

# Using Sensors to Bridge the Gap between Real Places and their Web-based Representation

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# Outline

## 1. The Problem

- Gap between Web and Real Places
- Gap between Web and Sensor Web

## 2. Our Approach: G-Sensing

- Frontend Architecture
- Backend Architecture

## 3. Evaluation

- Deployment
- Coverage
- Performance

## 4. Conclusions and Future Work

# Between Web and Real Places



The screenshot shows the homepage of St. James's Hospital's website. At the top, there is a banner featuring a photograph of the hospital building's exterior. Below the banner is a navigation bar with links for HOME, PATIENTS, VISITORS, DEPARTMENTS, GPS & HEALTHCARE PROFESSIONALS, and CAREERS. A search bar with the placeholder "Enter your search queries here" and a "Search" button are also present. The main content area includes sections for Patients (Hospital appointments, Clinics A-Z, Consultants A-Z), Visitors (Visiting Hours, Getting here, Wards A-Z), and GPs & Healthcare Professionals (Newsletters, Lab services, Referral). A news sidebar lists recent updates and alerts. At the bottom, there is contact information and social media links.

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- > Hospital appointments 
- > Clinics A-Z 
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**Visitors**

- > Visiting Hours 
- > Getting here 
- > Wards A-Z 

**GPs & Healthcare Professionals**

- > Newsletters 
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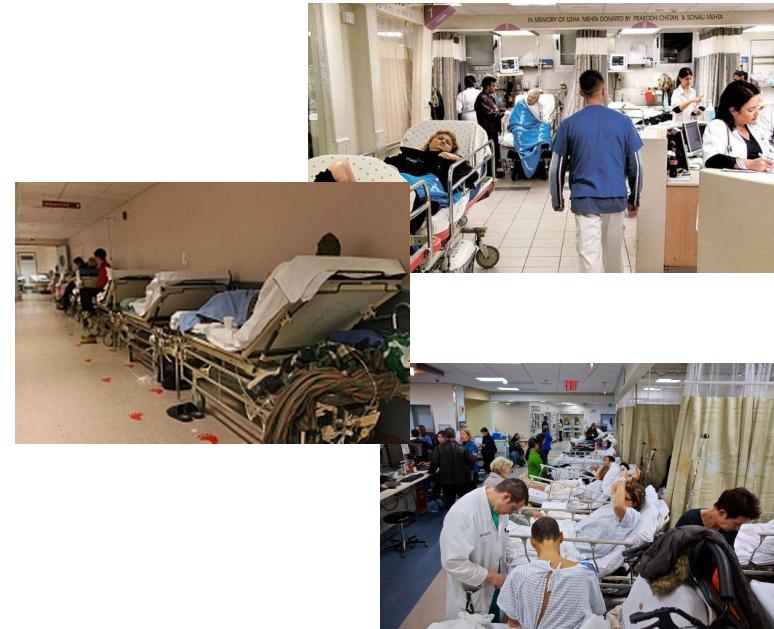
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Being sick is just your body's way of saying you're way too awesome and you need to slow down so everyone else can catch up.





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4.0 ★★★★★ 12 Google reviews

A James's Street

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B Elm Park

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(01) 221 4000

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C Beaumont Rd

Beaumont, Dublin 9  
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4.9 ★★★★★ 12 Google reviews

E Cork Street

Dublin 8  
(01) 408 5200

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[www.bonsecours.ie](http://www.bonsecours.ie)

Google+ page

F 9 Glasnevin Hill

Dublin  
(01) 837 5111

### National Maternity Hospital

[www.nmh.ie](http://www.nmh.ie)

4.4 ★★★★★ 10 Google reviews

G Holles Street

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(01) 637 3100

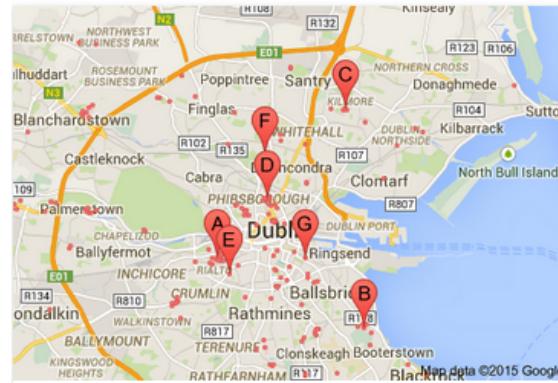
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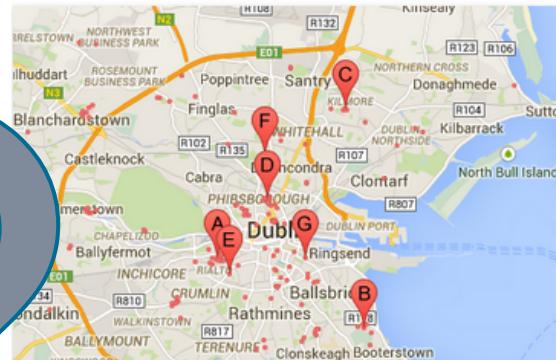
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- E Cork Street  
Dublin 8  
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Dublin  
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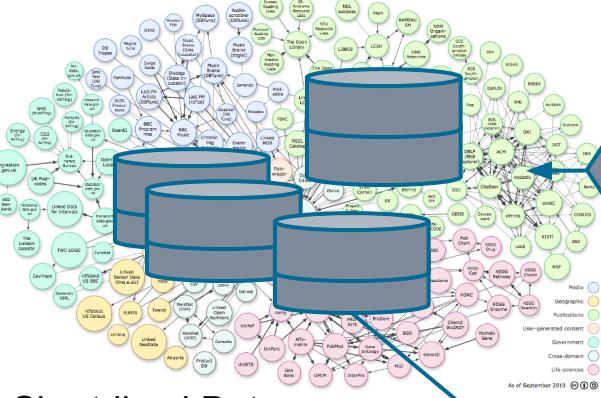
# Sensors provide real-world live data

But

What?

Where?

How?



Short-lived Data

Cost

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Long-lived Data

# G-Sensing

Seamless integration of live sensor data into a user's normal browsing experience

- Browser add-on
  - a. collects live sensor data from the backend
  - b. injects them into Google search result pages
- G-Sensing -enabled data source Requirements
  - a. expose SPARQL endpoint to query the data
  - b. provide semantically annotated sensor data
  - c. register on DataHub with its sensor tag metadata

= LD4S

# G-Sensing

1. Discovery of data sources
2. Extract search results referring to physical places
3. Live data fetching
4. Result dictionary update

**Algorithm 1:** *handlePageLoad(url)*

```
1 liveDataMap ← {};
2 if isGoogleSearchResult(url) = True then
3   searchResults ← extractSearchResults(url);
4   foreach result ∈ searchResult do
5     resultUrl ← result.url;
6     place ← requestPlaceData(resultUrl);
7     if place != ⊥ then
8       liveData ← requestLiveData(place.coords);
9       liveDataMap[resultUrl] ← liveData;
10    end
11  end
12 end
13 return liveDataMap;
```

# G-Sensing Frontend

Google  Search Sign in

Web Maps Images News Videos More ▾ Search tools Settings

About 4,950 results (0.27 seconds)

**Acupuncture TCM - Ideal For Pain Stress & Injuries**  
Ad lucytownsleyacupunctureclinicgalway.com ▾ 087 227 3084  
Depression Fertility & Lots More

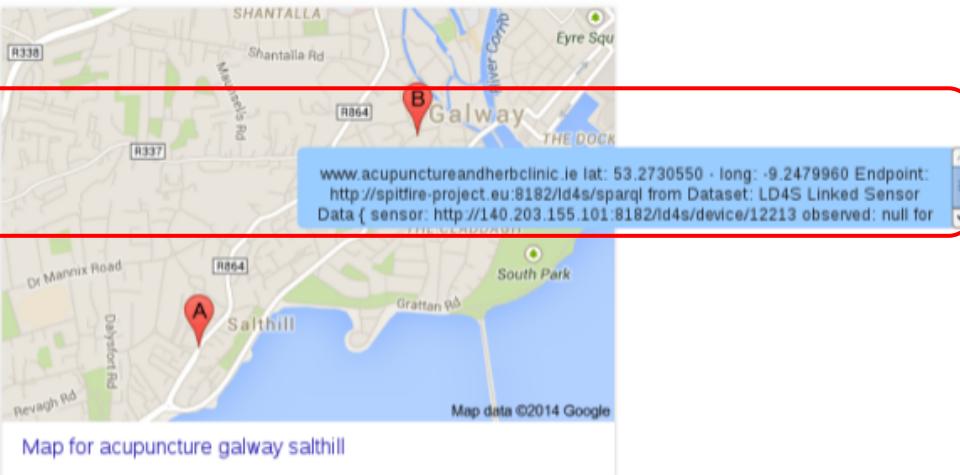
**Acupuncture & Chinese Herbal Medicine Clinic | Galway ...**  
[www.acupunctureandherbclinic.ie/](http://www.acupunctureandherbclinic.ie/) ▾  
Situated in Nile Lodge, Lower Salthill, the Acupuncture and Herb Clinic clinic first opened its doors in february 2002. Since then the clinic has specialised in ...

**Acupuncturist in County Galway | Yourlocal.ie**  
[www.yourlocal.ie/search/county-galway/acupuncturist](http://www.yourlocal.ie/search/county-galway/acupuncturist) ▾  
Chinese Medical Clinic. Acupuncture 1 Nile Lodge, Lower Salthill, Galway, County Galway. 087 799... 087 799... Website · Message now ...

**Salthill Therapy Clinic - Acupuncture Galway - Rate My Area**  
[galway.ratemyarea.com](http://galway.ratemyarea.com) > Health & Medical > Acupuncture ▾  
Aideen practices both 5-Element and 8-Principle Acupuncture. She treats a wide range of conditions including infertility, ante-natal care, Stress, Depression, ...

**Acupuncture Galway - Philip Lydon**  
[www.whatclinic.com](http://www.whatclinic.com)  
Google+ page

A Triskel Centre, 188 Upper Salthill Galway City, Galway



Map for acupuncture galway salthill

www.acupunctureandherbclinic.ie lat: 53.2730550 - long: -9.2479960 Endpoint: http://spitfire-project.eu:8182/id4s/sparql from Dataset: LD4S Linked Sensor Data { sensor: http://140.203.155.101:8182/id4s/device/12213 observed: null for

# G-Sensing Backend

- Specification-based sensor representation, storage and retrieval
- Resource Description Framework (RDF)
  - a. (semi-)structured data mixed, exposed and shared across data sources
- Ontology reuse principle
- OWL to support reasoning over concepts
- Linked Data principles
  - a. HTTP URLs
  - b. returning proper RDF description of the concepts
  - c. with RDF links to external resources
- SPARQL to query RDF graphs
  - a. in the form of subgraphs, URIs, blank nodes or literals

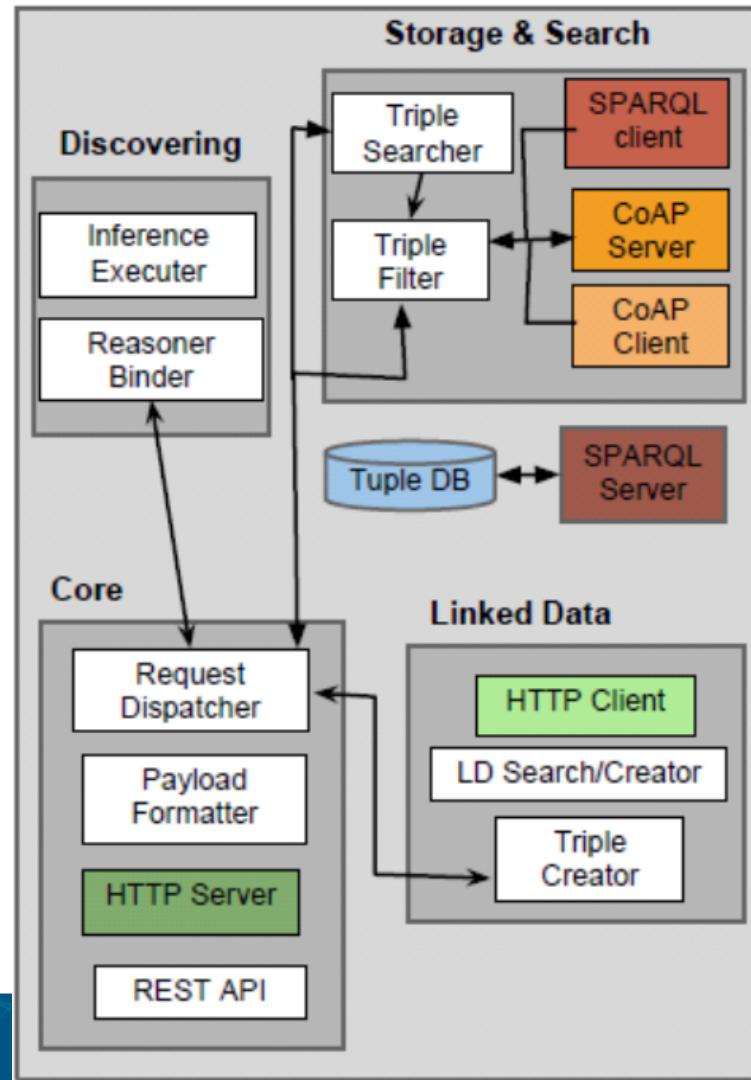
```
ld4s:sensorID12
  a spt:SensorTemporalProperty;
  ssn:featureOfInterest ld4s:parkingLot;
  spt:temporalOf ld4s:2_99;
  spt:tStart "2013-03-31T01:00:00Z"
    ^^xsd:dateTime;
  spt:tEnd "2015-05-31T01:00:00Z"
    ^^xsd:dateTime;
  dul:hasLocation ld4s:herbClinic.
ld4s:herbClinic
  a ssn:Place.
```

## No Ambiguity + Cross-dataset querying

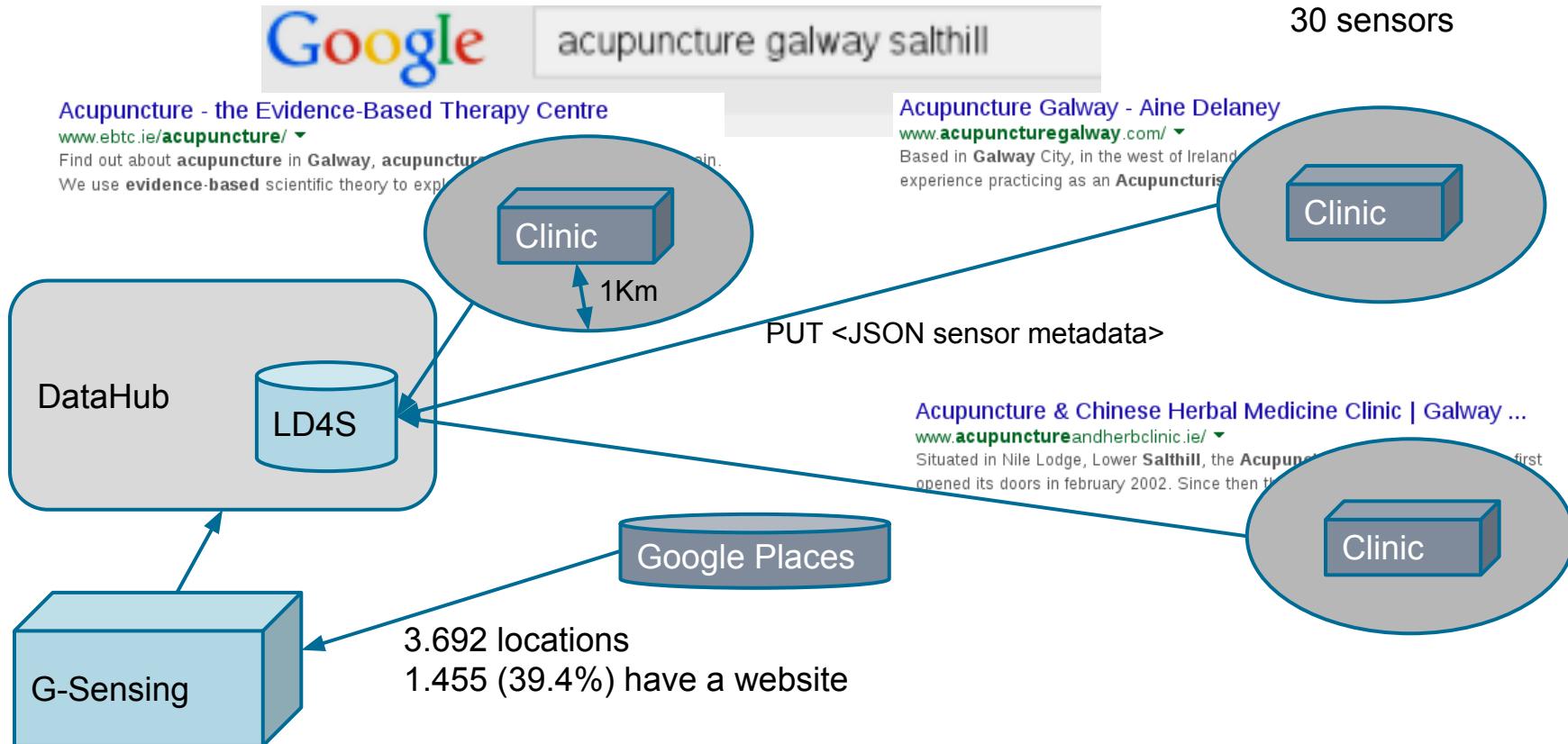
# G-Sensing Backend

## LD4S

- JSON Web-service
- automated annotation and linking for sensors
- alternative custom link creation
  - domain and/or context-related criteria )to search for linkable resources
  - RDF predicate used to express the linking criteria
    - e.g., spt:sameTime, spt:sameSpace
  - relying on Sindice search engine API
- RESTful API + GUI
- SPARQL endpoint published on DataHub

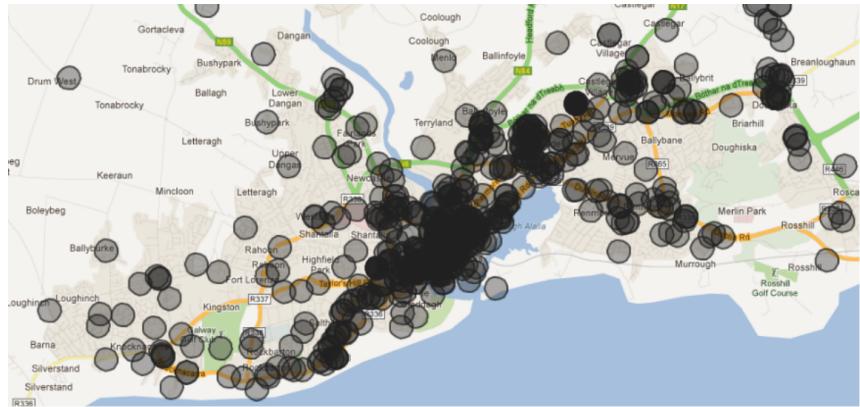


# Evaluation - Deployment

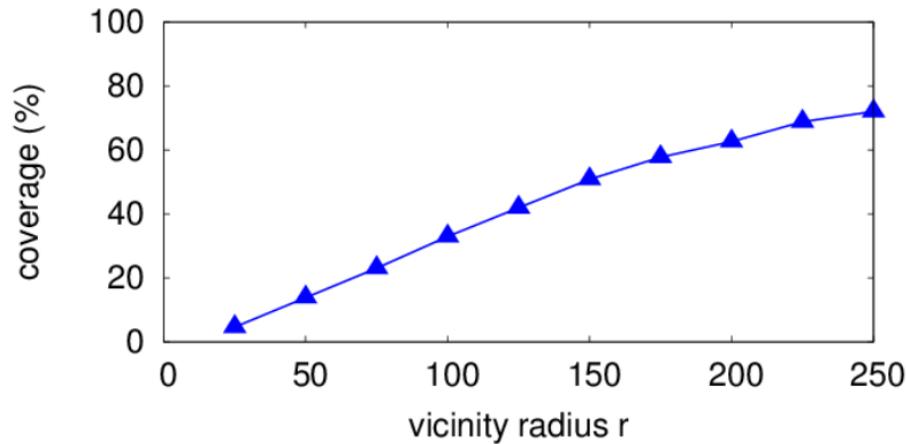


# Evaluation - Coverage

Added value of our approach for integrating live data into physical locations' websites:  
distribution of physical locations' websites

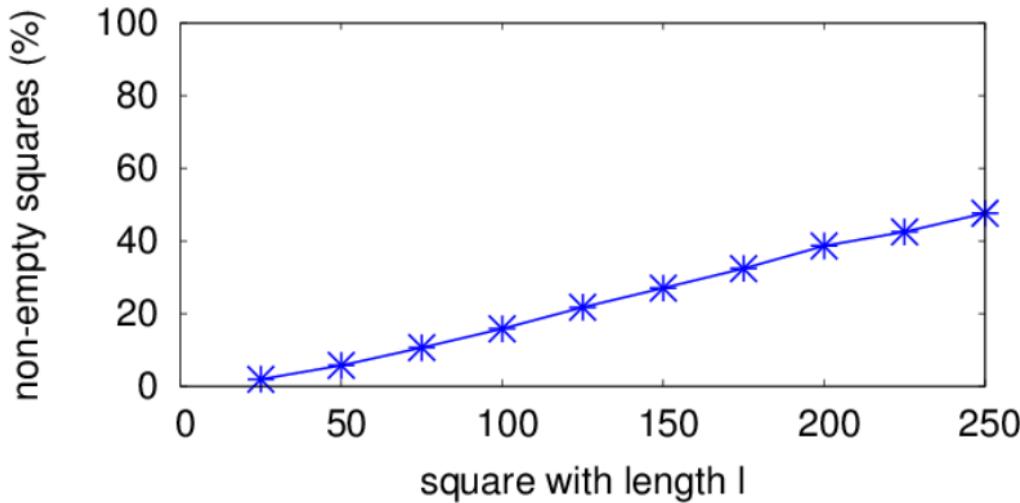


How much of the area defined by the virtual locations  
overlaps with the city of Galway  
within radius  $r=150m$



Coverage percentage as we vary the  
vicinity radius

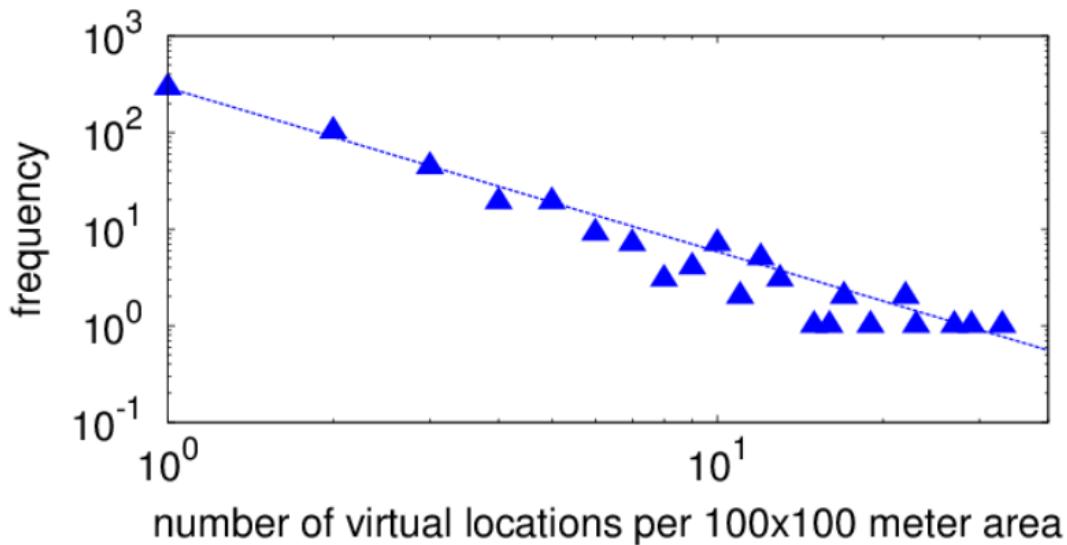
# Evaluation - Coverage



- We divided the areas of Galway divided into squares with different side lengths  $l$
- We counted the number of virtual locations within each square.

# Evaluation - Coverage

Distribution of non-empty squares for  $l = 100m$



- # virtual locations per square and their respective frequency shows a power-law relationship
- while most squares only contain a small set of locations, a few squares contain a very large number of locations
- (e.g., city centres, business parks).

# Evaluation - Performance

## G-Sensing does not impede on a user's browsing experience

### Bandwidth Overhead

- Google search result page: ~145 KB
- After enabling G-Sensing: ~175 KB (~20% increase)

### Response Time

- At browser start-up: query to DataHub for data source discovery: 3 ms
  - 20 sensor datasets discovered
  - 3 sensor datasets have an open license + expose a SPARQL endpoint
  - 1 sensor dataset's SPARQL endpoint was accessible (LD4S): 246 ms

```
SELECT ?sens ?starttime ?endtime ?obs
?foi ?value ?location
{ ?sens spt:obs ?obs .
  ?ov spt:outOf ?sens ;
    spt:value ?value ;
    spt:tStart ?starttime ;
    spt:tEnd ?endtime .
  ?tsp spt:temporalOf ?sens ;
    ssn:featureOfInterest ?foi ;
    wgs:lat ?latitude ;
    wgs:long ?longitude .
FILTER (
  xsd:dateTime(?starttime) >=
    '2014-11-30T02:00:00Z'
    ^^xsd:dateTime
    [...]
  && xsd:double(?latitude) <=
    '53.2692120'^^xsd:double
    [...].
}
```

# Conclusion

- Added value of G-Sensing
  - Websites about or referring to real-world locations are a common phenomenon in urban areas;
  - The performance of G-Sensing does not impede on a user's browsing experience
- Current Status of Sensor Data Sources
  - Limited availability of sensor datasets that are both open and public
  - Some of the SPARQL endpoints for such open and public datasets were inaccessible
- Beyond search result pages
  - Our add-on-based approach can allow us to inject sensor information into *any* website

# Future Work

- Extended linkage
  - extend these connections by injecting sensor information into other Web pages that also refer to such venues, e.g., *Tripadvisor*
  - explore which types of connections are meaningful in a given application context and how such connections can be established
  - Example: latest webcam feeds showing a location that is mentioned in a news article displayed next to the article
- User-centric live data representation
  - the G-Sensing output relevancy for an end user depends on the user's current interests and on the type (and low level location) of sensor data displayed
  - recommender system that decides whether to display or not the retrieved sensor data according to a prediction of their current relevancy for the user

# Thanks!

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