NLP SEMINAR
DL- SYNTAX DRIVEN SEMANTIC ANALYSIS

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WHAT IS DESCRIPTION LOGICS?

DL are family of formal languages designed to :

Represent structured knowledge

Support reasoning over that knowledge

Serve as the backbone for semantic web technologies like OWL

KEY CONCEPTS

- CONCEPTS (classes)
- ROLES (relations)
- INDIVIDUALS (objects)
- AXIOMS AND TBOXES
- A BOXES

CONCEPT (CLASSES)

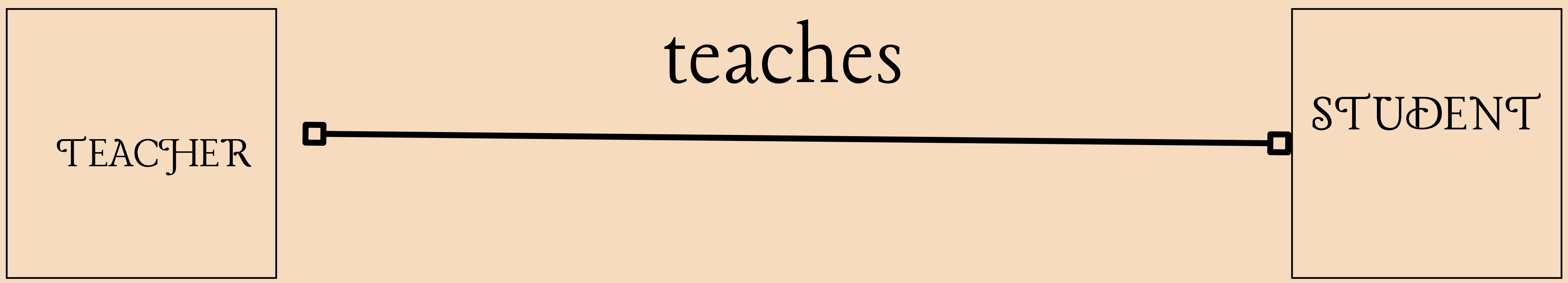
- Basic building blocks of DL
- represents set of objects or entities

TWO TYPES OF CONCEPT

ATOMIC CONCEPT	COMPLEX CONCEPT
SIMPLEST	CONSTRUCTED USING ATOMIC CONCEPT & LOGICAL OPERATOR
EG: PERSON CAR	EG : INTERSECTION UNION

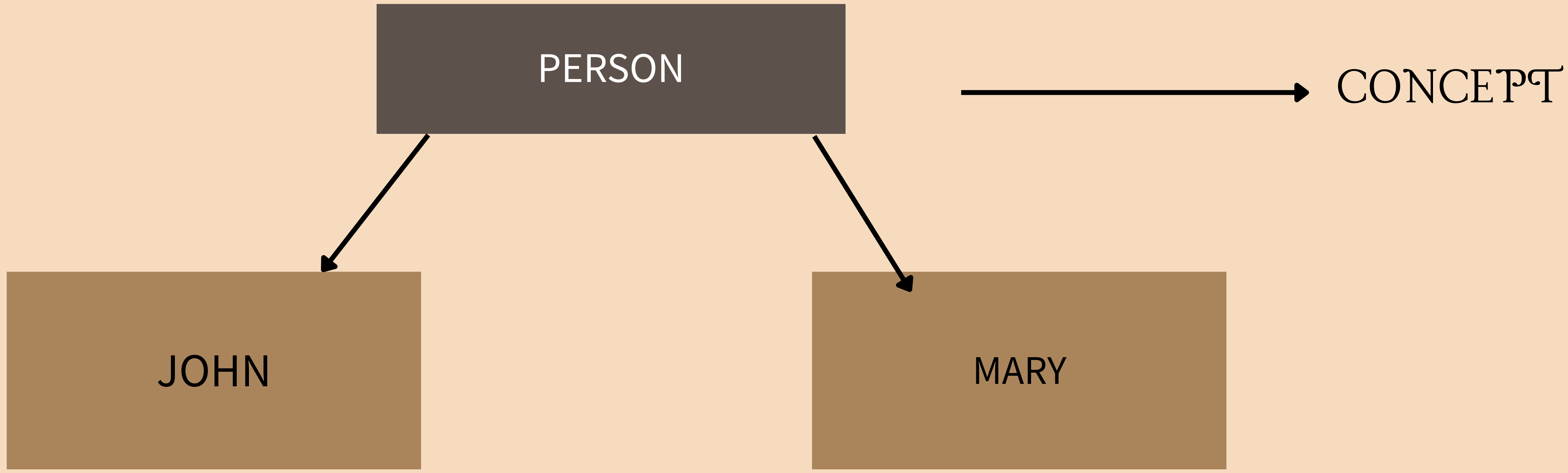
ROLES (RELATIONS)

- Relationship b/ w entities
- eg : Teacher might have a role of teaching a student



INDIVIDUALS (OBJECTS)

These are described as a specific objects or instances of concept.



AXIOMS & TBOXES AND A BOXES

TBOXES – TERMINOLOGICAL BOXES -- > Define relationship b/ w concepts
They consist of concept inclusion axioms

R BOXES –> Defines relationship b/ w roles such as transitivity

A BOXES – ASSERTIONAL BOXES → instances of concept and roles representing facts about individual entities

FOL VS DL

Feature	First-Order Logic (FOL)	Description Logic (DL)
Expressiveness	Very expressive, can handle complex relationships	Less expressive, focused on concepts and hierarchies
Reasoning	Semi-decidable (may not terminate)	Decidable (guaranteed termination)
Focus	General-purpose reasoning (math, logic, etc.)	Structured knowledge representation (ontologies, AI)
Syntax elements	Variables, predicates, functions, quantifiers	Concepts (classes), roles (properties), individuals

DIFFERENCES IN SENTENCE

🛠️ DL Representation Syntax

DL Symbol	Meaning	Example
⊓	Conjunction (AND)	`Doctor ⊓ Female`
⊔	Disjunction (OR)	`Doctor ⊔ Engineer`
¬	Negation (NOT)	`¬Doctor`
∃	Existential quantifier (some)	`∃treats.Patient`
∀	Universal quantifier (all)	`∀hasDegree.Medical`
:	Instance assertion	`DoctorOfMedicine(Alice)`
⊑	Subclass	`Surgeon ⊑ Doctor`

Sentence	Natural Language Sentence	FOL Representation	DL Representation
1	All humans are mortal.	∀x (Human(x) → Mortal(x))	Human ⊑ Mortal
2	Socrates is a human.	Human(Socrates)	Socrates:Human
3	Some cats are black.	∃x (Cat(x) ∧ Black(x))	Cat ⊓ Black ⊑ T
4	Every dog loves some person.	∀x (Dog(x) → ∃y (Person(y) ∧ Loves(x, y)))	Dog ⊑ ∃Loves.Person
5	John owns a car.	Owns(John, Car1) ∧ Car(Car1)	John:∃Owns.Car
6	Every person has a mother.	∀x (Person(x) → ∃y (MotherOf(y, x)))	Person ⊑ ∃MotherOf⁻.T
7	There exists a unicorn.	∃x (Unicorn(x))	Unicorn ⊑ T
8	No student is a teacher.	∀x (Student(x) → ¬Teacher(x))	Student ⊑ ¬Teacher

SYNTAX DRIVEN SEMANTIC ANALYSIS

Analyzing syntactic structure of sentence and using that structure to derive corresponding semantic representation.

- Mapping syntactic structures to ÐL representation
- Constructing semantics from syntax
- Reasoning with ÐL
- Reasoning with ÐL

GETTING THE RESULT

ASSIGNING SEMANTIC VALUES USING LAMBDA CALCULUS

```
S.sem  = VP.sem(NP.sem)
VP.sem = λx. λy. see(y, x)
NP.sem('John') = john
NP.sem('Mary') = mary
V.sem('sees') = λx. λy. see(y, x)
```

b. Semantic Composition:

1. NP ('John') → john
2. NP ('Mary') → mary
3. V ('sees') → λx. λy. see(y, x)
   This says: take object `x`, then subject `y`, return `see(y, x)`
4. VP = V NP → (λx. λy. see(y, x)) mary = λy. see(y, mary)
5. S = NP VP → (λy. see(y, mary)) john = see(john, mary)

→

FINAL RESULT:
(JOHN,MARY)

THANK YOU