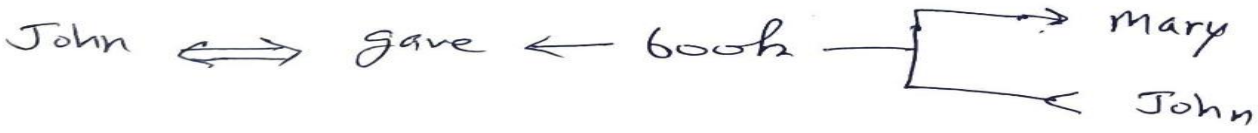
- The use of tense and mood in describing events is extremely important and schank introduced the following modifiers:
- **p**– past
- **f**– future
- **t**– Transition
- **ts**-start Transition
- **tr**-Finished Transition
- **k** -Continuing
- **? I**nterrogative
- **/** Negative
- Nil-Present
- **delta**– timeless
- **c**– conditional
- The absence of any modifier implies the *present tense*.

Examples of CD

(1) Mary took a book from John

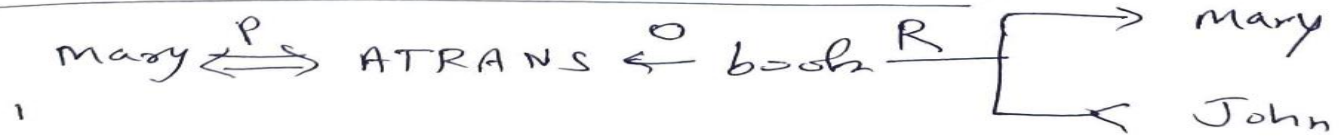


John gave a book to Mary

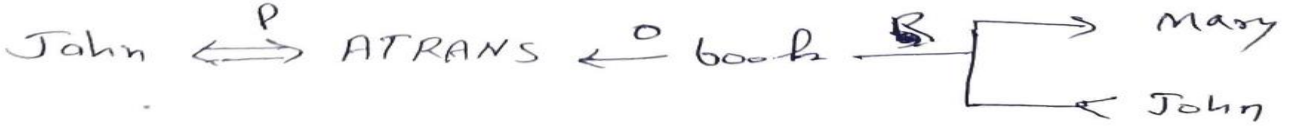


In General CD of both sentences

(1)



(2)



Rule 1: PP ⇔ ACT

- It describes the relationship between an actor and the event he or she causes.
  - This is a two-way dependency, since neither actor nor event can be considered primary.
  - The letter P in the dependency link indicates past tense.
- Example: John ran

CD Rep: John ⇔ (P) PTRANS

Dependencies of CD

- **Rule 2: PP $\Longleftrightarrow$ PA**

  Example: John is tall.

  John $\Longleftrightarrow$ height(>average)

- **Rule 3: PP $\longleftrightarrow$ PP**

  Example: John is doctor.

  John $\longleftrightarrow$ doctor

Dependencies of CD

- **Rule 4: PP ⟵ PA**

  Example: Smart John

  John ⟵ Smart

- **Rule 5: PP ⟵ PP**

  Example: John's dog

  dog $\xleftarrow{\text{poss-by}}$ John

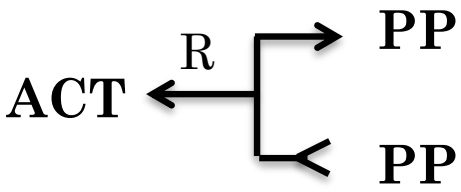
- **Rule 6: ACT $\xleftarrow{o}$ PP**

  Example: John pushed the bike.

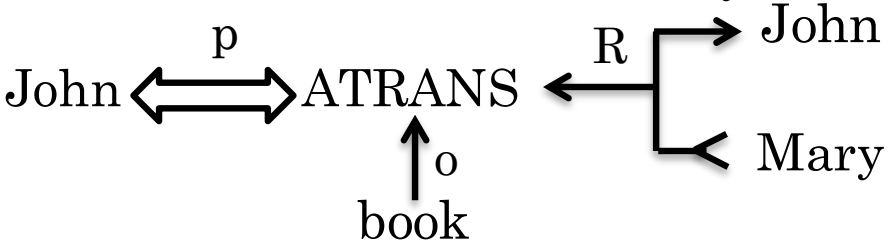
  John $\overset{p}{\Longleftrightarrow}$ PROPEL $\xleftarrow{o}$ bike

Dependencies of CD

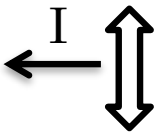
- **Rule 7:**



Example: John took the book from Mary.



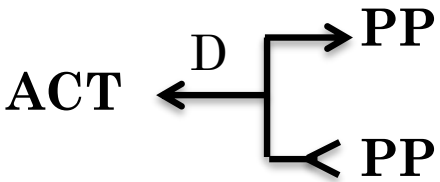
- **Rule 8: ACT**



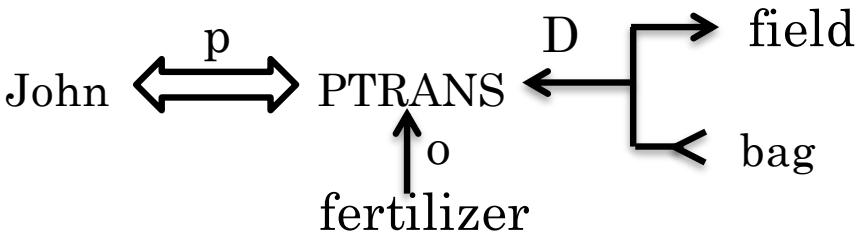
Example: John ate ice cream with spoon

Dependencies of CD

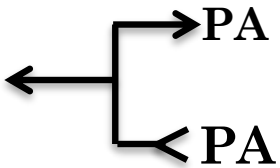
- **Rule 9:**



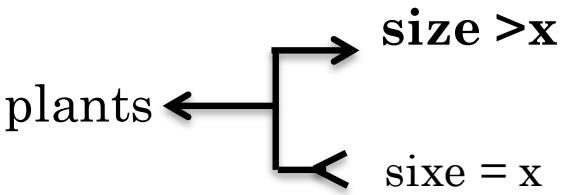
Example: John fertilized the field.



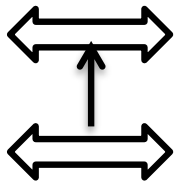
- **Rule 10: PP**



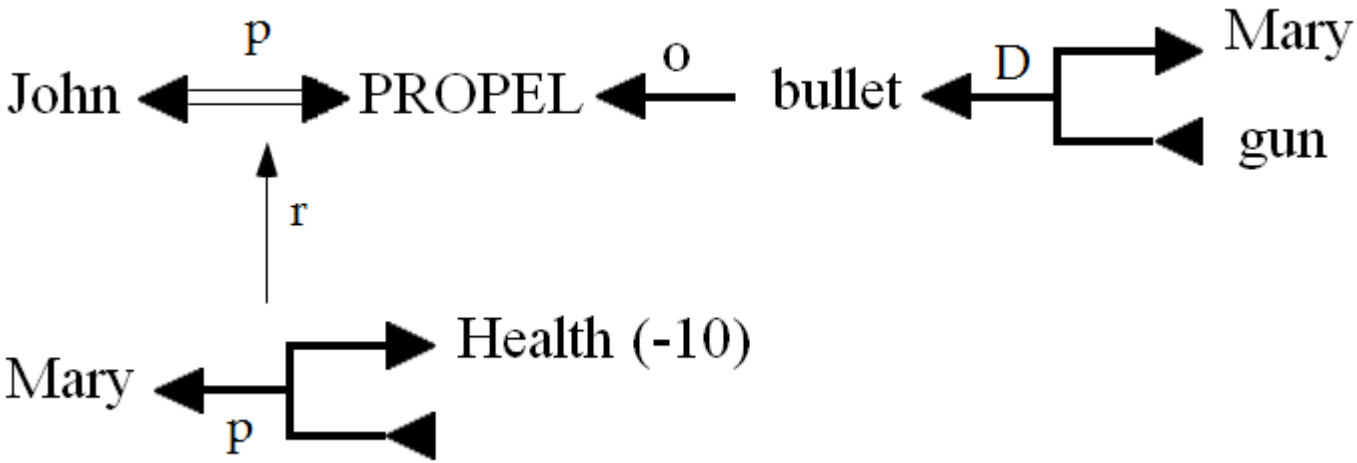
Example: The plant grew.



Dependencies of CD

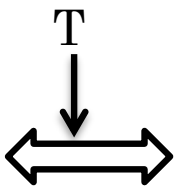
- **Rule 11:** 

Example: John shot Mary.

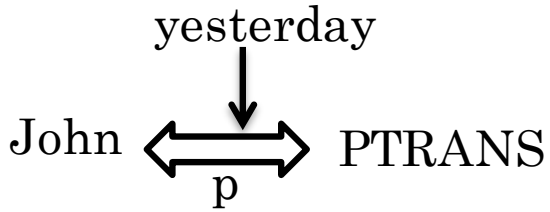


Dependencies of CD

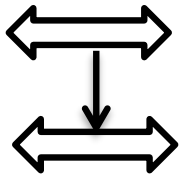
- **Rule 12:**



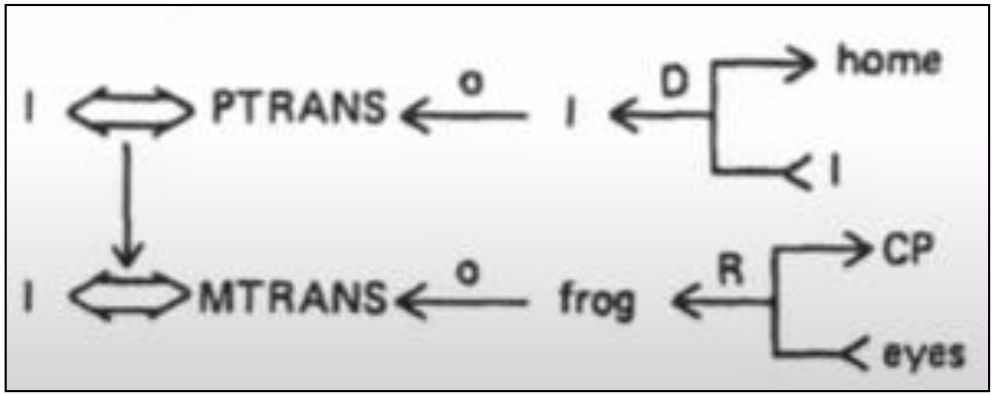
Example: John ran yesterday.



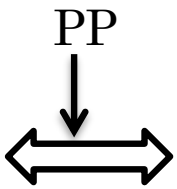
- **Rule 13:**



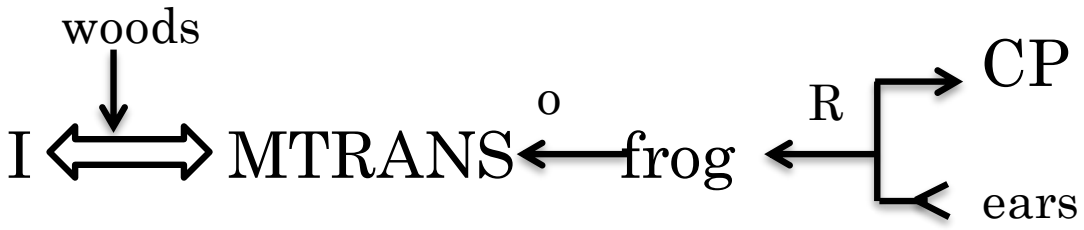
Example: While going home, I saw a frog.



Dependencies of CD

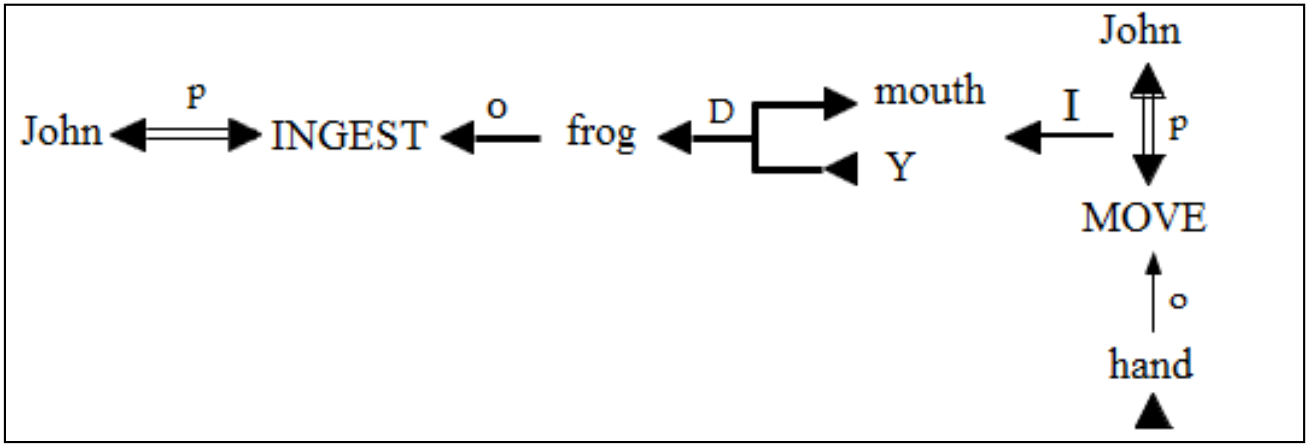
- **Rule 14:** 

Example: I heard a frog in the woods.

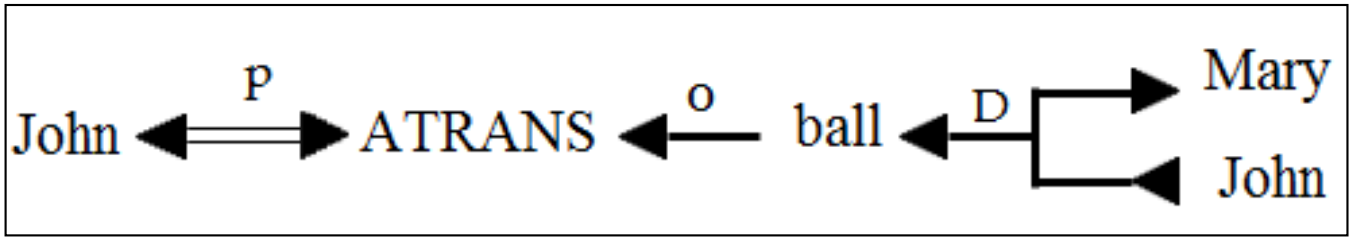


CD Examples

Example 1: John ate a frog.

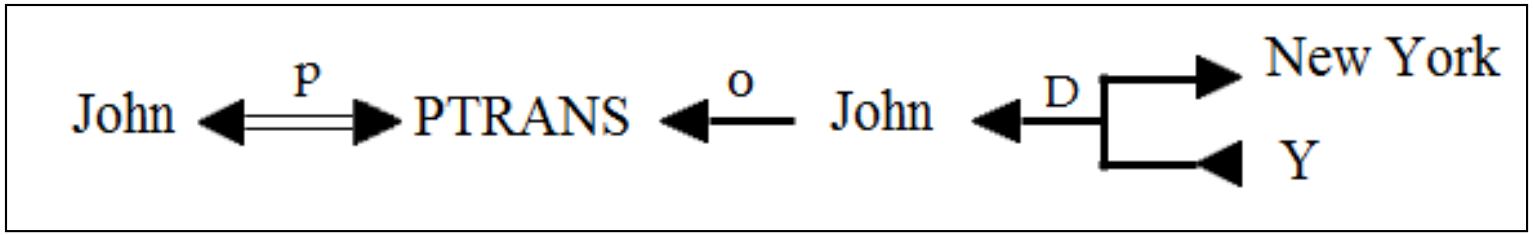


Example 2: John threw a ball to Mary.

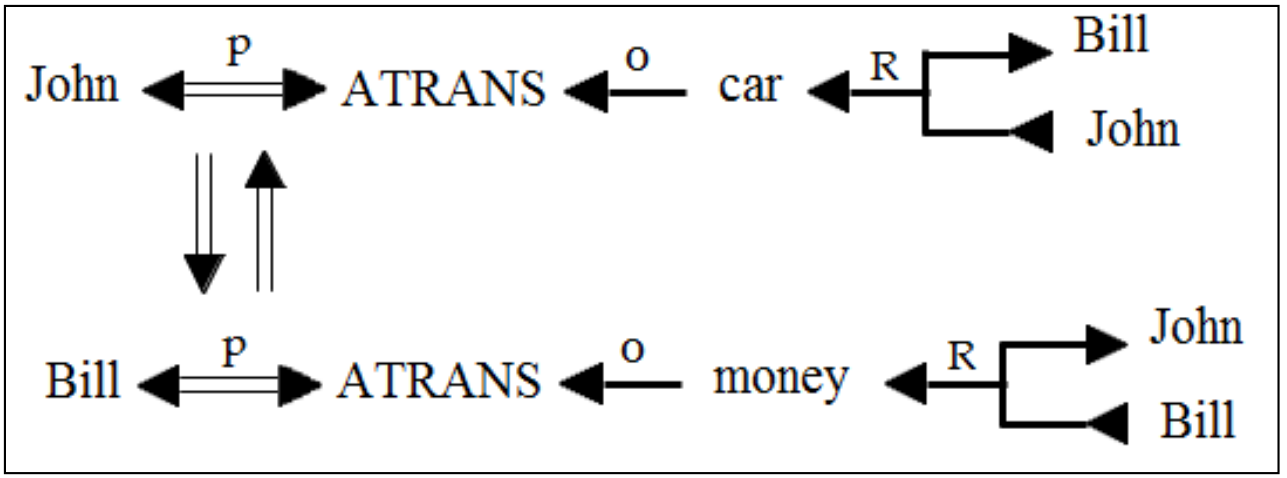


CD Examples

Example 3: John went to New York.

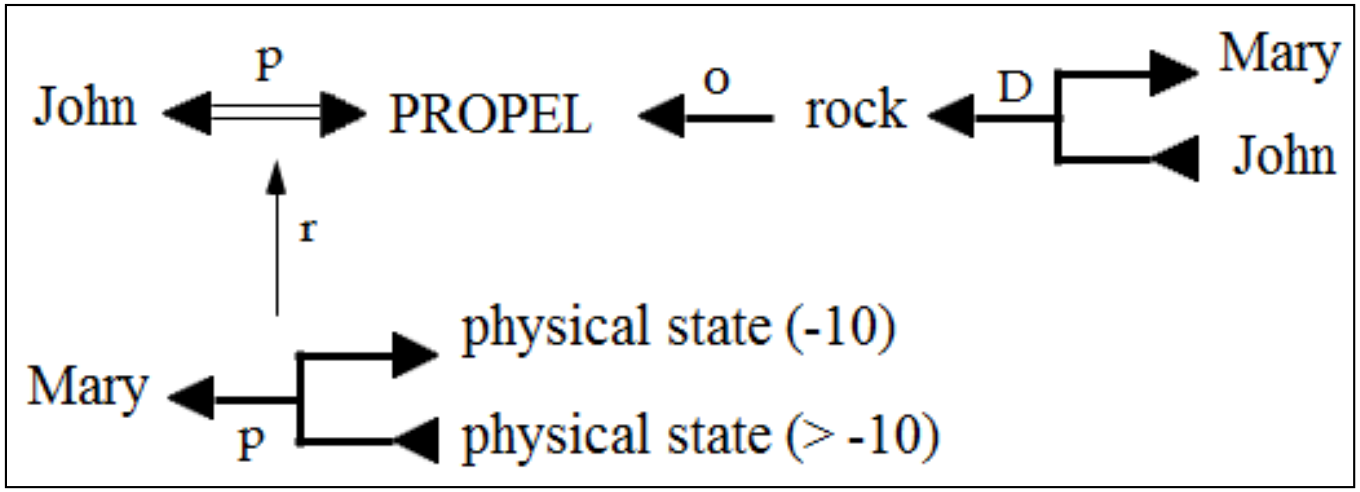


Example 4: John sold his car to Bill.

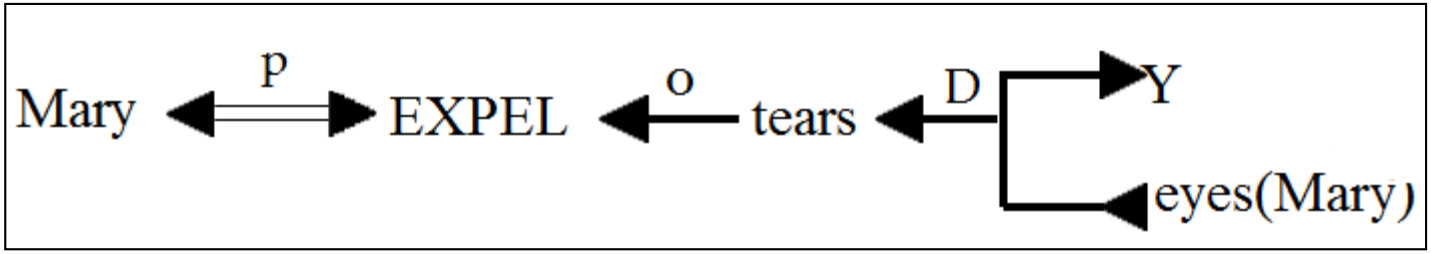


CD Examples

Example 5: John killed Mary by throwing rock at her.



Example 6: Mary cried.



Inferences Associated with Primitive Act

- General inferences are stored with each primitive Act thus reducing the number of inferences that need to be stored explicitly with each concept.
- For example, from a sentence "John killed Mike", we can infer that "Mike is dead".
- Let us take another example of primitive Act INGEST.
- The following inferences can be associated with it.
  - The object ingested is no longer available in its original form.
  - If object is eatable, then the actor has less hunger.
  - If object is toxic, then the actor's heath is bad.
  - The physical position of object has changed. So PTRANS is inferred.

Inferences associated with PTRANS

1. The object is located at the destination.
2. The object is no longer at the source.
3. If a human actor requested the action, then they will probably do whatever is normally done with the object.
4. Doing this will cause the person to be pleased.

John went to New York from Texas.

1. John is in New York.
2. John is no longer in Texas.
3. John wanted to do something in New York.
4. John thought he would enjoy being in New York.

Inferences associated with INGEST

1. PTRANS is inferred.
2. The object ceases to exist in its usual form.
3. If the object is edible, then the actor is nourished.
4. If the object is inedible, then the actor becomes sick.
5. If the actor thinks the object tastes good, then the actor is pleased.

John ate an apple.

1. An apple was put into John's mouth.
2. The apple ceased to exist.
3. John was nourished.
5. John liked eating the apple.

John ate poison.

4. John became sick.

Inferences associated with PROPEL

1. PTRANS is inferred.
2. The destination might be negatively affected (physically).
3. If the destination is human, the actor might have been mad at him/her.
4. If the object is brittle then it will become in a negative state.

John threw an egg at Mary.

1. The egg came in contact with Mary.
2. Mary was hurt.
3. John was angry at Mary.
4. The egg was broken.

Object-based inferences

Additional inferences can be made depending upon the representation of the objects.

1. If the object is liquor, then the actor may become drunk.
2. If the object is candy, then the actor may get bad teeth.
3. If the object is medicine, then the actor may feel better.

But these inferences represent information about the objects, and are therefore stored with the object and not the ACT.

SCRIPTS

- Conceptual dependencies are used to represent and reason about an event.
- In real time applications, events rarely occur in isolation.
- Script is a structure that describe a sequence of events in particular context scripts such as going to movies, shopping in supermarket, eating in restaurant, banking *etc*.
- A script consists set of **slots** and information (knowledge) contained in it .
- Scripts are beneficial because:
  - Events tend to occur in known runs or patterns.
  - Causal relationships between events exist.
  - Entry conditions exist which allow an event to take place

Components of Scripts

- Script Name: - Title
- Track: - Special situation, specific variation
- Roles:- people involved in the event described in script
- Props: - non live objects involved in the Script
- Entry condition: - required pre situation to execute the script
- Scenes: - The actual sequence of events that occur
- Result: - Condition(s) that will be True after execution of script

Script: Goint to a restaurant

Props: Food
Tables
Menu
Money

Roles: Owner
Customer
Waiter
Cashier

Entry Conditions:
Customer is hungry
Customer has money
Owner has food

Results:
Customer is not hungry
Owner has more money
Customer has less money
Owner has less food

Scene 1: Entering the restaurant
Customer enters the restaurant
Scans the tables
Chooses the best one
Decides to sit there
Goes there
Occupies the seat

Scene 2: Ordering the food
Customer asks for menu
Waiter brings it
Customer glances it
Chooses what to eat
Orders that item

Scene 3: Eating the food
Waiter brings the food
Customer eats it

Scene 4: Paying the bill
Customer asks for the bill
Waiter brings it
Customer pays for it
Waiter hands the cash to the cashier
Waiter brings the balance amount
Customer tips him
Customer moves out of the restaurant

Script for Eating in Resturant

```
Scene 1 Entering
      PTRANS     self into restaurant
      ATTEND     eyes to empty tables
      MBUILD     place to sit
      PTRANS     self to table
      MOVE       sit down
Scene 2 Ordering
      ATRANS     Get menu
      MTRANS     Read menu
      MBUILD     Decide what self wants
      MTRANS     Order to waitress/waiter
Scene 3 Eating
      ATRANS     Get food
      INGEST     Eat food
Scene 4 Exiting
      MTRANS     Ask for check
      ATRANS     Get check
      ATRANS     Tip waitress/waiter
      PTRANS     Self to cashier
      ATRANS     Money to cashier
      PTRANS     Self out of restaurant
```

- **Script Name: -Shopping Script**

Track:- Super Market

Roles: - Shopper , Check out clerk , sacking clerk

Entry Condition: - Shopper needs groceries, food market open

Props: - Shopping Cart , Display aisles , market items ,checkout stands, money

SCENE1: - Enter Market

Shopper PTRANS Shopper into Market

Shopper PTRANS Shopping Cart to Shopper

SCENE2: - Shop For Item

Shopper MOVE Shopper through aisles

Shopper ATTEND eyes to display items

Shopper PTRANS item to Shopping Cart

SCENE3:-Check Out

Shopper MOVE Shopper to check out stand
Shopper ATTEND Eyes to charges
Shopper ATRANS money to check out clerk
Sacker ATRANS bag to shopper

SCENE4:- Exit Market

Shopper PTRANS shopper to exit market

Results:- Shopper has less money
Shopper has grocery items
Market has less grocery items
Market has more money