# PurposeNet: A Knowledgebase Organized around Purpose

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# What is PurposeNet

A structured knowledge based system that consists of

- A knowledge base (facts about the world) and
- An inference system that reasons over those facts and deduces new facts and also checks consistencies.

# Significance: Comprehension of Discourse

"*The alarm clock goes off at 6:15 by my roommate's bed. I wake up, crawling down the stairs from my loft.*

*I put on my white Nike gym shorts and set out.*

*In an hour, I return, eager to jump in the shower*".

**Queries**

- What is an alarm clock?
- Did the author exercise?
- Why did the author put on white Nike gym shorts?
- Why the author wanted to take a shower?

Ans 1: An alarm clock is a clock that is designed to wake a person at a specific time.

Ans 2: Yes.

Ans 3: “Gym shorts are an article of clothing typically worn by people when exercising.”
*The author intended to exercise, and therefore, wore it.*

Ans 4: The author wanted to cool his body. A shower sprinkles water over the body. As a result, the body gets wet. A wet body feels cool when the evaporation of the moisture takes heat away from the skin. Therefore the author wanted to take a shower.

# Expected Factual Knowledge

Assertion 1 - “An alarm clock is a clock that is designed to wake a person at a specific time.”

Assertion 2 - “Gym shorts are an article of clothing typically worn by people when exercising.”

Assertion 3 - “Shower is an apparatus used for bathing under a spray of water”.

# There is a need for factual knowledge

# Proposal

- *creation and use of world knowledge*
- by engineering a KB consisting of a network of entities developed using a formal principle
- used in conjunction with a state-of-the-art inference engine
- thereby bridging the man-machine gap
- providing knowledge to NLP and reasoning systems.

# Organization of Knowledge

# Organizing Principle

- How does one organize knowledge?
- Principle: Purpose as the organizing principle
- Domain: Artifacts (Man made objects)

# Indian Philosophical Tradition

**Objects are described in terms of four major types of attributes**

- **Dharm (Purpose)**:
  - Property which is intrinsic (essential) to the objects in the category
  - Helps distinguish the category from other categories.

  Example, Dharm /Purpose of a car is to transport people from one place to another on land.
- **Svabhaav**:
  - Attributes which the object shares with objects of the same class

  Example, Car shares attributes with other machines, but does not share attributes with living beings.
- **Rup** (**Form**):
  - Attributes which can directly be perceived by our sensory organs.

  For example, rupa of car would be its shape, colour, weight, etc.
- **Gun (Quality)**:
  - Properties that are not perceived directly but indirectly such as load carrying capacity, etc.

# Example: Pen

- **Purpose/Dharm**: To transport human beings from one place to another place
- **Feature/Rupa**
  - Cylindrical shape
    - Purpose: In order to hold the pen comfortably
  - Pointed tip
    - Purpose: In order to put mark on the paper

# Dictionaries and Encyclopaedia

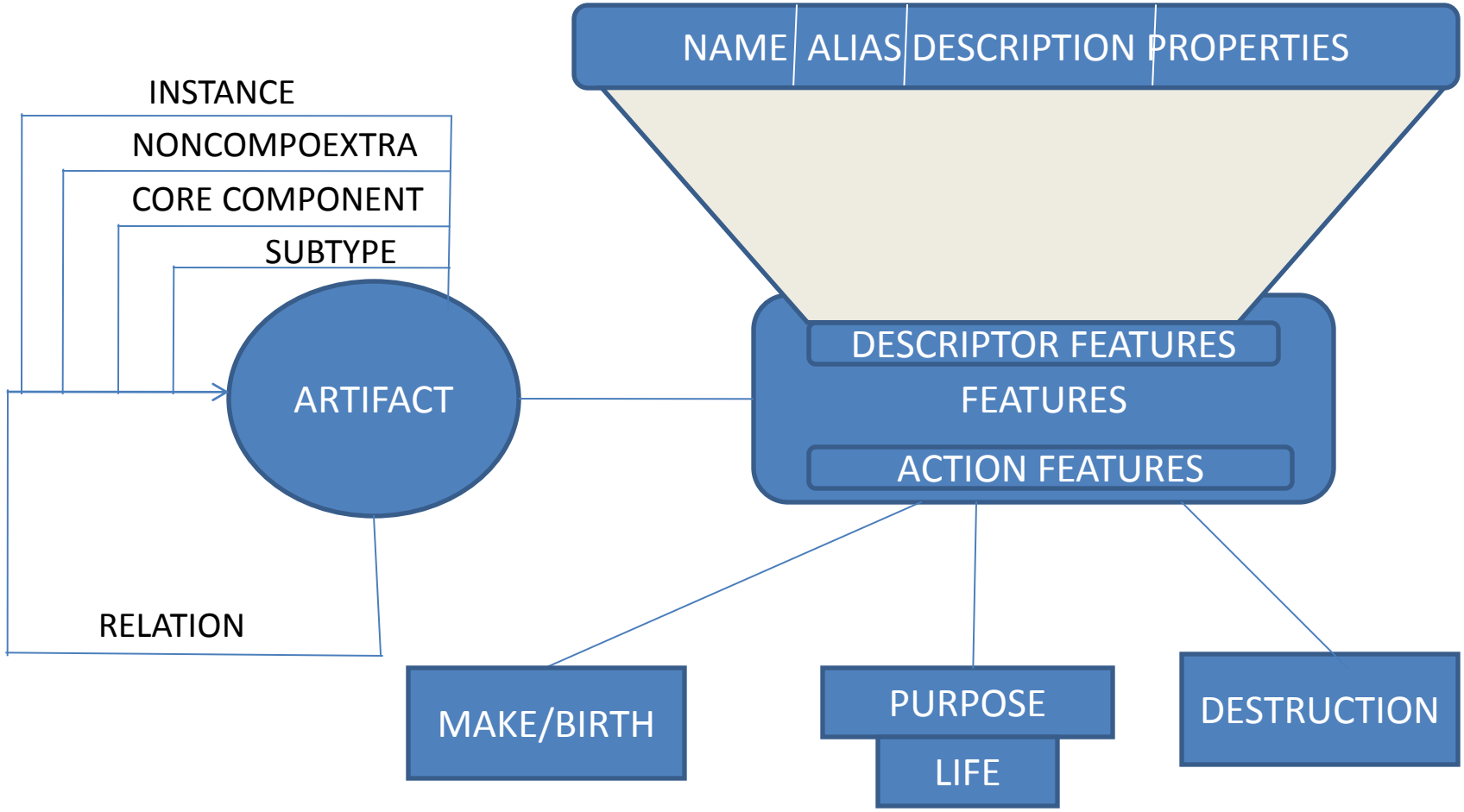
| Resources | Artifact | Defined as |
|---|---|---|
| WordNet | Fork | Cutlery used for serving and eating food |
| | Knife | Edge tool used as a cutting instrument |
| Wikipedia | Chair | A raised surface, commonly for use by one person |
| | Wall | A vertical structure, usually solid, that defines and sometimes protects an area |
| Cambridge Dictionary | Telephone | A device for speaking to someone in another place by means of electrical signals |
| | Rack | A frame, often with bars or hooks, for holding or hanging things |

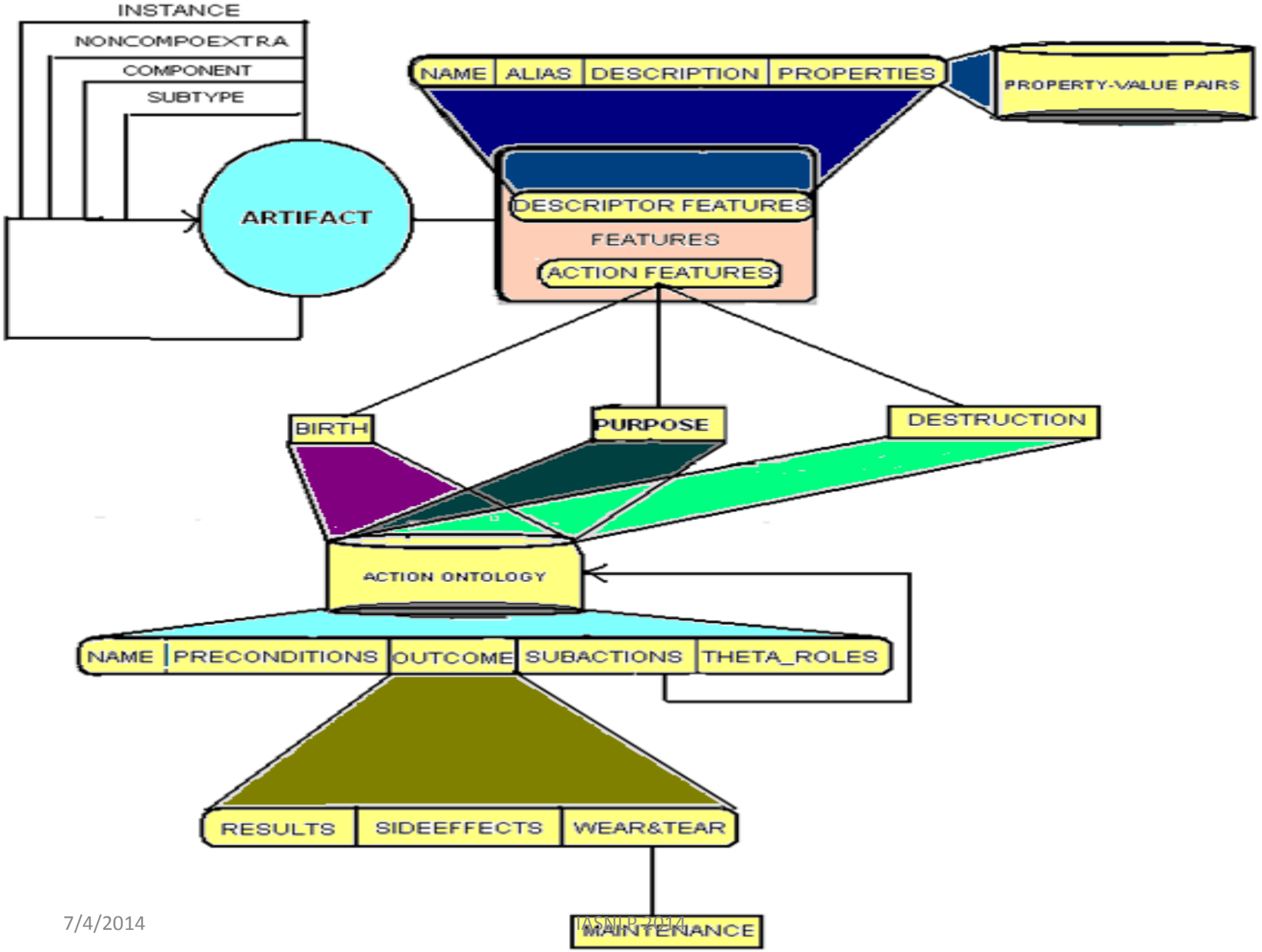
# Artifacts: Structure

- Structure: Parts put together in an organized way
- Related with the purpose
  - Parts have sub-purpose in turn
  - Each sub-purpose relates to the purpose
- Actions relate parts and purpose together

# Architecture of PurposeNet

# Architecture of PurposeNet

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SUBACTIONS
THETA_ROLES
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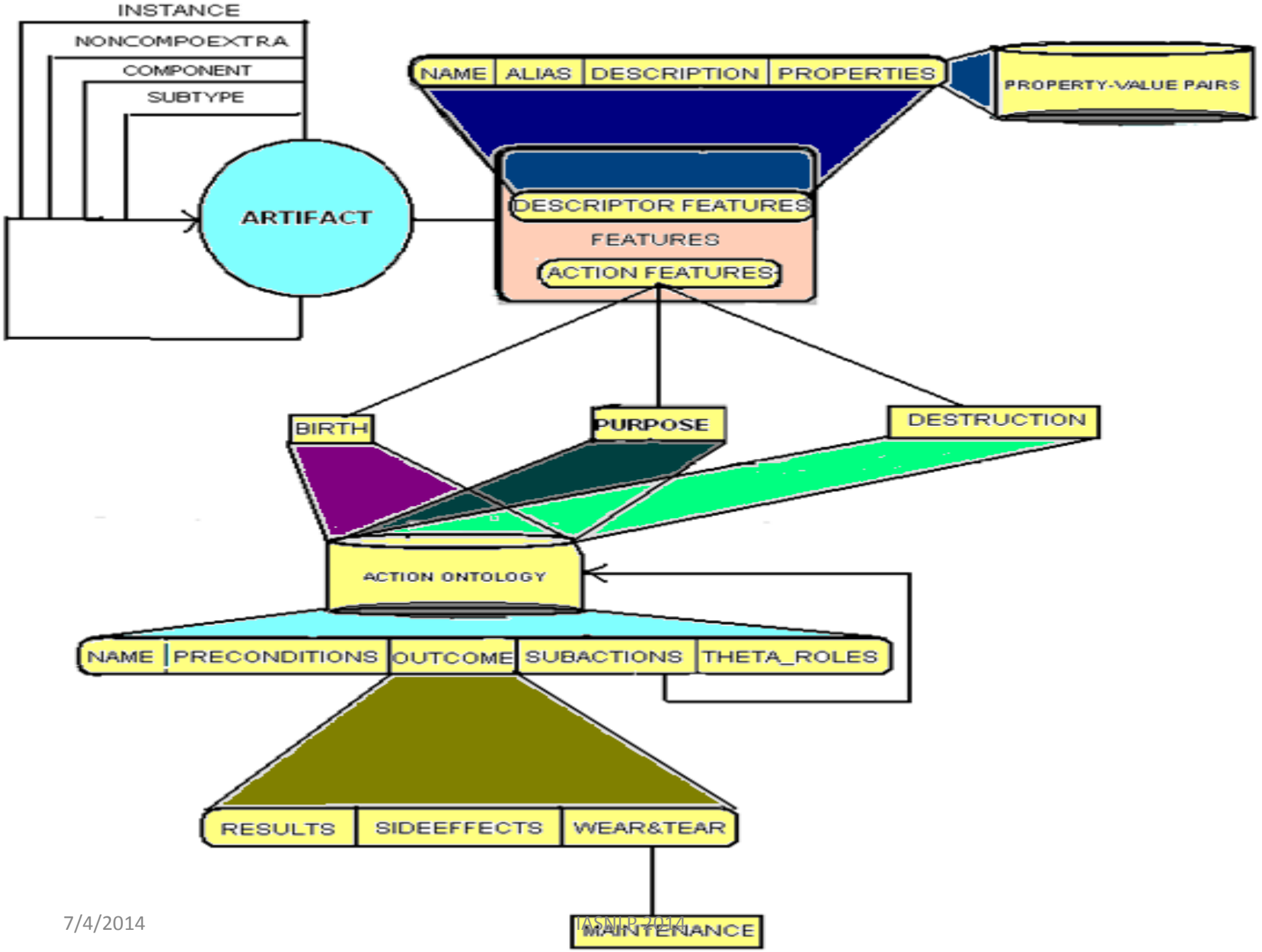
WEAR&TEAR
MAINTENANCE

# Action Frame

| Artifact: Car:: Purpose - Transport_Thing | | | |
|---|---|---|---|
| **No** | **Action Frame Element** | | **Value(s)** |
| 1 | Precondition | | Exists_Car_at_Source<br>Exists_Thing_Near_Car |
| 2 | Outcome | Result | Change_Position (Thing) |
| | | Side Effect | Change_Position (Car)<br>Change_Position (Driver) |
| | | Wear-and-tear | Worn_out(Engine)<br>Worn_out(Tyre) |
| 3 | Subactions | | Load(Thing)<br>Drive(Car)<br>Unload(Thing) |
| 4 | Theta Roles | | Theme – Thing<br>Source – Place<br>Destination – Place<br>Instrument – Car |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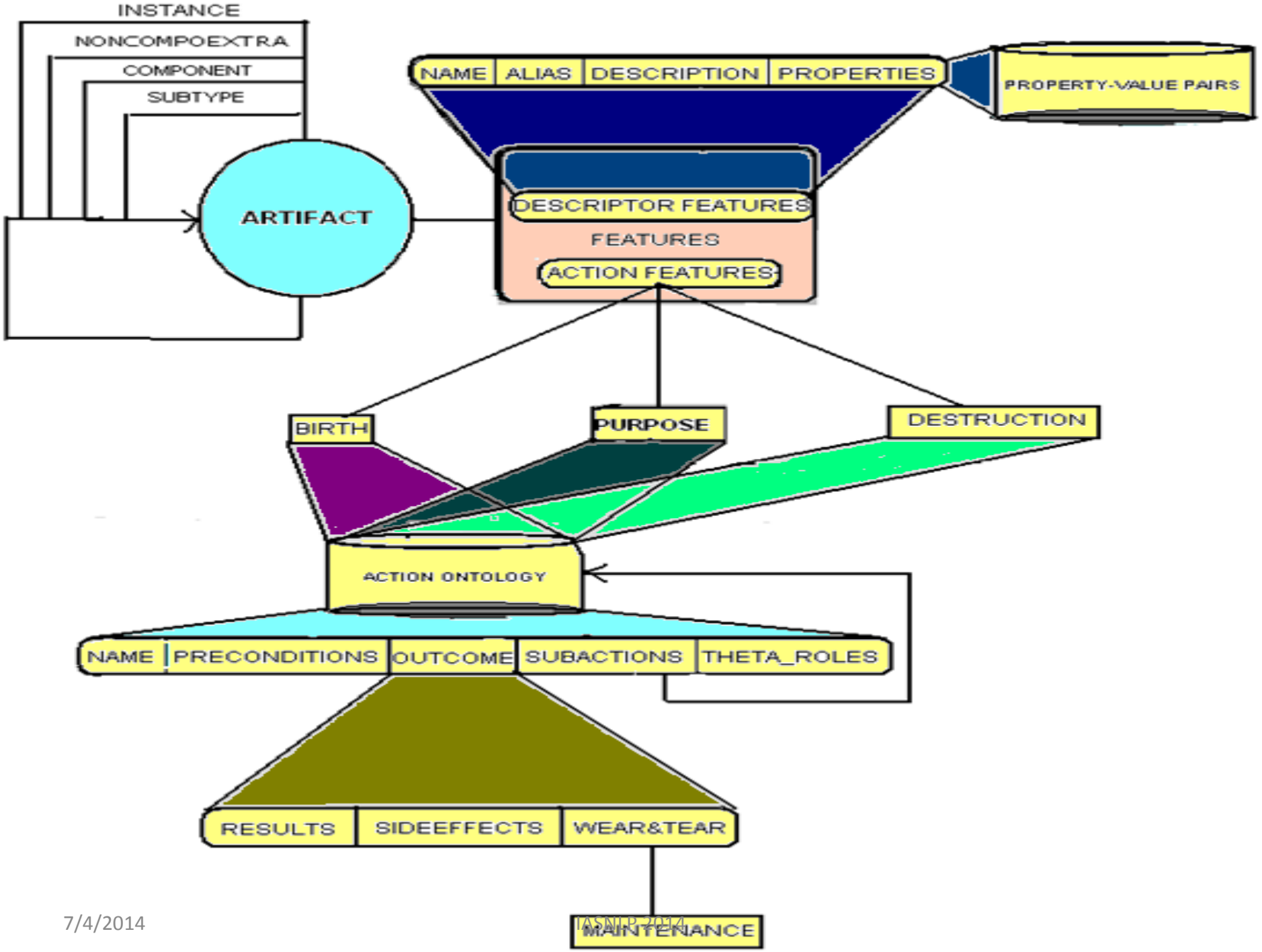
# Descriptor Features

| Feature | Definition | Value | Example: Car |
|---|---|---|---|
| Color | Produces different sensations on the eye due to Light | Red, Blue, Green, Cyan, Indigo, Pink, Orange, Black, White, Any | Any |
| Constitution | Material made of | Metal, rubber, wood, foam, plastic, glass | Metal |
| Shape | External appearance | Cubical, Oval, Triangular, Circular, Spherical, Aero, Any | Aerodynamic |
| Size | Amount of space occupied | Microscopic, very small, small, medium, large, any | Moderate_ Size |
| State | Usual physical state | Solid, liquid, gas | Solid |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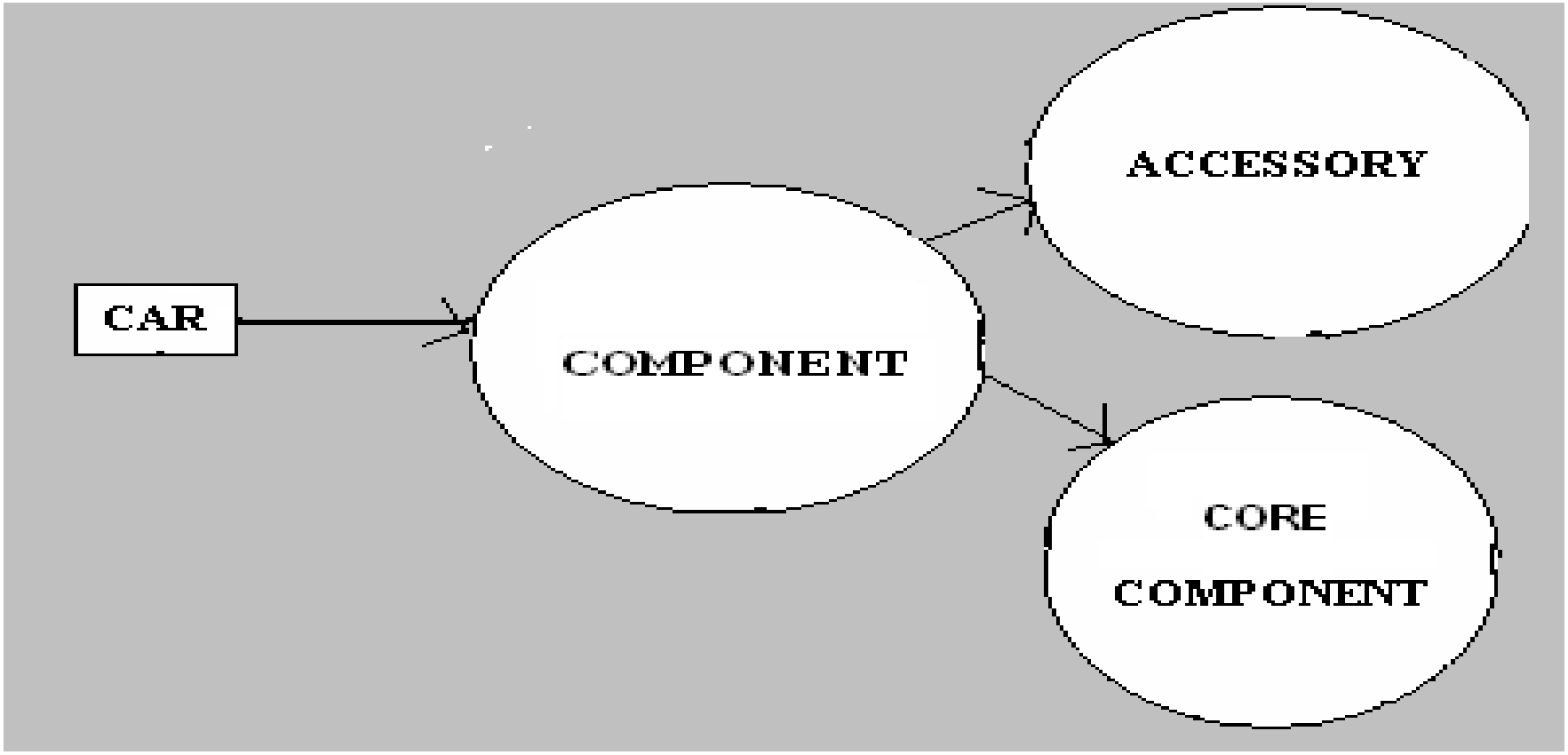
# … Relationships

CAR

# … Relationships



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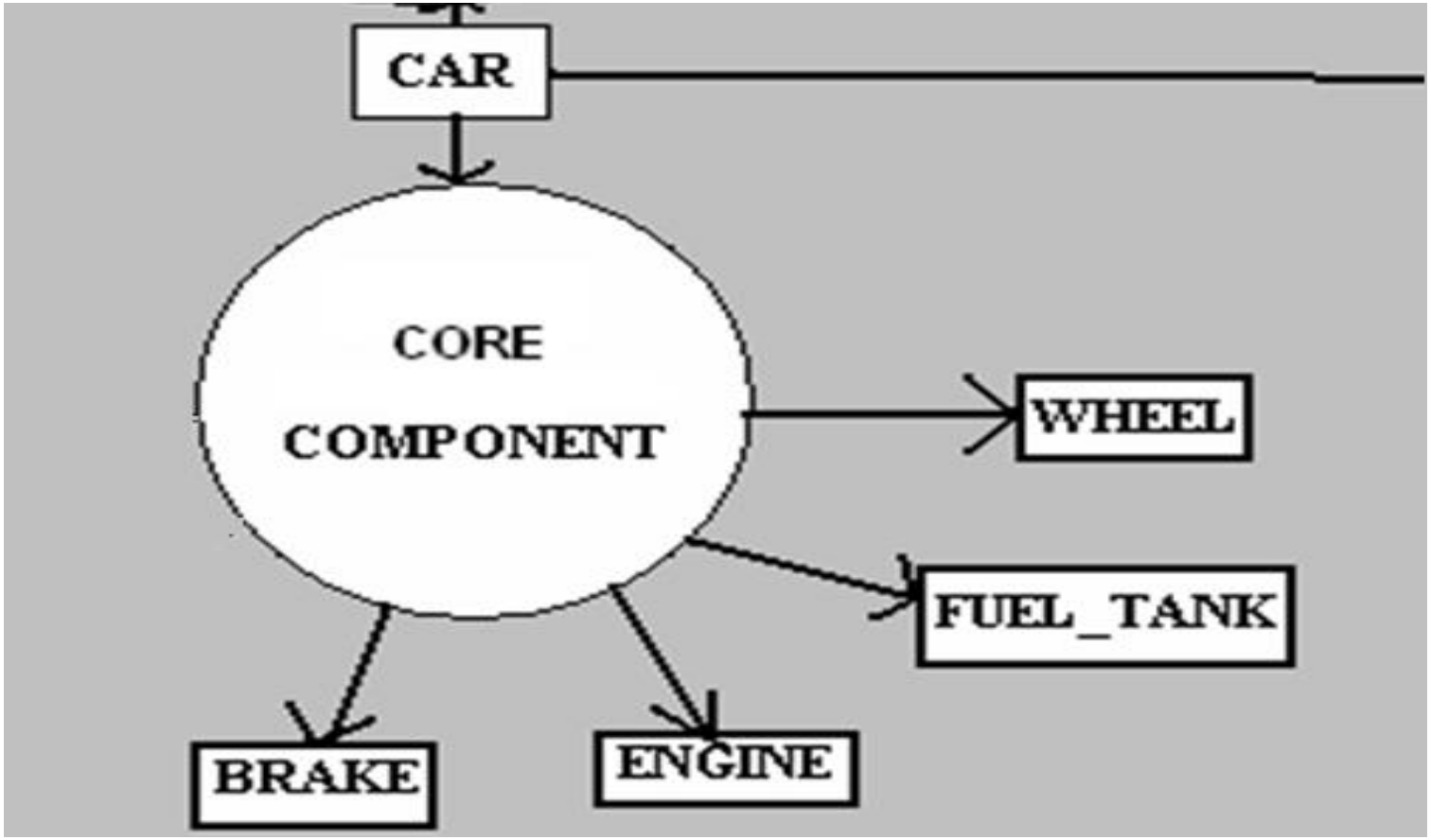

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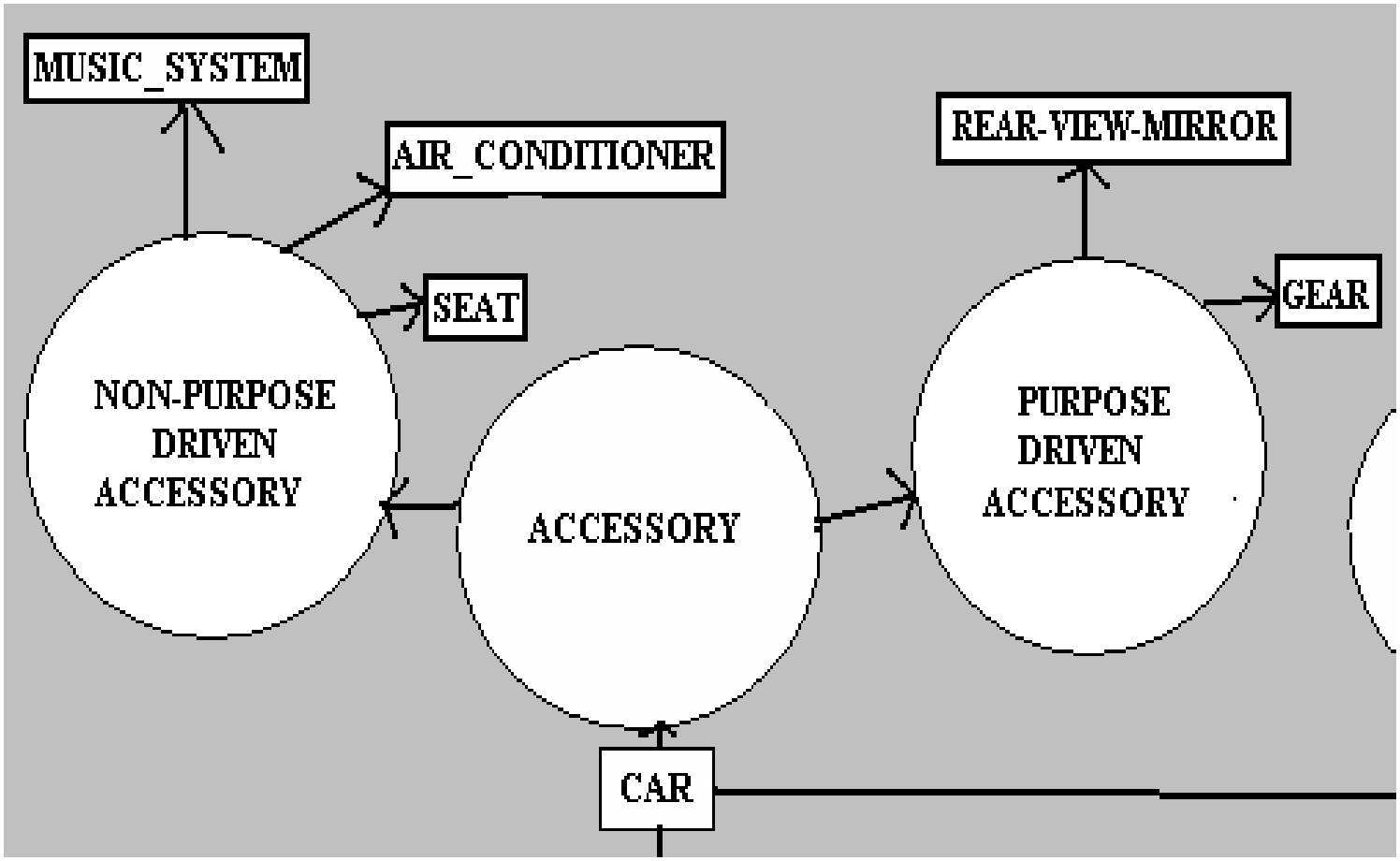

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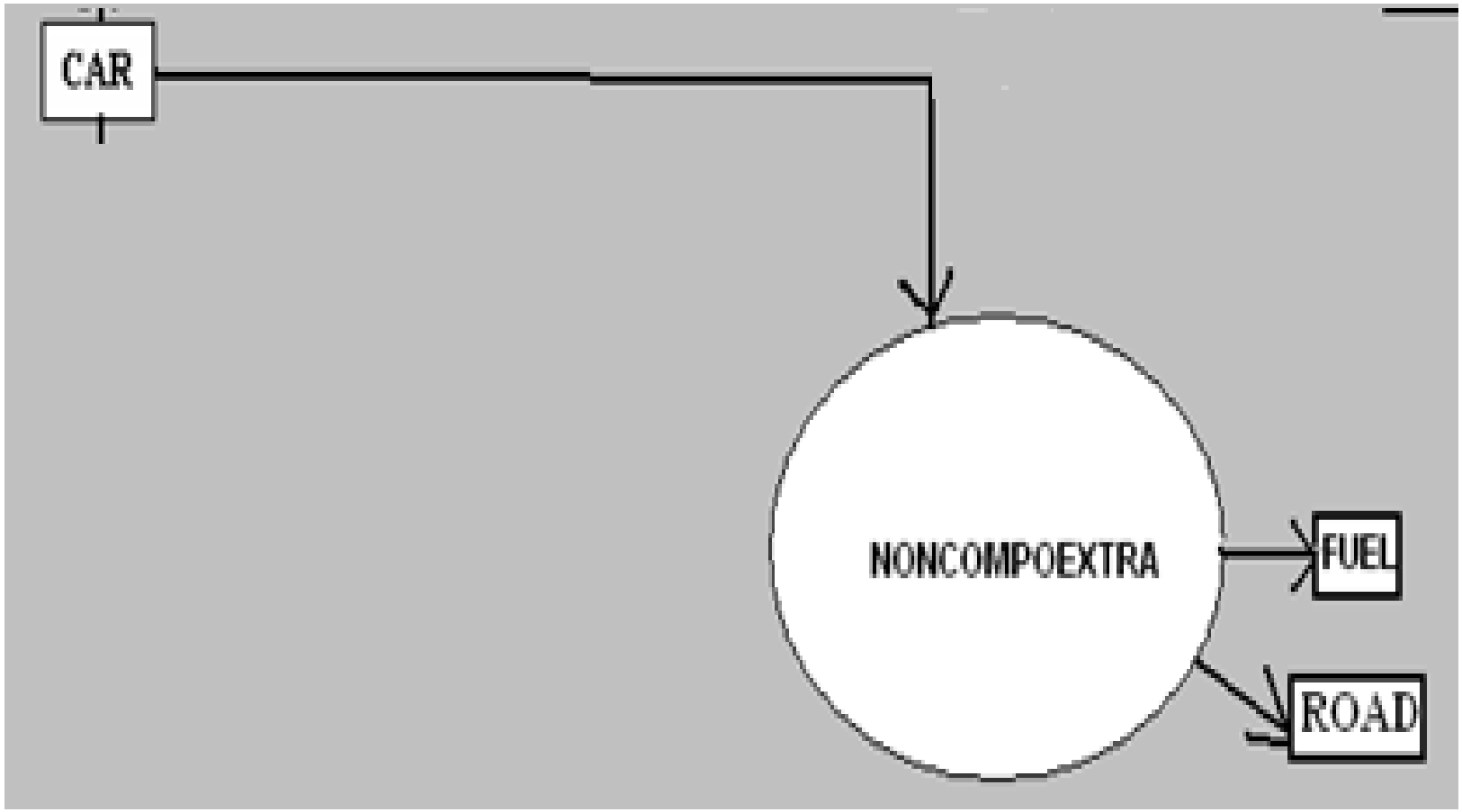

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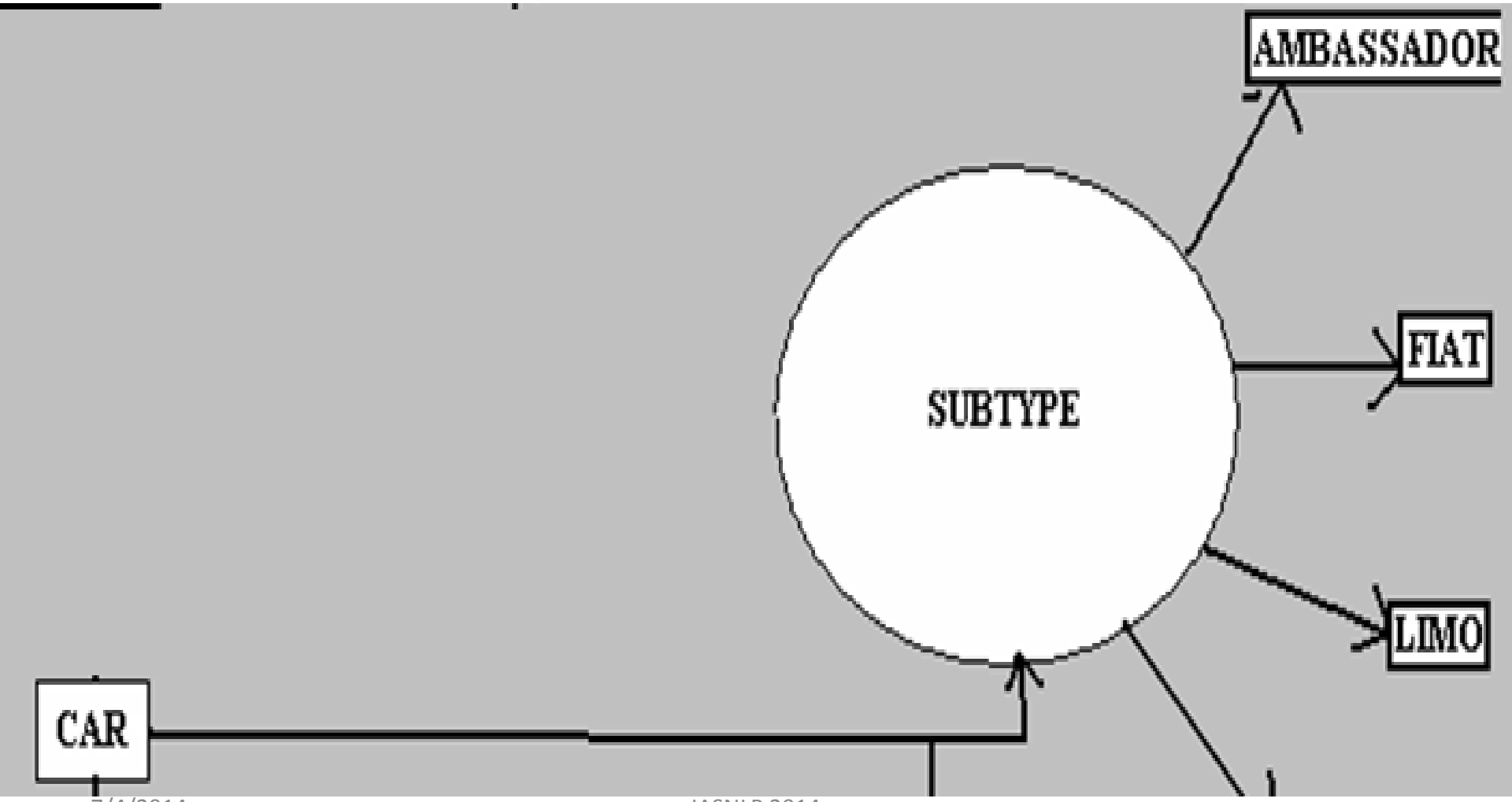

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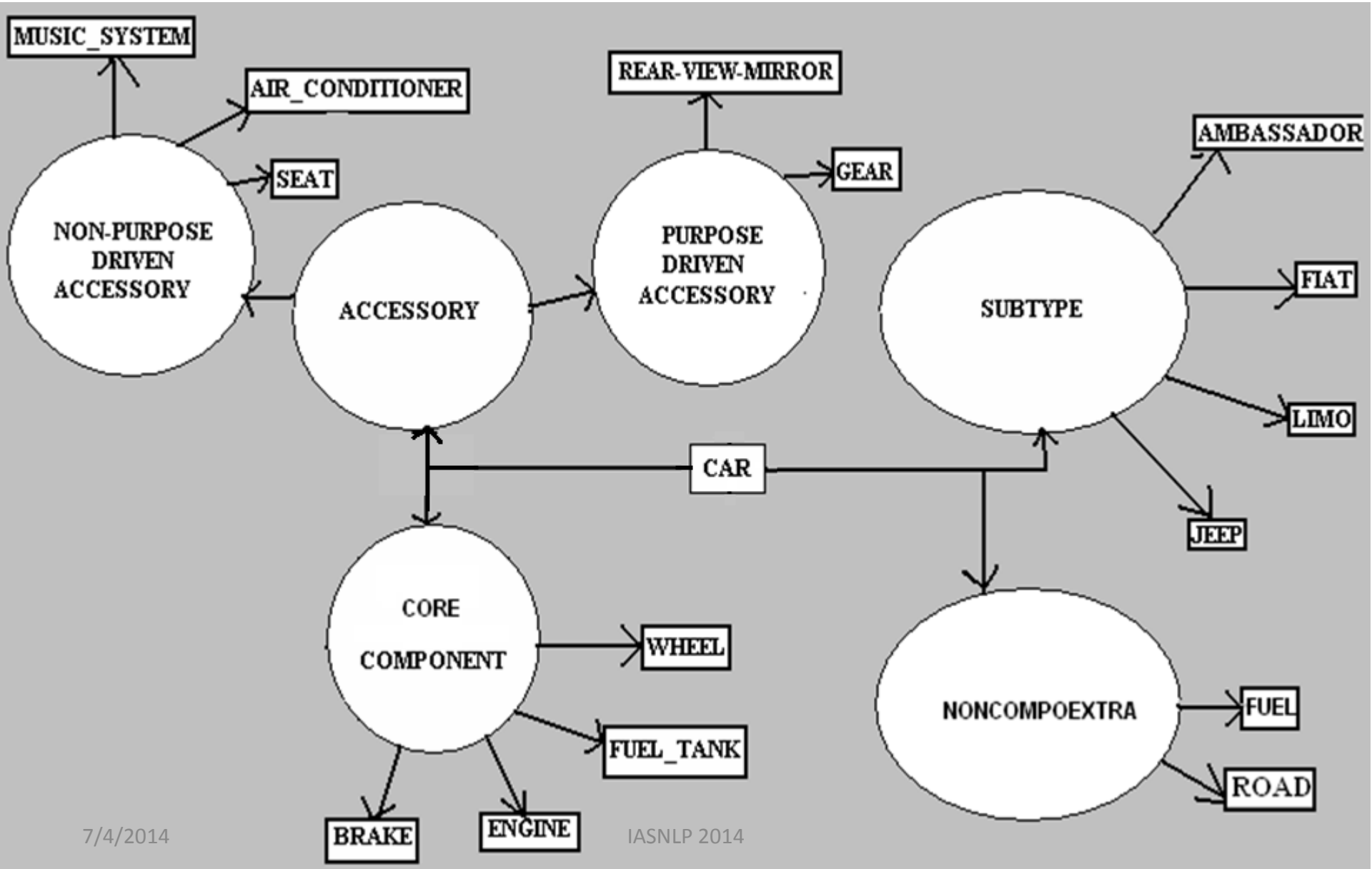

# Building the knowledge base

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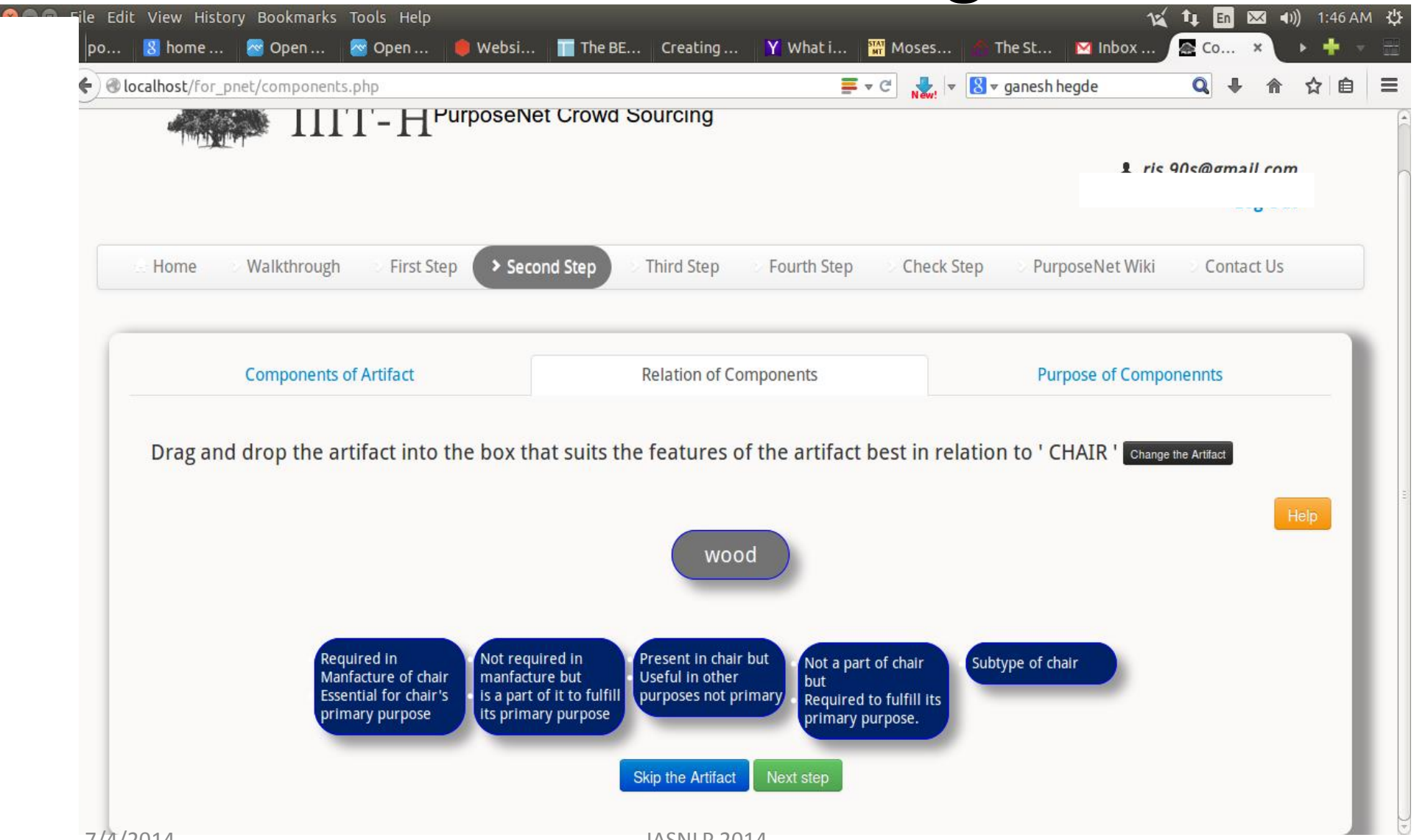
- Manual:
  - Labour intensive,
  - Time consuming,
  - Accurate
- Semi-Automatic:
  - Scalable,
  - Corpus dependent: web or static corpus
  - Requires manual checking
- Crowd-Sourcing:
  - Scalable,
  - Independent of data resource
  - Requires manual checking

# Crowd-Sourcing



# Detection and Extraction of Purpose

## Experiments for detecting purpose data in text

| Sno | Method | Precision | Recall | F-Measure |
|---|---|---|---|---|
| 1 | Typed dependency | 0.84 | 0.68 | 0.751 |
| 2 | Simple Decision Tree | 0.83 | .67 | .74 |
| 3 | Decision Tree Forest | 0.679 | 0.644 | .661 |
| 4 | Bagging | .755 | .619 | .68 |
| 5 | Naïve Bayes | .7 | .638 | .668 |
| 6 | Bayes Net | .699 | .639 | .668 |
| 7 | RBF Neural Network | .679 | .595 | .634 |
| 8 | SVM | .694 | .639 | .665 |

# Detection and Extraction of Purpose

Experiments for extracting artifact, action pair from sentence containing purpose

| Method | Precision for extraction of (artifact, action) pair given purpose-containing sentences |
|---|---|
| | |
| Surface text patterns | 88 |
| Typed dependency parse | 98.1 |

# Application

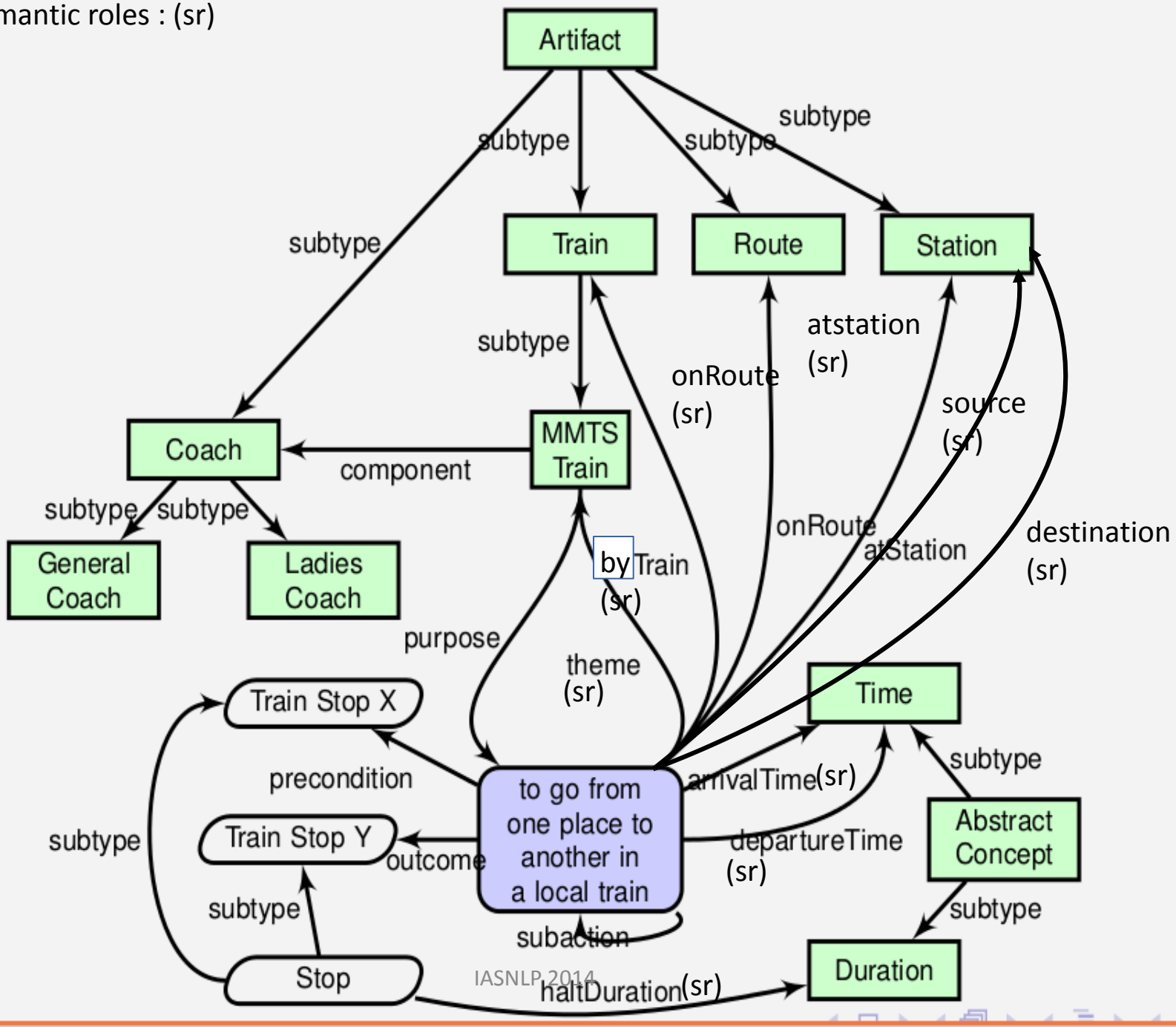
# Application: Domain Specific QA System for Hindi

For a given question in a specific domain, answer the question as precisely as possible

The knowledgebase is deemed to be a conceptual representation of the domain.

The Ontology and the questions expected are in different languages (cross-lingual answer retreival)

Semantic roles : (sr)



| Type of Questions | Example |
| --- | --- |
| kab (Factoid single answer question) | *Hyderabad se Secunderabad ki train kab jaegi*? |
| kahan kahan (Factoid list answer question) | *Hyderabad se Secunderabad ki train kahan kahan rukti hai?* |
| Kaise (Reasoning question) | *Ticket kaise khraidi jati hai?* |
| kyun (Causal – Reasoning question) | *Train chal kyun nahi rahi hai?* |
| kya (Description/Boolean) | *MMTS train hai kya?* |

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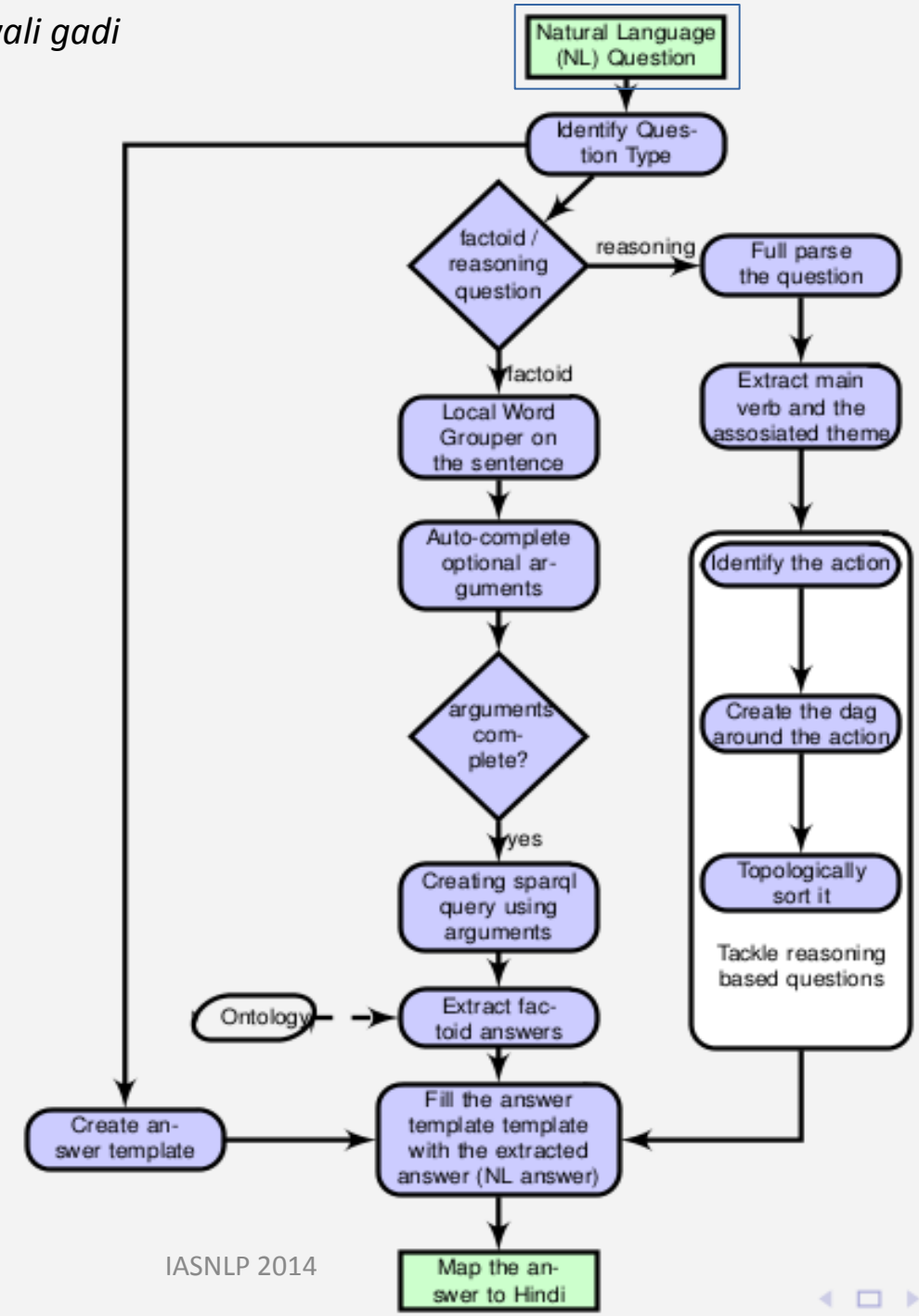
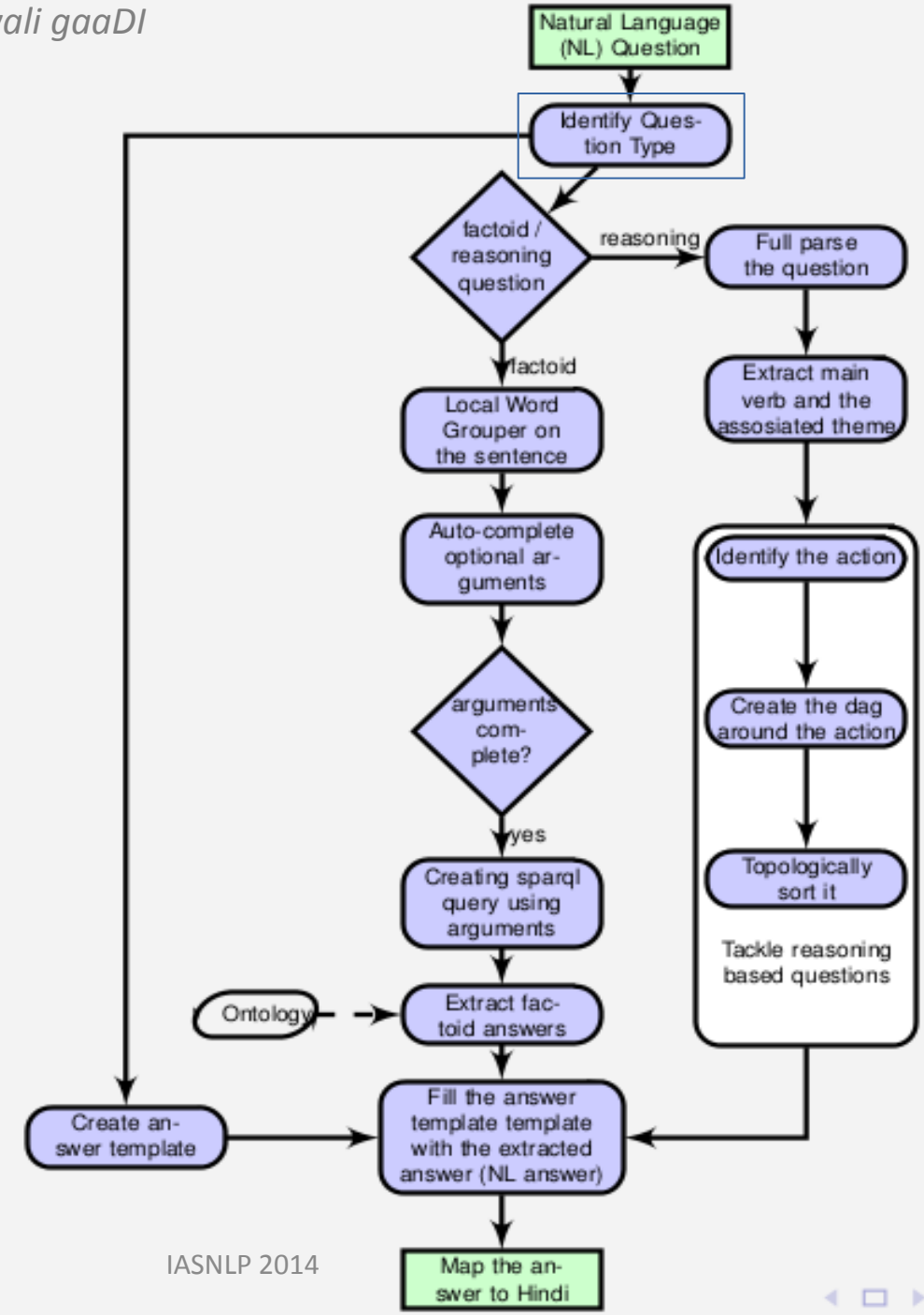


*Q. falaknuma se lingampally tak jane wali gaaDI bharatnagar par kab pahunchti hai?*

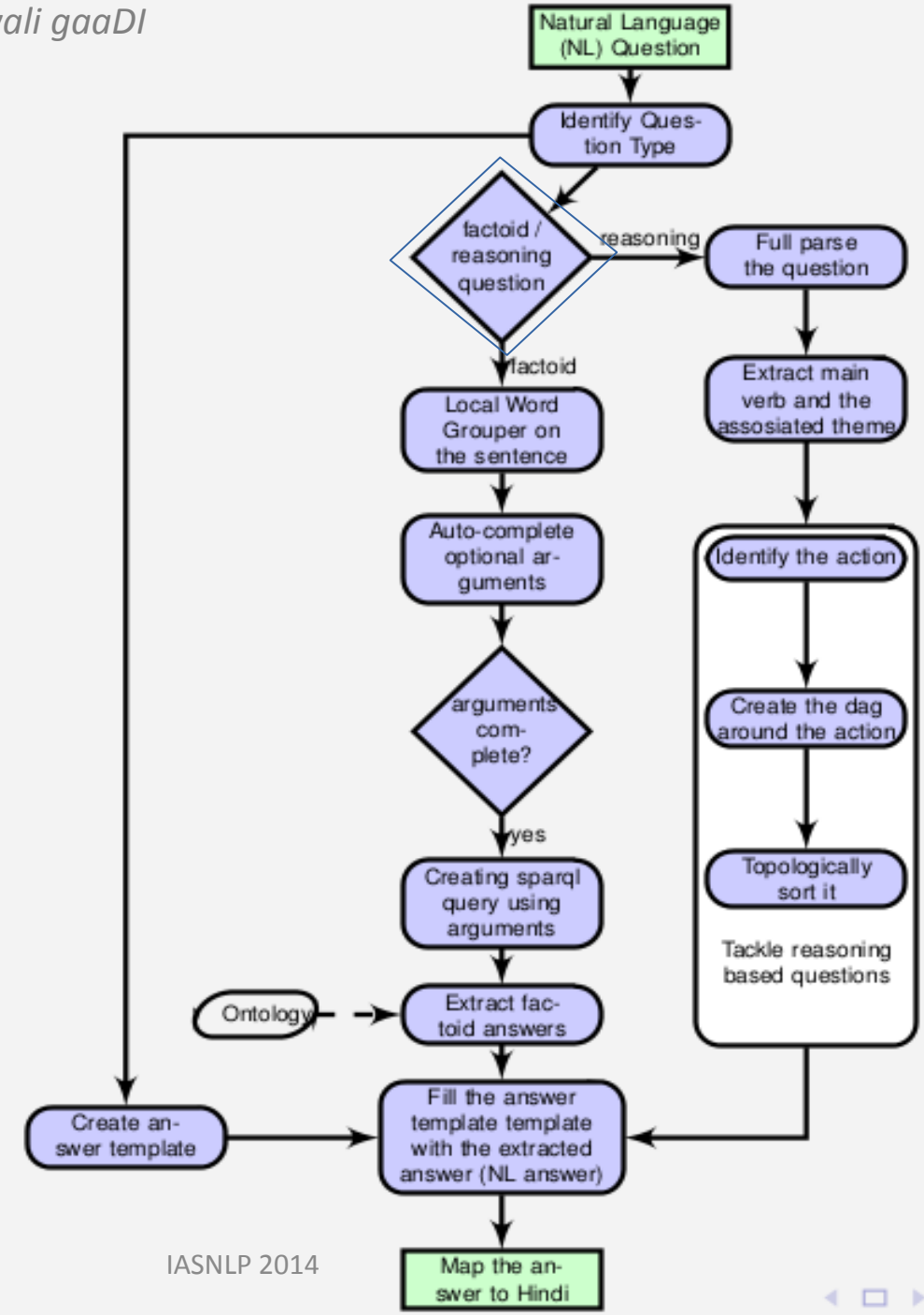
*identify the question word: kab*



*Q. falaknuma se lingampally tak jane wali gaaDI bharatnagar par kab pahunchti hai?*

*identify the question word: kitne baje*

*identified as a factoid question type*



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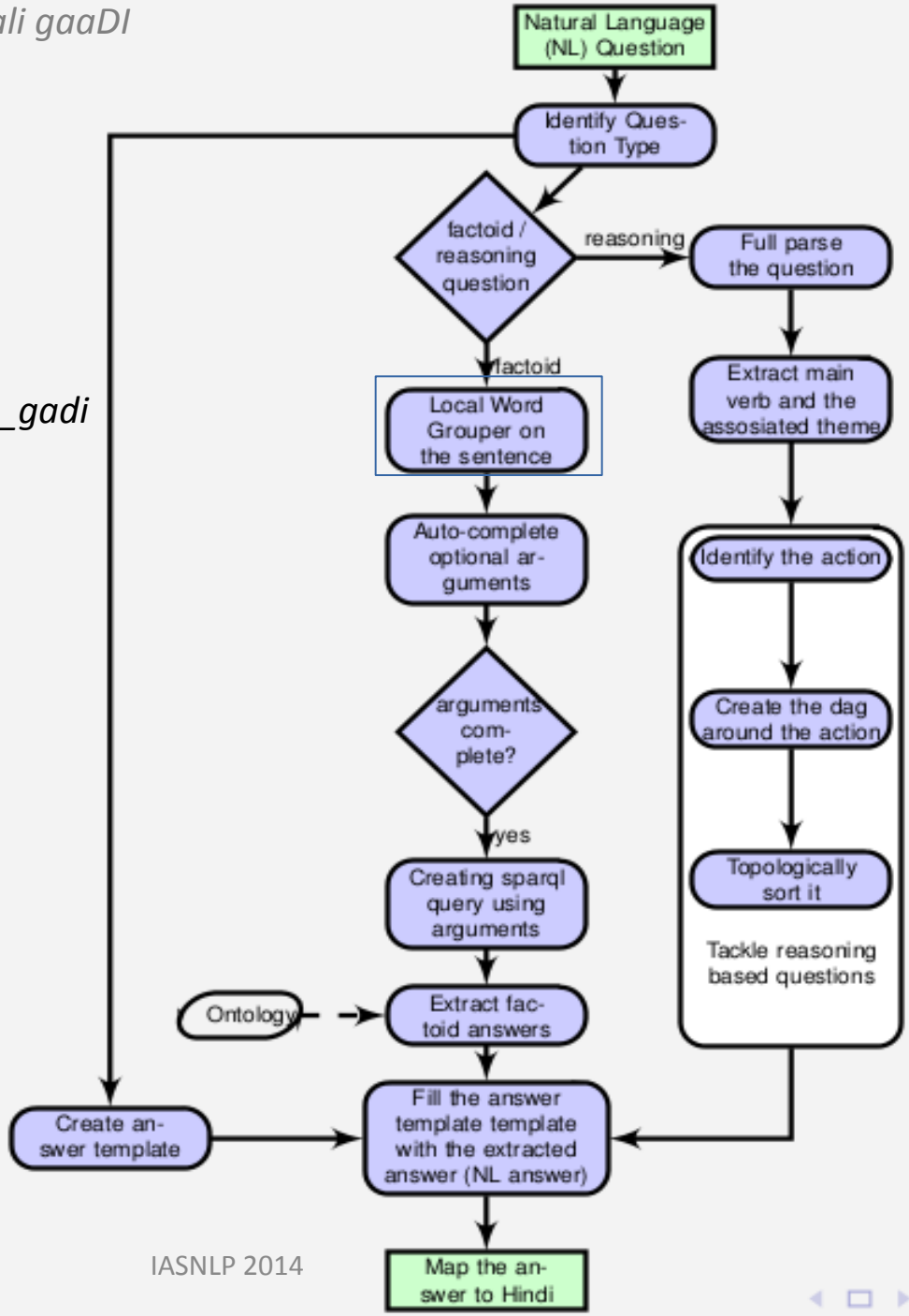
*Falaknuma_se lingampally_tak ja_wali_gadi bharatnagar_par kab pahunch_hai?*



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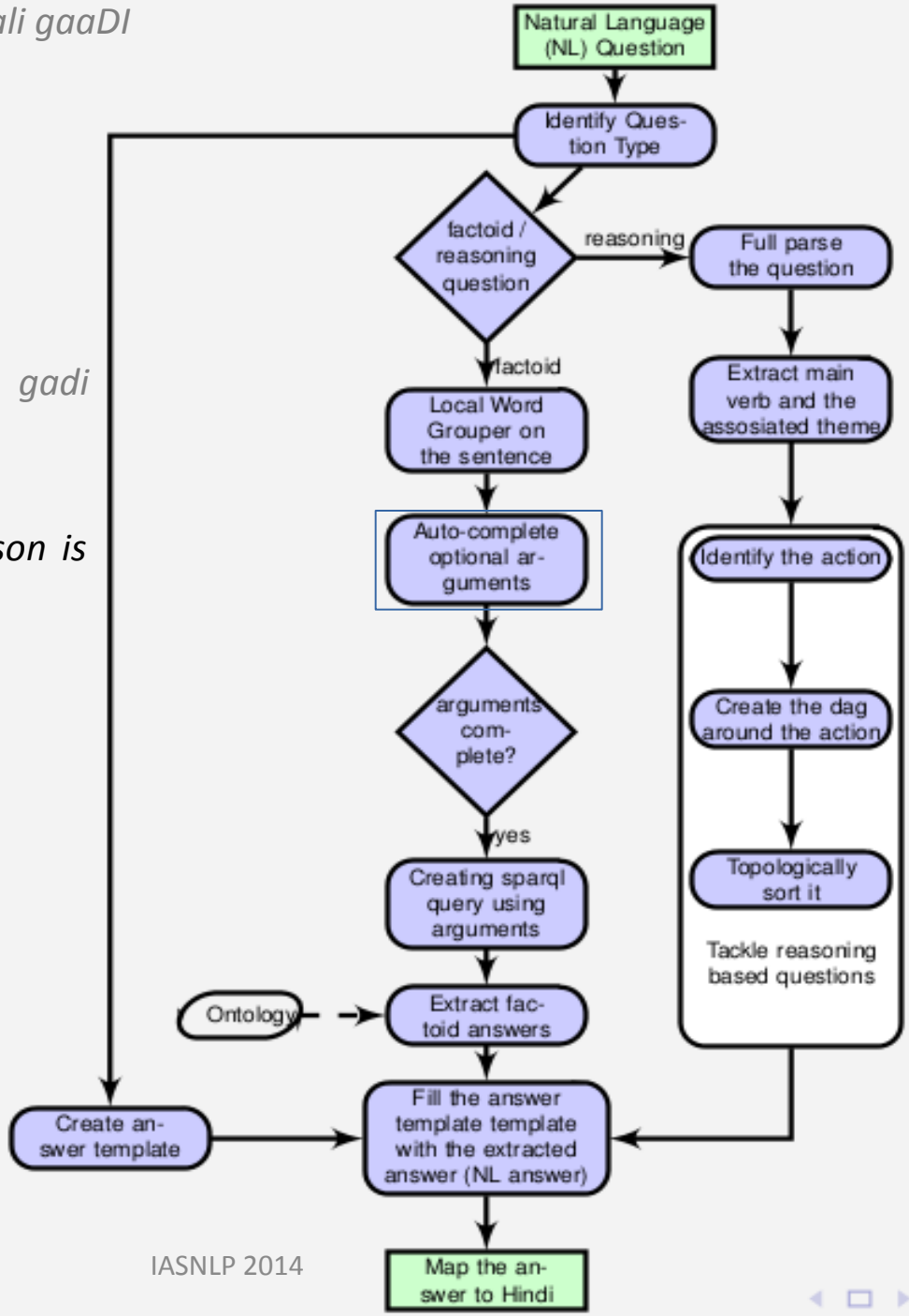
*some arguments assumed like the person is talking about the first train from now.*



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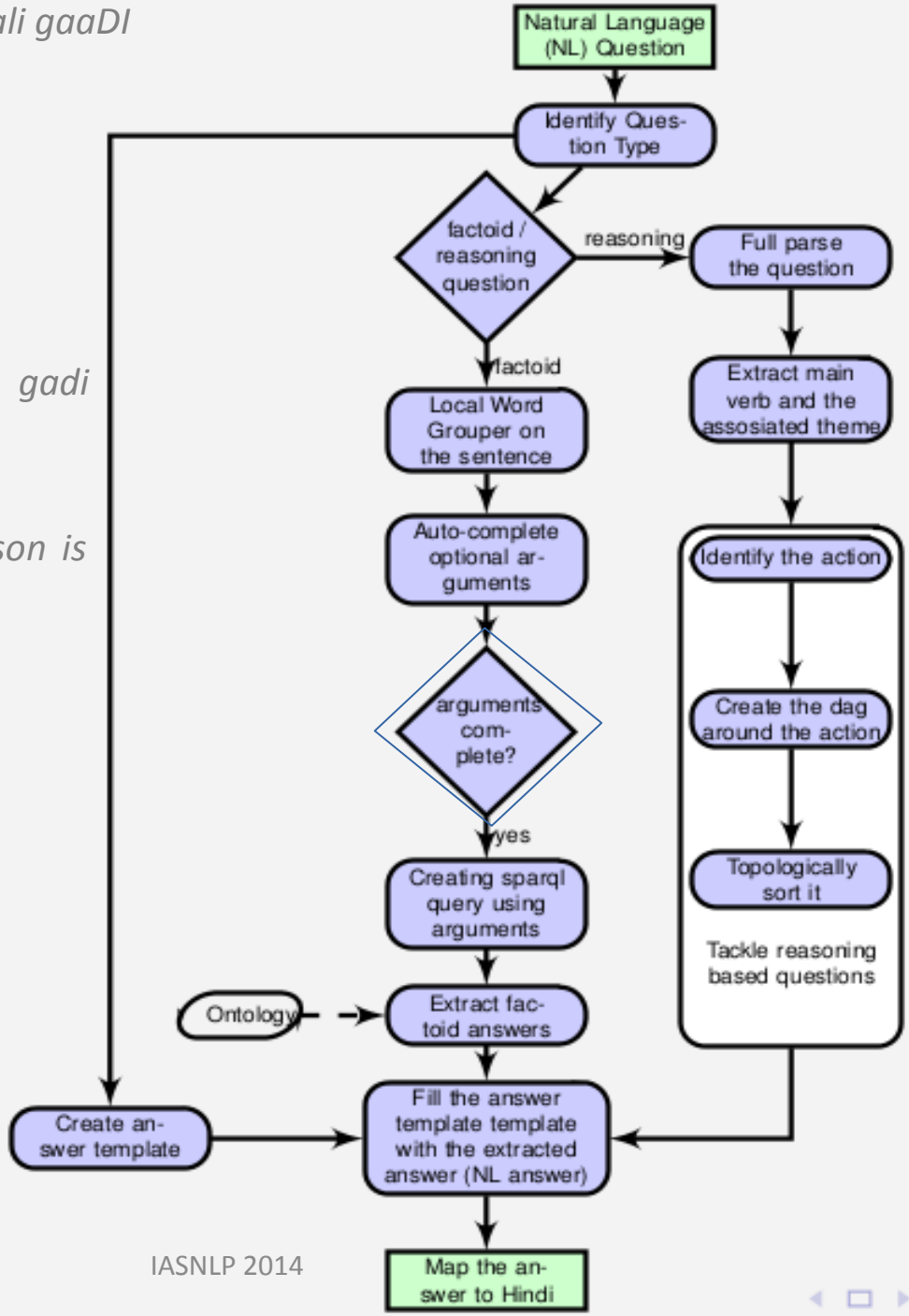
*at station - bharatnagar (par);*



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*source - falaknuma (se);*
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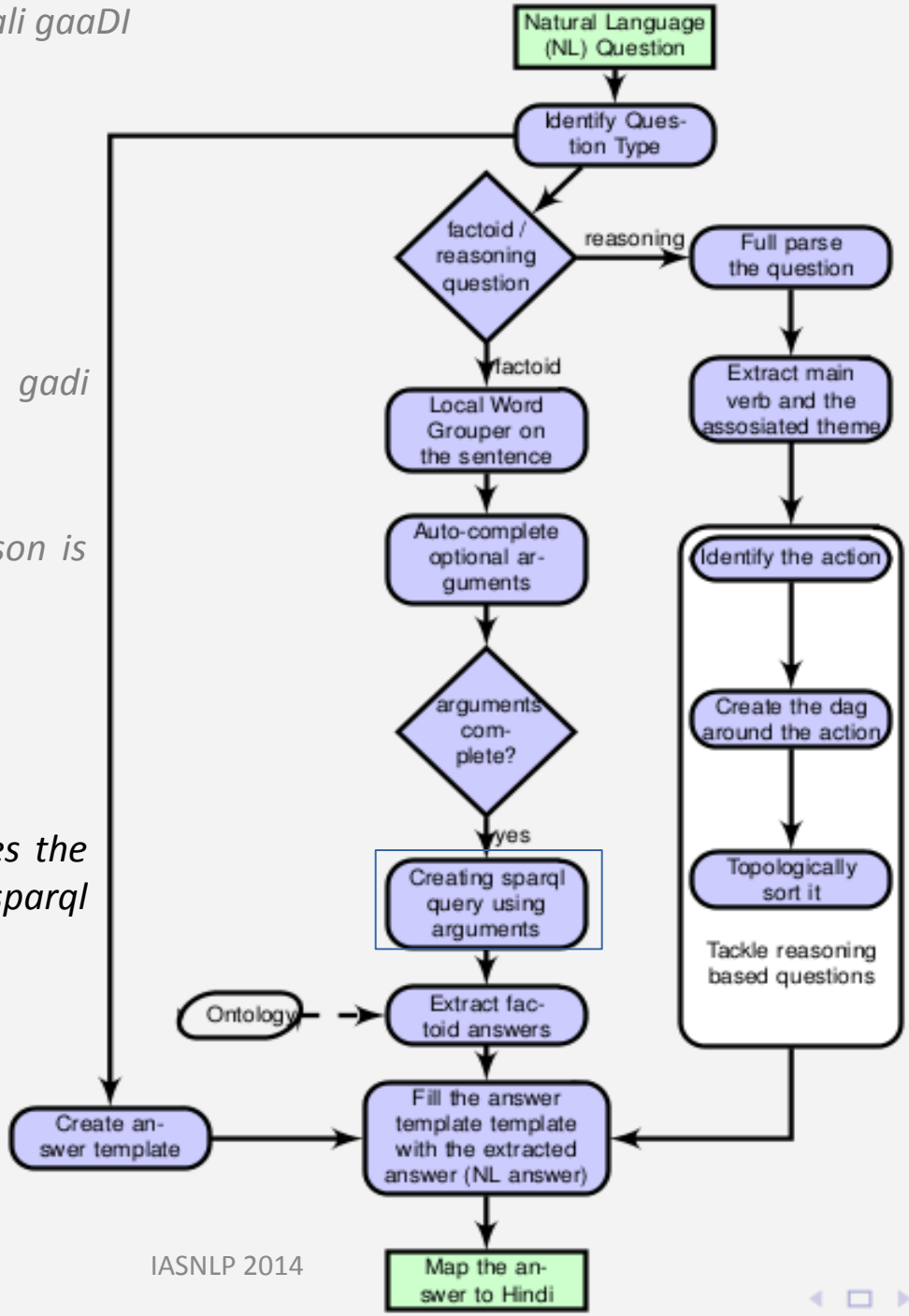
***identify the sparql query which enquires the time and fill in these arguments to the sparql query***



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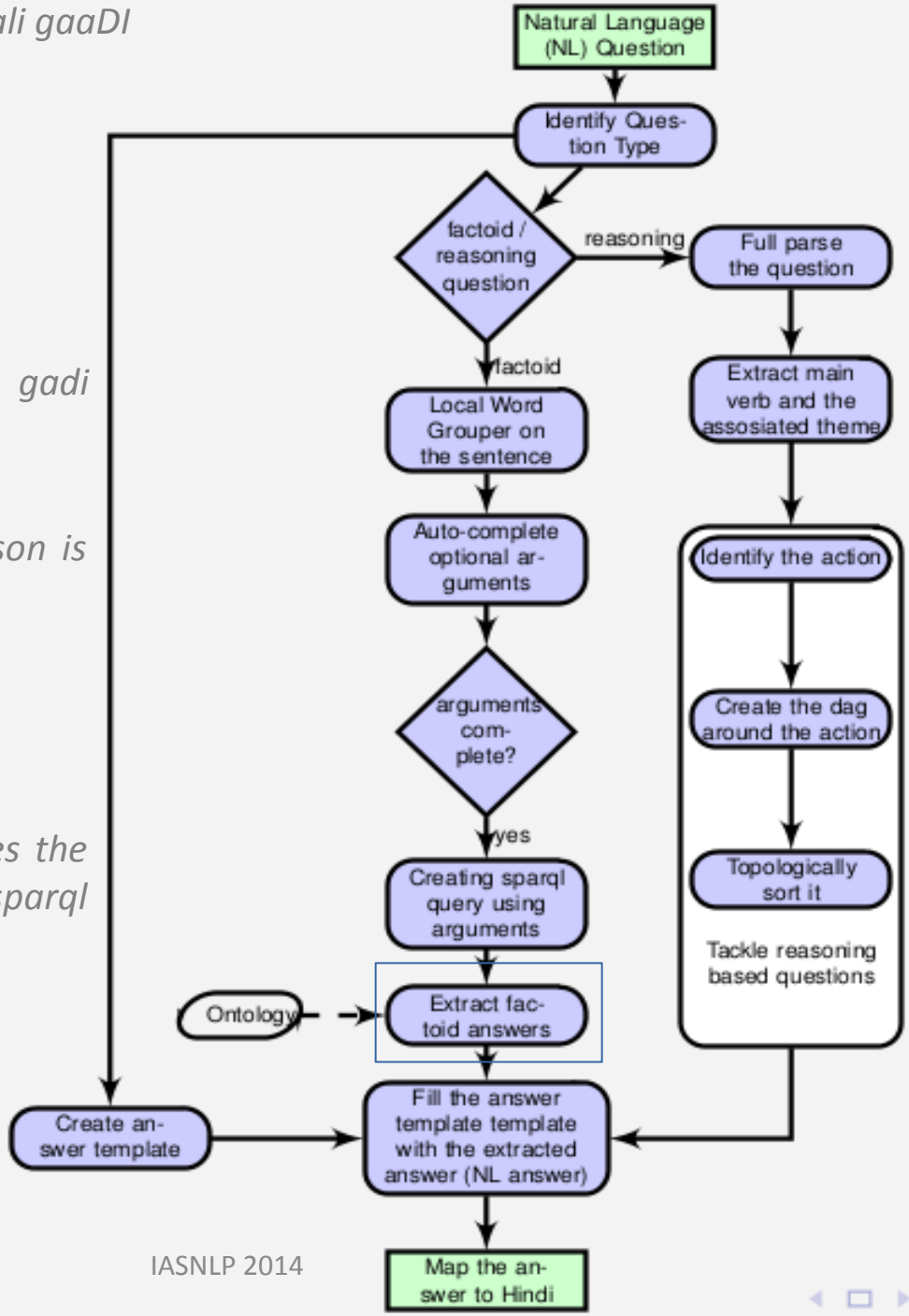
*6:30*



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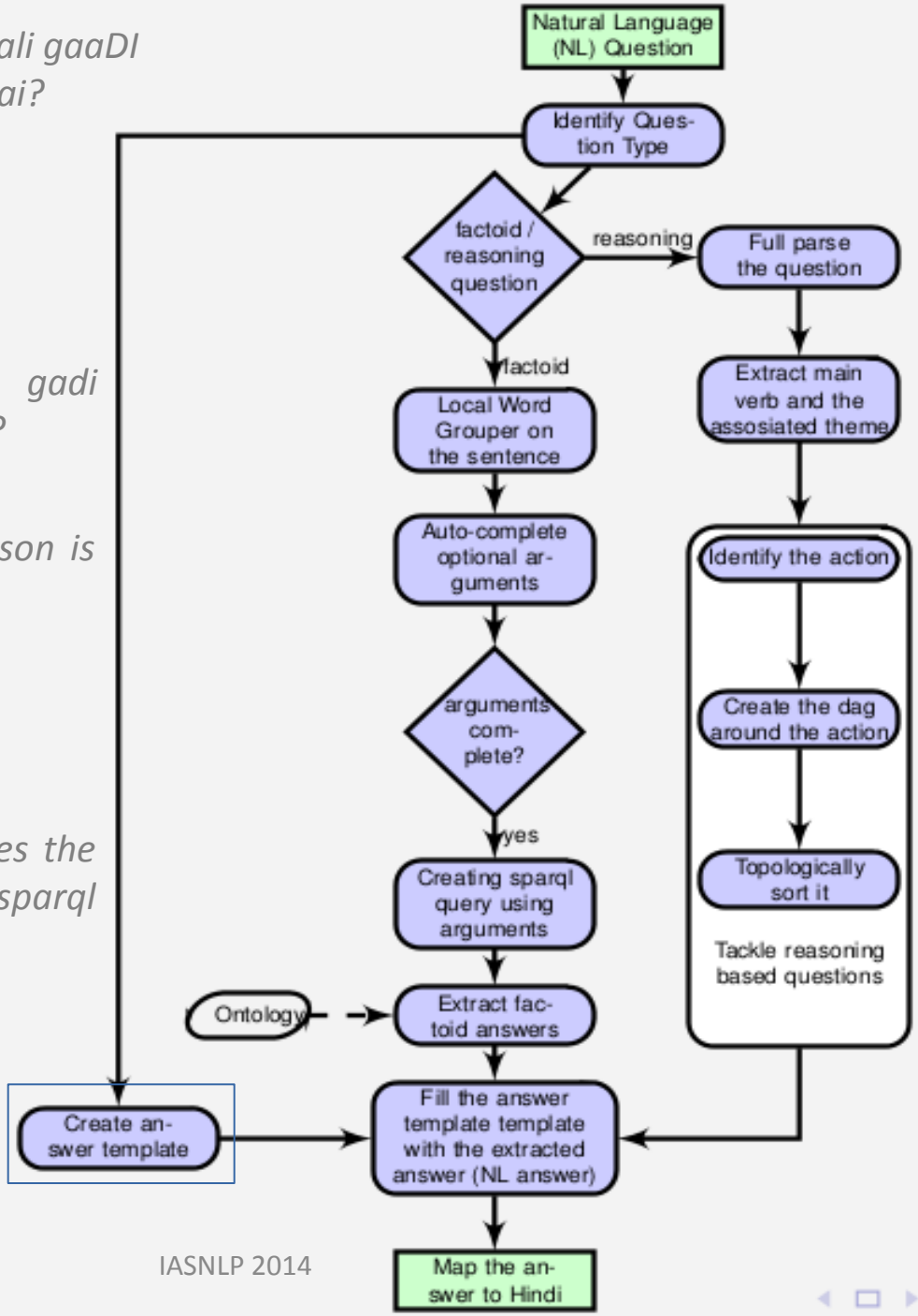
*_ se _ tak ki _ gadi _ _ itne* baje hai



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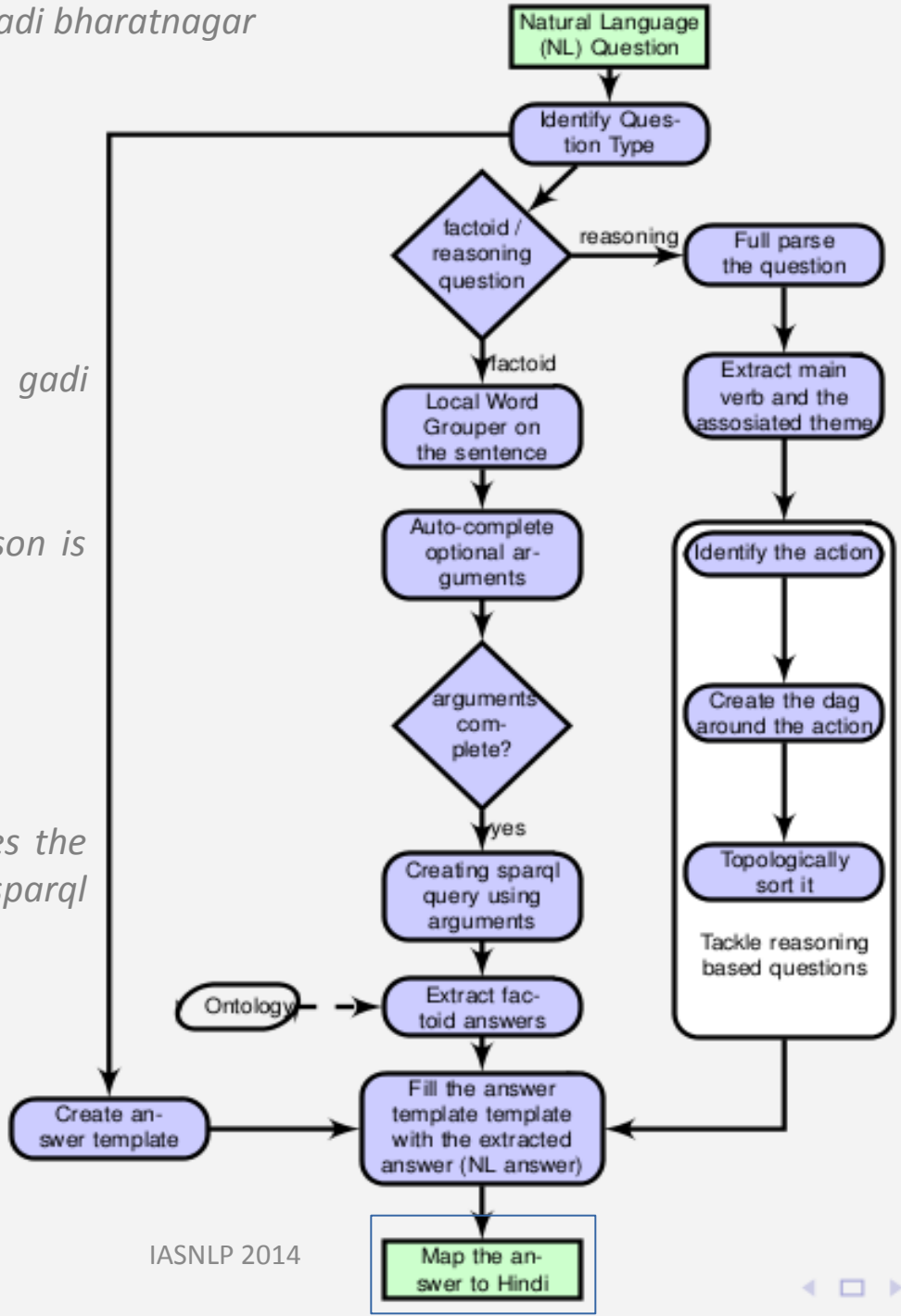
*6:30*

*_ se _ tak ki _ gadi _ _ itne* baje hai

***falaknuma se lingampally tak ki gadi bharatnagar par itne inte baje pahunchti hai***



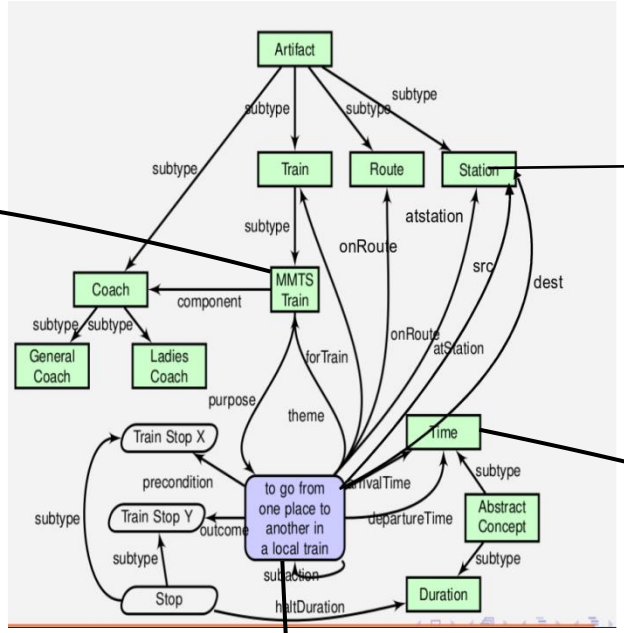
# Sparql Query

*Q. falaknuma se lingampally jane wali gadi bharatnagar par kitne baje pahunchti hai?*

```
SELECT ?deptime
WHERE {
   SELECT (MIN(?time) AS ?deptime)
   WHERE {
   :source(?trav, "Falaknuma")
   :dest(?trav, "Lingampally")
   :departureTime(?trav, ?time1)
   :byTrain(?trav, ?t)
}
   GROUP BY ?t
}
```

*Instances of Train*

14567
12342
21345
36243
.
.
.




*Instances of Station*

Falaknuma
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*Instances of Travel*

Trav1
Trav2
Trav3
Trav4
.
.
.

*Instances of Time*

5:45
6:15
6:30
6:45
.
.
.

*Instances of Train*

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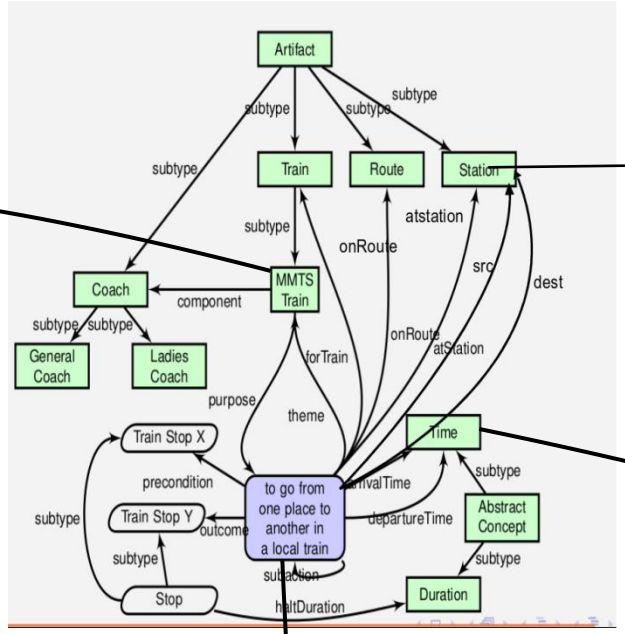


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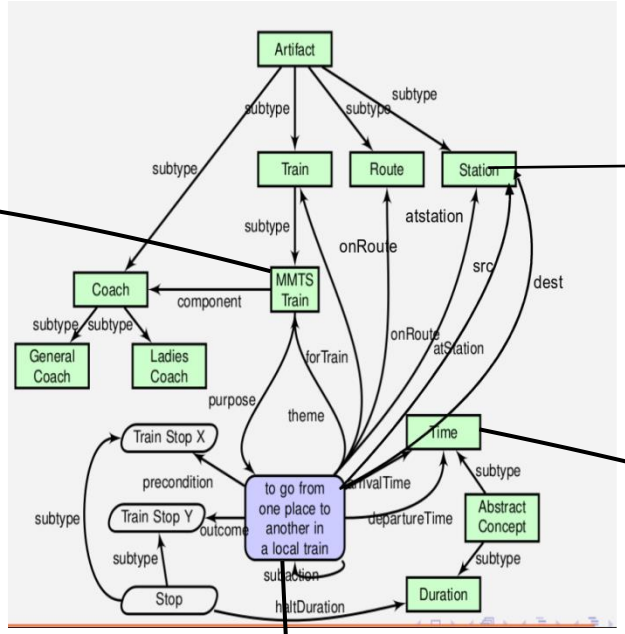


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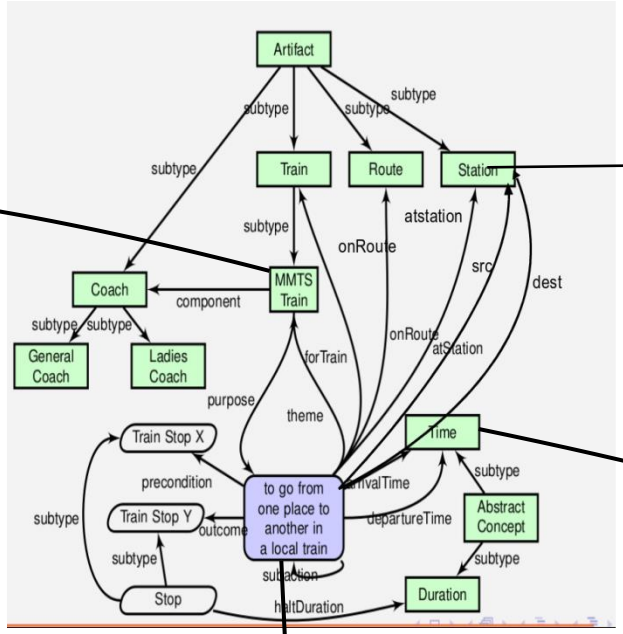



*Instances of Station*

Falaknuma
Lingampally
Hyderabad
Secunderabad
.
.
.

*Q. falaknuma se lingampally jane wali gadi bharatnagar par kitne baje pahunchti hai?*

```
SELECT ?deptime
WHERE {
   SELECT (MIN(?time) AS ?deptime)
   WHERE {
   :source(?trav, "Falaknuma")
   :dest(?trav, "Lingampally")
   :departureTime(?trav, ?time1)
   :byTrain(?trav, ?t)
}
   GROUP BY ?t
}
```

*Instances of Travel*

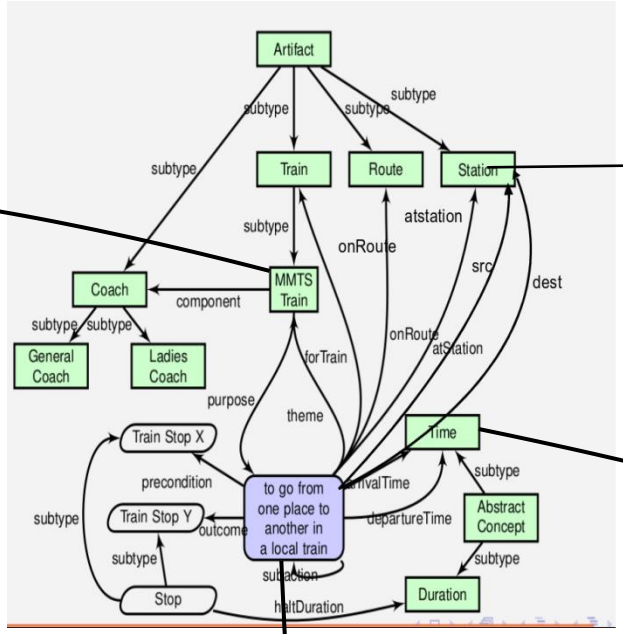
Trav1
Trav2
Trav3
Trav4
.
.
.

*Instances of Time*

5:45
6:15
6:30
6:45
.
.
.

*Instances of Train*

14567
12342
21345
36243
.
.
.

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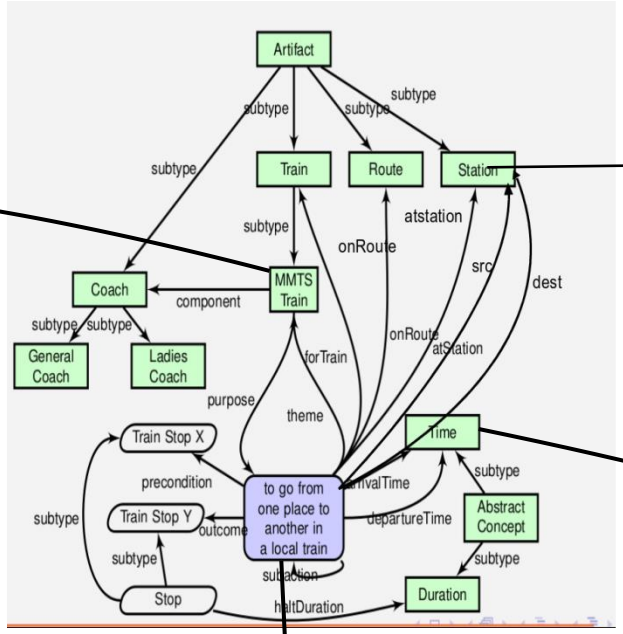


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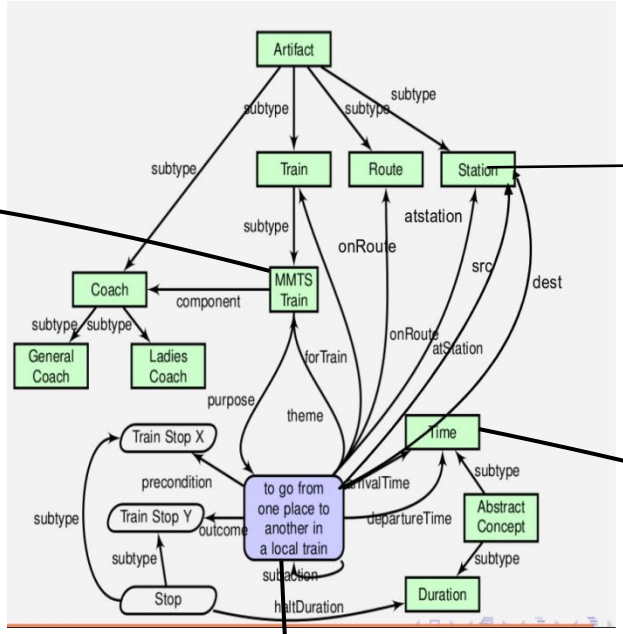


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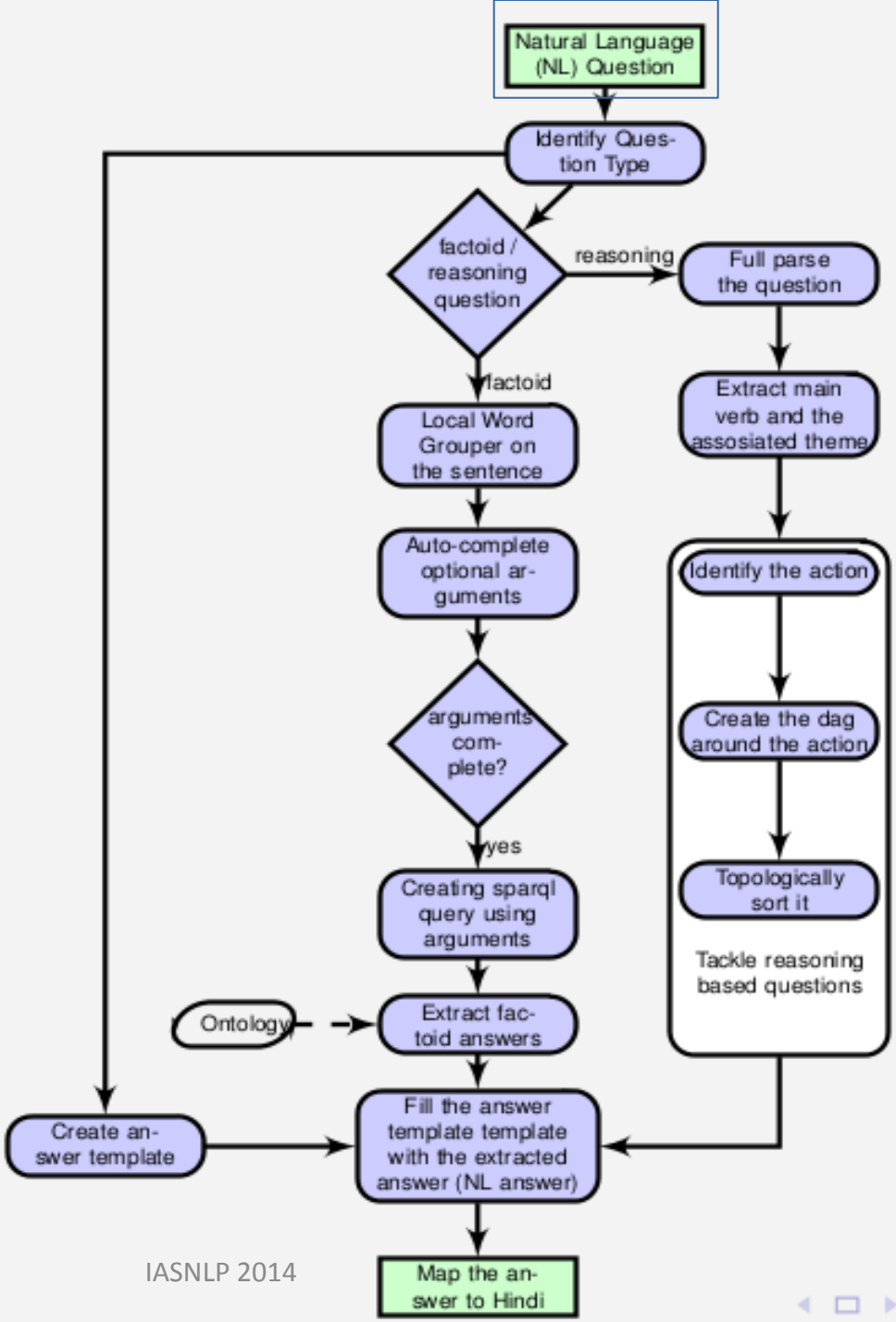
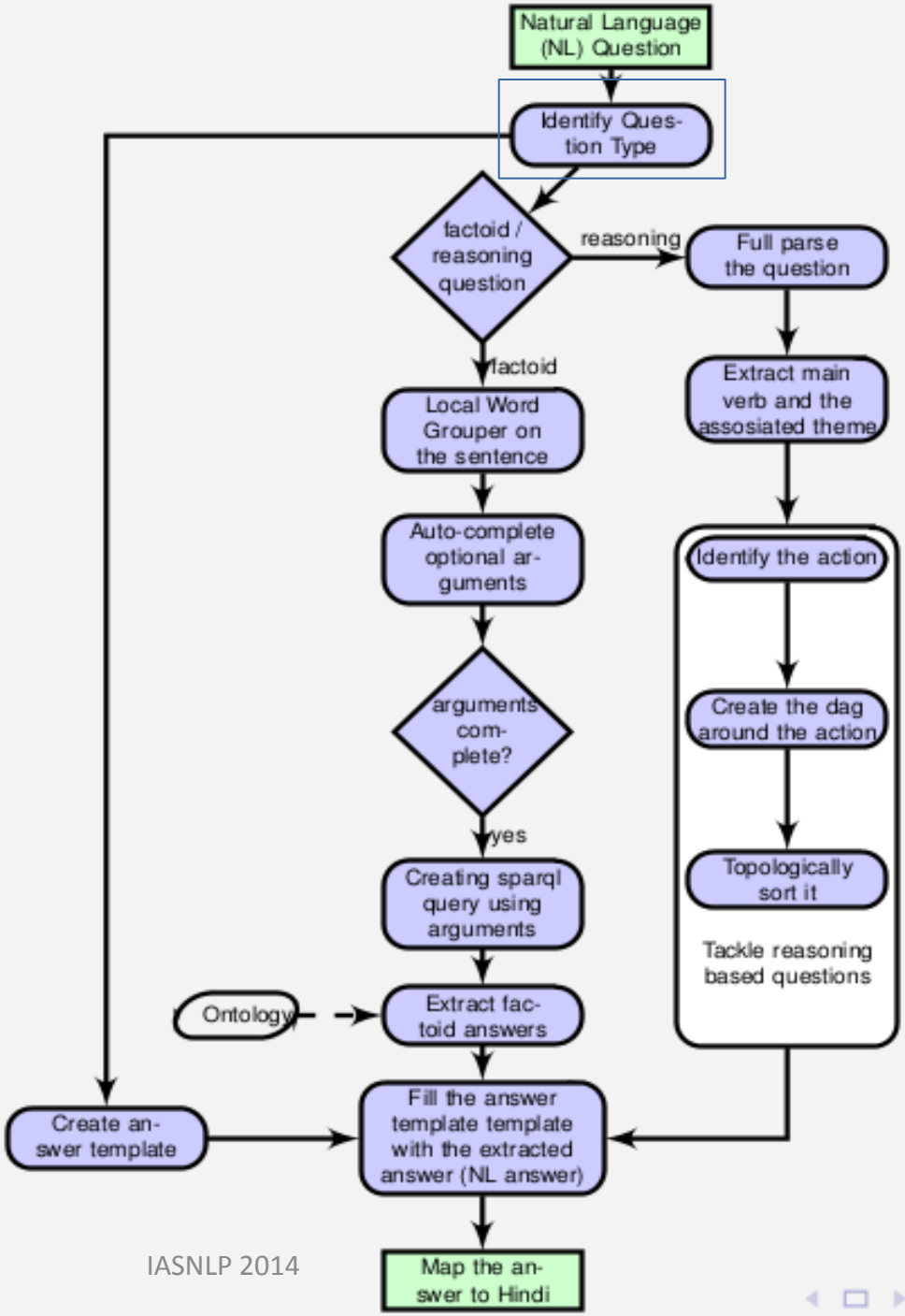
}
   GROUP BY ?t
}
```

*Q. ticket kaise kharidi jaati hai?*



*Q. ticket kaise kharidi jaati hai?*

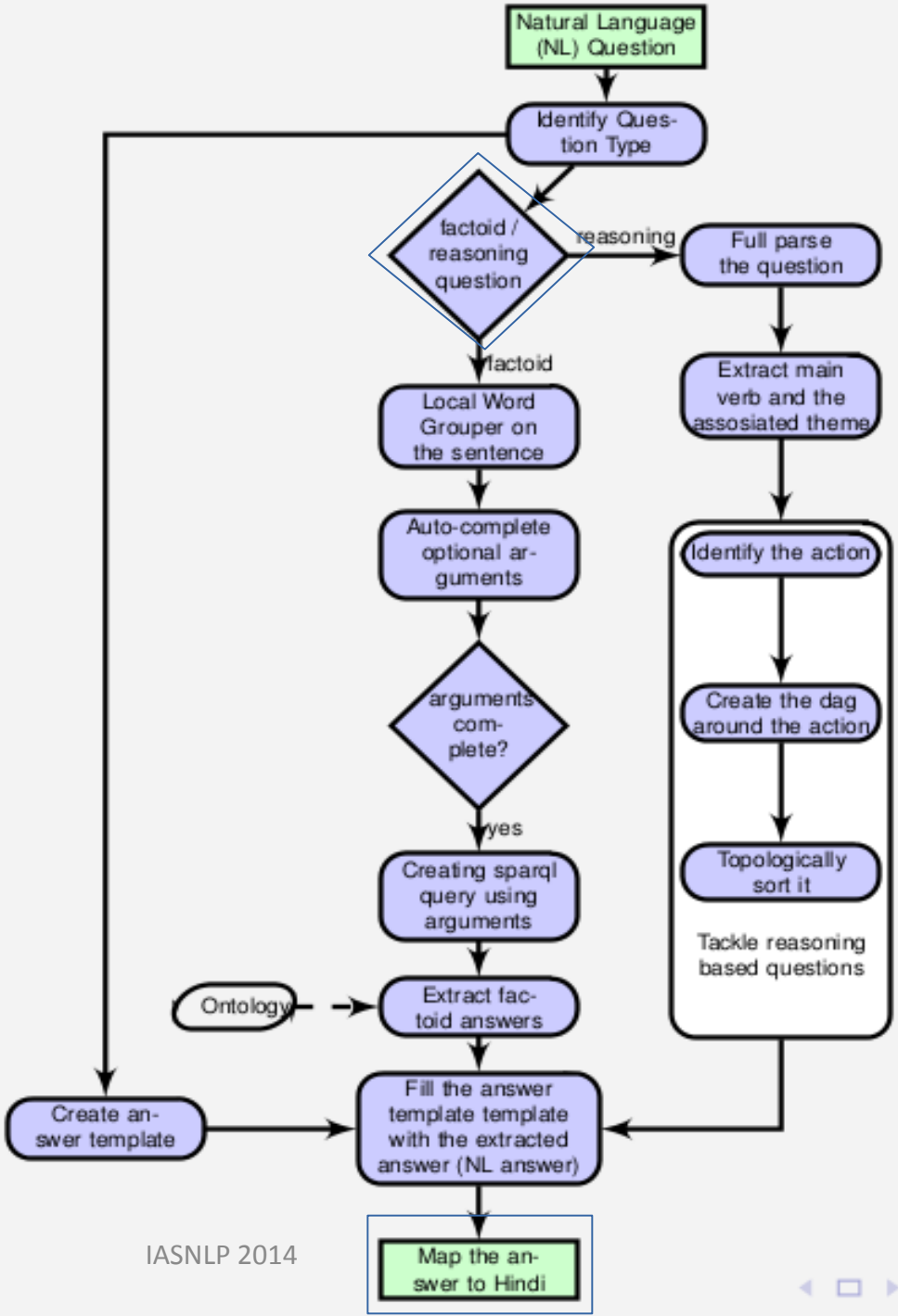
*identify the question word: kaise*



*Q. ticket kaise kharidi jaati hai?*

*identify the question word: kaise*

***identified as a reasoning question type***

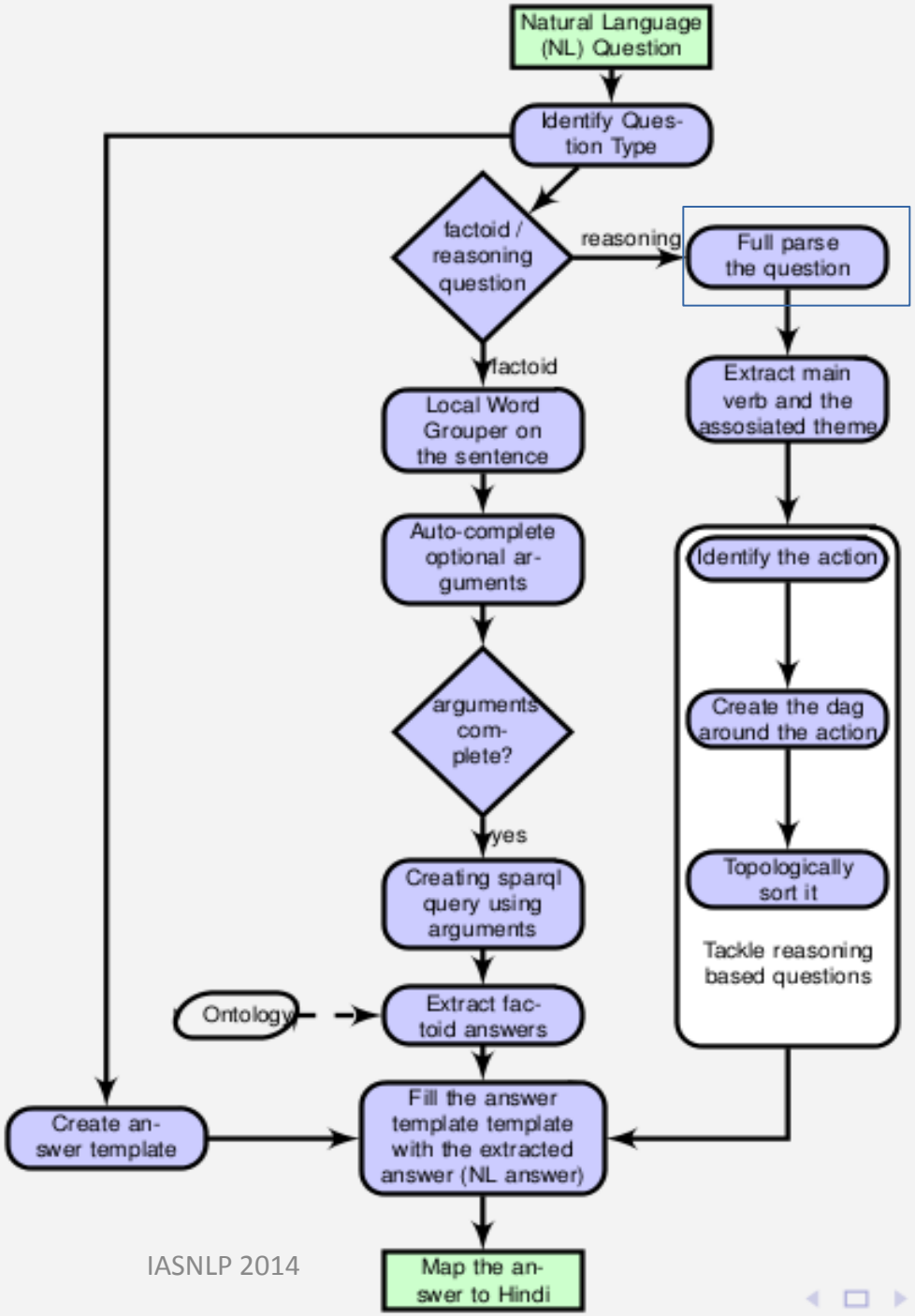


*Q. ticket kaise kharidi jaati hai?*

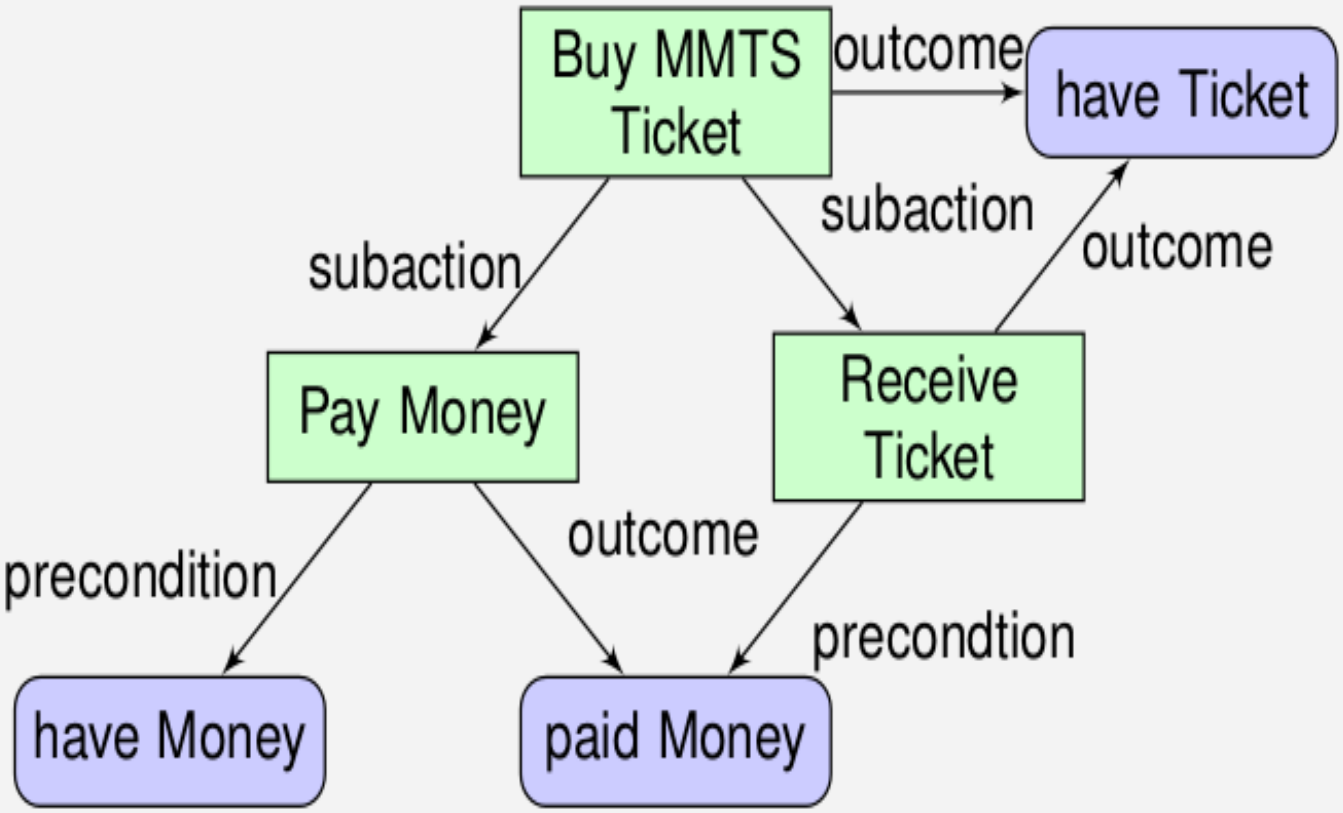
*identify the question word: kaise*

*identified as a reasoning question type*

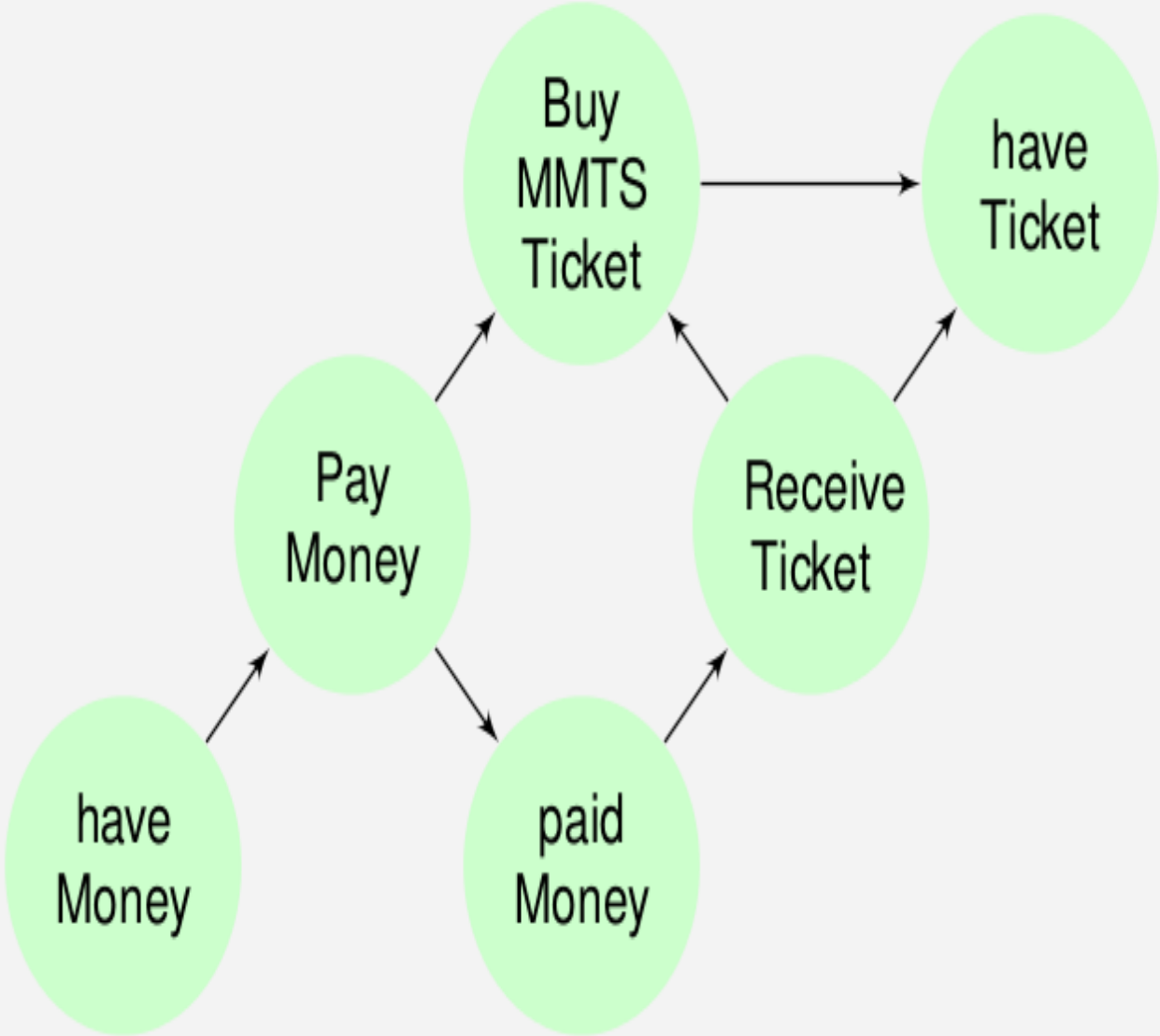
*v:kharid k2:ticket*



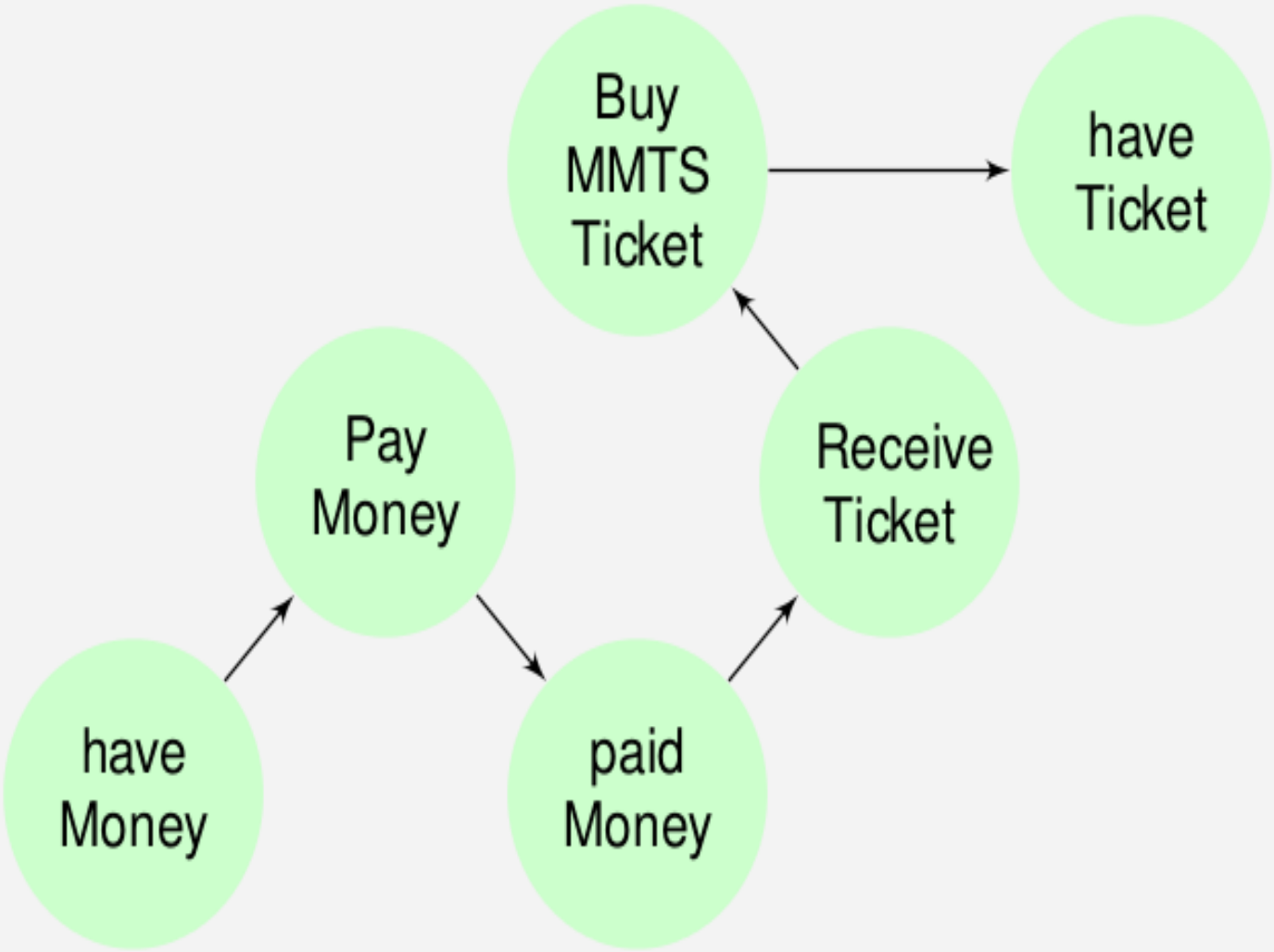
# Build a graph around the main action



# Convert the graph to DAG



# Topologically sort the DAG



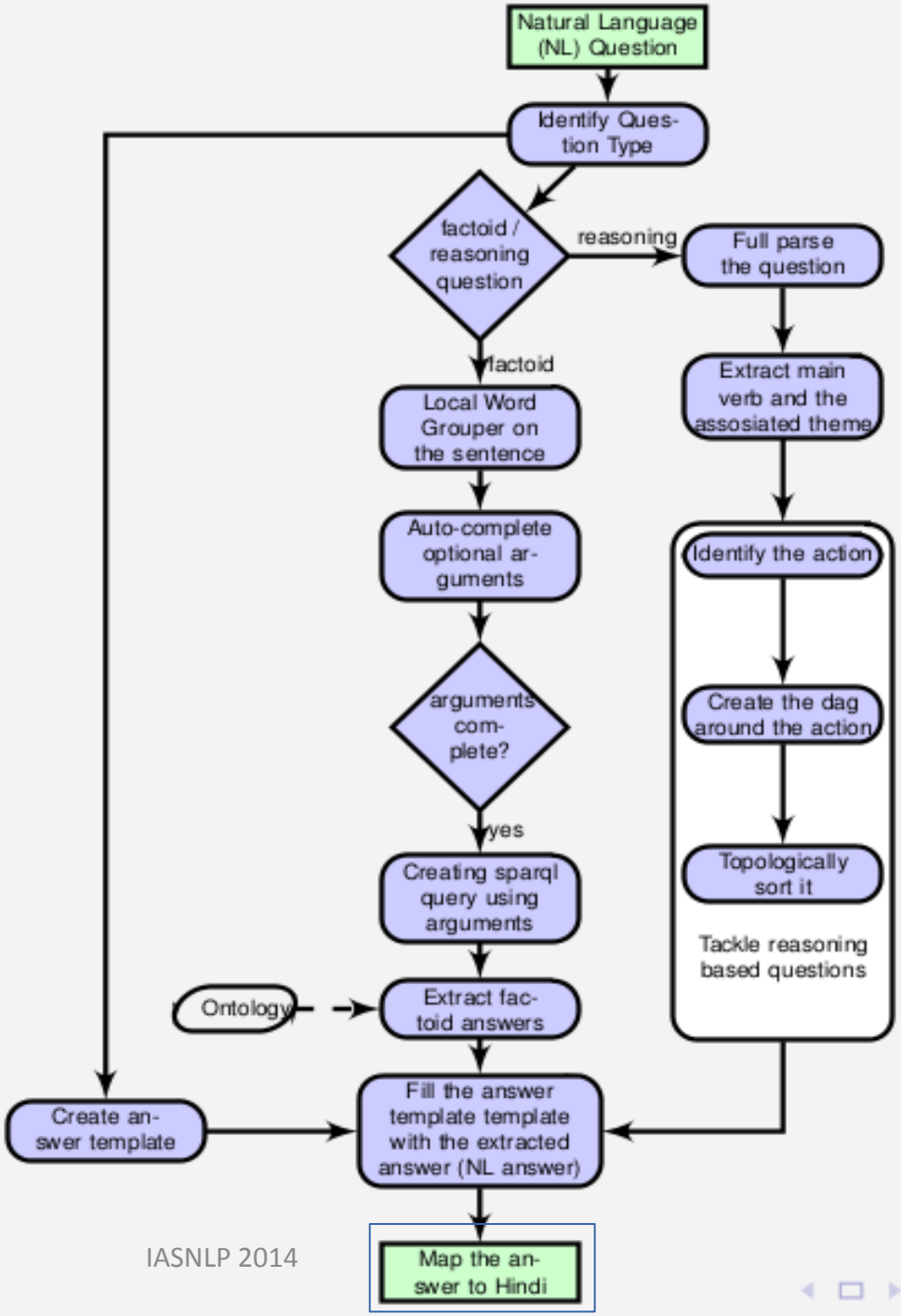
*Q. ticket kaise kharidi jaati hai?*

*identify the question word: kaise*

*identified as a reasoning question type*

*v:kharid k2:ticket*

*BuyMMTSTicket*




*Paise dein, Ticket lein, Ticket kharidein*

# Application
# Experiment and Result

Input: Random questions from users

| Question Type | Total Questions | Questions Answered |
|---|---|---|
| Factoid single-answer questions | 38 | 32 |
| Factoid list-answer questions | 15 | 13 |
| Reasoning Type questions | 4 | 4 |
| Description Type questions | 1 | 1 |
| Boolean Type questions | 6 | 3 |

# Analysis

Of the 11 unanswered questions

- frames of 5 question were were not formed. eg.
  - *lingampally se falaknuma ki agli gaadi mein kya ladies coach hai?*
- 3 question could not be linguistically parsed. eg.
  - *lingampally se falaknuma kaun kaun si train kitne kitne baaje jaati hai?*
- information for 3 questions was not present In the ontology. eg.
  - *lingampally se falaknuma ki agli train kitni late hai?*

# Summary

- PurposeNet is a knowledgebase of artifacts that present
  - Properties of artifacts,
  - Their relationship with other artifacts and
  - Actions in which they participate
- Purpose is the organizing principle
- Experimental results in domain-specific question answering using PurposeNet produces promising results.

# Acknowledgement

Dr. Rajeev Sangal

Kiranmayee – PhD student

Rishabh, Harshavardhan, Prateek – MS student