Mashup-based Linked Data Integration

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Agenda

1. Introduction
2. Linked Widgets Framework
3. Mashup Models
4. Conclusion and Future Work

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1. Introduction

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Motivation

CSV(lat, long, name, etc.)

980 parks in Vienna

XML(lat, long, Image URL)

Flickr/Google Image Search

JSON(lat, long, CO, NO_2, etc.)

Air quality data

CSV(lat, long, name, etc.)

51 public swimming pools in Vienna

?

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Motivation

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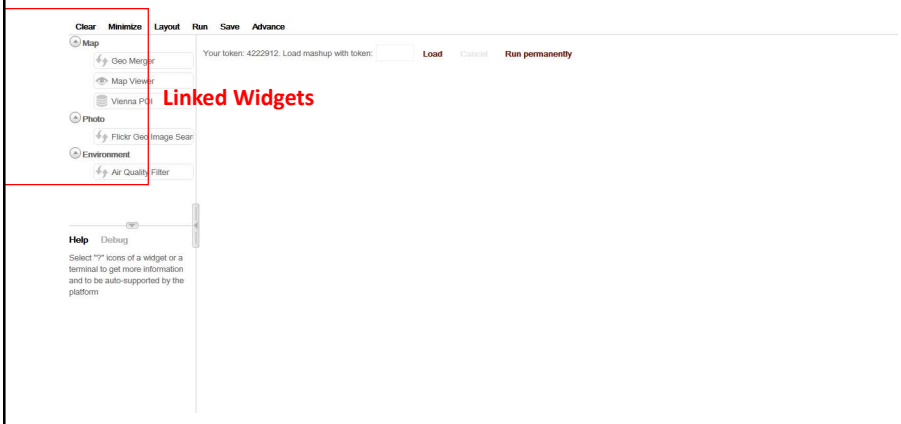
Modular approach for data integration



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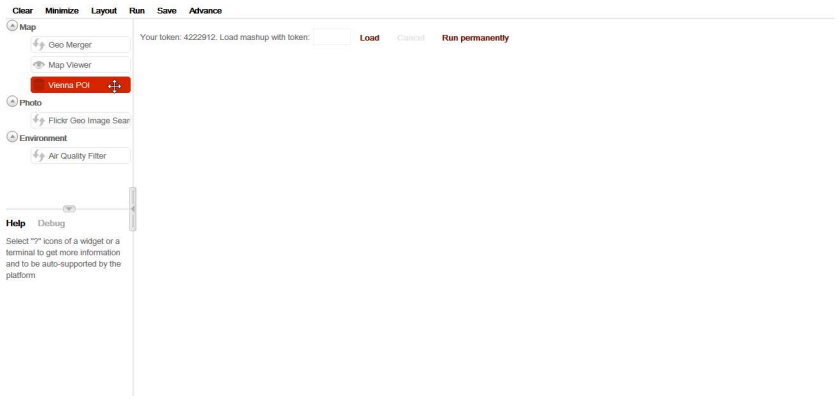

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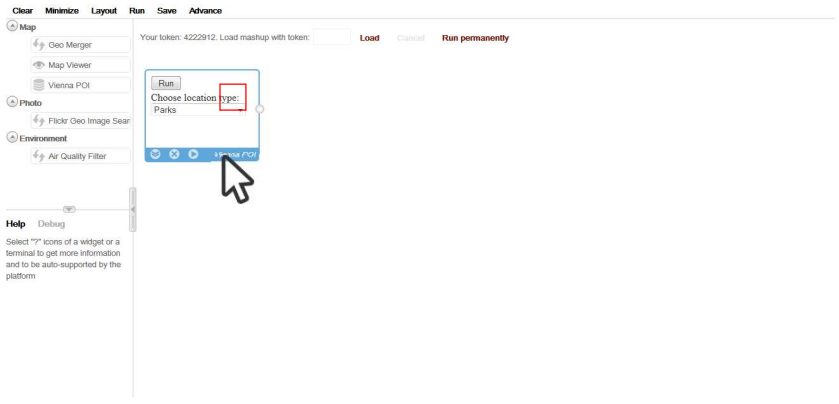

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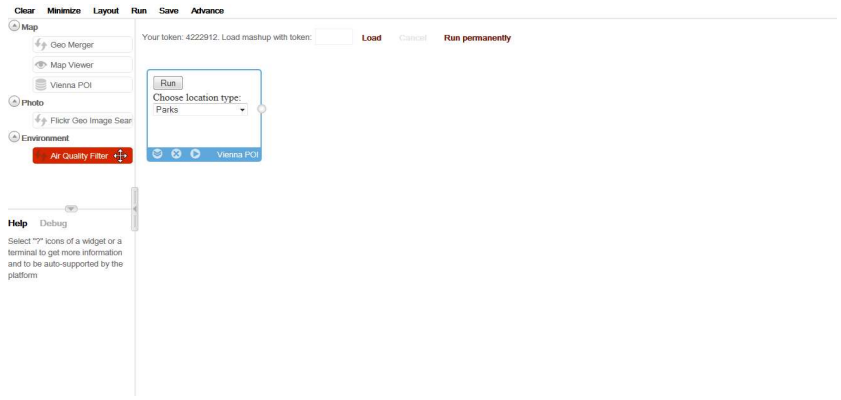
Modular approach for data integration



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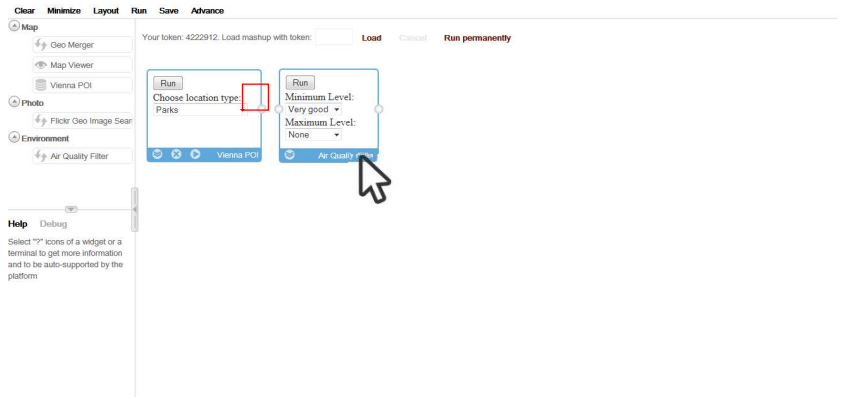

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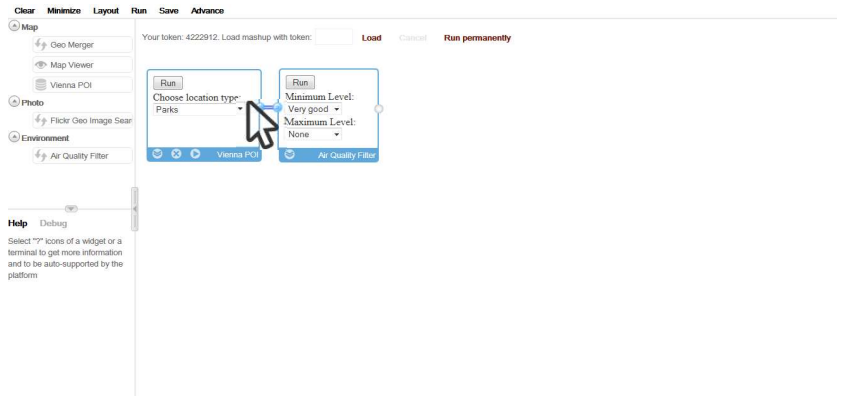

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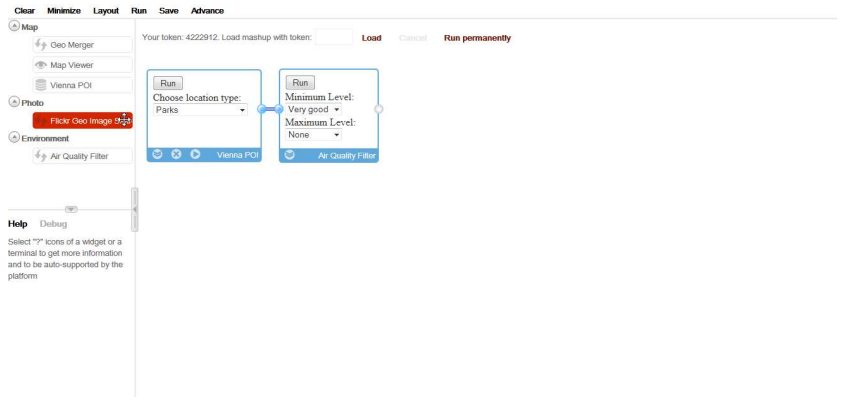

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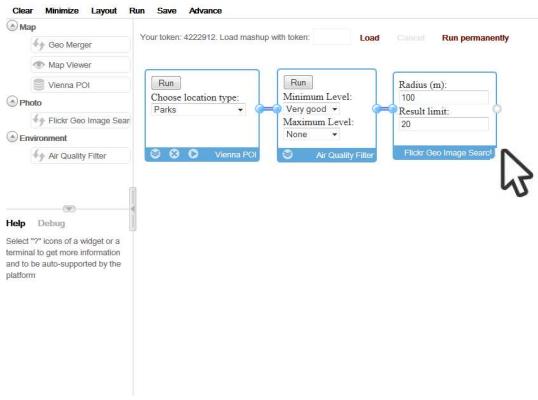

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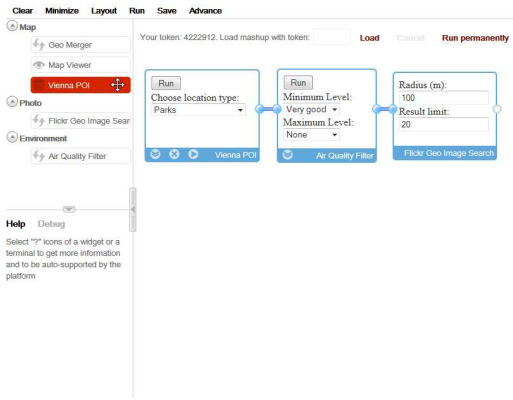
Modular approach for data integration



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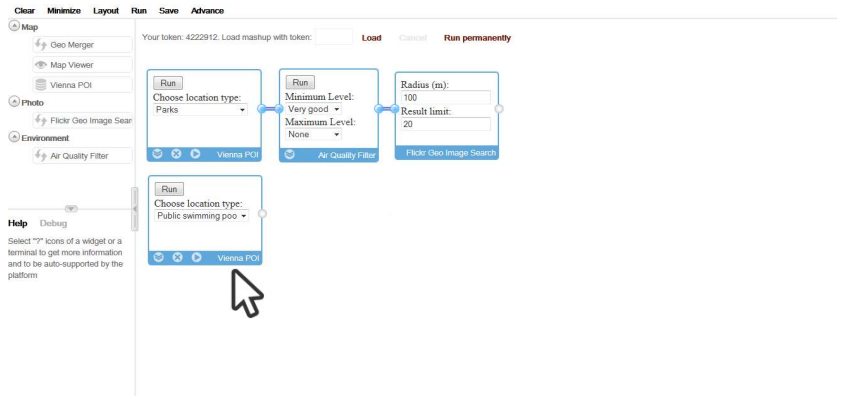

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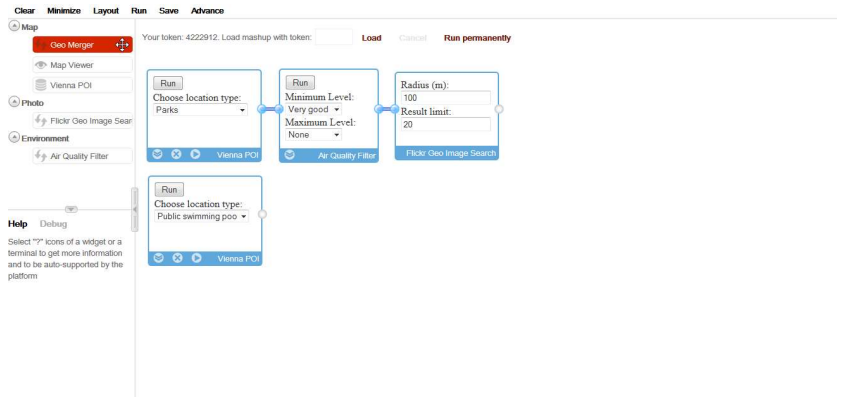

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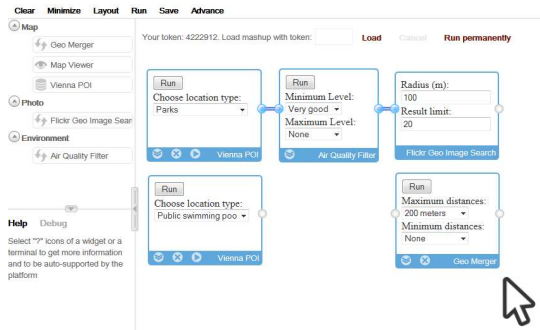

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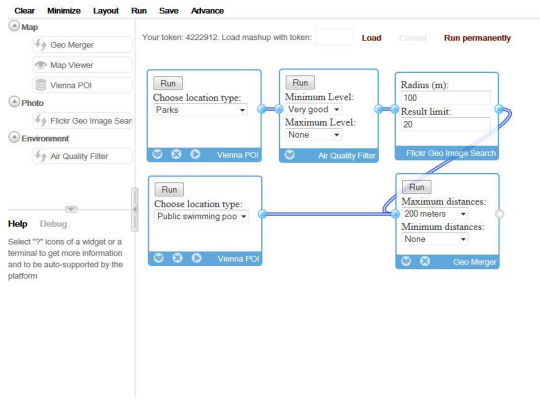

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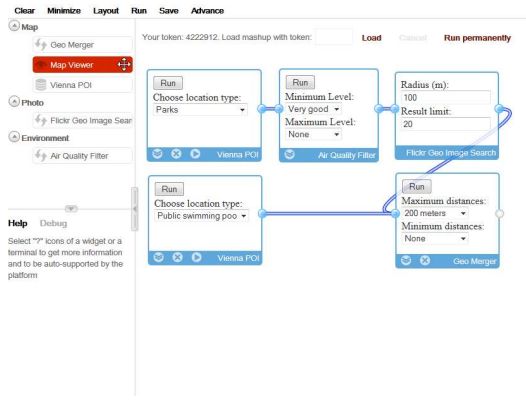

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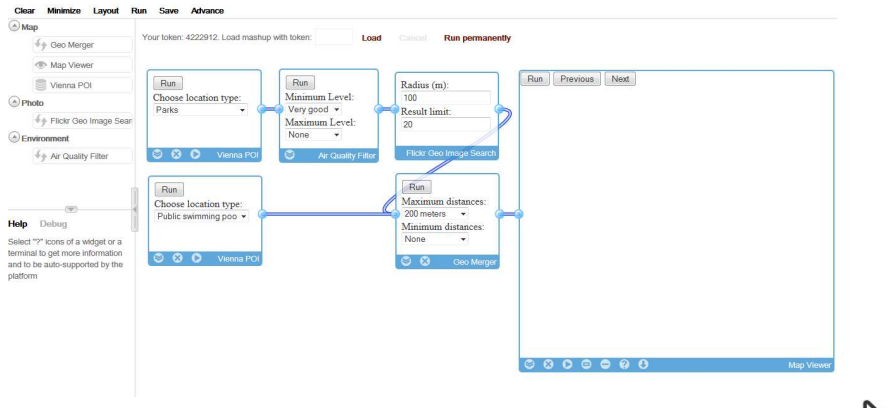

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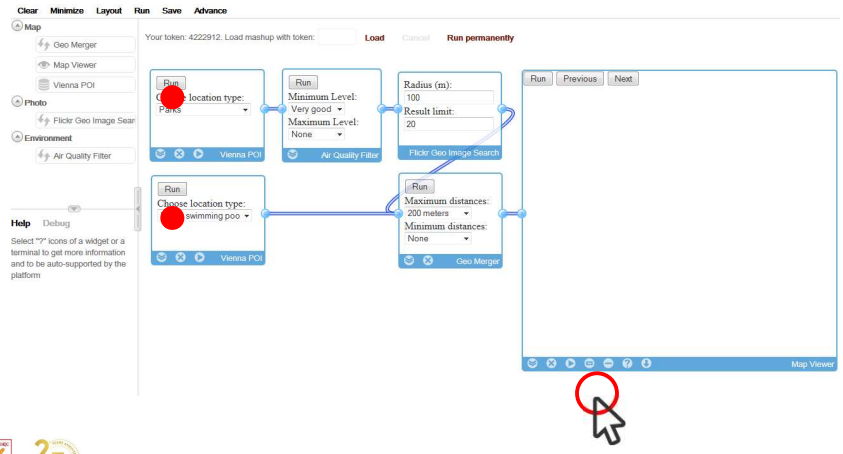

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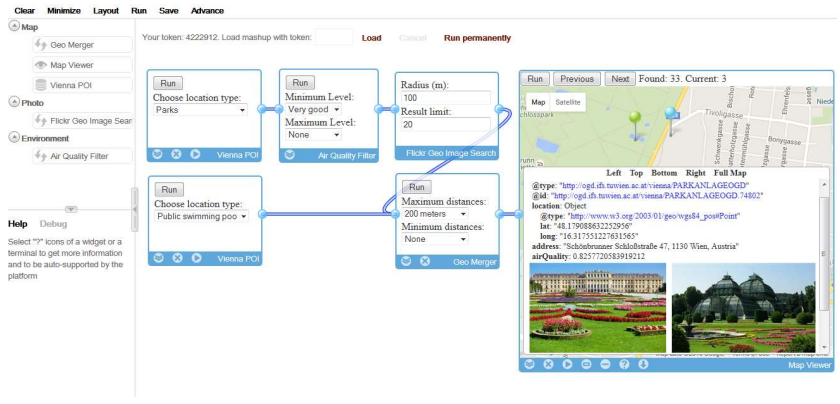

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Mashup-based data integration

- Mashups: innovative paradigm that "*combines data from multiple sources into an integrated and single graphical interface*" [1]
  - are quick, flexible, and cost-effective
  - turn users from content consumers to content providers

[1] Yu, J., Benatallah, B., Casati, F., Daniel, F.: *Understanding mashup development*. IEEE Internet Computing (2008)

Challenges of mashup-based data integration research

1. Collaborative work among end-user, data publisher and developer communities is not considered
2. Integrating data that is distributed in different devices and not available on the web is not considered
3. Semantic mashup – "*A data mashup using RDF(S) as data model*" [2] – is still in its early stage

[2] Endres-Niggemeyer, Brigitte. *Semantic mashups: Intelligent Reuse of Web Resources* (2013)

Research Question

How can non-expert users be enabled to explore and integrate heterogeneous data sources?

RQ1: *How is it possible to support non-expert users in addressing data heterogeneity?*

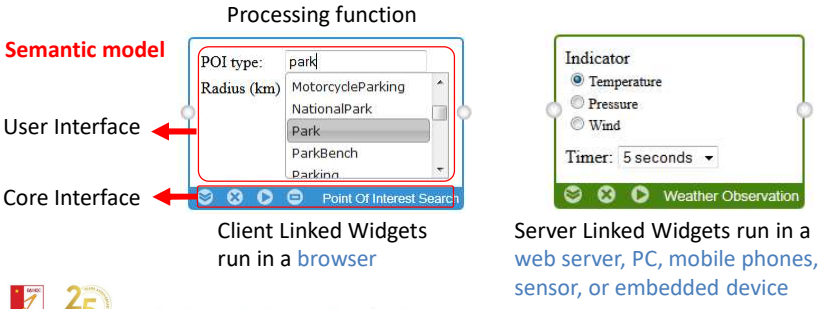
RQ2: *How can non-expert users be enabled to collaboratively integrate data?*

***RQ3**: How is it possible to automate the data exploration and integration process?*

2. Linked Widgets Framework

Linked Widgets

- extends W3C standard web widgets with a semantic model
- lift data sources to a semantic level to facilitate data processing
- can be created by independent developers, hosted on different servers



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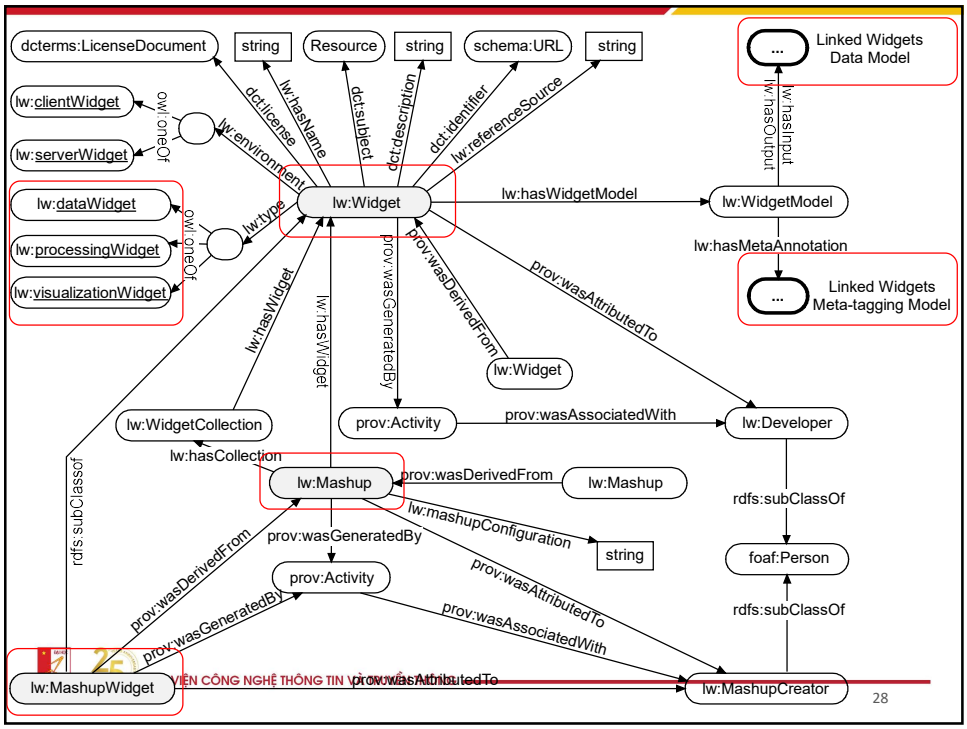

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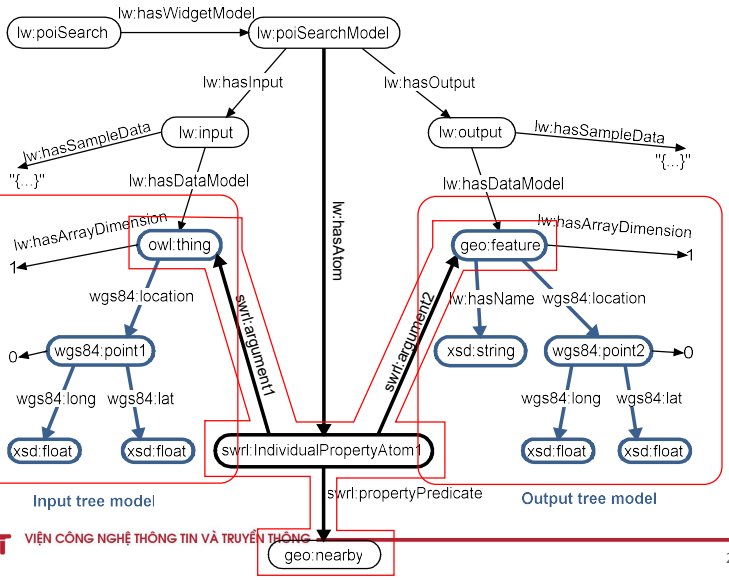
Example: Data model of the POI search widget



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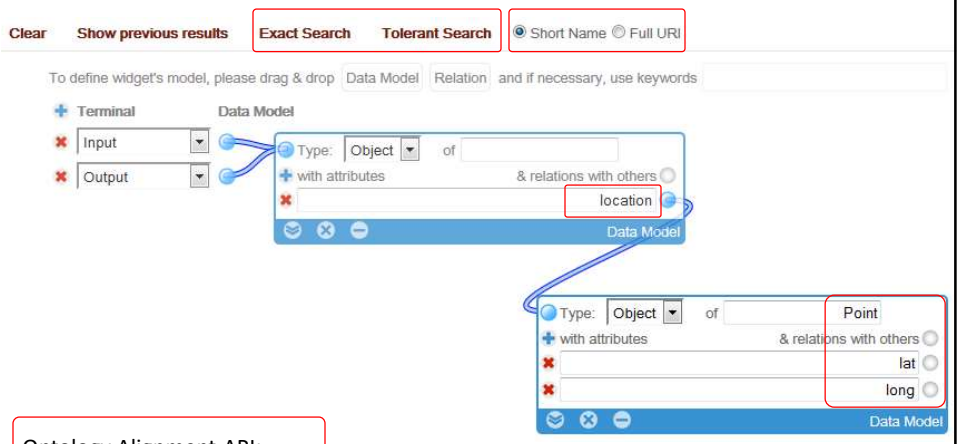
M1: Semantic Widget Discovery



Ontology Alignment API:
http://alignapi.gforge.inria.fr/

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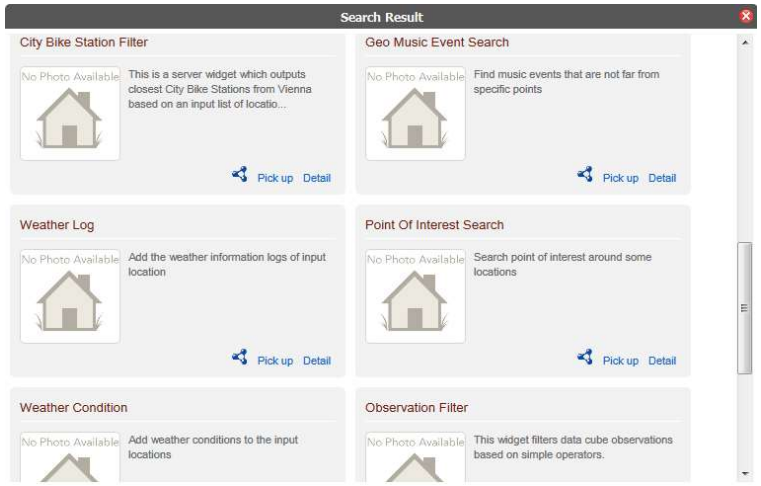
M1: Semantic Widget Discovery



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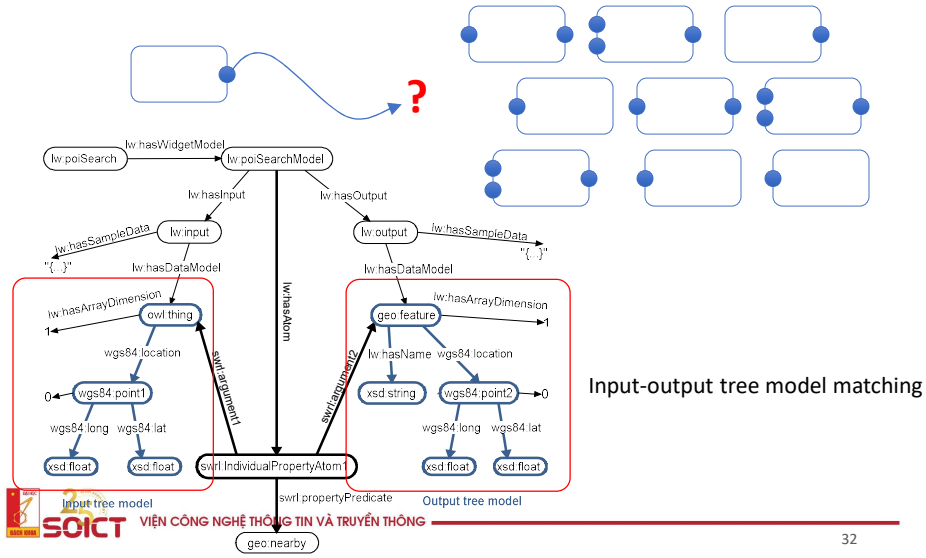
M2: Terminal matching



Input-output tree model matching

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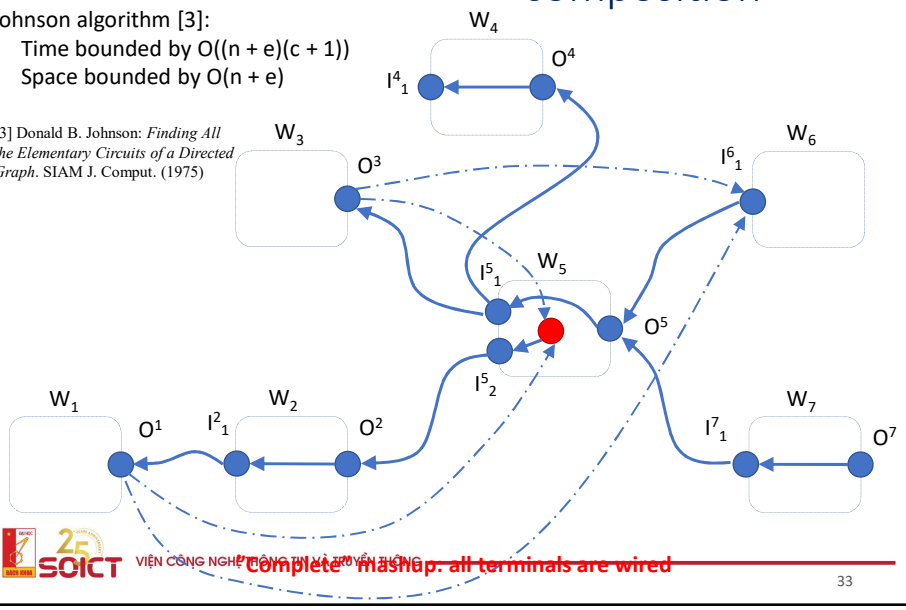
M3: Automatic mashup composition

Reduce "*automatic composition*" to "*list all cycles*" algorithm

Johnson algorithm [3]:
- Time bounded by O((n + e)(c + 1))
- Space bounded by O(n + e)

[3] Donald B. Johnson: *Finding All the Elementary Circuits of a Directed Graph*. SIAM J. Comput. (1975)



Complete mashup: all terminals are wired

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M4: Interactive tag-based composer

1. Define requirement → 2. Locate related widgets → 3. Execute automatic composition algorithm → 4. Rank and return mashups

Enter text + tie words to DBpedia (Wikipedia) resources

Restaurant nearby Bank

http://dbpedia.org/resource/Restaurant

http://www.geonames.org/ontology#nearby

http://dbpedia.org/resource/Bank

A bank is a financial intermediary that creates credit by lending money to a borrower, thereby creating a corresponding deposit on the bank's balance sheet etc.

Benefits of the semantic tagging techniques
- No ambiguity
- Multiple language

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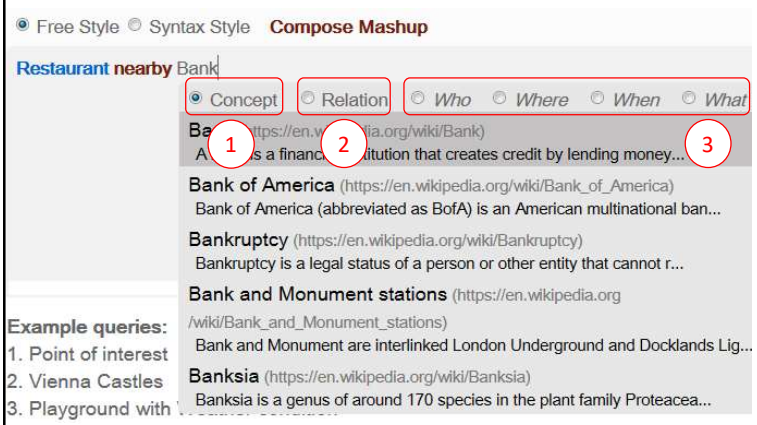
Define mashup requirement



1. Concept tagging (DBpedia concepts)

2. Relation tagging (LOD properties)

3. Entity tagging DBpedia entities

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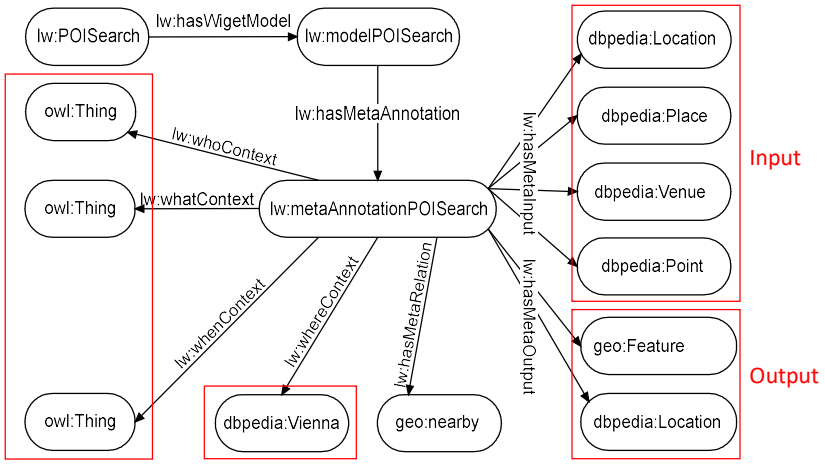
Meta-tagging model



lw http://linkedwidgets.org/ontologies/ **dbpedia** http://dbpedia.org/resource/
owl http://www.w3.org/2002/07/owl# **geo** http://www.geonames.org/ontology#

Example: Meta-tagging model of the Vienna POI Search widget

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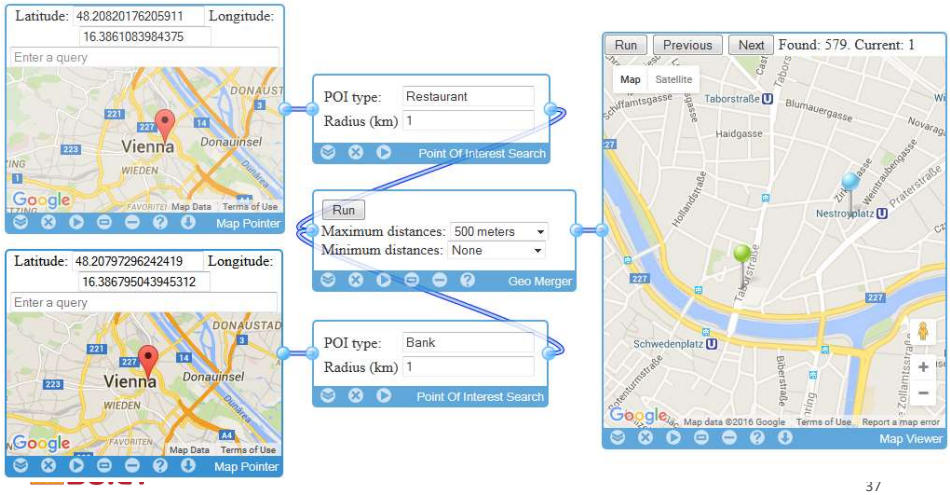
Example

4 widgets: Map pointer, Geo merger, POI search, Map viewer



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3. Mashup Models

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3. Mashup models

- Model 1: collaborative mashups
- Model 2: persistent mashups
- Model 3: streaming mashups
- Model 4: distributed mashups

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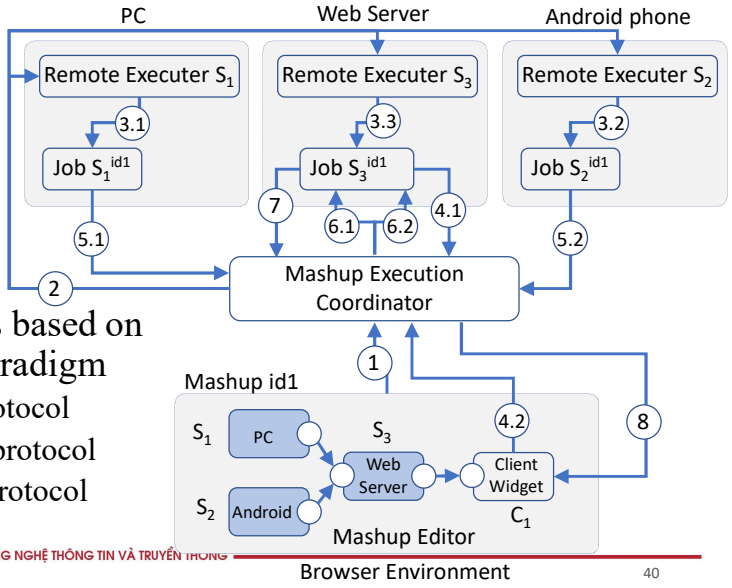
Linked Widget communication protocols



- 3 protocols based on Pub/sub paradigm
  - Local protocol
  - Remote protocol
  - Hybrid protocol

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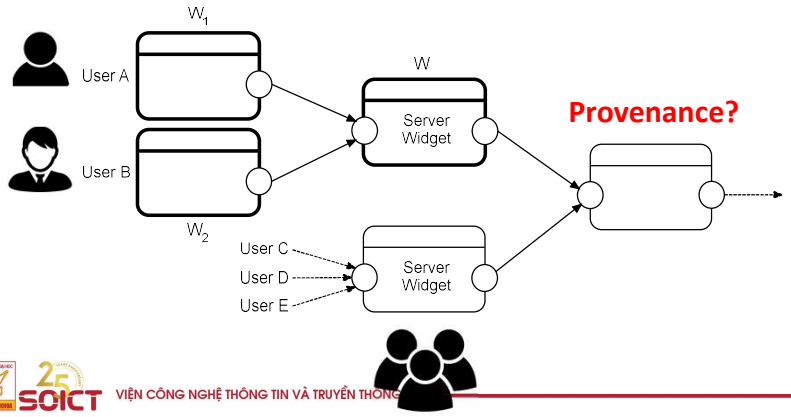
Model 1 – Collaborative mashups

- Mashups are created and/or operated by multiple users at the same time



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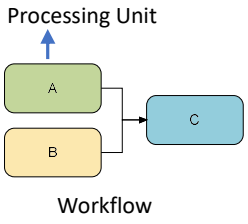
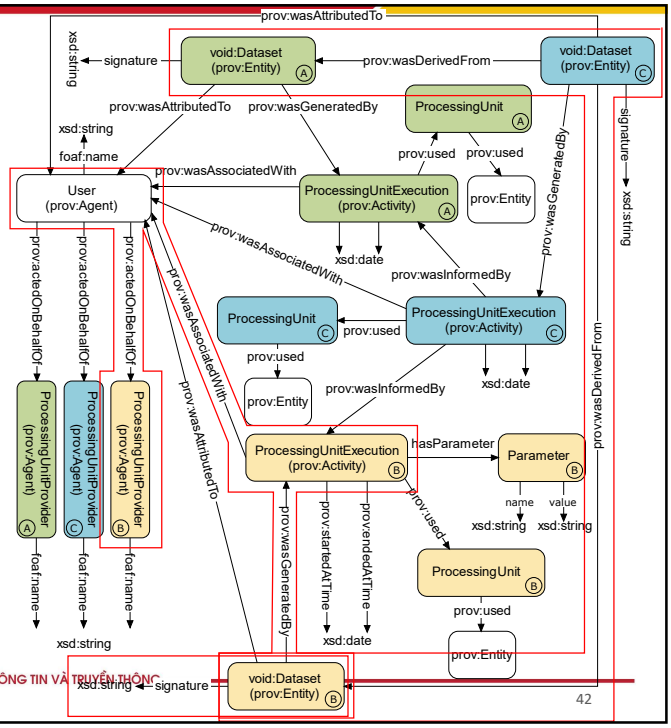
Provenance Model



The model is based on **PROV-O ontology**



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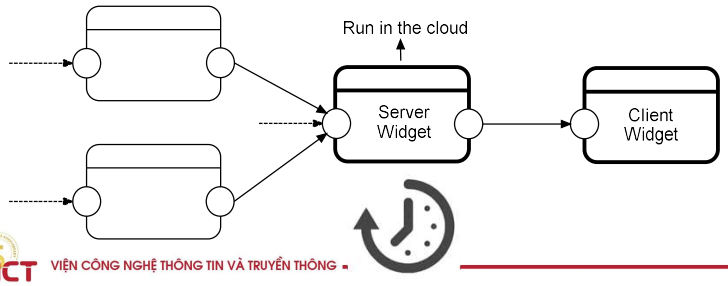
Model 2 – Persistent mashups

- run continuously in the background
- are useful for time-consuming data integration tasks



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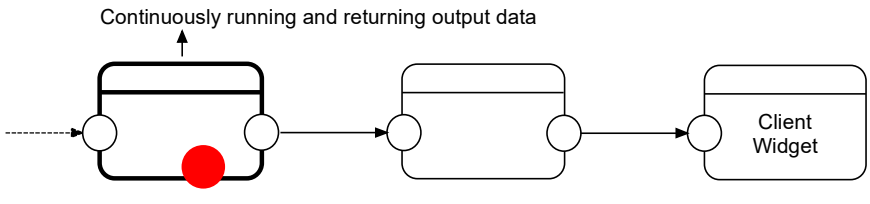
Model 3 – Streaming mashups

- Data is continuously flowing from a widget to others
- Streaming mashups are useful for data monitoring use cases.



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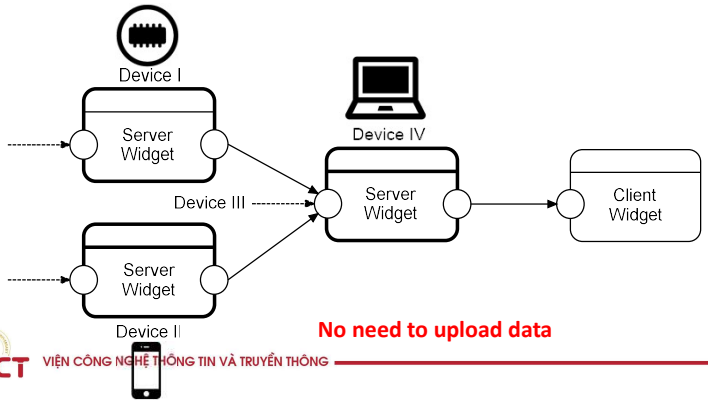
Model 4 – Distributed mashups

- Widgets are hosted by distributed nodes and devices
- Useful for integrating sensor data and data from embedded devices



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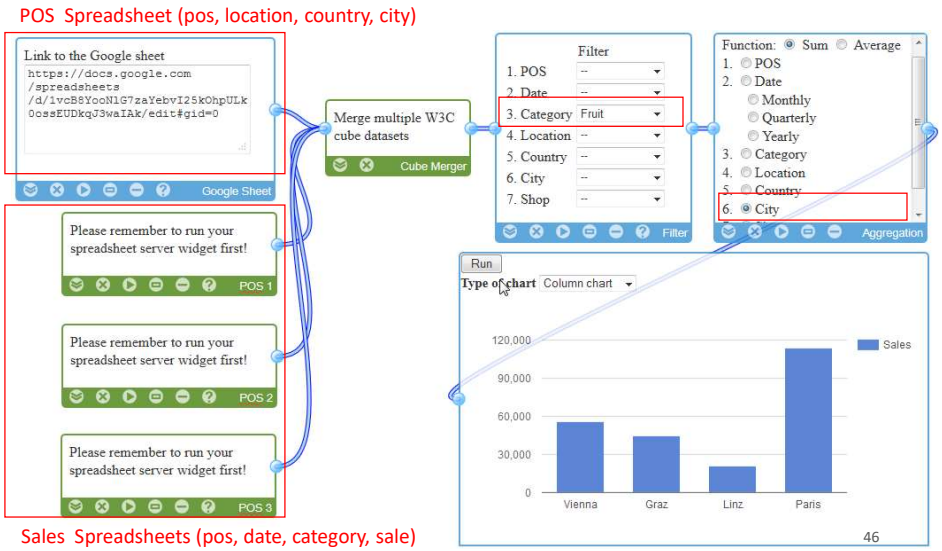
Distributed & collaborative mashup example: Combine and visualize sales data for a series of retail points of sale (POS)



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Conclusions

- Development of concepts combining semantic web and mashups
- Semantic model for widgets
- Facilitating collaborative work among end-user, data publisher and developer communities
- Introducing a new model of *semantic*, *distributed*, and *collaborative* mashups
- Running prototype: http://linkedwidgets.org