



The iCity Ontology:

Transportation Data to Transportation Knowledge

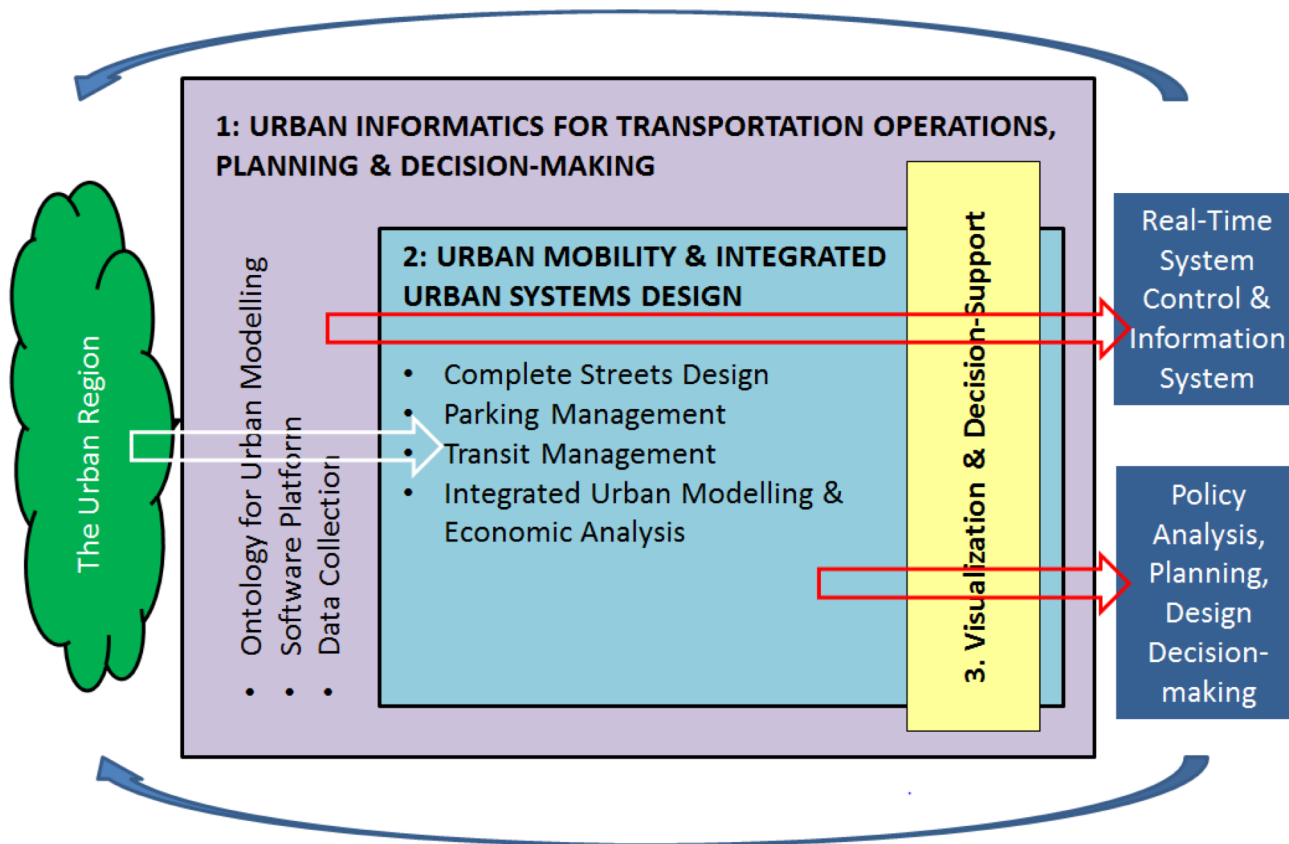
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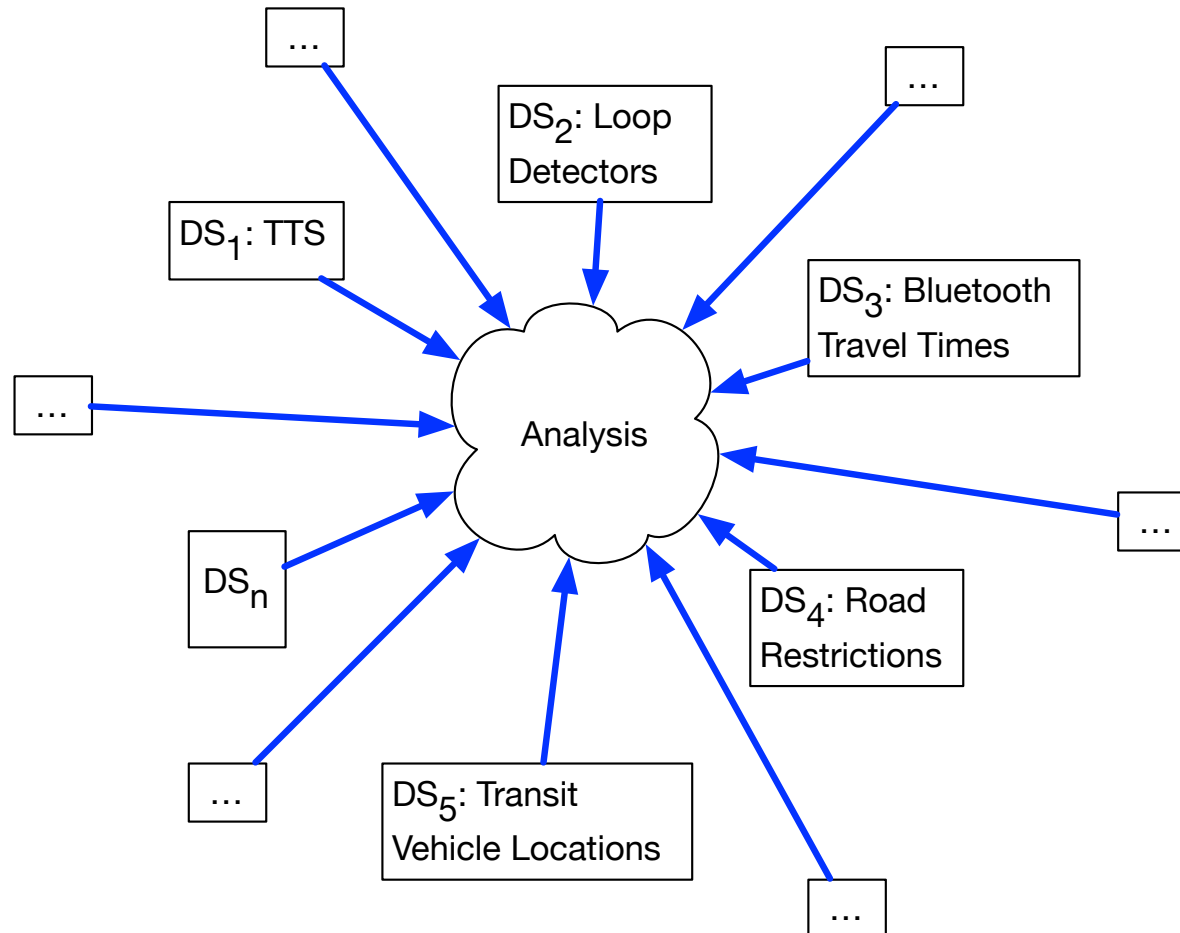
iCity: Three themes and 10 projects



<http://uttri.utoronto.ca/research/projects/icity/>

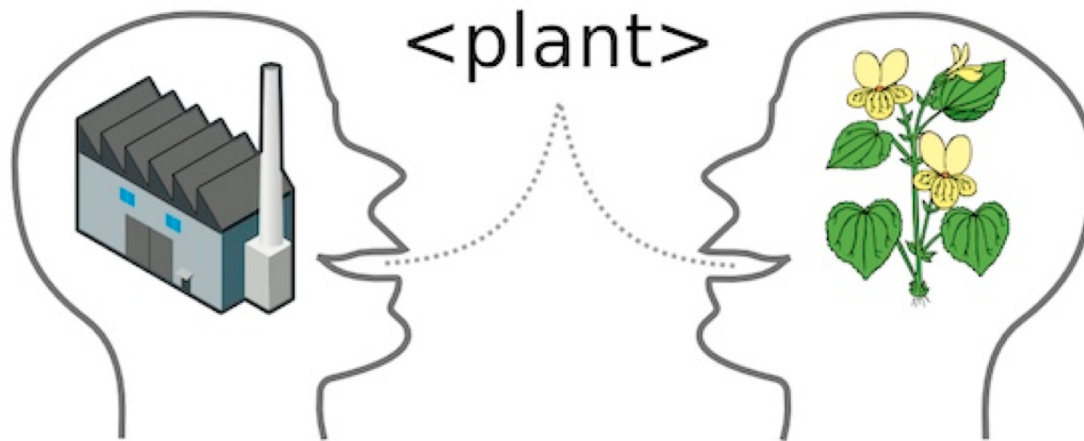
A Morass of Data

- Sensors, studies, simulations,...



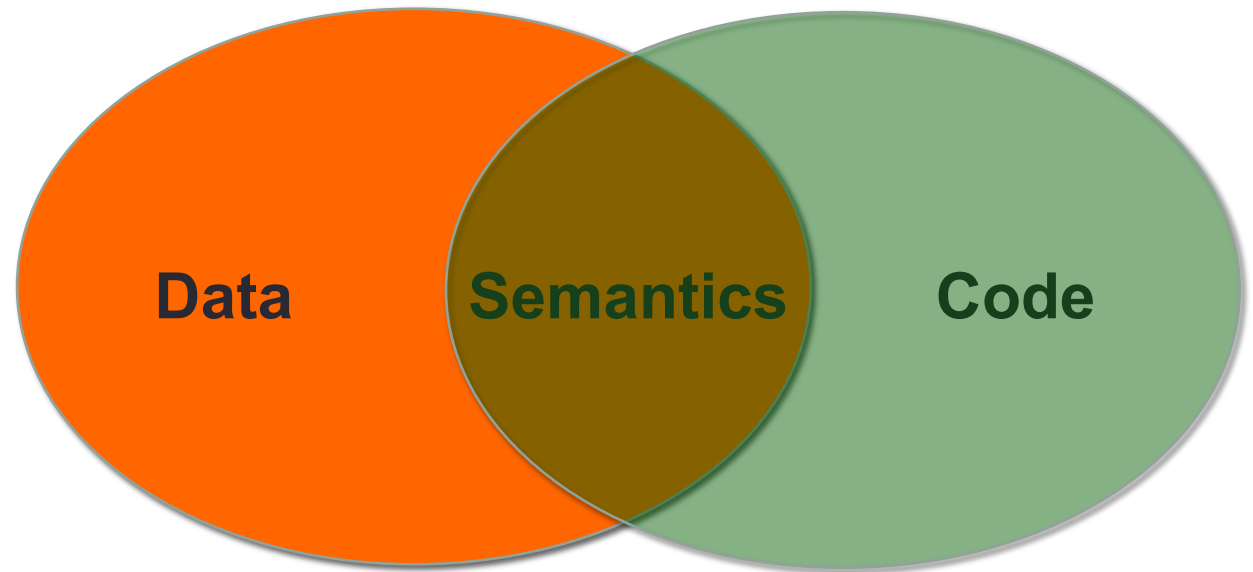
Challenge: Semantic Interoperability

- Ability of computer systems to exchange data with unambiguous, shared meaning.



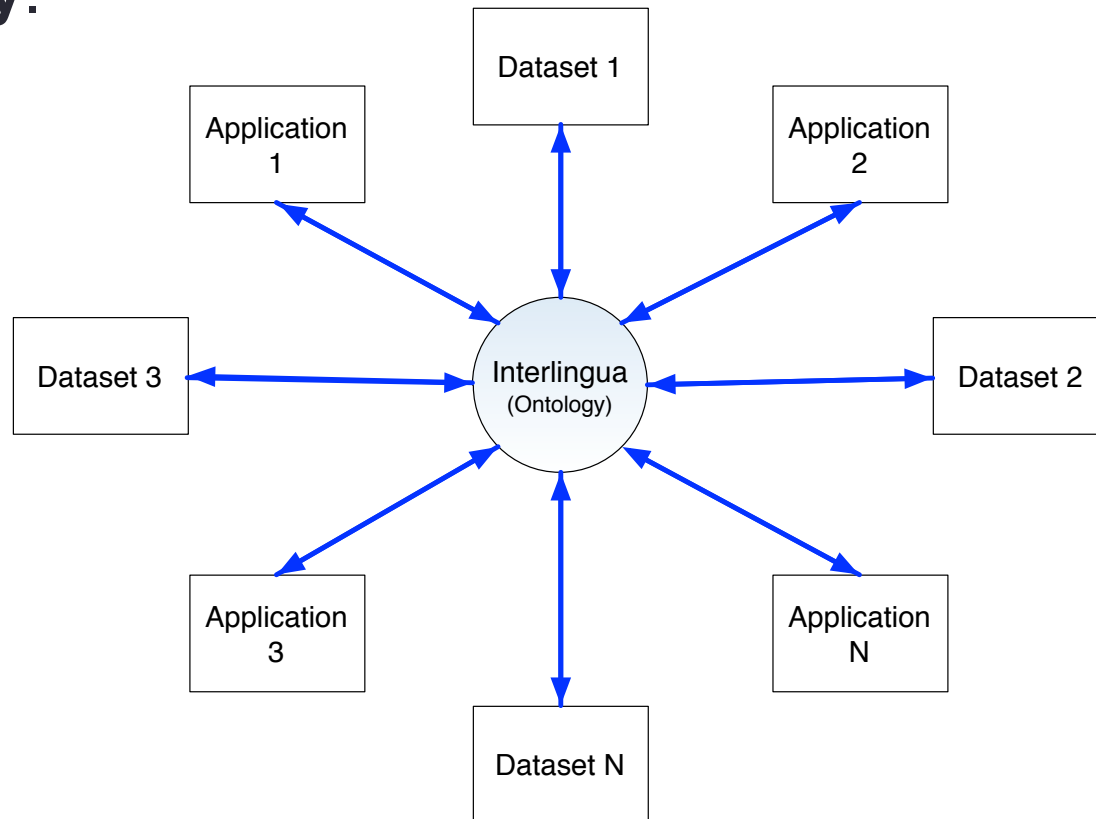
- A requirement for machine reasoning, knowledge discovery, and data federation across information systems.

The Source Of Problem

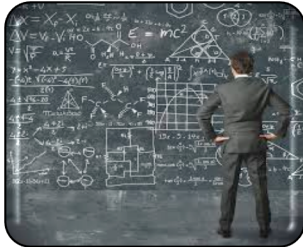


Solution: an Ontology for Urban Informatics

- The iCity project addresses this challenge by designing a formal representation of the transportation domain: **an ontology.**

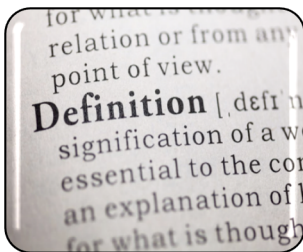


The Ontology Approach



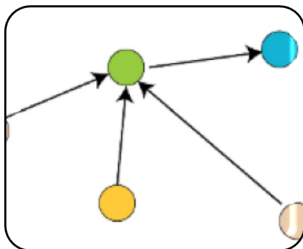
Micro-Theory

- Axioms/Rules
- Deduction – answering questions



Definitions and Constraints

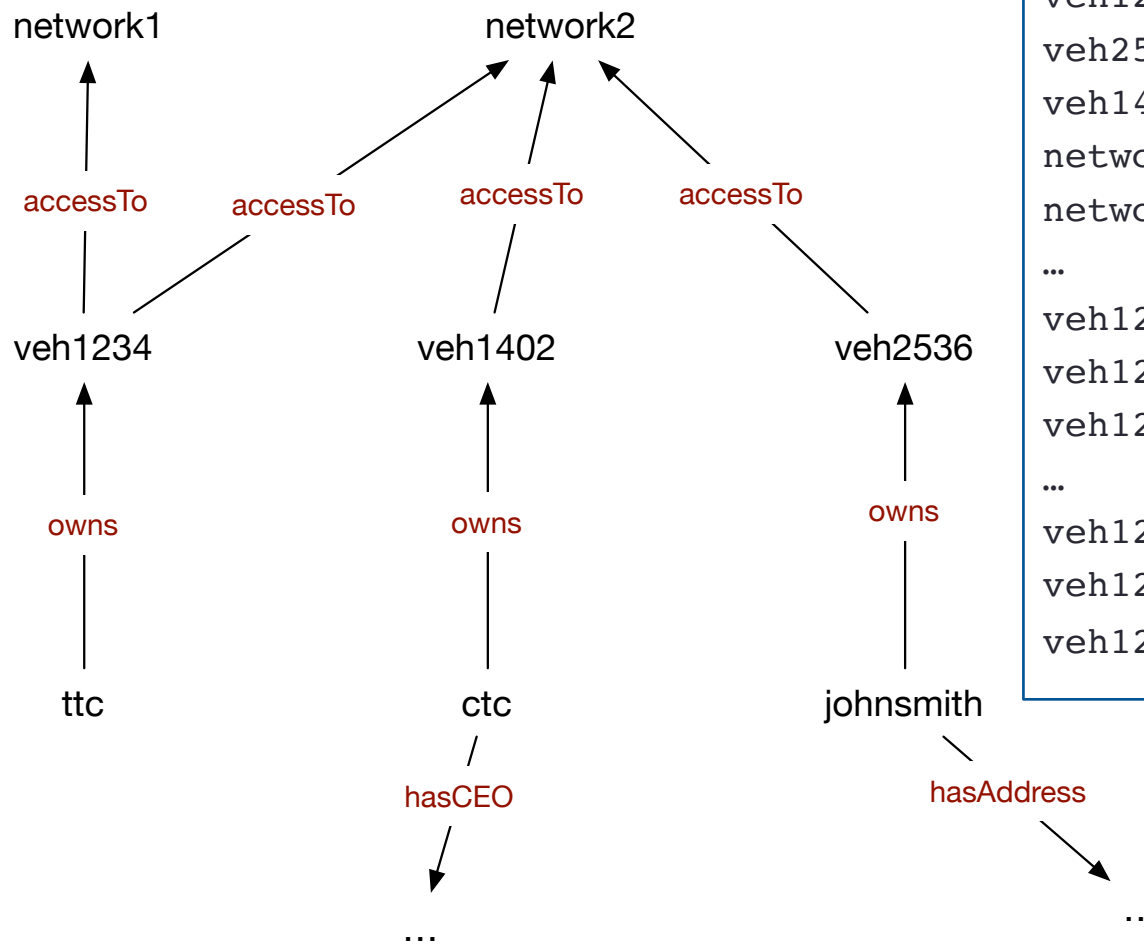
- Class Definitions (in Logic)
- Automated classification



Knowledge Graph

- Classes and Properties
- Taxonomy and Inheritance

Example Knowledge Graph

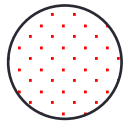


```
veh1234 rdfs:type Vehicle.  
veh2536 rdfs:type Vehicle.  
veh1402 rdfs:type Vehicle.  
network1 rdfs:type RoadSystem.  
network2 rdfs:type TransitSystem.  
...  
veh1234 accessTo network1.  
veh1234 accessTo network2.  
veh1234 accessTo network1.  
...  
veh1234 ownedBy ttc.  
veh1234 ownedBy ctc.  
veh1234 ownedBy johnsmith.
```

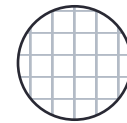

An Example: Definitions and Constraints



Vehicle



\exists accessTo.RoadSystem



TransitVehicle:

TransitVehicle \equiv Vehicle \sqcap
 \exists accessTo.TransitSystem

TransitVehicle \sqsubseteq
 \neg (HouseholdVehicle)



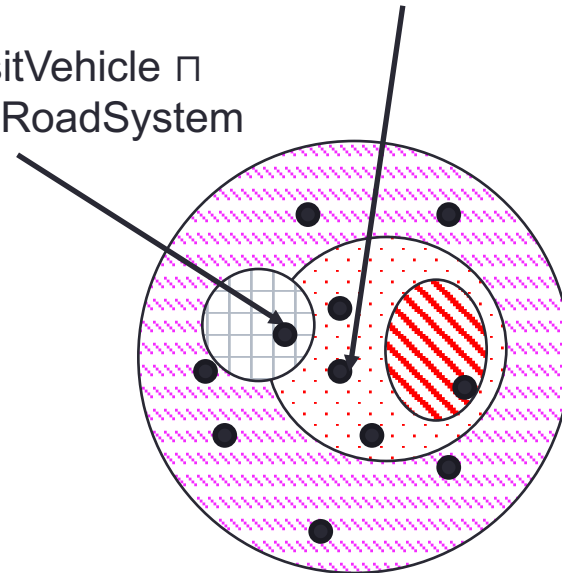
HouseholdVehicle:

HouseholdVehicle \equiv Vehicle
 \sqcap \exists ownedBy.Person

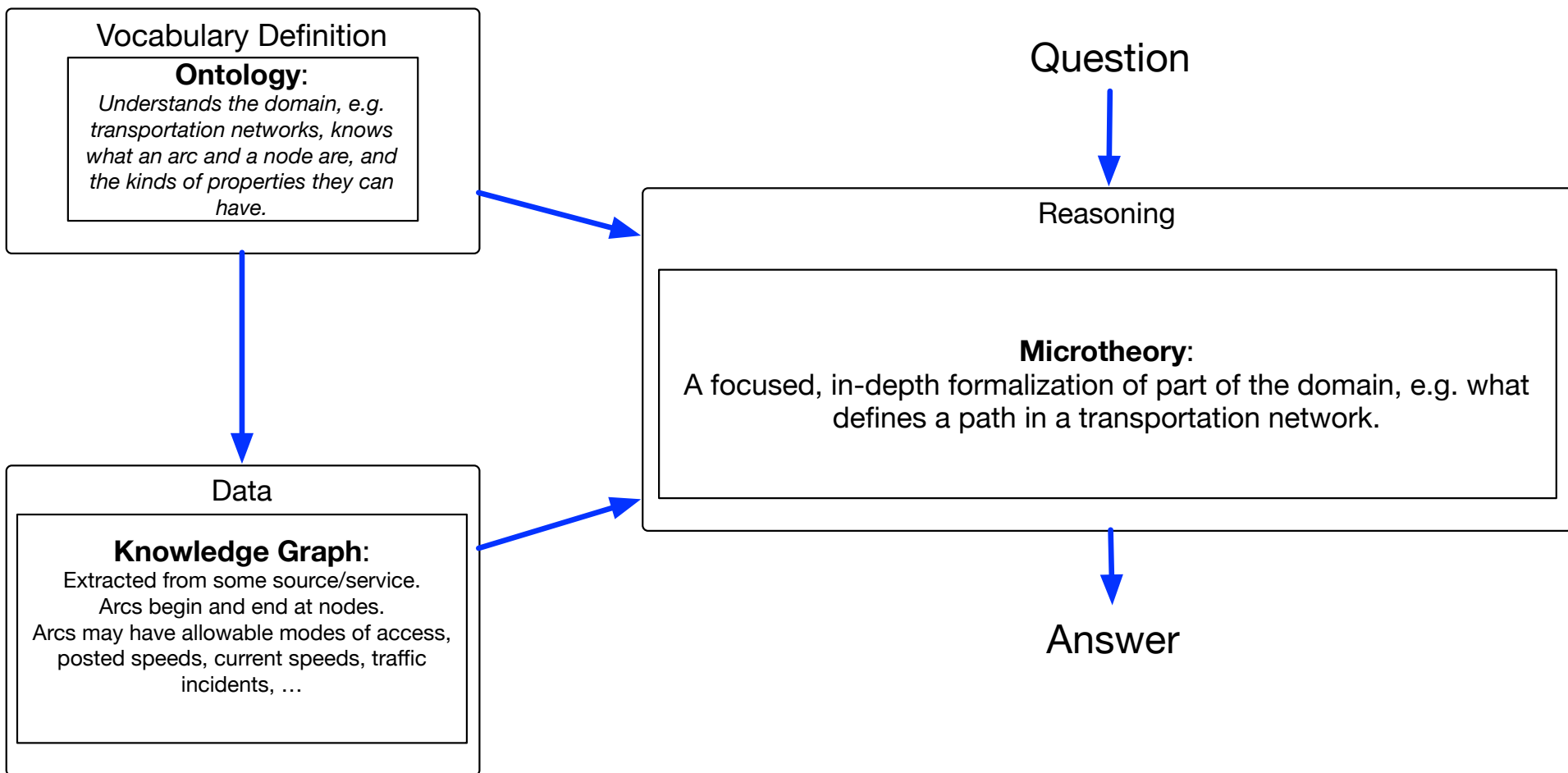
HouseholdVehicle \sqsubseteq \neg (TransitVehicle)

CommercialVehicle \equiv Vehicle \sqcap
 \exists accessTo.RoadSystem \sqcap \neg (TransitVehicle)
 \sqcap \neg (HouseholdVehicle)

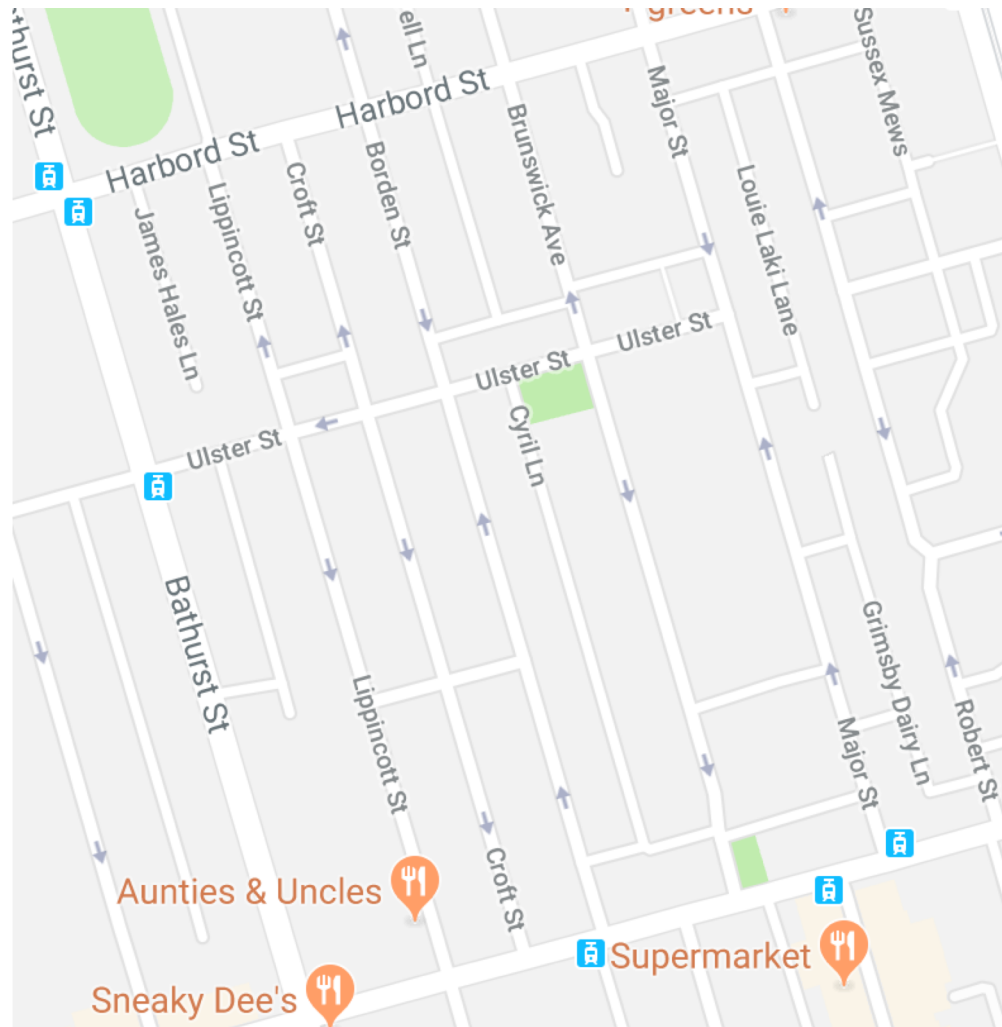
Bus \equiv TransitVehicle \sqcap
 \exists accessTo.RoadSystem



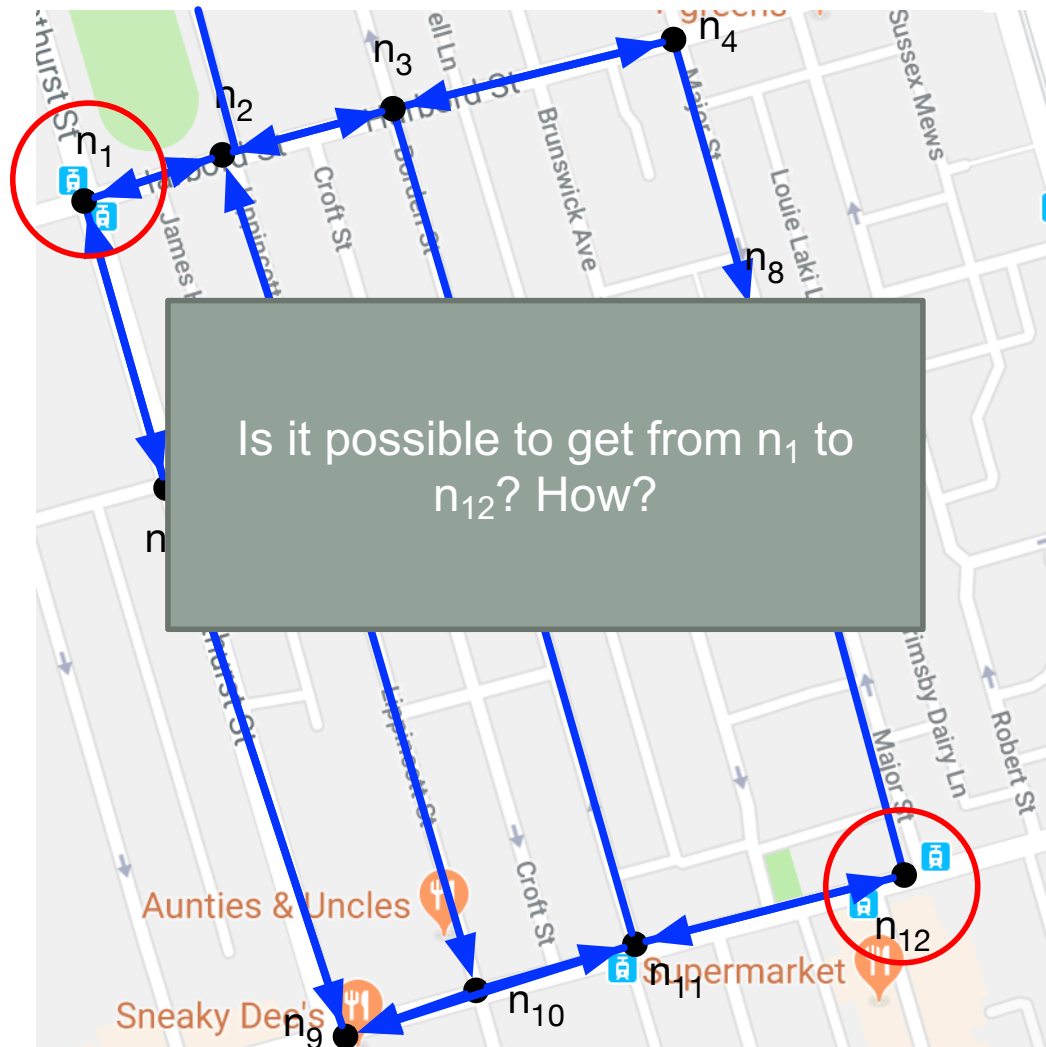
Beyond Queries & Classification: Inference



Example Road Network



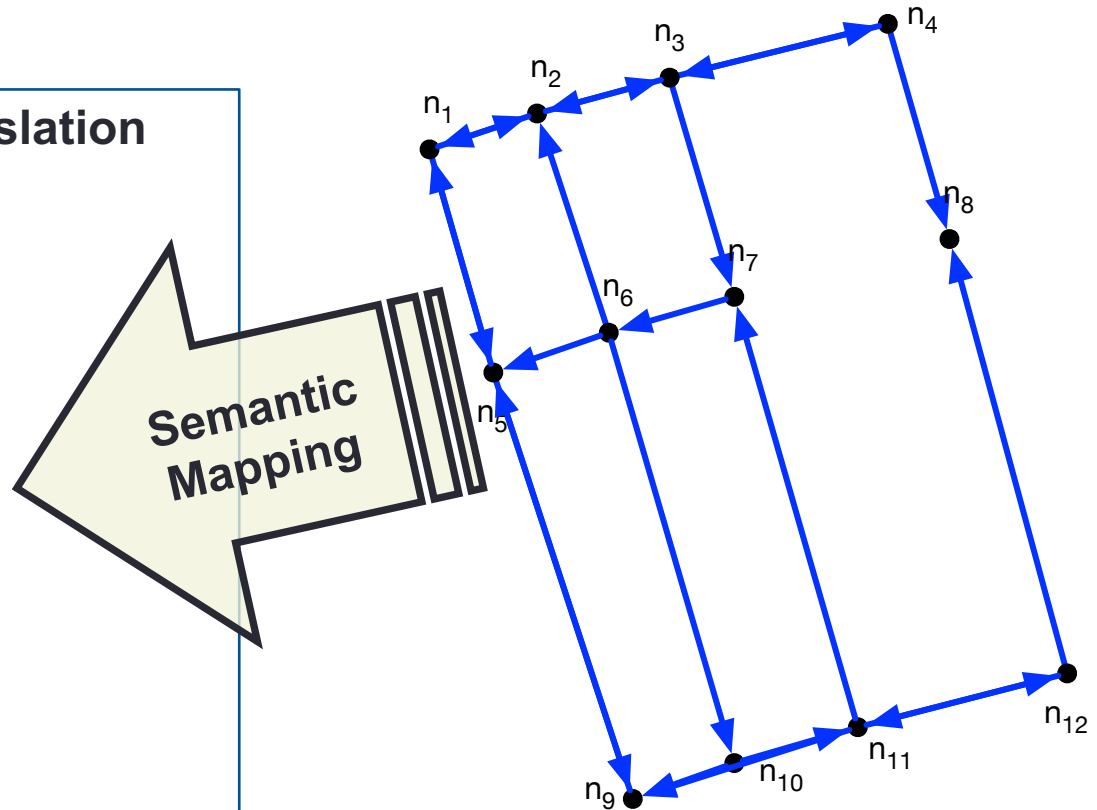
Example Road Network



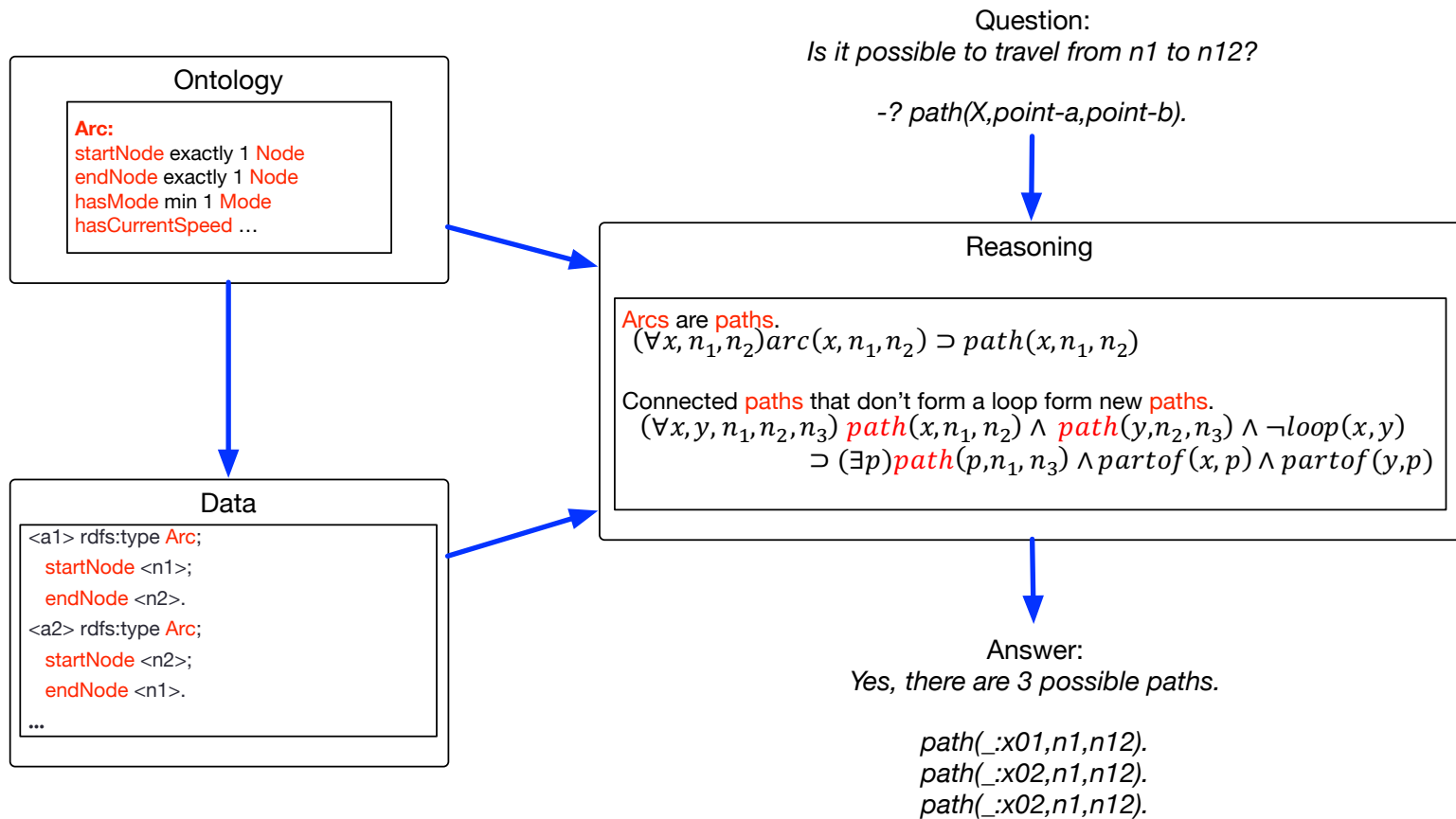
Formalization

Knowledge Graph Translation

```
<a1> rdfs:type Arc;  
  startNode <n1>;  
  endNode <n2>.  
<a2> rdfs:type Arc;  
  startNode <n2>;  
  endNode <n1>.  
<a3> rdfs:type Arc;  
  startNode <n6>;  
  endNode <n2>.  
...
```

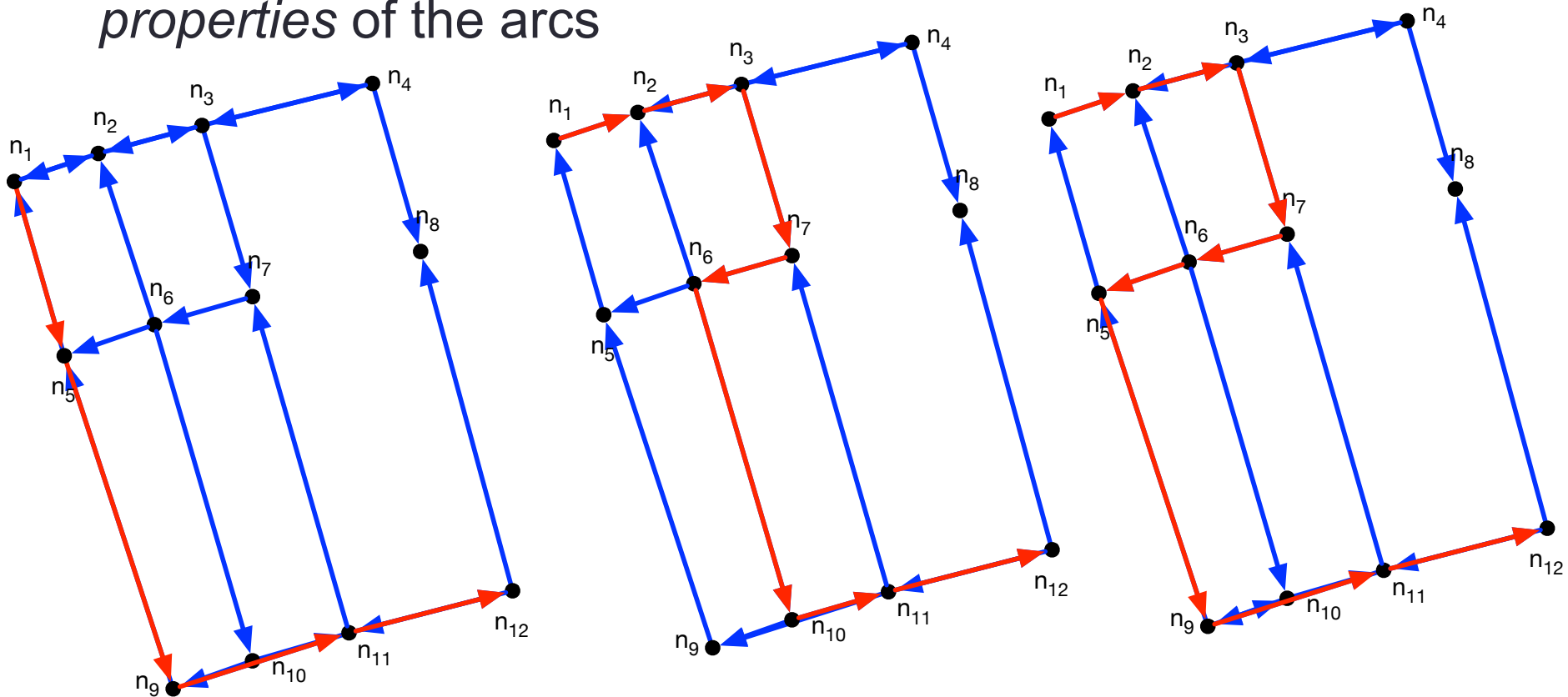


Automated Reasoning



New Knowledge

- Infer the existence of paths
- Infer additional knowledge about the paths based on *properties* of the arcs



Final Thoughts

- Explicit specification of semantics supports:
 - Integration
 - Deduction of new knowledge
- Applications beyond the iCity project
 - Any datasets with these concepts can be mapped into a knowledge graph in the same way, reusing the defined vocabulary
- Ongoing Work
 - Implementation with IT-SoS
 - Development of microtheories: focused, detailed extensions to enable specialized reasoning
 - Deployment as web application(s)
 - Explore visualization solutions to support communication of the ontology and its instances.

Thank you

- Questions?
- Contact me:
 - katsumi@mie.utoronto.ca
- More on the iCity Ontology and related work:
 - <http://uttri.utoronto.ca/research/projects/icity/papers/theme-one/>