Conceptual Dependency

Conceptual Dependency (CD)

- CD theory was developed by Schank in 1973 to 1975 to represent the meaning of NL sentences.
  - It helps in drawing inferences
  - It is independent of the language
- CD representation of a sentence is not built using words in the sentence rather built using conceptual primitives which give the intended meanings of words.
- CD provides **structures** and specific **set of primitives** from which representation can be built.

Primitive Acts of CD theory

- ATRANS — Transfer of an abstract relationship (i.e. give)
- PTRANS — Transfer of the physical location of an object (e.g., go)
- PROPEL — Application of physical force to an object (e.g. push)
- MOVE — Movement of a body part by its owner (e.g. kick)
- GRASP — Grasping of an object by an action (e.g. throw)
- INGEST — Ingesting of an object by an animal (e.g. eat)
- EXPEL — Expulsion of something from the body of an animal (e.g. cry)
- MTRANS — Transfer of mental information (e.g. tell)
- MBUILD — Building new information out of old (e.g decide)
- SPEAK — Producing of sounds (e.g. say)
- ATTEND — Focusing of a sense organ toward a stimulus (e.g. listen)

Conceptual category

- There are four conceptual categories
  - ACT Actions {one of the CD primitives}
  - PP Objects {picture producers}
  - AA Modifiers of actions {action aiders}
  - PA Modifiers of PP's {picture aiders}

Example

- I gave a book to the man. CD representation is as follows:

- It should be noted that this representation is same for different saying with same meaning. For example
  - I gave the man a book,
  - The man got book from me,
  - The book was given to man by me etc.

Few conventions

- 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

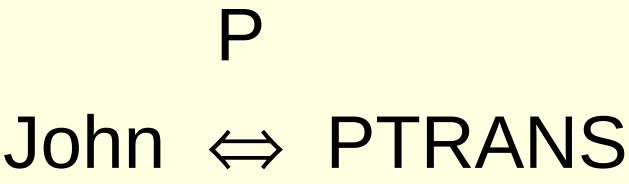
Some of Conceptualizations of CD

- Dependency structures are themselves conceptualization and can serve as components of larger dependency structures.
- The dependencies among conceptualization correspond to semantic relations among the underlying concepts.
- We will list the most important ones allowed by CD.
- Remaining can be seen from the book.

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:



Rule 2: ACT ← PP

- It describes the relationship between a ACT and a PP (object) of ACT.
  - The direction of the arrow is toward the ACT since the context of the specific ACT determines the meaning of the object relation.

- Example: John pushed the bike

CD Rep: John $\Leftrightarrow$ PROPEL $\overset{o}{\leftarrow}$ bike

Rule 3: PP $\leftrightarrow$ PP

- It describes the relationship between two PP's, one of which belongs to the set defined by the other.

- Example:John is doctor

  CD Rep: John $\leftrightarrow$ doctor

Rule 4: PP ← PP

- It describes the relationship between two PP's, one of which provides a particular kind of information about the other.
  - The three most common types of information to be provided in this way are possession (shown as POSS-BY), location (shown as LOC), and physical containment (shown as CONT).
  - The direction of the arrow is again toward the concept being described.

- Example: John's dog

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

Rule 5: PP ⇔ PA

- It describes the relationship between a PP and a PA that is asserted to describe it.
  - PA represents states of PP such as height, health etc.

- Example:John is fat

CD Rep John ⇔ weight (> 80)

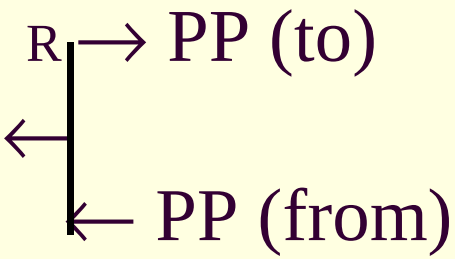
Rule 6: PP ← PA

- It describes the relationship between a PP and an attribute that already has been predicated of it.
  - Direction is towards PP being described.

- Example: Smart John

CD Rep John ← smart

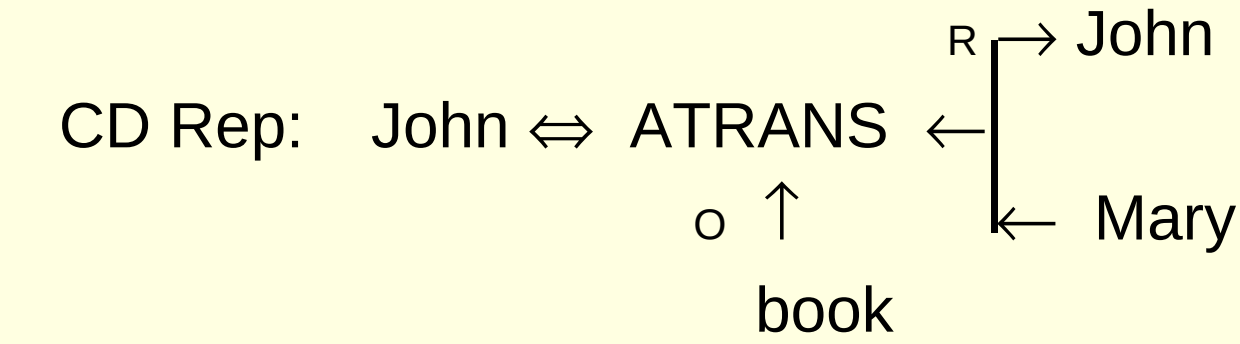
Rule 7:



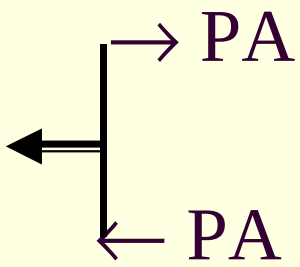
- It describes the relationship between an ACT and the source and the recipient of the ACT

- Example: John took the book from Mary

CD Rep:

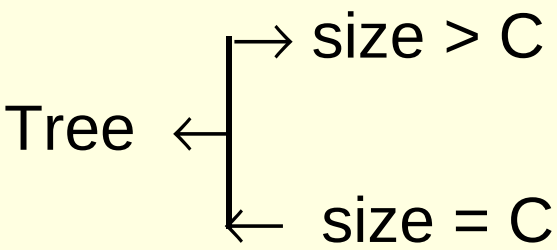


Rule 8: PP



- It describes the relationship that describes the change in state.
- Example: Tree grows

CD Rep:



Rule 9:

$\Leftrightarrow \{x\}$

$\uparrow$

$\Leftrightarrow \{y\}$

- It describes the relationship between one conceptualization and another that causes it.
  - Here {x} is causes {y} i.e., if x then y

- Example: Bill shot Bob

{x} : Bill shot Bob

$\uparrow$

{y} : Bob's health is poor

Rule 10:

⇔ {x}
↓
⇔ {y}

- It describes the relationship between one conceptualization with another that is happening at the time of the first.
  - Here {y} is happening while {x} is in progress.

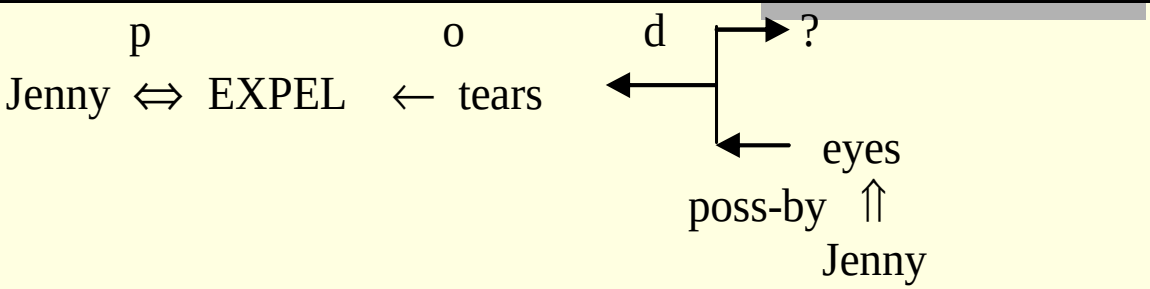
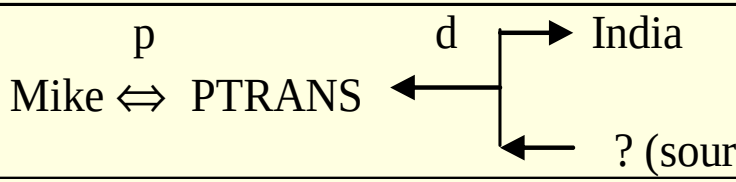
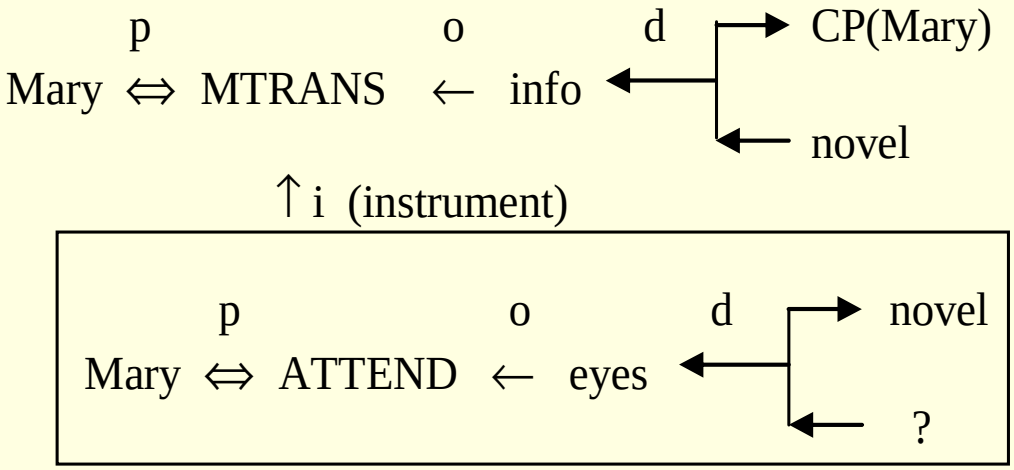
- Example: While going home I saw a snake

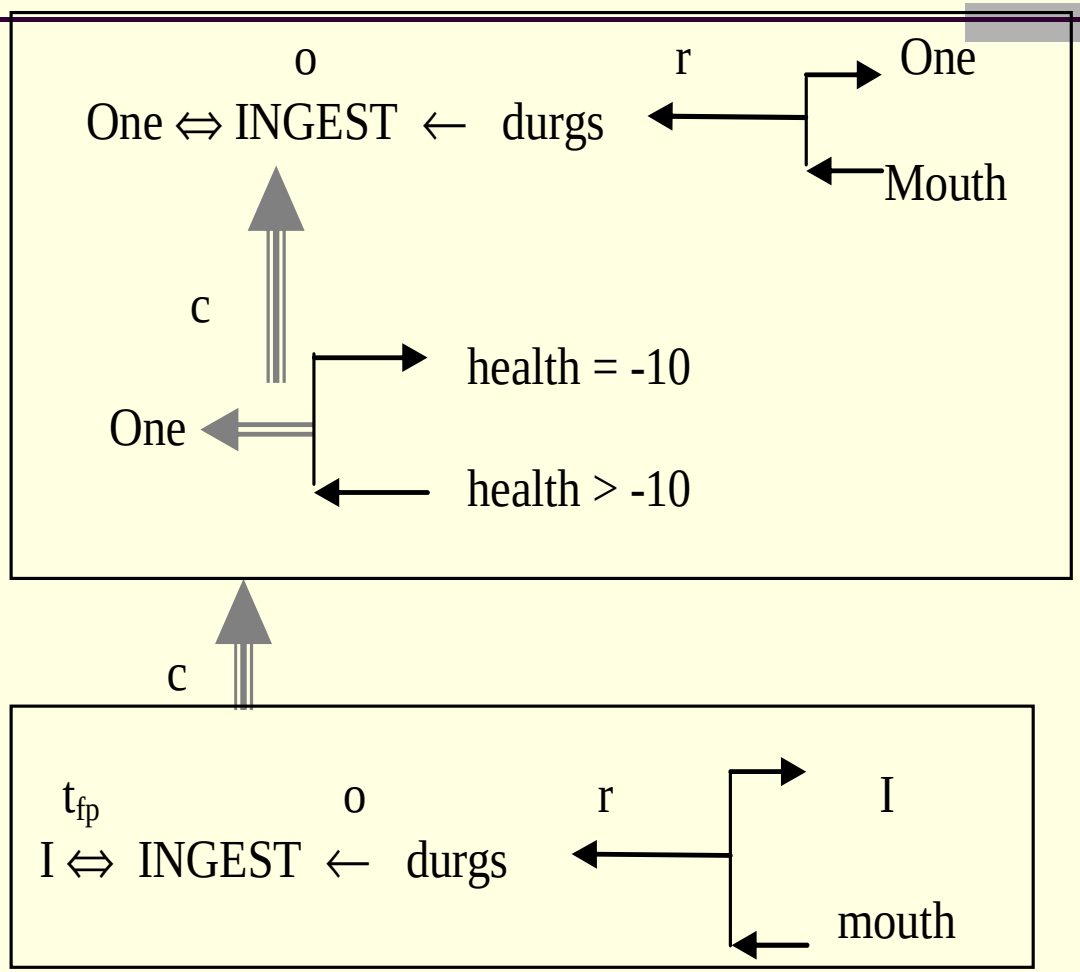
I am going home

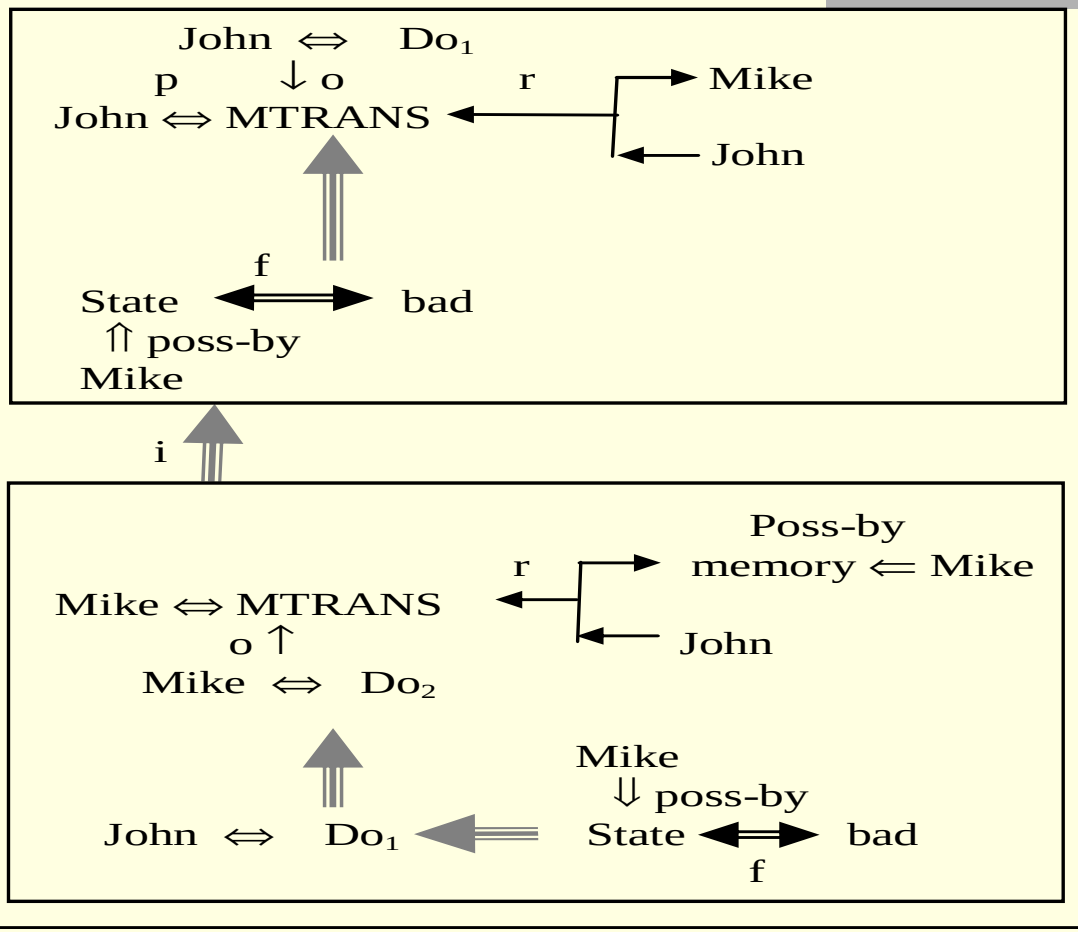
↓

I saw a snake

Generation of CD representations

Sentences	CD Representations
Jenny cried	
Mike went to India	
Mary read a novel	

Sentence	CD Representation
Since drugs can kill, I stopped.	

Sentence	CD Representation
John warned Mike with dire consequence.	

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.

Cont…

- Example: The verbs {give, take, steal, donate} involve a transfer of ownership of an object.
  - If any of them occurs, then inferences about who now has the object and who once had the object may be important.
  - In a CD representation, these possible inferences can be stated once and associated with the primitive ACT "ATRANS".
- Consider another sentence "Bill threatened John with a broken nose"
  - Sentence interpretation is that Bill informed John that he (Bill) will do something to break john's nose.
  - Bill did (said) so in order that John will believe that if he (john) does some other thing (different from what Bill wanted) then Bill will break John's nose.

Problems with CD Representation

- It is difficult to
  - construct original sentence from its corresponding CD representation.
  - CD representation can be used as a general model for knowledge representation, because this theory is based on representation of events as well as all the information related to events.
- Rules are to be carefully designed for each primitive action in order to obtain semantically correct interpretation.

Contd…

- Many verbs may fall under different primitive ACTs, and it becomes difficult to find correct primitive in the given context.
- The CD representation becomes complex requiring lot of storage for many simple actions.
- For example, the sentence “John bet Mike that Indian cricket team will win incoming world cup” will require huge CD structure.

Conceptual Parsing

- Conceptual parsing is required for generating CD representation from source sentences in natural language.
- The main steps involved in CD parsing are as follows:
  - Syntactic processor extracts main verb and noun along with syntactic category of the verb (transitive or intransitive) from the sentence.
  - Conceptual processor then makes use of verb–ACT dictionary.
  - Once the correct entry from dictionary is chosen, CD processor analyses the rest of sentence looking for arguments for empty slots of the verb.
  - CD processor examines possible interpretation in a well-defined order.

Example

- **Case1**: Handling of ‘with PP’ phrase by CD processor and formulating strategies to disambiguate the meanings.
  - **Type1**: John broke the door with **hammer** non animate
  - **Type2:** John broke the door with **Mike** animate
- **Rule 1:** If PP in ‘with PP’ phrase is non-animate and CD Act requires instrument then the sentence is of Type1, where PP (hammer) is resolved to instrument.
- **Rule 2:** If PP in ‘with PP’ phrase is animate and CD Act requires instrument then the sentence is of Type2, where PP (Mike) is resolved as co-actor.

Contd..

- **Case2:** If PPs in both the sentences are non-animate, then they have to be resolved using semantic lexicon.
  - **Type3:** John went to the garden *with flowers*
  - **Type4:** John went to the garden *with bag*
- In Type3, non-animate noun ‘flowers’ is part of garden, whereas in Type4, non-animate ‘bag’ is some object not related to garden.
- Such association of word senses could be found in Word-Net and then disambiguation is possible.
- Here noun ‘bag’ is treated as possession by John.

Contd..

- Case 3: If PPs in the sentences are animate, then they have to be resolved using semantic lexicon and context.
- Consider the following examples.
  - **Type5:** John went to the *garden with Mike*
  - **Type6:** John went to the *garden with butterflies*
  - **Type7:** John went to the *garden with dog*
- In these sentences, Mike, butterflies and dog are animate PPs and can be resolved as follows:
- Mike is easily resolved to co-actor of John as both are human and have similar characteristics.

Contd..

- Word-Net can be used to check if butterfly and garden has some common sense.
- Dog is still ambiguous.
- It may be treated as possession of actor or may be a part of garden as animals many wonder in garden.
- Such situations can be further resolved by considering the context of sentences.
- We can use semantic lexicon dictionary to resolve some of the ambiguities.

Script Structure

- Scripts were introduced by Schank and Abelson introduced in 1977 that used CD framework.
- The scripts are useful in describing certain stereotyped situations such as going to theater
- It consists of set of slots containing default values along with some information about the type of values similar to frames.
- It differs from FS as the values of the slots in scripts must be ordered and have more specialized roles.
- In real world situations, we see that event tends to occur in known patterns because of clausal relationship to the occurrence of events

Script Components

- Each script contains the following main components.
  - ***Entry Conditions*:** Must be satisfied before events in the script can occur.
  - ***Results:*** Conditions that will be true after events in script occur.
  - ***Props:*** Slots representing objects involved in the events.
  - ***Roles:*** Persons involved in the events.
  - ***Track:*** Specific variation on more general pattern in the script. Different tracks may share many components of the same script but not all.
  - ***Scenes:*** The sequence of *events* that occur. Events are represented in conceptual dependency form.

Script : Play in theater	Various Scenes
Track: Play in Theater **Props:** • Tickets • Seat • Play **Roles:** • Person (who wants to see a play) – P • Ticket distributor – TD • Ticket checker – TC **Entry Conditions:** • P wants to see a play • P has a money **Results:** • P saw a play • P has less money • P is happy (optional if he liked the play)	***Scene 1: Going to theater*** • P PTRANS P into theater • P ATTEND eyes to ticket counter ***Scene 2: Buying ticket*** • P PTRANS P to ticket counter • P MTRANS (need a ticket) to TD • TD ATRANS ticket to P ***Scene 3: Going inside hall of theater and sitting on a seat*** • P PTRANS P into Hall of theater • TC ATTEND eyes on ticket POSS_by P • TC MTRANS (showed seat) to P • P PTRANS P to seat • P MOVES P to sitting position ***Scene 4: Watching a play*** • P ATTEND eyes on play • P MBUILD (good moments) from play ***Scene5: Exiting*** • P PTRANS P out of Hall and theater

Script Invocation

- It must be activated based on its significance.
- If the topic is important, then the script should be opened.
- If a topic is just mentioned, then a pointer to that script could be held.
- For example, given “John enjoyed the play in theater”, a script “Play in Theater” suggested above is invoked.
- All implicit questions can be answered correctly.
- Here the significance of this script is high.
  - Did john go to theater?
  - Did he buy ticket?
  - Did he have money?
- If we have a sentence like “John went to theater to pick his daughter”, then invoking this script will lead to many wrong answers.
  - Here significance of the script theater is less.
- Getting significance from the story is not straightforward. However, some heuristics can be applied to get the value.

Advantages / Disadvantages of Script

- Advantages
  - Capable of predicting implicit events
  - Single coherent interpretation may be build up from a collection of observations.
- Disadvantage
  - More specific (inflexible) and less general than frames.
  - Not suitable to represent all kinds of knowledge.
- To deal with inflexibility, smaller modules called memory organization packets (MOP) can be combined in a way that is appropriate for the situation.