DEC 2025

INTRODUCTION TO
KNOWLEDGE ENGINEERING

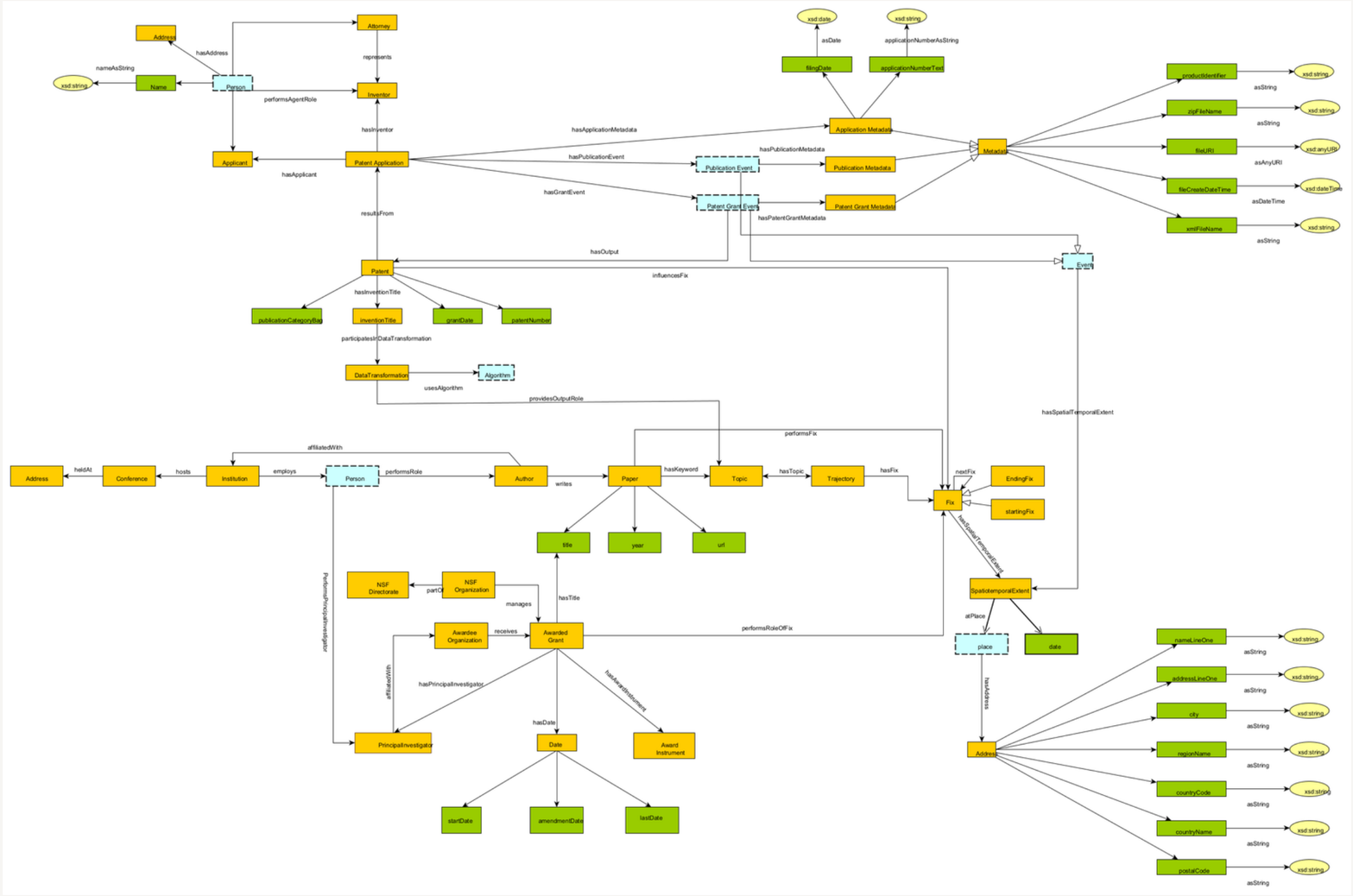
CS RESEARCH KNOWLEDGE GRAPH

JULIA GRACE M
MOSES RAJ M
SUBRITI
SUMANTH

Introduction

- Research in CS generates thousands of papers, patents, and grants every year.
- All of these are stored in different datasets: DBLP, NSF, USPTO.
- **Challenge:** lack of unified structure for analyzing CS research evolution.
- **Goal:** Create a semantic knowledge graph connecting funding, publications, innovation in the field of CS

Schema Diagram



Classes and Relations

- **Core classes:**

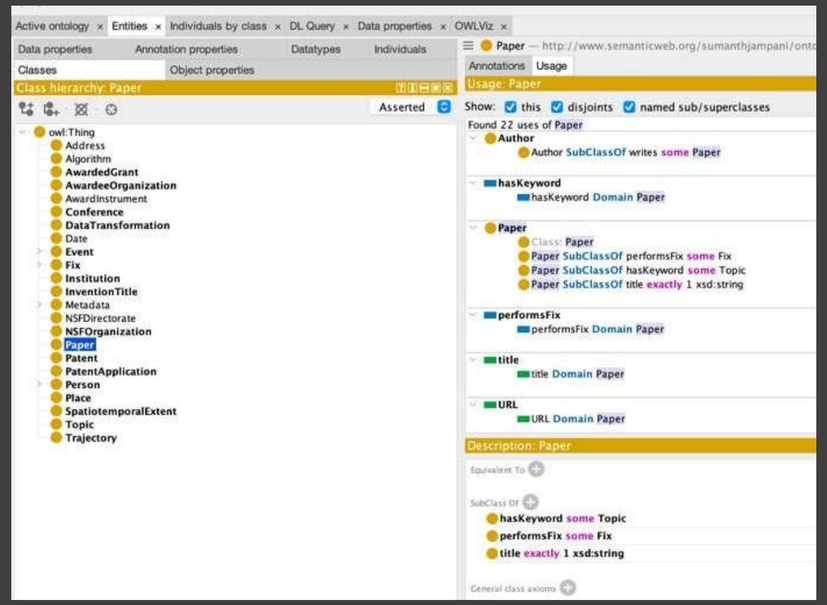
Paper, Patent, Grant, Author, Institution, Topic, Trajectory, Fix, SpatiotemporalExtent

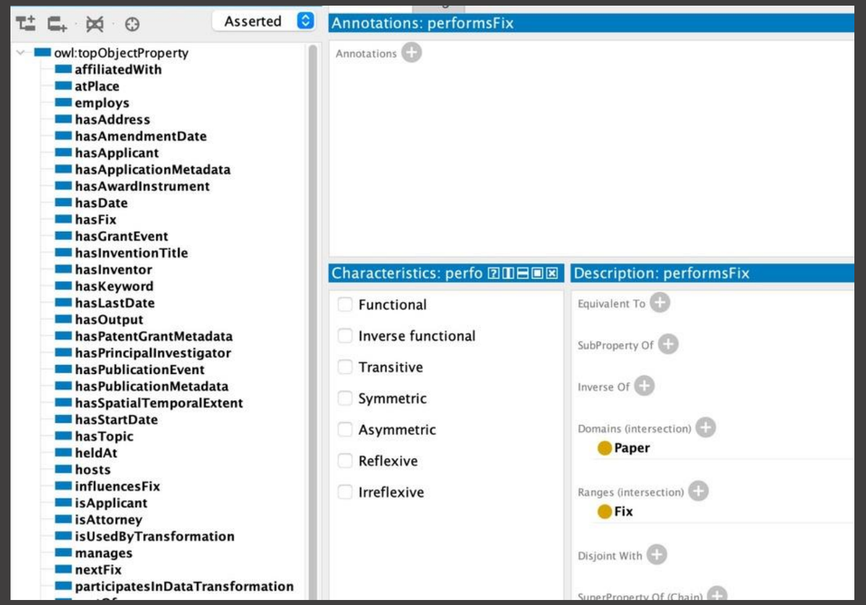
- **Key relations:**

writes, performs, manages, hasTopic, hasFix, influences, hasGrantEvent, partOfTrajectory, etc.

Axiomatization

Axiomatization is the process of defining the core rules and constraints of a knowledge domain so that all other facts can be logically derived.

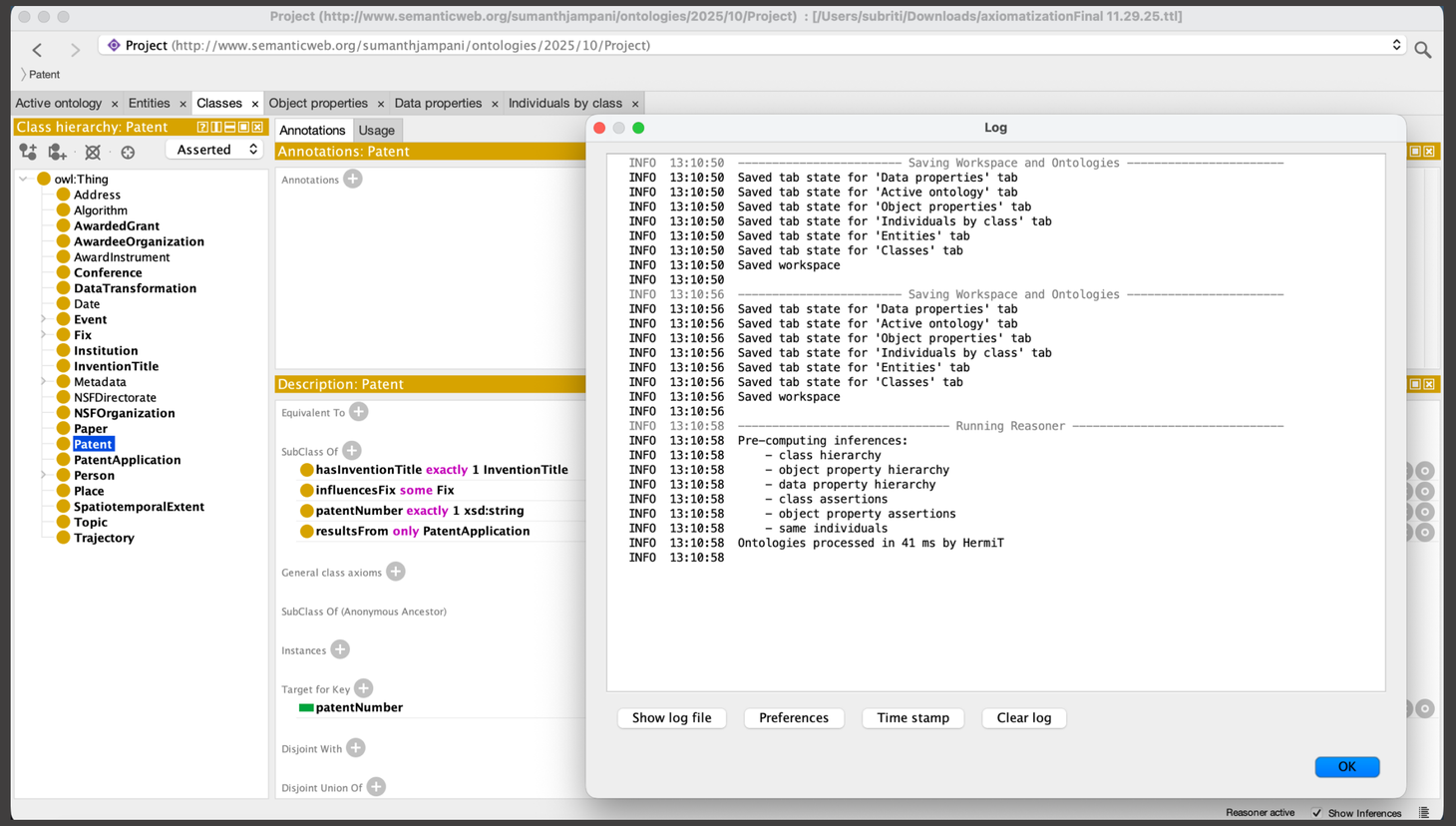




Why is Axiomatization important?

Because once these axioms are in place, the reasoner can start doing the heavy lifting.
It can infer new relationships, detect errors, and verify whether our model is logically sound—almost like having a built-in quality check for the ontology.

```
###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/manages
:manages rdf:type owl:ObjectProperty ;
         rdfs:domain :NSFOrganization ;
         rdfs:range :AwardedGrant .


###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/nextFix
:nextFix rdf:type owl:ObjectProperty ;
         rdfs:domain :Fix ;
         rdfs:range :Fix .


###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/partOf
:partOf rdf:type owl:ObjectProperty ;
        rdfs:domain :NSFOrganization ;
        rdfs:range :NSFDirectorate .


###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/participatesInDataTransformation
:participatesInDataTransformation rdf:type owl:ObjectProperty ;
                                  rdfs:domain :InventionTitle ;
                                  rdfs:range :DataTransformation .


###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/performsAgentRole
:performsAgentRole rdf:type owl:ObjectProperty ;
                   rdfs:domain :Person ;
                   rdfs:range :Inventor .


###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/performsFix
:performsFix rdf:type owl:ObjectProperty ;
             rdfs:domain :Paper ;
             rdfs:range :Fix .


###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/performsRole
:performsRole rdf:type owl:ObjectProperty ;
              rdfs:domain :Person ;
              rdfs:range :Author .


###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/performsRoleOfFix
:performsRoleOfFix rdf:type owl:ObjectProperty ;
                   rdfs:domain :AwardedGrant ;
                   rdfs:range :Fix .


###  http://www.semanticweb.org/sumanthjampani/ontologies/2025/10/Project/providesOutputRole
:providesOutputRole rdf:type owl:ObjectProperty ;
                    rdfs:domain :DataTransformation ;
                    rdfs:range :Topic .
```



Data Transformation

Common Entities

- **Authors**

DBLP → authors of papers
Patents → inventors
NSF → Principal Investigators (PI/Co-PI)

- **Research Topics / Keywords**

DBLP → extracted from paper titles/keywords
Patents → extracted from abstracts/claims
NSF → topics from award abstracts/keywords

- **Temporal Information**

DBLP → publication year
NSF → award year & duration
Patents → filing date, grant date

Data Transformation

Data Cleaning

- Convert all dates to a single format
- Standardize author/institution names
- Normalize topics/keywords

Topic Extraction

- TF-IDF keyword extraction
- Contextual embeddings (BERT)
- Topic modeling

Clustering to Find Topic Groups

- Group similar papers, patents, and NSF awards together
- Creates unified topic clusters

Competency Questions

1Q. Which institutions have received the most NSF grants related to AI research?

Ans) Grants are identified through the hasKeyword relation connecting a Paper to a Topic.

Each Grant is then linked to an Institution via the awardedTo relation.

Counting the number of grants for a particular Topic gives the answer of how much funding is going into one Research Topic.

2Q. How has CS topics evolved over time?

Ans) Each Topic has a Trajectory, made up of time-ordered Fixes, and each Fix corresponds to a Paper with a publication date.

By aggregating these fixes along the trajectory, the ontology provides a timeline showing how a CS topic has evolved over time.

3Q. Which NSF projects produced the highest innovation velocity?

Ans) The number of papers and patents that are being released in a particular Topic after a grant is issued is the innovation velocity

Using the awardDate of the grant and the hasDate values of resulting papers/patents, the ontology measures how quickly new outputs appear.
This allows computation of innovation velocity.

4Q. Which authors frequently publish in both academic venues (conferences/journals) and also file patents?

Ans) The schema links an Author to Paper and Inventors to their Patents.

Person who appear in both sets—those who have writes → Paper (Venue) and files → Patent (hasInventor) —are identified as publishing academically while also generating patents.

5Q. Which NSF-funded areas have produced patents most rapidly (shortest time lag)?

Ans) Each Grant is linked to one or more Topics and to resulting Patents.

By comparing the awardDate of a grant with the hasDate of patents connected to it, the ontology can compute the shortest time lag.

This shows which NSF-funded areas generate patents the fastest.

THANKYOU