Exploring Semantic Hierarchies to Improve Resolution Theorem Proving on Ontologies

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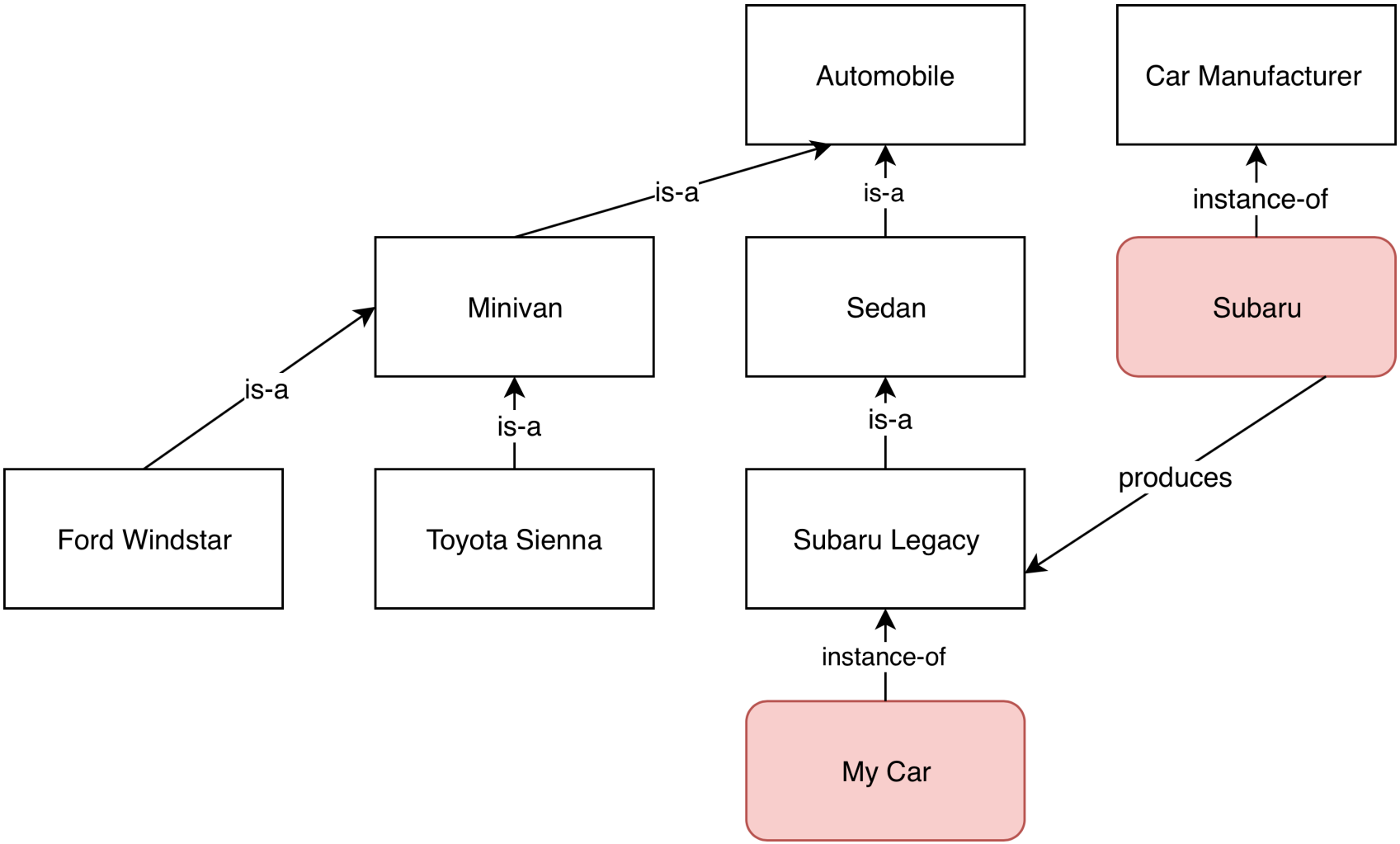
May 2, 2019

Agenda

Defense (2.5 Hours)

- Honors Thesis (1 Hour)
  - Presentation (20 min)
  - Questions (40 min)
- Honors Reading List (1 Hour)
  - Reading List Description (5 min)
  - Reading List Discussion (55 min)
- Committee Deliberation (30 min)
  - Level of honors discussion
  - Suggestions for Revision

Ontologies


Automobile
Car Manufacturer
is-a
is-a
instance-of
Minivan
Sedan
Subaru
is-a
is-a
is-a
produces
Ford Windstar
Toyota Sienna
Subaru Legacy
instance-of
My Car

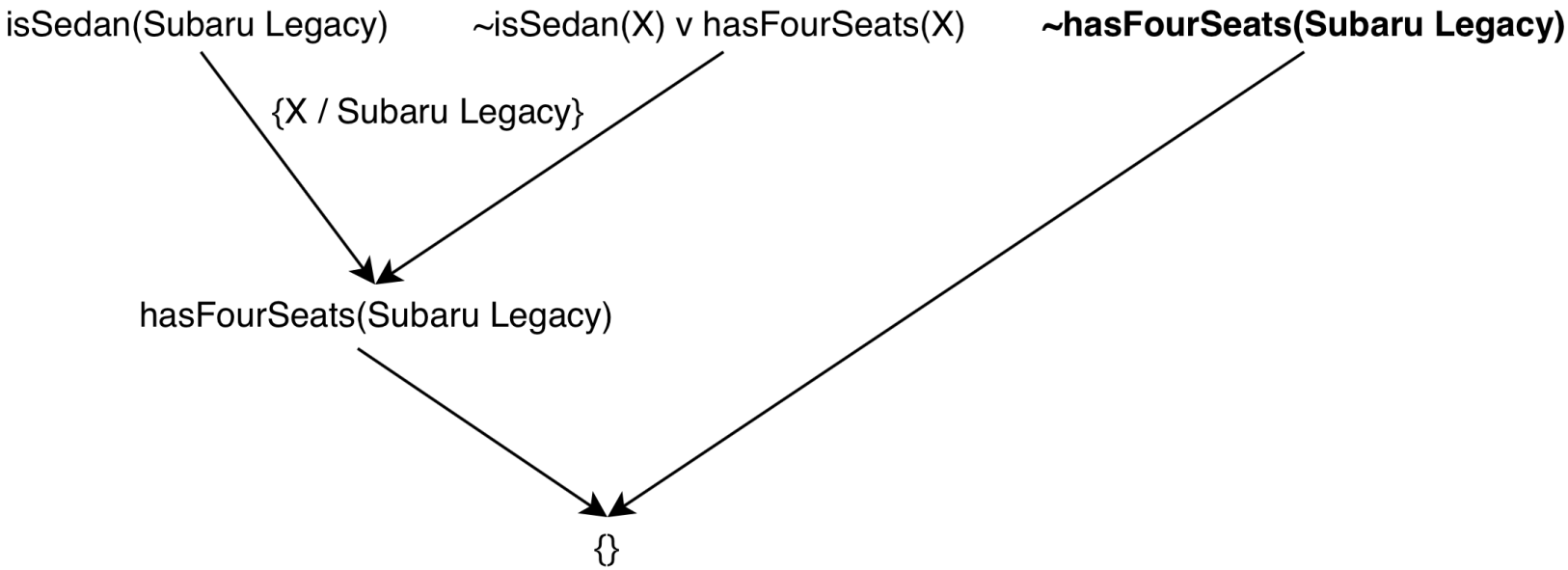
First Order Logic

$$SubaruLegacy(myCar)$$

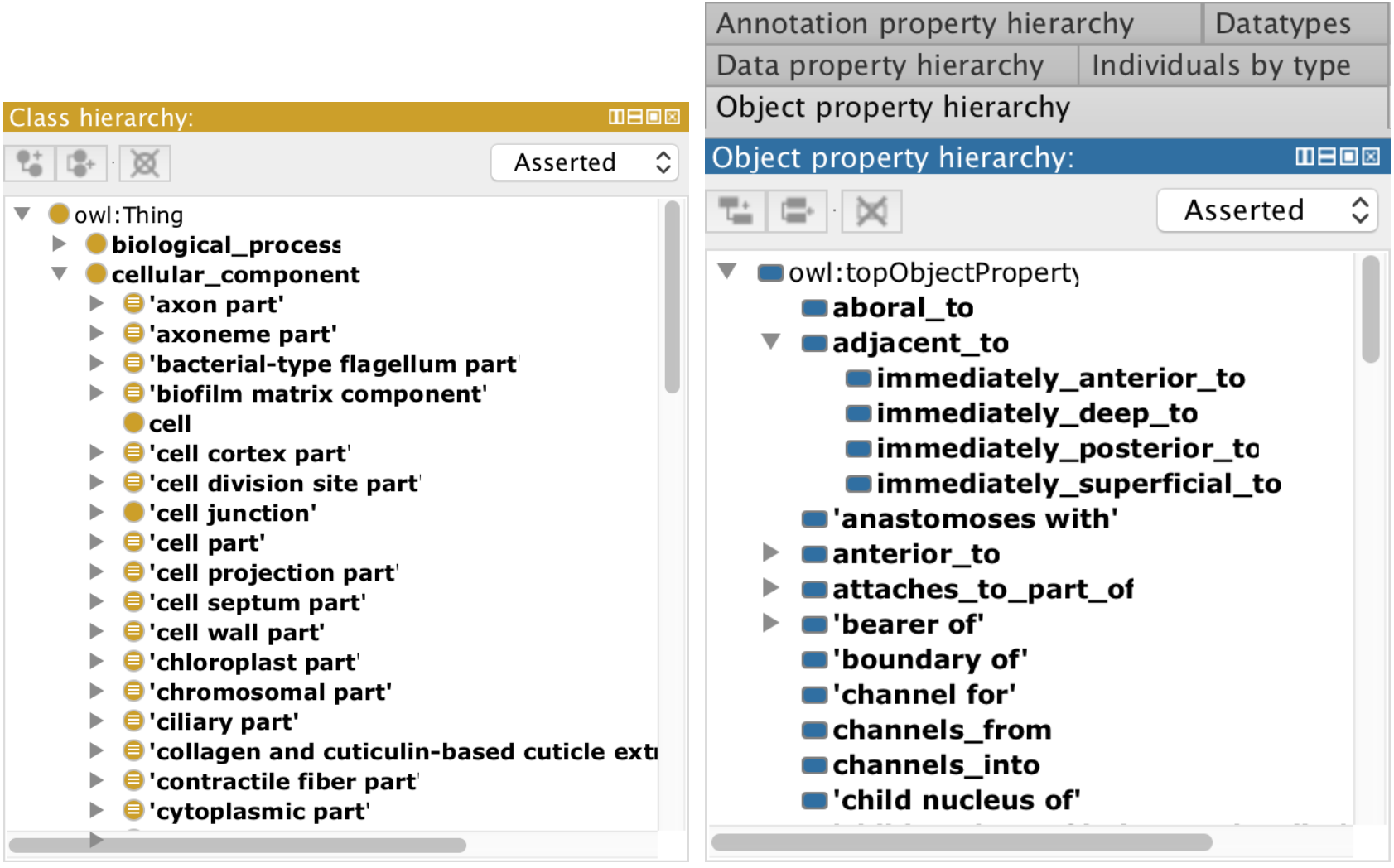
$$\forall x\ SubaruLegacy(x) \rightarrow Sedan(x)$$

$$\forall x\ Sedan(x) \rightarrow Automobile(x)$$

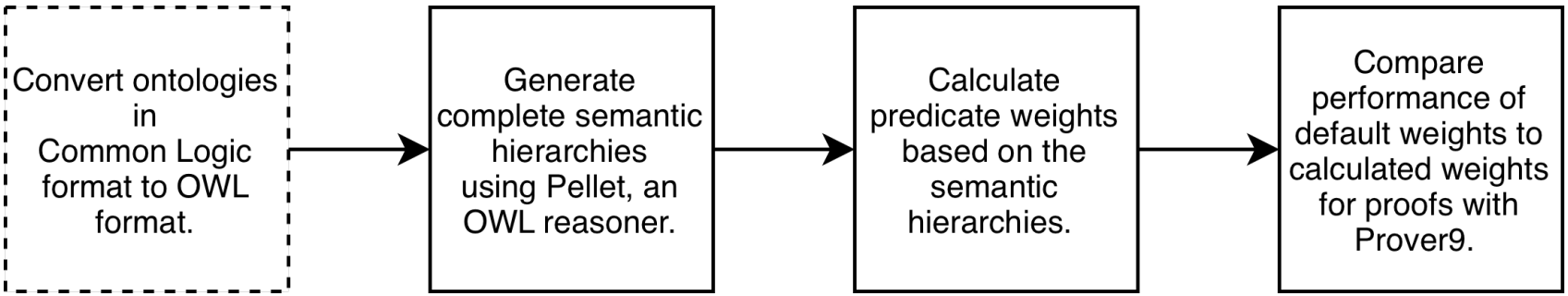
Theorem Proving

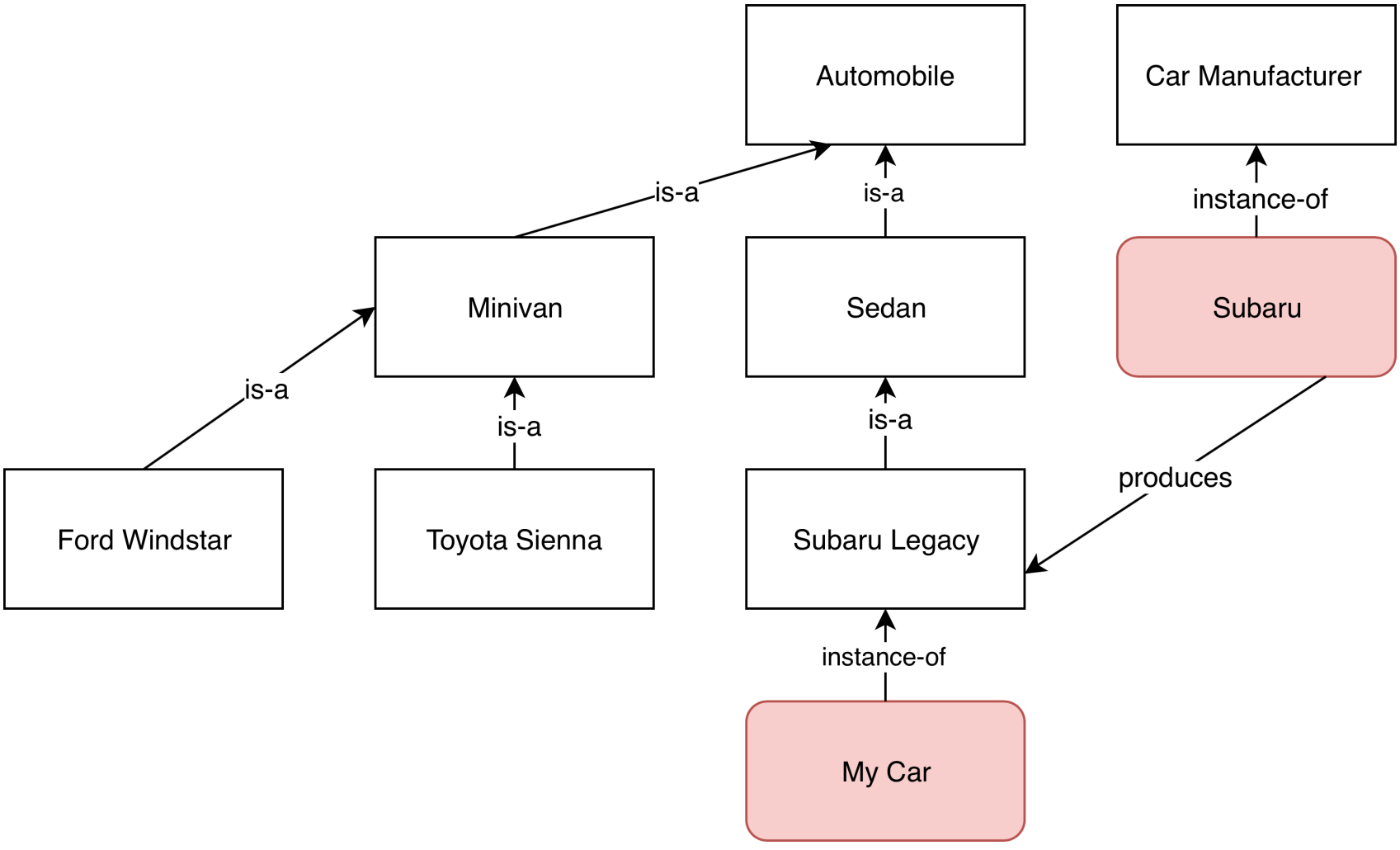


Semantic Hierarchies



Approach


Convert ontologies in Common Logic format to OWL format.
Generate complete semantic hierarchies using Pellet, an OWL reasoner.
Calculate predicate weights based on the semantic hierarchies.
Compare performance of default weights to calculated weights for proofs with Prover9.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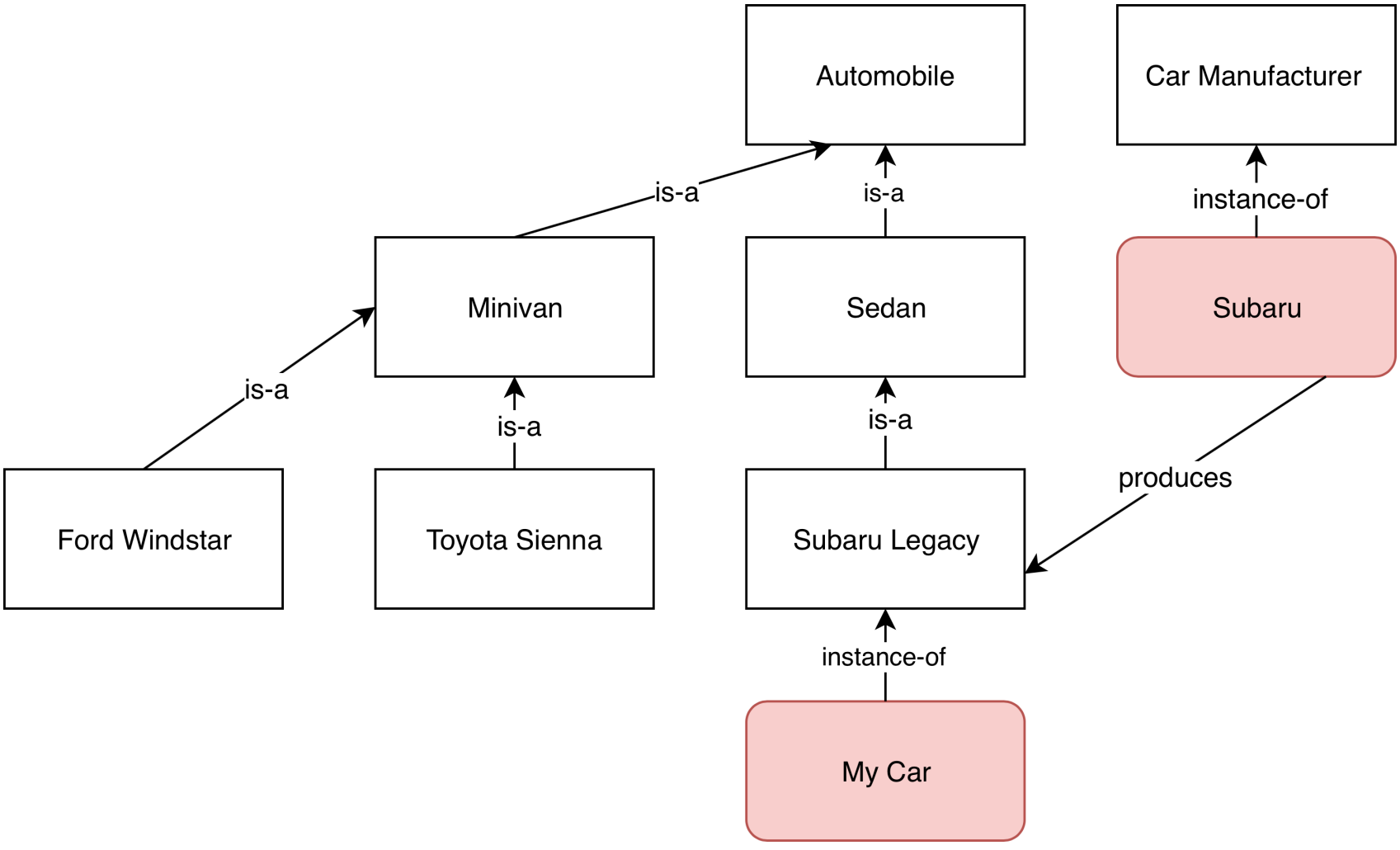
Ford Windstar
Toyota Sienna
Subaru Legacy
instance-of
My Car

Function 1 Weights

- weight(SubaruLegacy(x)) = 1.
- weight(Sedan(x)) = 1.
- weight(Automobile(x)) = 1.
- weight(Minivan(x)) = 2.
- weight(ToyotaSienna(x)) = 3.
- weight(FordWindstar(x)) = 3.
- weight(CarManufactuer(x)) = 10.
- weight(Produces(x,y)) - This is not defined as the conjecture contains no relationships.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is-a
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produces
Ford Windstar
Toyota Sienna
Subaru Legacy
instance-of
My Car

Function 2 Weights

- weight(SubaruLegacy(x)) = 1.
- weight(FordWindstar(x)) = 1.
- weight(Automobile(x)) = 1. (LCA)
- weight(Sedan(x)) = 2.
- weight(Minivan(x)) = 2.
- weight(ToyotaSienna(x)) = 3.
- weight(CarManufactuer(x)) = 3.

Conjecture	Default	Function 1	Percent Change 1	Function 2	Percent Ch
1	85691	9165	-89	9231	-89
2	1803	1803	-	1803	-
3	1803	1803	-	1803	-
4	175	175	-	175	-
5	175	175	-	175	-
6	172	172	-	172	-
7	6357	6337	0	6225	-2
8	6015	5855	-3	2352	-61
9	1802	1802	-	1802	-
Average	11555	3032	-73	2638	-77
Median	1803	1803	0	1803	0
Sum	103993	27287	-74	23738	-77

Table: Results for the multidim_space_voids Ontology

Conjecture	Default	Function 1	Percent Change 1	Function 2	Percent Ch
1	140734	50476	-64	50476	-64
2	480	754	57	742	55
3	295	295	-	234	-21
4	308	308	-	332	8
5	28188	28188	-	28188	-
6	11793	7830	-34	7830	-34
Average	30300	14642	-52	14634	-52
Median	6137	4292	-30	4286	-30
Sum	181798	87851	-52	87802	-52

Table: Results for the inch Ontology

Conjecture	Default	Function 1	Percent Change 1	Function 2	Percent Ch
1	426	426	-	410	-4
2	285	285	-	285	-
3	426	426	-	430	-1
4	289	266	-8	324	-12
5	438	438	-	323	-26
6	283	240	-15	283	-
7	495	425	-14	255	-48
Average	377	358	-5	330	-12
Median	426	425	0	323	-24
Sum	2642	2506	-5	2310	-13

Table: Results for the multidim_space_physcont Ontology

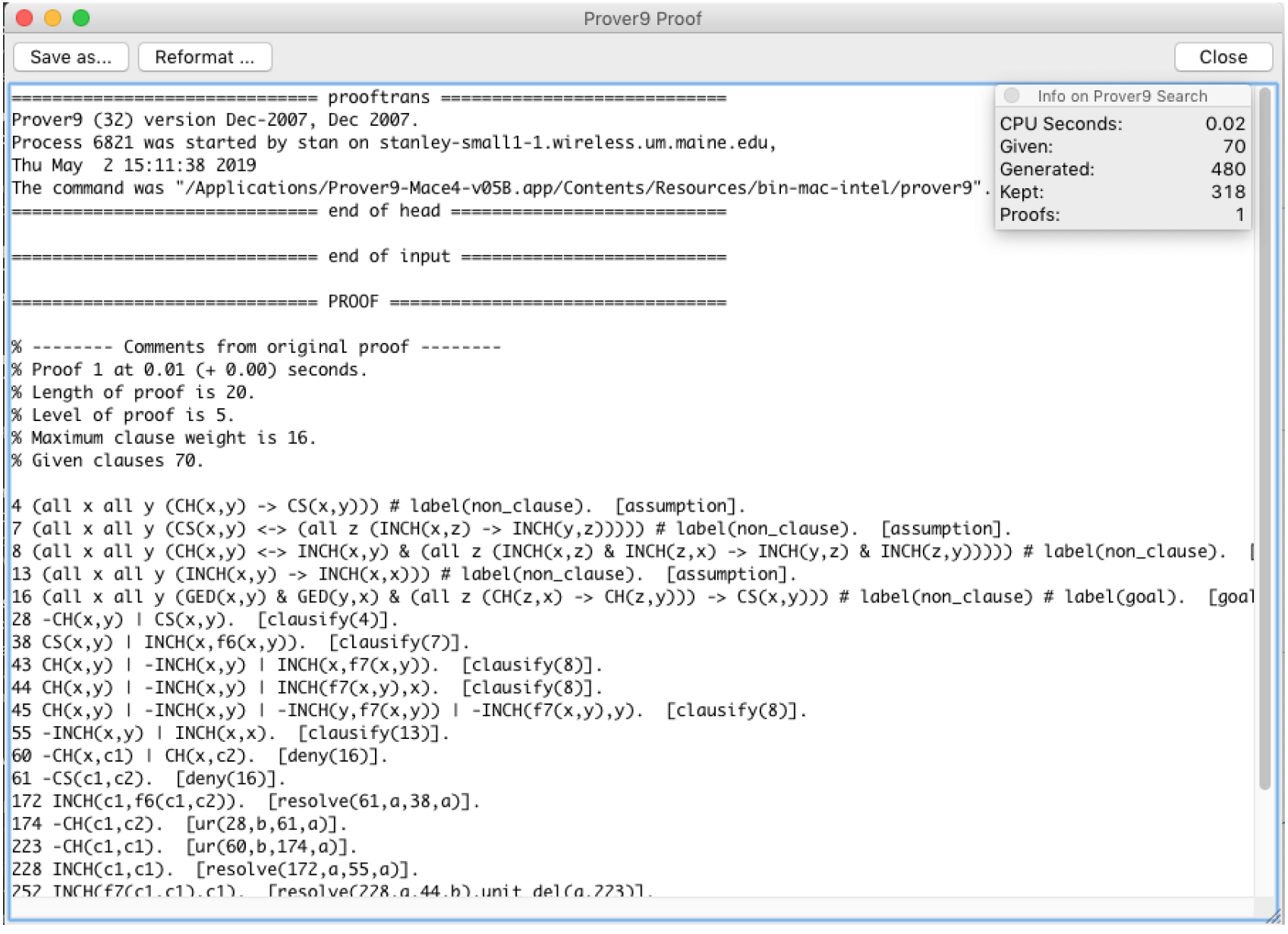
Metric	Default	Function 1	Percent Change 1	Function 2	Percent Chang
Average	13111	5347	-59	5175	-61
Median	459	432	-6	420	-8
Sum	288433	117644	-59	113850	-61

Table: Overall Results

Limitations

- Increase in clauses for inch ontology
- `(all x all y (GED(x,y) & GED(y,x) & (all z (CH(z,x) -> CH(z,y))) -> CS(x,y))).`
- Semantic hierarchy has a depth of 2

Prover9 Output



Summary

- When proving specific conjectures with few predicates on large ontologies, semantic hierarchies can focus the search of a resolution theorem prover.
- Results of the experiments conducted indicate further work might yield lucrative results, especially for exceptionally large ontologies.
- Tests demonstrated success in a relatively unexplored domain of research.

Thank You

Questions

My Thoughts

- A Mind for Numbers
- The Inner Game of Tennis
- Trying Not to Try
- I Ching

My Career

- Algorithms to Live By
- Black Mirror
- The Signal and the Noise
- Disrupted

My Worldview

- What Every BODY is Saying
- Mr. Nobody
- The Lobster
- BoJack Horseman