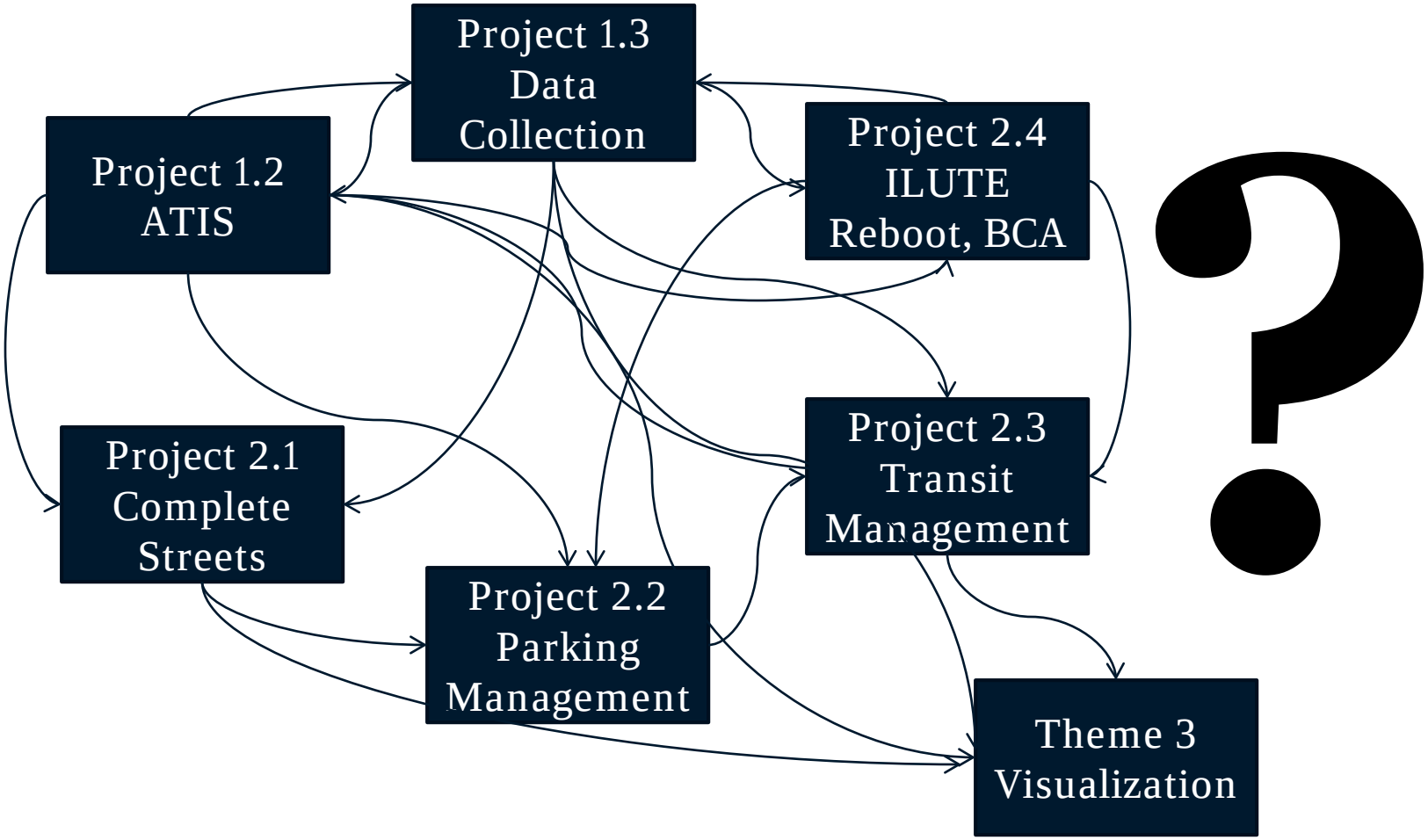
Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO

Using the iCity Ontology

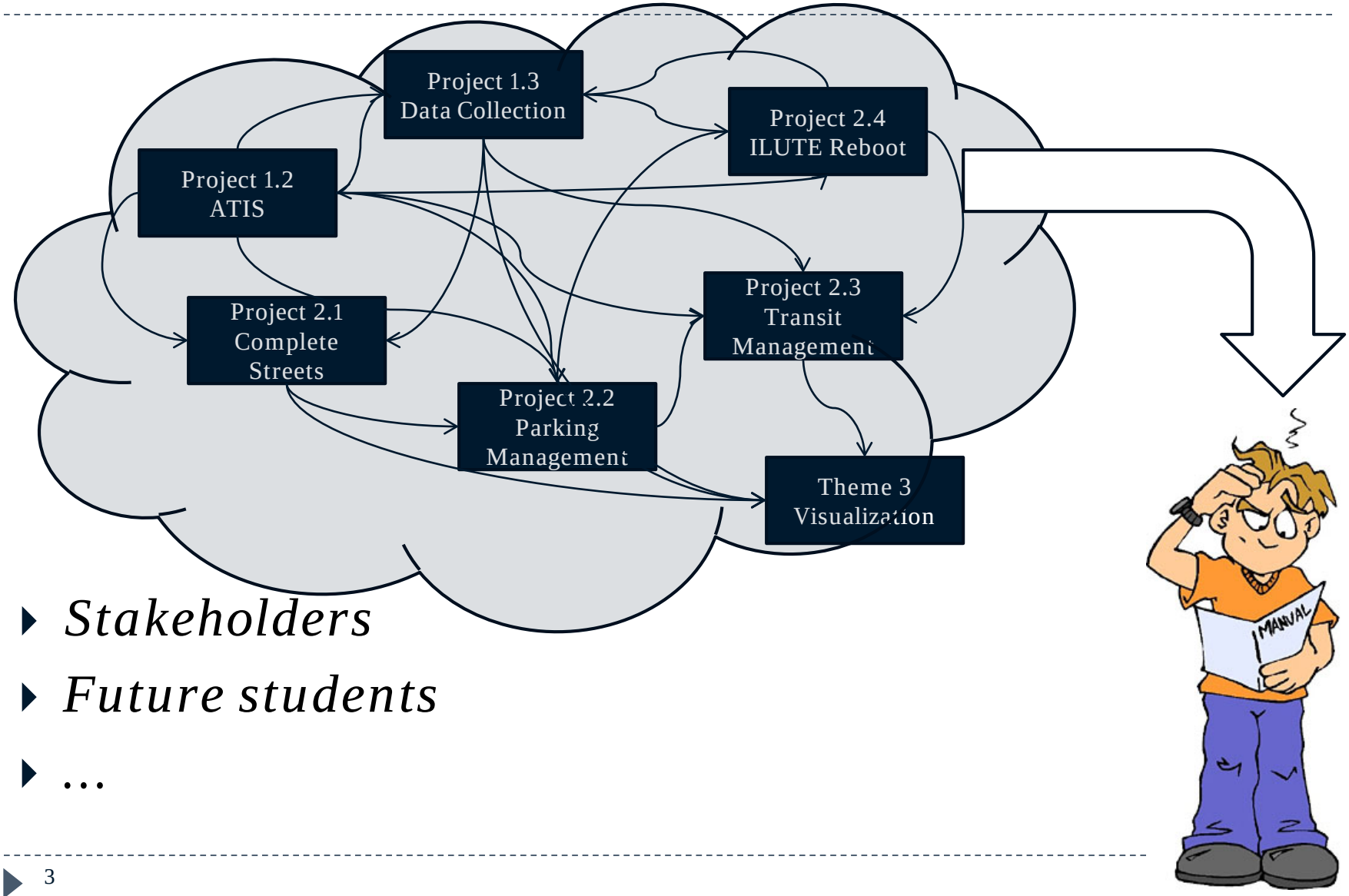
iCity Research Presentation Day: June 26, 2017

Megan Katsumi, Mark Fox

The iCity Project: How is it all related?

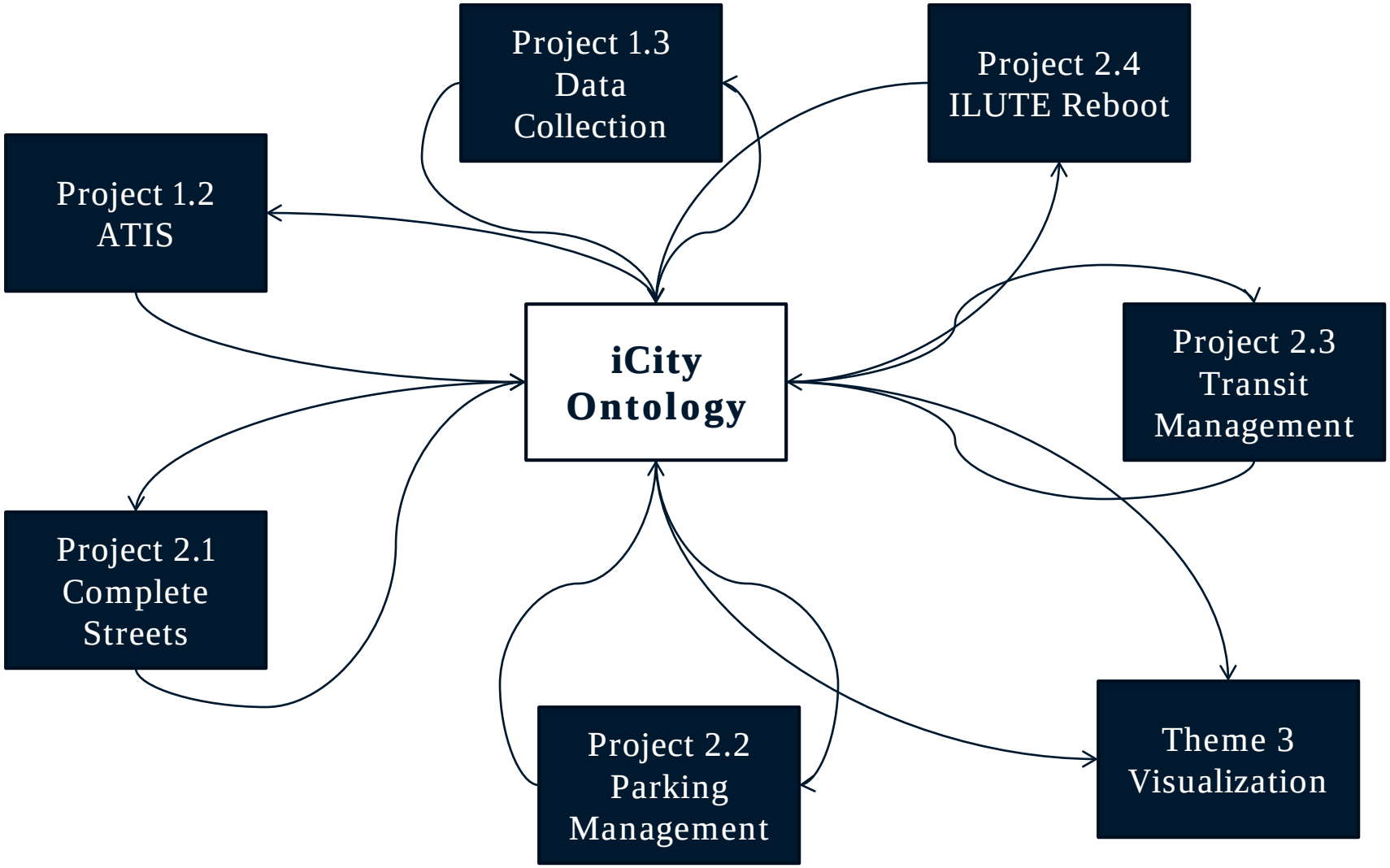


The iCity Project: How can others understand it?

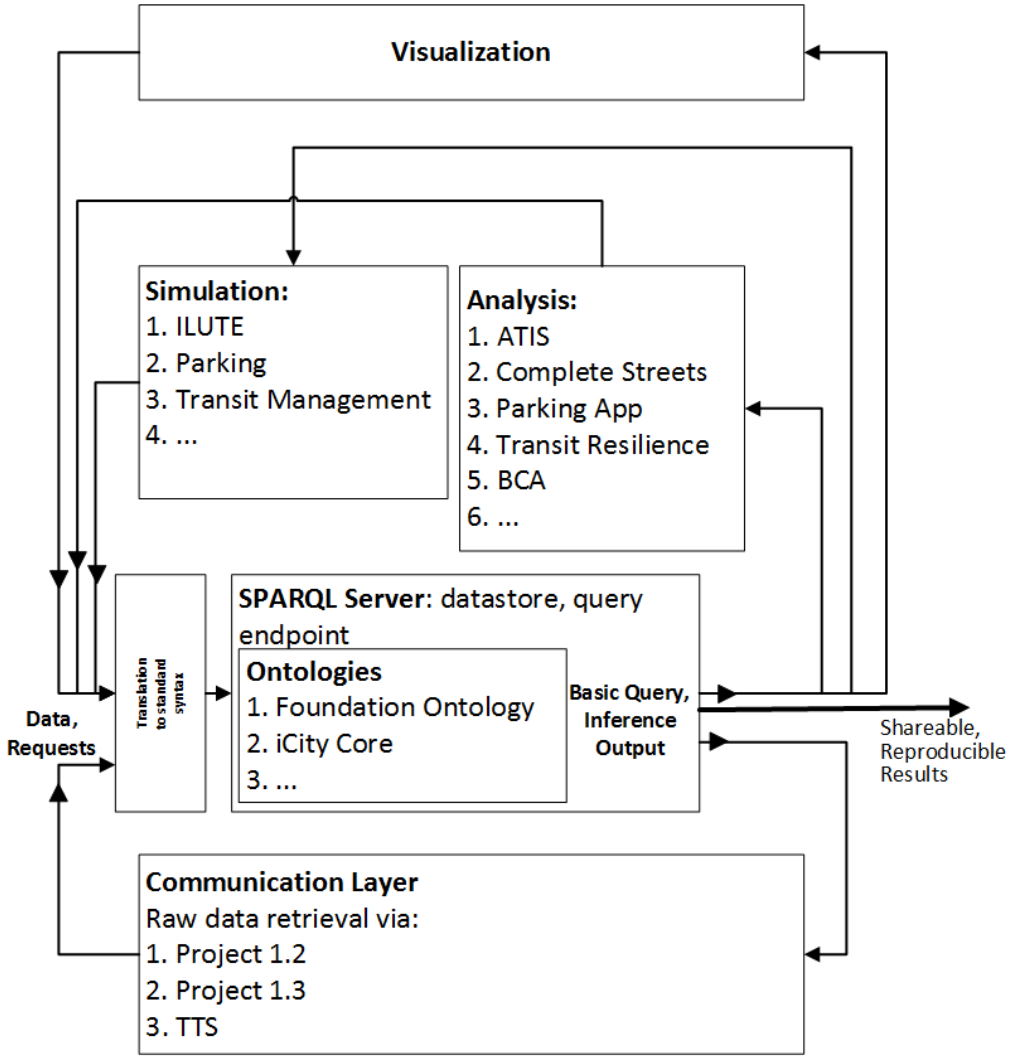


- *Stakeholders*
- *Future students*
- …

Urban Informatics Project 1.1: An Ontology to Define it

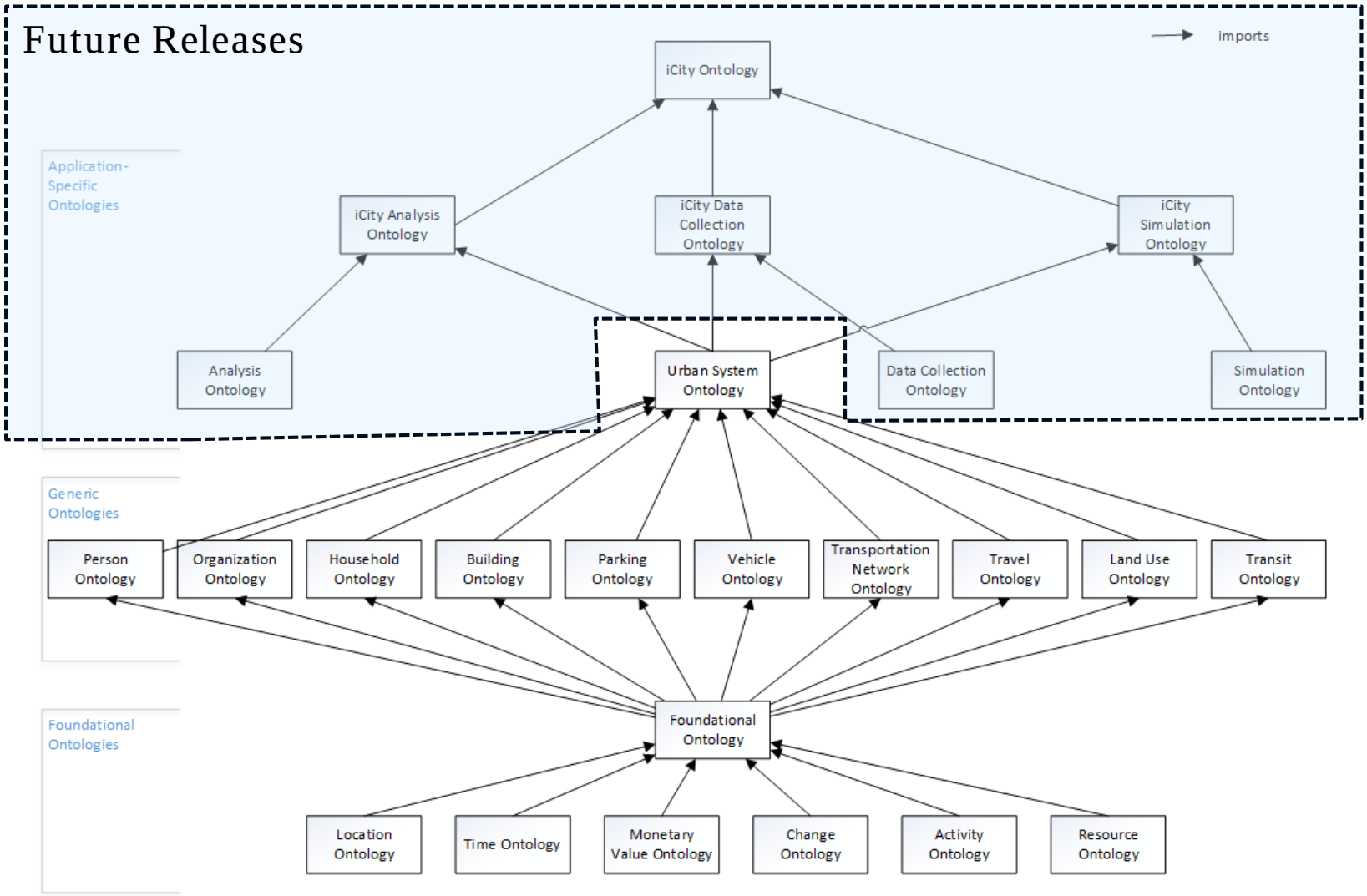


The iCity Architecture



- The Ontology supports a Knowledge Base for iCity with precise, formal definitions to support:
  - Integration between iCity Applications
  - Queries
  - Inference
  - Consistency Checking
  - Reproducibility

iCity Ontology Design



A Small Example

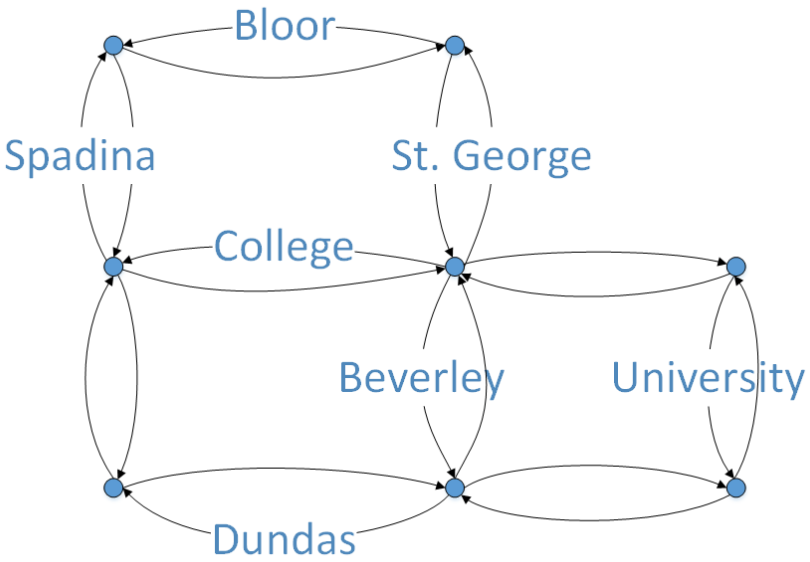
- Consider the following datasets
  - Transportation network
  - Road restrictions
  - Festivals and Events
  - Possible trip routes
- Possible Sources:
  - Open Data
  - iCity projects and partners

Example Data

- Transportation Network Data

FID	GEO_ID	LFN_ID	LF_NAME	FNODE	x_start	y_start	TNODE	x_end	y_end	FCODE
71	913876	2597	Spadina Ave	13470073	43.666681	-79.403811	13470066	43.657942	-79.400056	201300
72	20061686	2598	Spadina Ave	13470066	43.657942	-79.400056	13470073	43.666681	-79.403811	201300
73	913875	2597	Spadina Ave	13470066	43.657942	-79.400056	14257963	43.652935	-79.398018	201300
74	20061688	2598	Spadina Ave	14257963	43.652935	-79.398018	13470066	43.657942	-79.400056	201300
75	913883	10562	St George St	13470080	43.667519	-79.39982	13470126	43.658702	-79.395947	201300
76	913963	10563	St George St	13470126	43.658702	-79.395947	13470080	43.667519	-79.39982	201300
77	7283615	11624	Beverly St.	13470126	43.658702	-79.395947	13470382	43.65382	-79.393823	201500

...

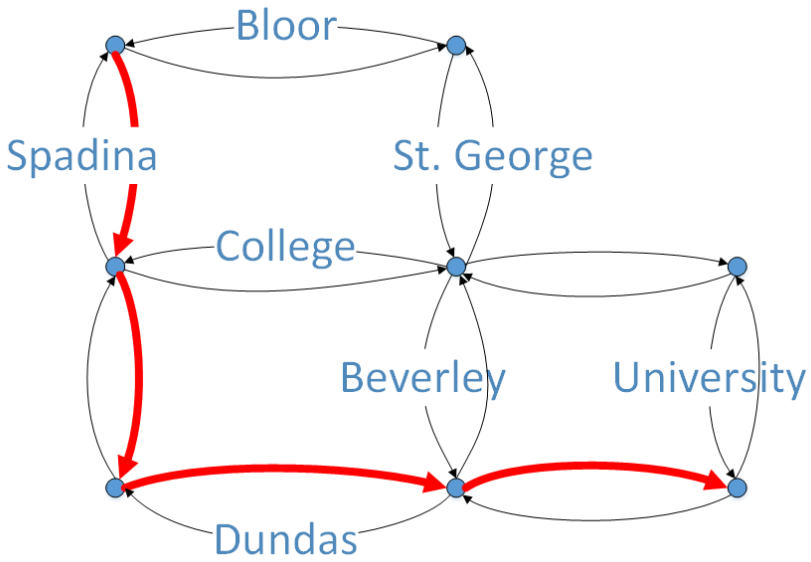


Example Data

- Trips

ID	pathStart	pathStart Name	pathEnd	pathEnd Name	segmentStart	segmentStart Name	segmentEnd	segmentEnd Name
1	13470073	Spadina and Bloor	13470348	University and Dundas	13470073	Spadina and Bloor	13470066	Spadina and College
1	13470073	Spadina and Bloor	13470348	University and Dundas	13470066	Spadina and College	14257963	Spadina and Dundas
1	13470073	Spadina and Bloor	13470348	University and Dundas	14257963	Spadina and Dundas	13470382	Beverly and Dundas
1	13470073	Spadina and Bloor	13470348	University and Dundas	13470382	Beverly and Dundas	13470348	University and Dundas
2	13470073	Spadina and Bloor	13470348	University and Dundas	13470073	Spadina and Bloor	13470080	St George and Bloor
2	13470073	Spadina and Bloor	13470348	University and Dundas	13470080	St George and Bloor	13470126	St George and College
2	13470073	Spadina and Bloor	13470348	University and Dundas	13470126	St George and College	13470382	Beverly and Dundas

...

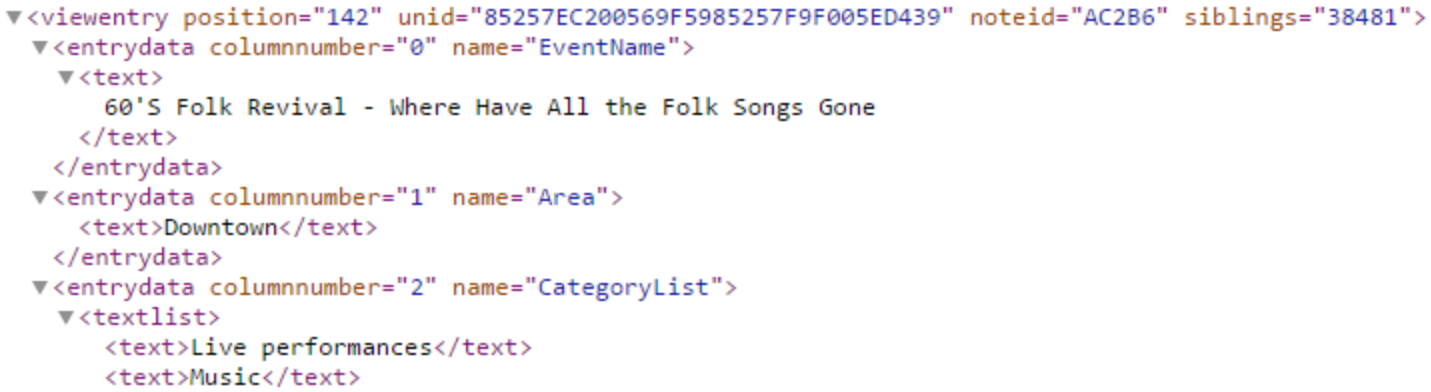


Example Data

- Road Restriction Data

Activity ID	ActivityType	Contractor	lat	long
55723	Construction	Munteomery Square Inc.	43.657942	-79.400056
37610	Construction	Rabcon Contractors Ltd	43.657942	-79.400056
41593	Construction	DRAINSTAR CONTRACTING LTD.	43.667519	-79.39982
20072	Accident		43.667519	-79.39982
35518	Construction	DM Robichaud Associates	43.657942	-79.400056

- Festivals and Events



Mapping the Transportation Network Data

Raw Data		**Ontology**
Row(x)	→	ArcPD(x)
FNODE(n)	→	startNode(x,n)
X_start(z)	→	hasLocation(n,s),geom(s,g),lat(g)=z
Y_start(z)	→	hasLocation(n,s),geom(s,g),long(g)=z
TNODE(n)	→	endNode(x,n)
		...

Mapping Event Data

Raw Data		**Ontology**
<viewentry unid="x">	→	Activity(x)
<name>y</name>	→	name(x) = "y"
<long>n</long>	→	hasLocation(x,z),geom(z,g),long(g)=n
<lat>n</lat>	→	hasLocation(x,z),geom(z,g),lat(g)=n
<startTime>t</startTime>	→	occursAt(x,t_x),hasBeginning(t_x,t)
		…

An Integrated Knowledge Base

- Once the data is mapped to the ontology it is easy to create an integrated knowledge base with any number of the data sources.
  - Infer new information
  - Detect errors

- For today's example, we'll use Prolog.
  - Logic programming language.
  - RDF and (potentially OWL) libraries.

Some queries

- What activities are occurring on a particular trip?
- Are any paths potentially blocked?
- Are all trip segments connected?

Some queries

- What are all the trips in the knowledge base?
  - ?- rdf(X,rdf:type,trip:'Trip').
- What are the activities?
  - ?- rdfs_individual_of(A,activity:'Activity').
- What activities are occurring on a particular trip?
  - Roughly,

```
(tripdemo:'1',trip:contains,X),
(X,trip:accessNode,_N1),(X,trip:exitNode,N2),
(N1,spatialLoc:'hasLocation',Y1),
(Y1,geom:geometry,G1),
(G1,wgs:lat,Lat1),rdf(G1,wgs:long,Long1),…
rdfs_individual_of(A,activity:'Activity'),
(A,spatialLoc:'hasLocation',ALoc),
(ALoc,geom:geometry,AGeo),
(AGeo,wgs:lat,Lat1),rdf(AGeo,wgs:long,Long1).
```

  - We used coordinates here, but other comparisons are possible.

Some queries

- Are any of the trips blocked?
  - Roughly,

```
(Y,:type,trip:’Trip’),(Y,trip:contains,X),
(X,trip:accessNode,N1),(X,trip:exitNode,N2),
(N1,spatialLoc:'hasLocation',Y1),(Y1,geom:geometry,G1)
,(G1,wgs:lat,Lat1),(G1,wgs:long,Long1),…,
(A,:type,activity:'Construction'),
(A,spatialLoc:'hasLocation',ALoc),
(ALoc,geom:geometry,AGeo),
(AGeo,wgs:lat,Lat1),(AGeo,wgs:long,Long1).
```

Some queries

- Are all of the trip segments connected?
  - To each other?
  - Via Arcs?
- We can simplify queries with the definition of rules to query the knowledge base:

```
?- path(X). %true if all trip segments are connected
to one another in a trip.
?- validpath(X). %true if all trip segments occur on
an arc.
```

What's Next?

- More data sets
- Identify valuable reasoning problems for iCity
  - Query the integrated data
  - Query the data sources
  - Query the ontology's concepts (understand and communicate the data model)
- Other implementations
  - Integration with other tools (ESRI, ITSoS, OCAD visualizations)
- Extensions to the ontology as required

We need you!

- We need your data and your requirements
  - To begin mapping and using the data
  - To guide the design of the next iteration