Semi-Automatically Modeling Web APIs to Create Linked APIs

Mohsen Taheriyan, Craig A. Knoblock, Pedro Szekely, and Jose Luis Ambite

USC Information Sciences Institute

OPENLINK SOFTWARE

dbpedia.org

About: Downtown Los Angeles

Sponge Permalink

An Entity of Type : Neighborhoods in Los Angeles, California, within Data Space : dbpedia.org

Type: yago:NeighborhoodsInLosAngeles,California Constrain facet

Downtown Los Angeles is the central business district of Los Angeles, California, United States, located close to the geographic center of the metropolitan area. The area features many of the city's major arts institutions and sports facilities, sightseeing opportunities, a variety of skyscrapers and associated large multinational corporations and an array of public art and unique shopping opportunities. Downtown is the hub of the city's freeway network and growing Metro rapid transit system.

leader title	City Council U.S. House State Senate State Assembly
population total	39537(xsd:integer)
area total (km2)	8.538 13.73988692533248
foaf:homepage	http://www.downtownla.com
foaf:depiction	

Slide by Shubham Gupta

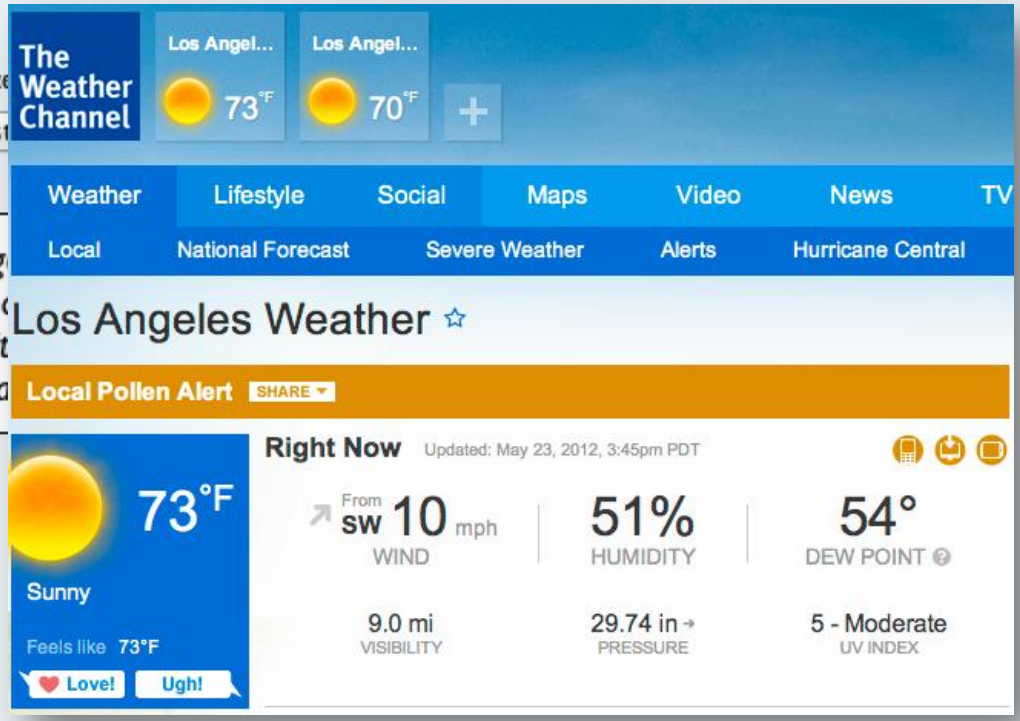
not dbpedia.org

About: Downtown Los Angeles Sponge Permalink
An Entity of Type : Neighborhoods in Los Angeles, California, within Data Space

Type: yago:NeighborhoodsInLosAngeles,California

Downtown Los Angeles is the central business district of Los Ang
center of the metropolitan area. The area features many of the
opportunities, a variety of skyscrapers and associated large mult
shopping opportunities. Downtown is the hub of the city's freewa

leader title	City Council U.S. House State Senate State Assembly
population total	39537(xsd:integer)
area total (km2)	8.538 13.739886925332



Current temperature	73°F
Wind	10 mph SW
Humidity	51%
Dew Point	54°

Live weather

Slide by Shubham Gupta

OPENLINK SOFTWARE

not dbpedia.org

About: Downtown Los Angeles

Sponge Permalink

An Entity of Type : Neighborhoods in Los Angeles, California, within Data Space : dbpedia.org

Type: yago:NeighborhoodsInLosAngeles,California

Downtown Los Angeles is the central business district o
center of the metropolitan area. The area features mar
opportunities, a variety of skyscrapers and associated l
shopping opportunities. Downtown is the hub of the cit

leader title	City Council U.S. House State Senate State Assembly
population total	39537(xsd:integer)
area total (km2)	8.538 13.73988692533248

Events for May. 2012

Film
Transparent Cities
5/1/2012
REDCAT Theater

Meeting
Saving Our Sons: A Community Conversation
5/2/2012
Los Angeles Trade Tech College

Special Event
Autumn Lights Night
5/3/2012
401 s Main Street

Concert
Martin Hasselbock Leads LACO's Baroque
nversations
012
urn School of Performing Arts

Ongoing Events

Exhibit
A Nation Emerges: The Mexican Revolution Revealed
9/8/2011 - 6/3/2012
LA Public Library - Central

Museum
Justice, Balance and Achievement: African Americans in the California Courts
1/12/2012 - 5/27/2012
California African American Museum

Exhibit
Trouble In Paradise: Music and Los Angeles, 1945-1975
2/22/2012 - 6/3/2012
GRAMMY Museum

Exhibit
Xploration Lab 2012
3/17/2012 - 6/17/2012

Current temperature	73°F
Wind	10 mph SW
Humidity	51%
Dew Point	54°
Events	Transparent Cities 5/1/2012 REDCAT Theater Saving Our Sons : A Community Conversatio… …

Events

Slide by Shubham Gupta

OPENLINK SOFTWARE

not dbpedia.org

About: Downtown Los Angeles

Sponge Permalink

An Entity of Type : Neighborhoods in Los Angeles, California, within Data Space : dbpedia.org

Type: yago:NeighborhoodsInLosAngeles,California Constrain facet

Downtown Los Angeles is the central business district of Los Angele
center of the metropolitan area. The area features many of the cit
opportunities, a variety of skyscrapers and associated large multin
shopping opportunities. Downtown is the hub of the city's freeway

leader title	City Council U.S. House State Senate State Assembly
population total	39537(xsd:integer)
area total (km2)	8.538 13.73988692533248
Current temperature	73°F
Wind	10 mph SW
Humidity	51%
Dew Point	54°
Events	Transparent Cities 5/1/2 Saving Our Sons : A Com Conv ...
Twitter Feed	Los Angeles becomes the largest U.S. city to ban.. Plastic grocery bags will now be banned in ... ...

Yale Environment 360 @YaleE360 18m
Los Angeles becomes the largest U.S. city to ban **plastic bags**
bit.ly/JA0PdX #LosAngeles #plasticbagban
Expand

DestinationTampaBay @DestTampaBay 48m
Plastic grocery **bags** will now be banned in #LosAngeles. What do you think of that concept for #Florida?
Expand

annmarie anderson @AnnmarieCloud 55m
"@HuffingtonPost: The nation's second largest city has just banned **plastic bags** in grocery stores huff.to/Jygs5N" #LosAngeles #green
Expand

gomaam @gomaam 1h
#LosAngeles is now the largest U.S. city to #ban #**plastic bags**
dlvr.it/1cX0bW
Expand

Ozzyopolis @Ozzyopolis 3h
Los Angeles Becomes Largest U.S. City to Ban **Plastic Bags**:
bit.ly/Jpl9xw via @TreeHugger #LosAngeles #plasticbagban
Expand Reply Retweet Favorite

Live Twitter Feed

Slide by Shubham Gupta

But, the Information is Available in Web APIs ....

OPENLINK SOFTWARE

About: Downtown Los A

An Entity of Type : Neighborhoods in Los A

Type: yago:NeighborhoodsInLosAngele

Downtown Los Angeles is the central business district of Los Angeles, California, United States, located close to the geographic center of the metropolitan area. The area features many of the city's major arts i opportunities, a variety of skyscrapers and associated large multinational corpora shopping opportunities. Downtown is the hub of the city's freeway network and g

programmableweb

leader title	City Council U.S. House State Senate State Assembly
population total	39537(xsd:integer)
area total (km2)	8.538 13.73988692533248
Current temperature	73°F
Wind	10 mph SW
Humidity	51%
Dew Point	54°
Events	Transparent Cities 5/1/2012 REDCAT Theater Saving Our Sons : A Community Conversatio... ...
Twitter Feed	Los Angeles becomes the largest U.S. city to ba Plastic grocery bags will now be banned in ... ...

World Weather Online API

Summary | Mashups (1) | How-To (1) | Developers (1) | Comments

WORLD WEATHER ONLINE

World Weather Online provides weather forecast and we for worldwide city and towns. The Developer Weather AP

Eventful API

Summary | Mashups (46) | How-To | Developers (30) | Comments

eventful

Eventful is the world's largest collection of events, takin markets throughout the world, from concerts and sports

Twitter API

Summary | Mashups (709) | How-To (34) | Developers (432) | AP

twitter

The Twitter micro-blogging service includes two RE Twitter REST API methods allow developers to acce

Slide by Shubham Gupta

OPENLINK SOFTWARE

About: Downtown Los Angeles

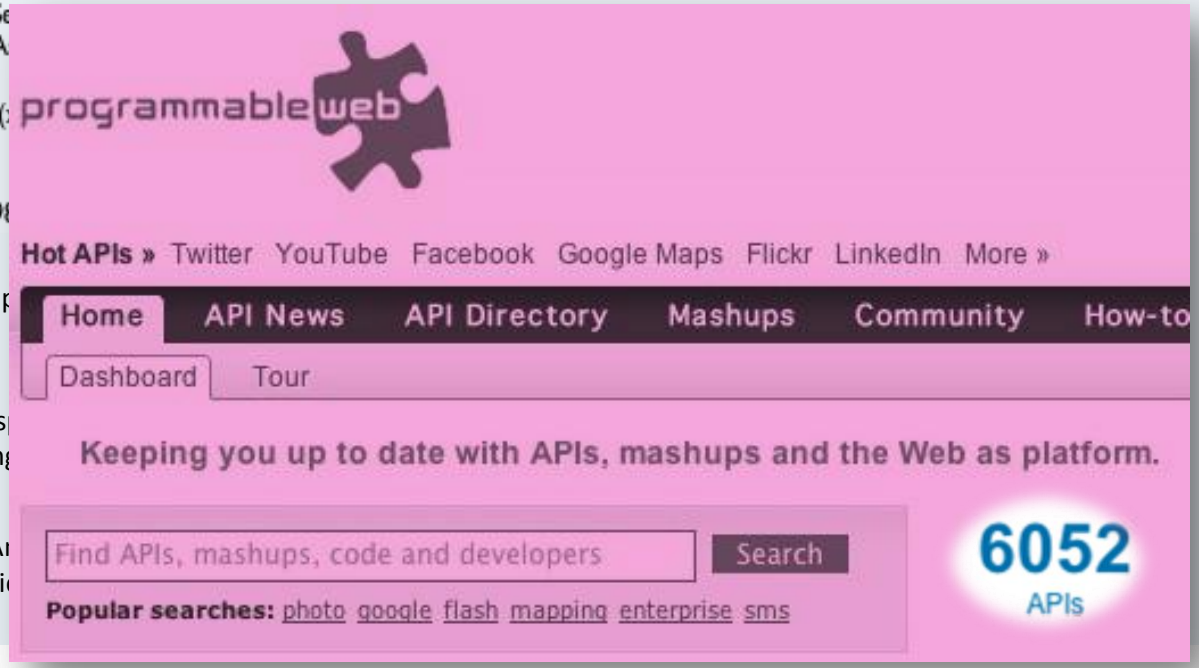
Sponge Permalink

An Entity of Type : Neighborhoods in Los Angeles, California, within Data Space : dbpedia.org

Type: yago:NeighborhoodsInLosAngeles,California Constrain facet

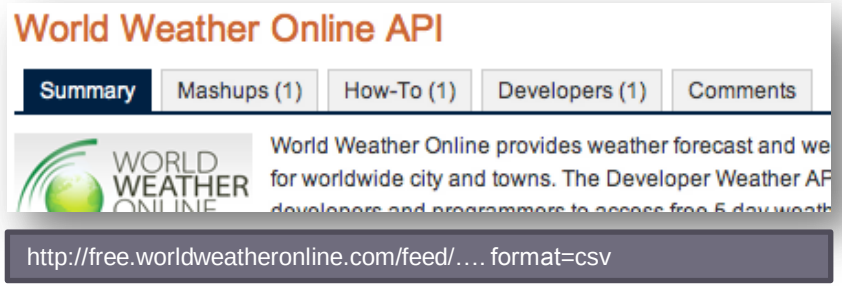
Downtown Los Angeles is the central business district of Los Angeles, California, United States, located close to the geographic center of the metropolitan area. The area features many of the city's major arts institutions and sports facilities, sightseeing opportunities, a variety of skyscrapers and associated large multinational corporations and an array of public art and unique shopping opportunities. Downtown is the hub of the city's freeway network and growing Metro rapid transit system.

leader title	City Council U.S. House State Se State A
population total	39537(
area total (km2)	8.538 13.739
Current temperature	73°F
Wind	10 mp
Humidity	51%
Dew Point	54°
Events	Trans Saving ...
Twitter Feed	Los An Plasti ...



Slide by Shubham Gupta

The Problem



Web-service Invocation request

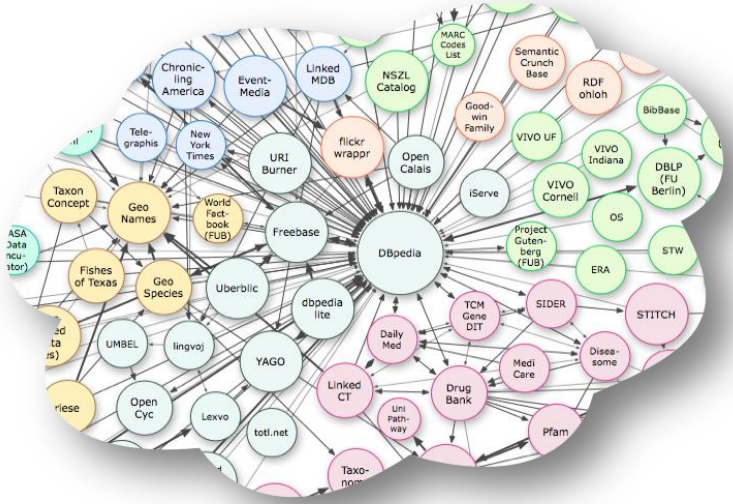
JSON/XML

?

?

RDF

RDF/SPARQL Query

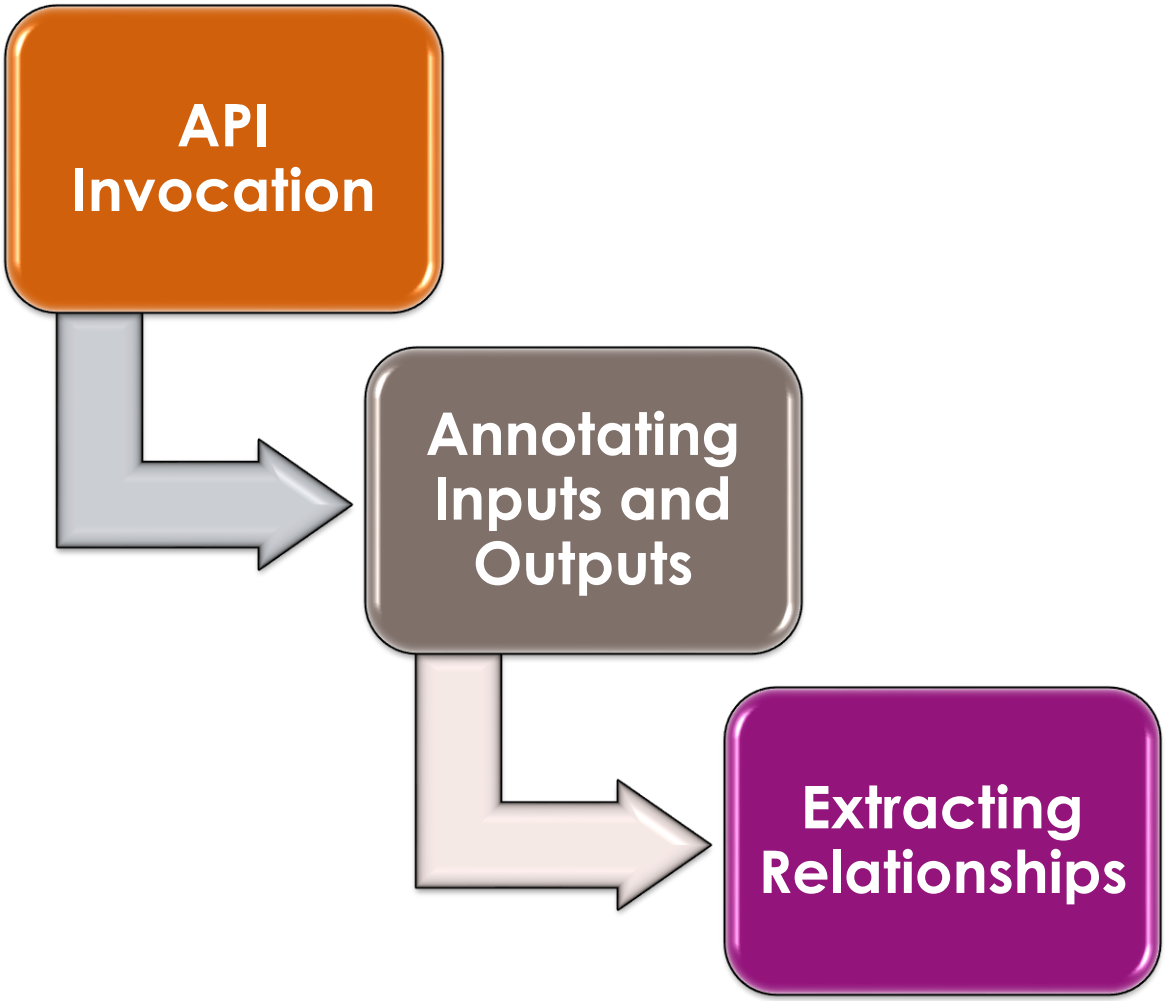


Slide by Shubham Gupta

Modeling APIs

- Input
  - Examples of the request URLs
  - Ontology
- Output
  - A semantic model of the API built interactively

Approach


API Invocation
Annotating Inputs and Outputs
Extracting Relationships

Service Invocation

Sample Request URLs

KARMA

example-requests

URL
http://example.com/weather?city=Irvine&state=CA
http://example.com/weather?city=Chicago&state=IL
http://example.com/weather?city=Miami&state=FL
http://example.com/weather?city=New+York&state=NY

Show: 10 20 50 records Previous Next

Invoking API

CITY	STATE	DATE	ICAO	TEMPERATURE	DEWPOINT	HUMIDITY	WINDSPEED	SKYCONDITION
Irvine	CA	1-Mar-12	KLOX	61	53	67%	07	Mainly clear
Chicago	IL	1-Mar-12	KMDW	54	48	45%	11	Some sun with spotty showers
Miami	FL	1-Mar-12	KMIA	60	57	60%	06	Turning cloudy
New York	NY	1-Mar-12	KJFK	27	26	70%	08	Mostly sunny

Previous Next

Inputs

Outputs

Slide by Mohsen Taheriyan

Annotating Inputs and Outputs

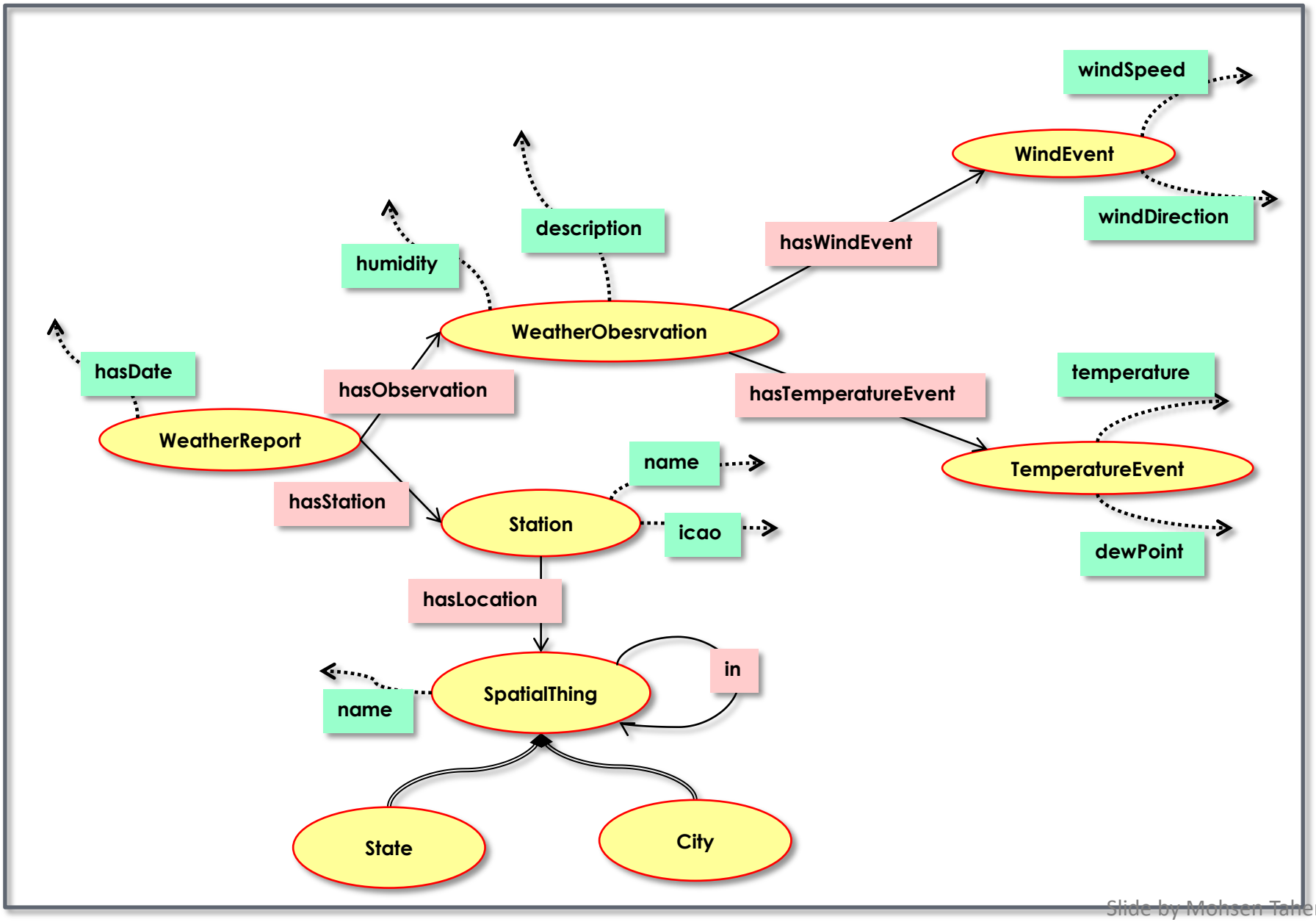
- Using Conditional Random Fields (CRF) to assign a *semantic type* to each column

- Semantic Types
  - Class
  - Data property and domain

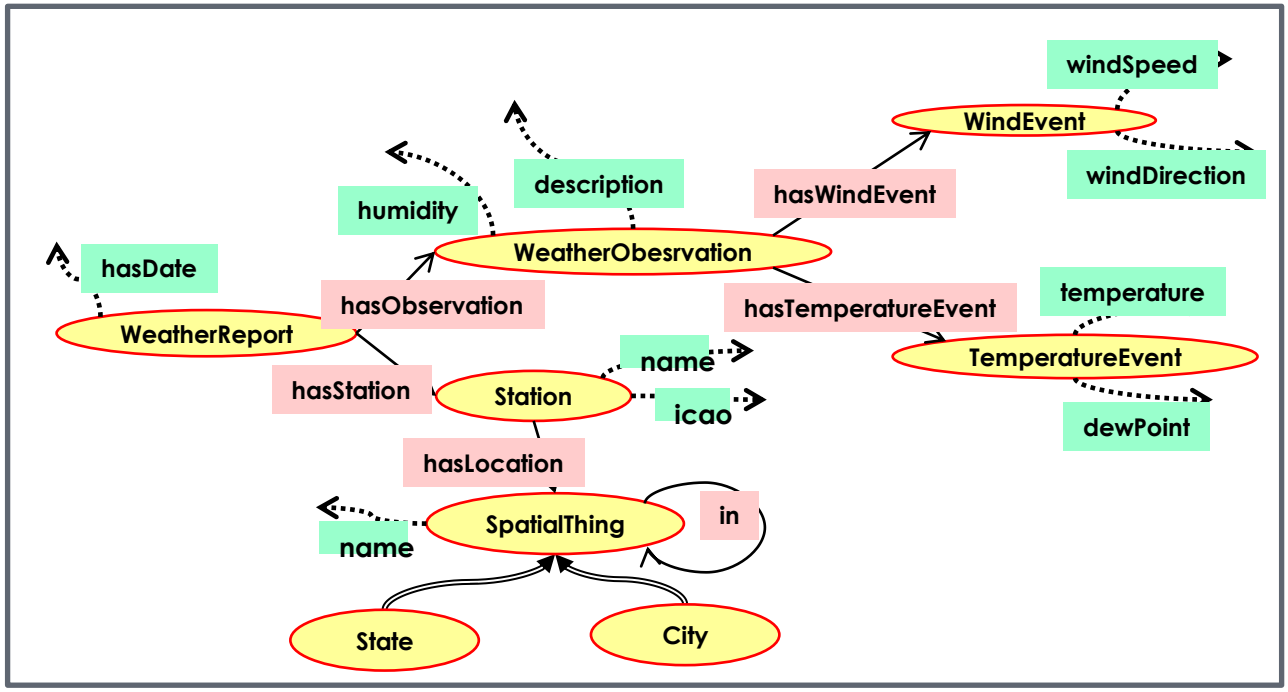
- Example
  - OWL Class: State
    - http://dbpedia.org/page/California
  - OWL Data Property, Domain class: State.name
    - Califonia

Slide by Mohsen Taheriyan

Weather Ontology



Slide by Mohsen Taheriyan



CITY	STATE	DATE	ICAO	TEMPERATURE	DEWPOINT	HUMIDITY	WINDSPEED	SKYCONDITION
Irvine	CA	1-Mar-12	KLOX	61	53	67%	07	Mainly clear
Chicago	IL	1-Mar-12	KMDW	54	48	45%	11	Some sun with spotty showers
Miami	FL	1-Mar-12	KMIA	60	57	60%	06	Turning cloudy
New York	NY	1-Mar-12	KJFK	27	26	70%	08	Mostly sunny

Previous Next

City.name

State.name

WeatherReport.hasDate

Station.ICAO

WeatherObservation.description

WindEvent.windSpeed

WeatherObservation.humidity

TemperatureEvent.tempeature

Wrong Label

TemperatureEvent.temperature

Slide by Mohsen Taheriyan

Extracting the Relationships

- Construct a graph from
  - Assigned Semantic Types
  - Ontology Graph
- Select minimal tree that connects all semantic types
  - A customized Steiner tree algorithm
- Steiner minimal tree (SMT)
  - $G=(V,E)$, $S \subset V$, $c: E \rightarrow \Re$ (S: Steiner Nodes)
  - Shortest network connecting vertices of T
  - Approximation Alg. [Kou & Markowsky, 1981]
    - $O(|V|^2|S|)$, Approximation Ratio: less than 2

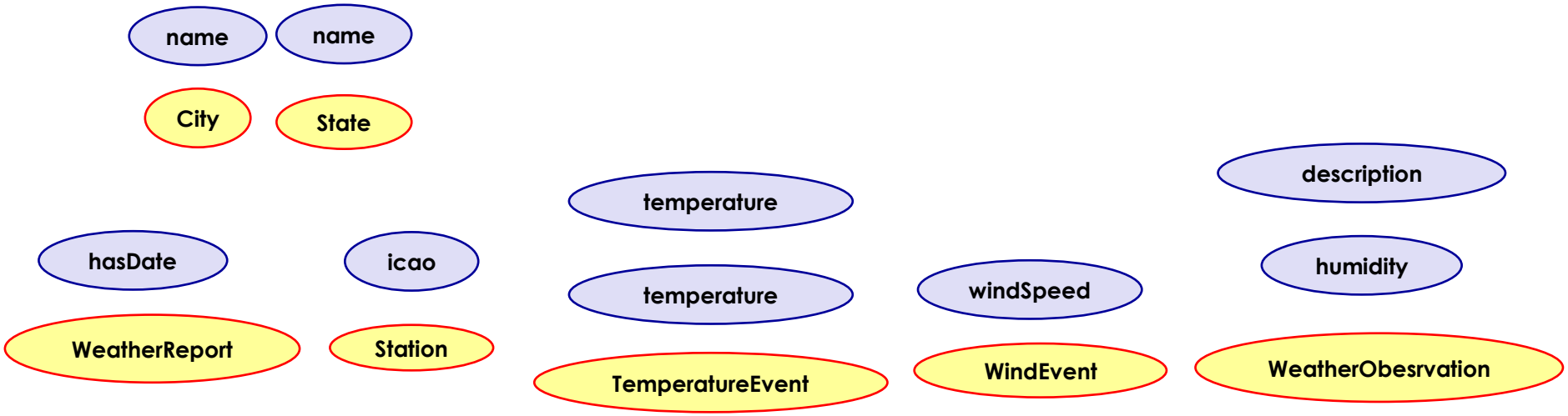
Slide by Mohsen Taheriyan

Constructing Graph

- Graph Initialization
  - Add one node for each semantic type
  - For data property types, also add the domain (if not added before)

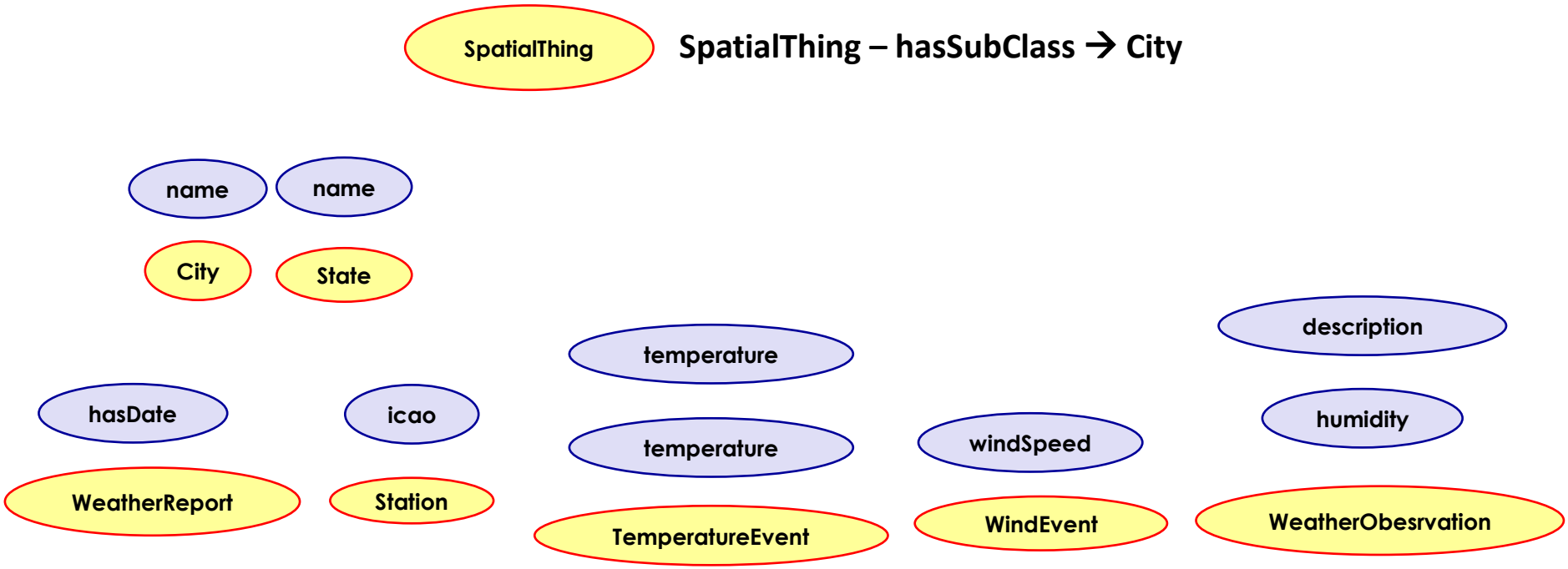
CITY	STATE	DATE	ICAO	TEMPERATURE	DEWPOINT	HUMIDITY	WINDSPEED	SKYCONDITION
Irvine	CA	1-Mar-12	KLOX	61	53	67%	07	Mainly clear
Chicago	IL	1-Mar-12	KMDW	54	48	45%	11	Some sun with spotty showers
Miami	FL	1-Mar-12	KMIA	60	57	60%	06	Turning cloudy
New York	NY	1-Mar-12	KJFK	27	26	70%	08	Mostly sunny

Previous Next



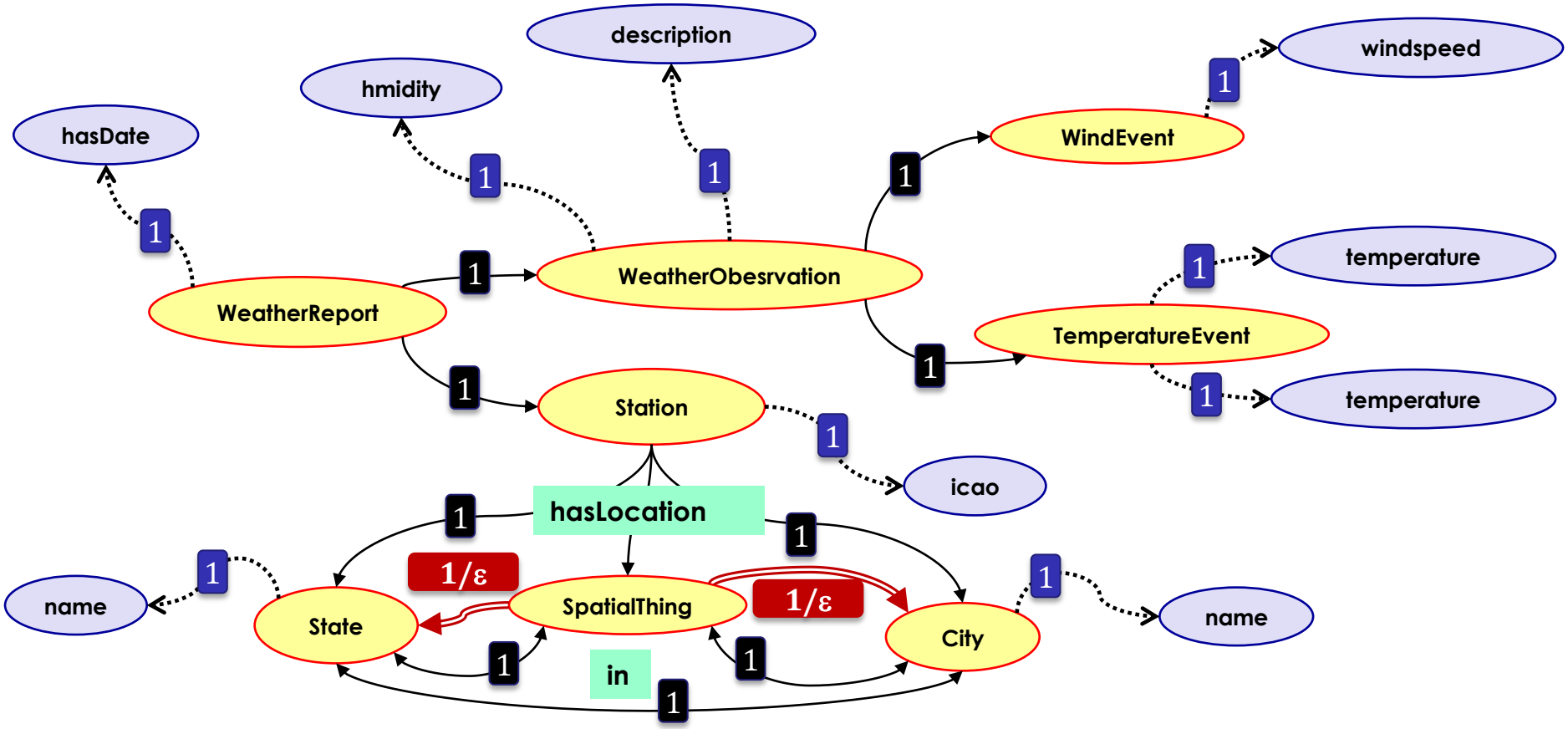
Constructing Graph

- Compute Nodes Closure
  - Object Property or hasSubClass relations

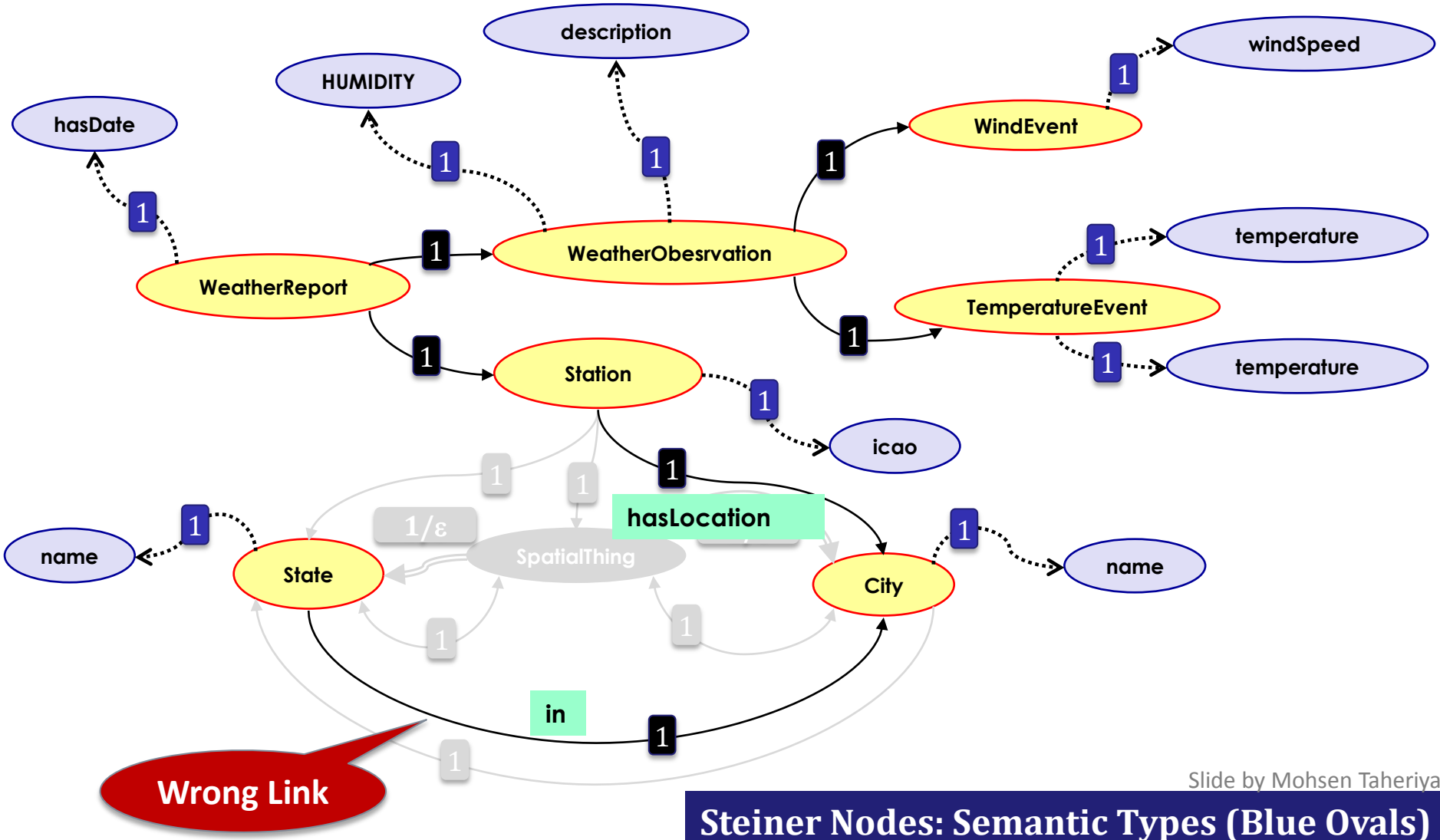


Constructing Graph

- Adding the Links
  - Put a link with w=1 from the domains to data property nodes
  - For every pair of class nodes like A and B:
    - Put a link with w=1 from A to B if there is a direct or inferred object property in the ontology
    - If B is a direct or inferred subclass of A, put a link with w=1/ε from A to B



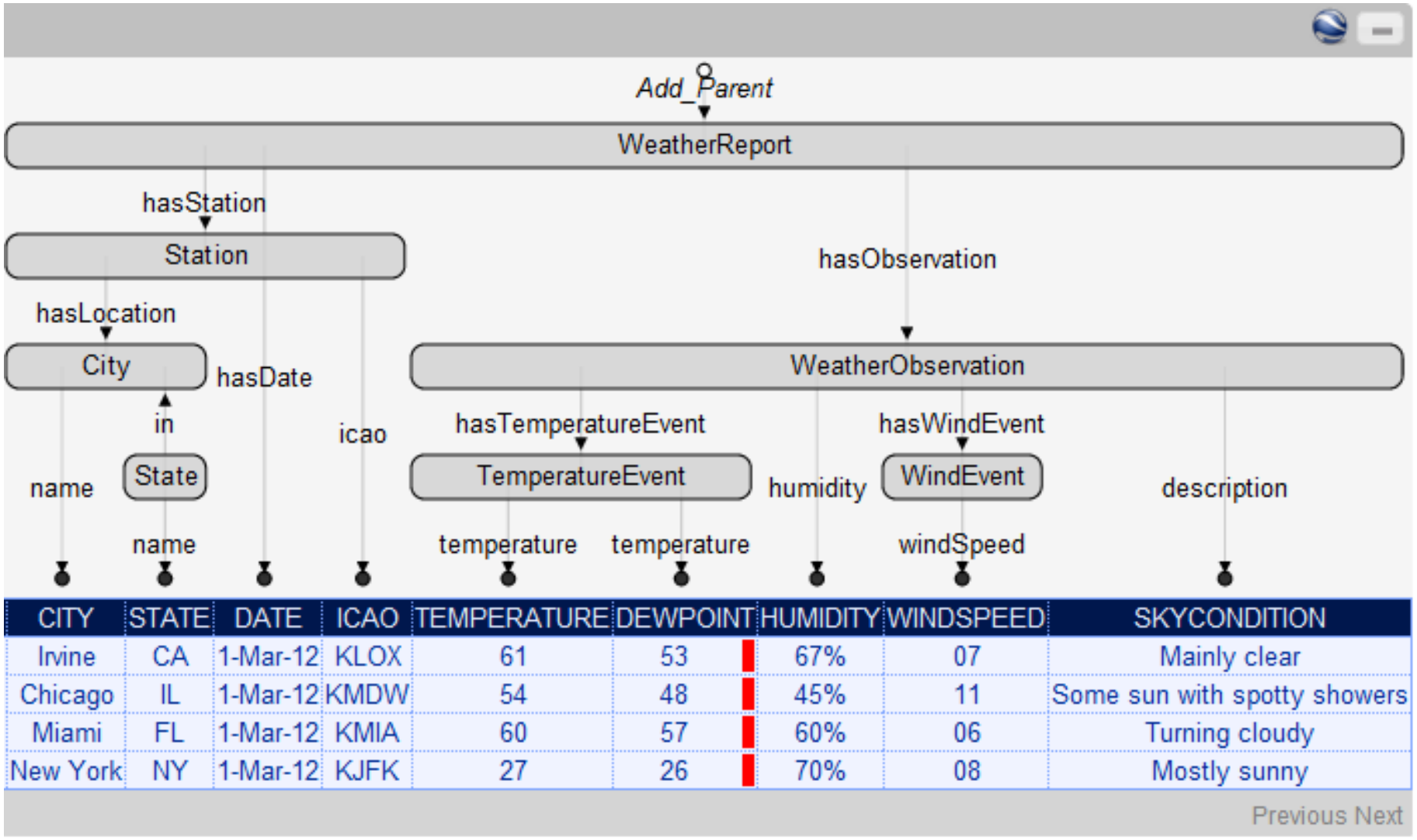
Steiner Tree



Slide by Mohsen Taheriyan

Steiner Nodes: Semantic Types (Blue Ovals)

Visualizing Model in Karma



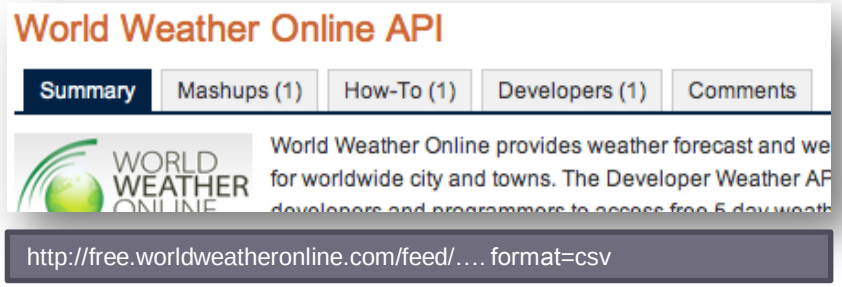
CITY	STATE	DATE	ICAO	TEMPERATURE	DEWPOINT	HUMIDITY	WINDSPEED	SKYCONDITION
Irvine	CA	1-Mar-12	KLOX	61	53	67%	07	Mainly clear
Chicago	IL	1-Mar-12	KMDW	54	48	45%	11	Some sun with spotty showers
Miami	FL	1-Mar-12	KMIA	60	57	60%	06	Turning cloudy
New York	NY	1-Mar-12	KJFK	27	26	70%	08	Mostly sunny

Previous Next

Slide by Mohsen Taheriyan

Status

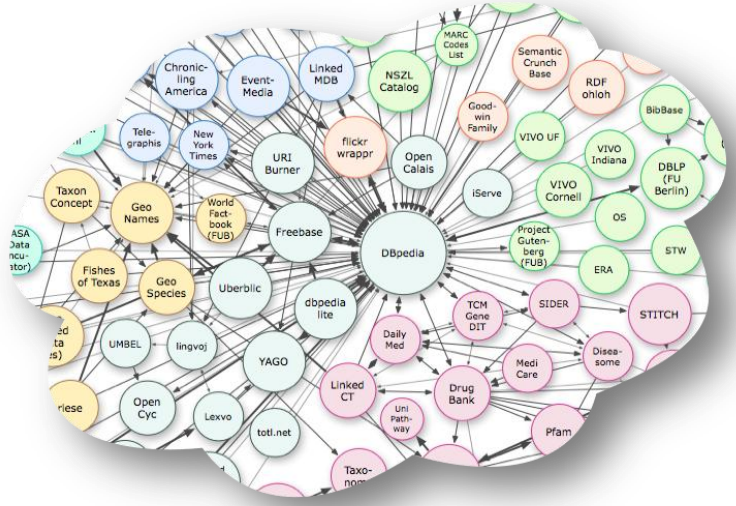
Web-service
Invocation request



JSON/XML

Karma

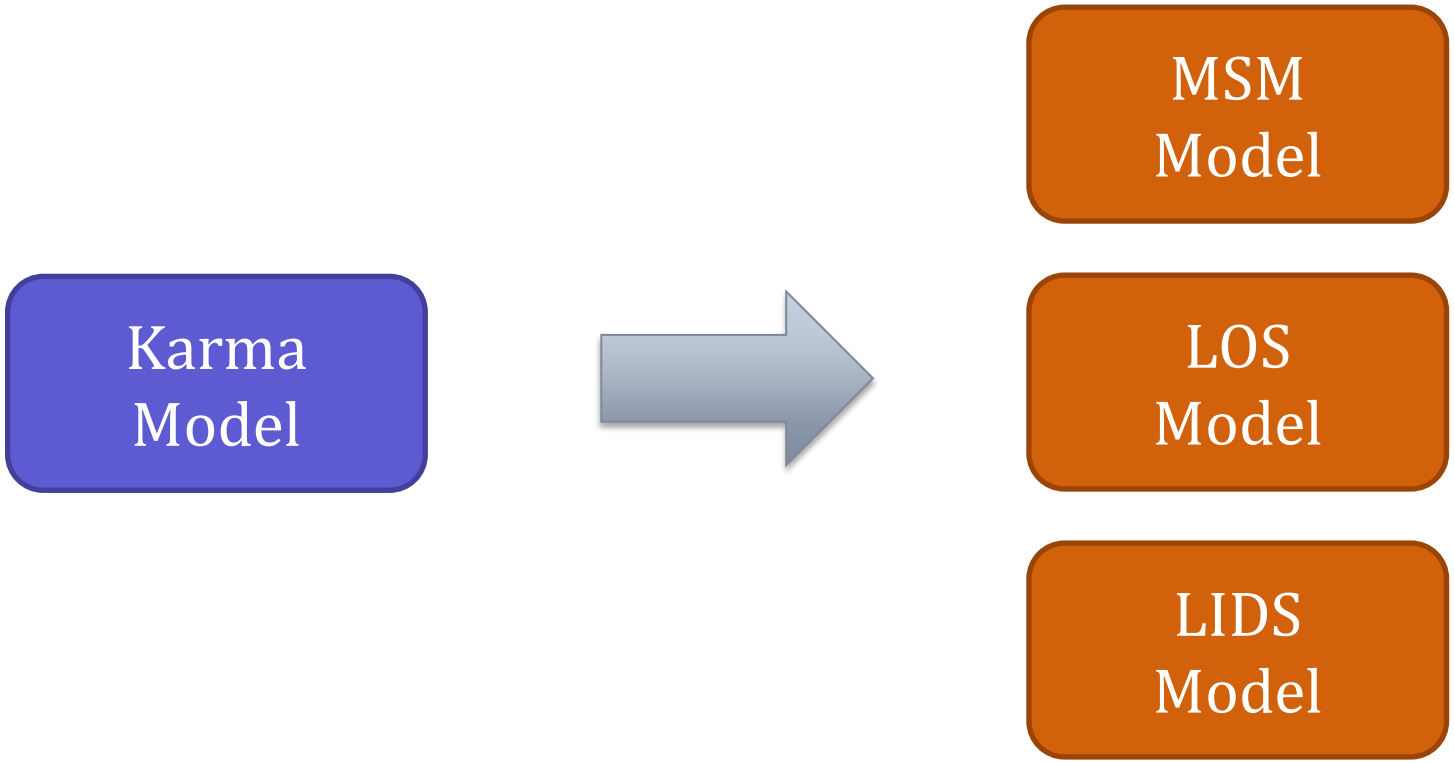
RDF/SPARQL Query



RDF

Slide by Pedro Szekely

Generate Other Models?



OPENLINK SOFTWARE

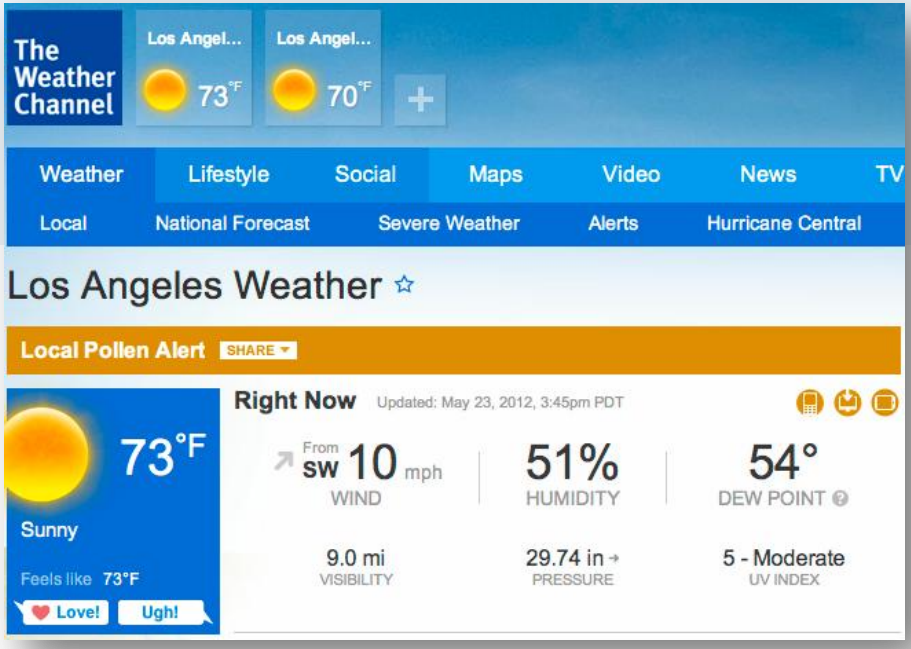
About: Downtown Los Angeles Sponge Permalink

An Entity of Type : Neighborhoods in Los Angeles, California, within Data Space : dbpedia.org

Type: yago:NeighborhoodsInLosAngeles,California Constrain facet

Challenge 1: Live Weather in DBPedia (For Every City)

leader title	City Council U.S. House State Senate State Assembly
population total	39537(xsd:integer)
area total (km2)	8.538 13.73988692533248
Current temperature	73°F
Wind	10 mph SW
Humidity	51%
Dew Point	54°



Slide by Pedro Szekely

OPENLINK SOFTWARE

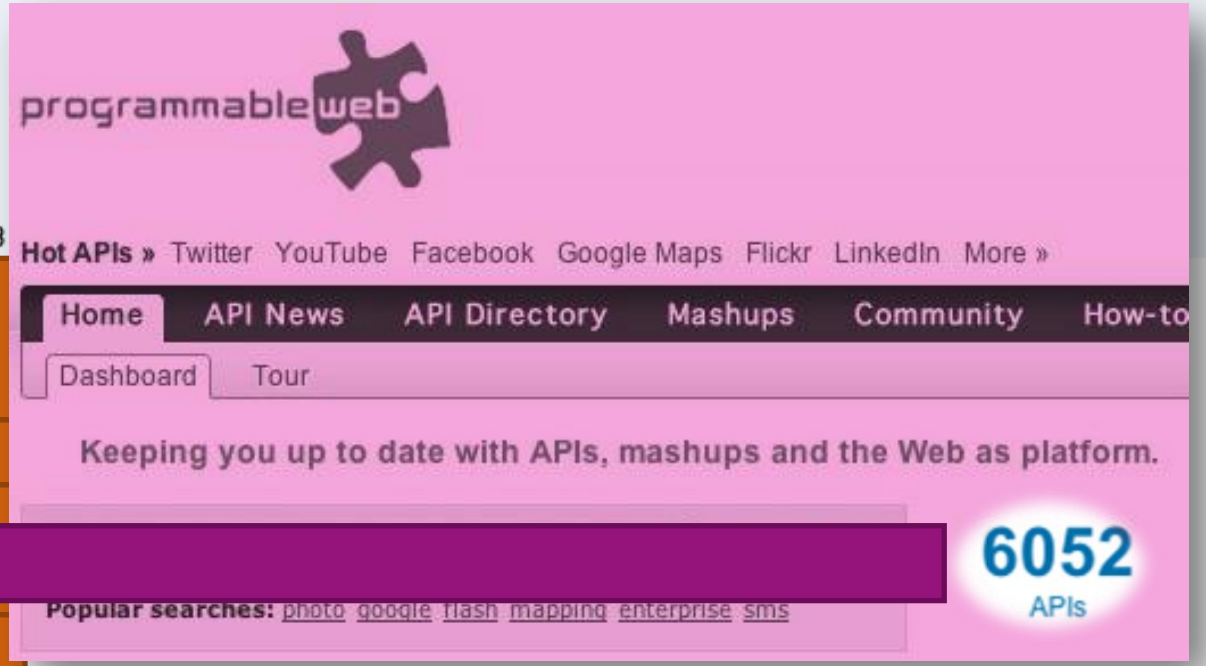
About: Downtown Los Angeles Sponge Permalink

An Entity of Type : Neighborhoods in Los Angeles, California, within Data Space : dbpedia.org

Type: yago:NeighborhoodsInLosAngeles,California Constrain facet

Challenge 2: Scale-Up

leader title	City Council U.S. House State Senate State Assembly
population total	39537(xsd:integer)
area total (km2)	8.538 13.73988692533248
Current temperature	73°F
Wind	10 mph SW
Humidity	51%
Dew Point	54°



Slide by Pedro Szekely