

# Linked Data

Tom Heath and Nadeem Shabir

Talis Group Ltd

December 2010

University of Manchester



## About Talis

- 80-90 people, headquarters in Birmingham
- One of the oldest software companies in the country
- UK market leader in library management software
- One of the leading commercial exploiters of Linked Data and Semantic Web technologies
  - (yes, we actually make money from this stuff!)

## The next two hours...

- Less Semantics, More Web
- Tom (2/3)
  - Linked Data Fundamentals
  - Simple Linked Data Apps
- Nad (1/3)
  - Building Enterprise Linked Data Apps

# Linked Data: Part 1

Tom Heath  
Lead Researcher  
Talis Systems Ltd

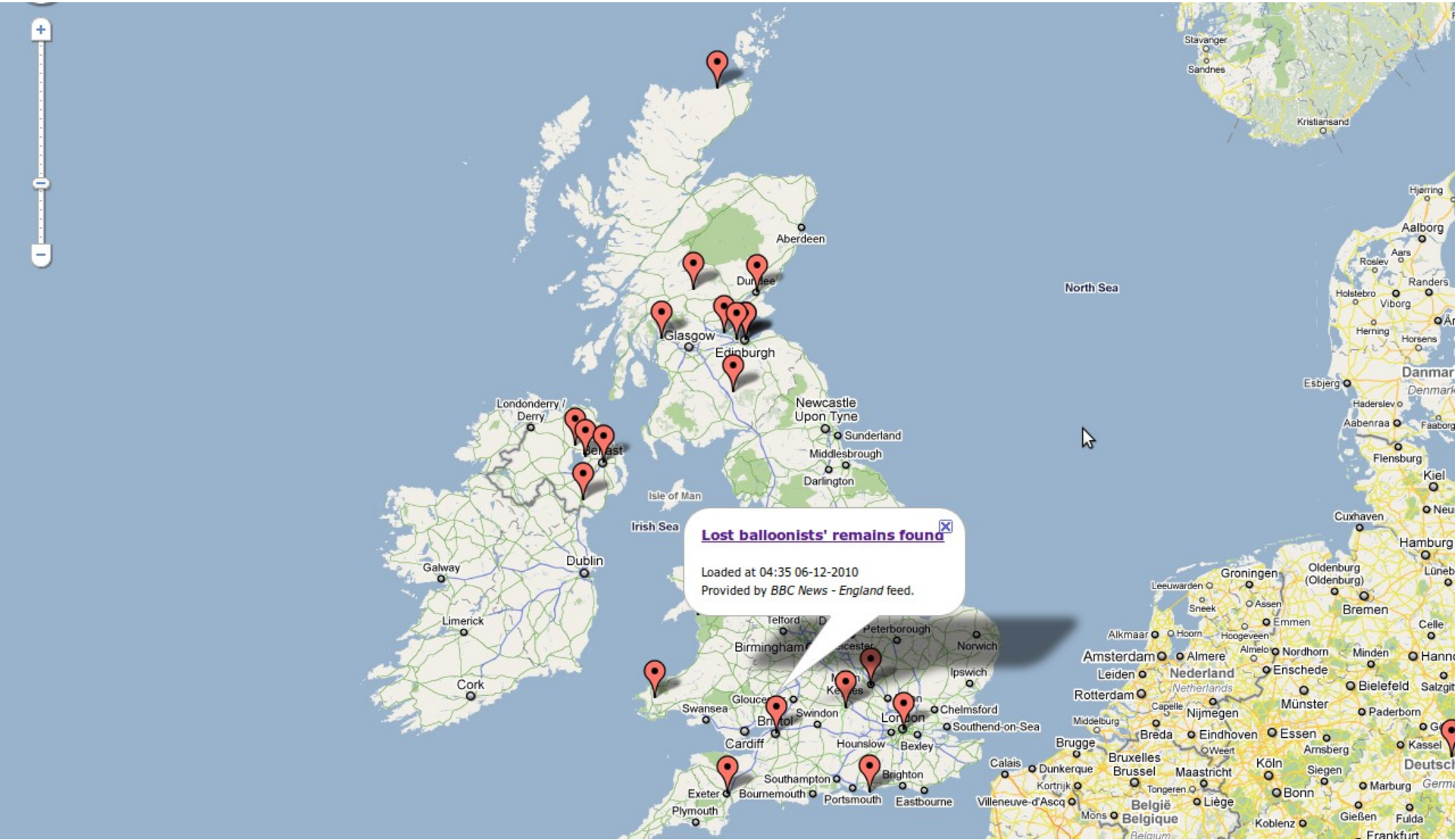
tom.heath@talis.com  
<http://tomheath.com/id/me>

December 2010  
University of Manchester

# Overview

- What's Wrong with Mashups?
- A History Lesson
- Linked Data: Web-Scale Data Integration
- Linked Data: State of the Art
- Linked Data: In Practice

# What's Wrong with Mashups?



<http://dev.benedictoneill.com/bbc/>





1001 fishing holes @ 1001SEAFOODS.COM

{ zoom + / - }

## Sherburne National Wildlife Refuge

### Description

Sherburne National Wildlife Refuge is located in the east central region of the state, approximately 50 miles northwest of the Minneapolis/St. Paul metropolitan area and 30 miles southeast of St. Cloud. The refuge protects 30,665 acres of habitat for migratory birds and other wildlife. The primary mission of the refuge is to represent a diverse biological community characteristic of the transition zone between tallgrass prairie and forest. Established in 1965 to protect and restore the habitats associated with the St. Francis River Valley, refuge management today focuses on the restoration of oak savanna, wetland and big woods habitats.

### Recreational Activities:

- Auto Touring
- Boating
- Fishing
- Hiking
- Hunting
- Interpretive Programs
- Wildlife Viewing

### Address:

17076 293rd Ave.  
Zimmerman, MN, 55398  
Phone: 763-389-3323  
Email: [sherburne@fws.gov](mailto:sherburne@fws.gov)

### Directions:

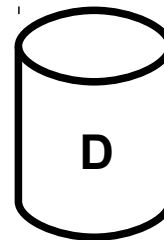
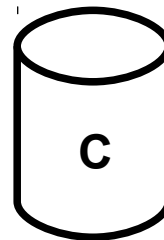
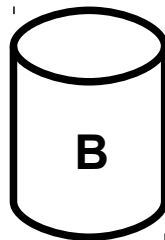
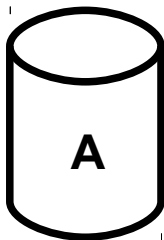
Sherburne National Wildlife Refuge is located in east central Minnesota, approximately 50 miles northwest of Minneapolis and 30 miles southeast of St. Cloud. From Minneapolis, take Interstate 94 west to Highway 101 at Rogers. Go north on 101 to Highway 169 north, then follow Highway 169 north four miles past Zimmerman to County Road 9. Go west on County Road 9 four miles to the refuge entrance and one additional mile to the refuge office. From St. Cloud, take Highway 23 north to Highway 95, then east on Highway 95 approximately 15 miles. After the sign for Sherburne Refuge, take the first right, which is Mille Lacs County Road 7. Go south on County 7 four miles to

<http://www.1001seafoods.com/fishing/fishing-maps.php>

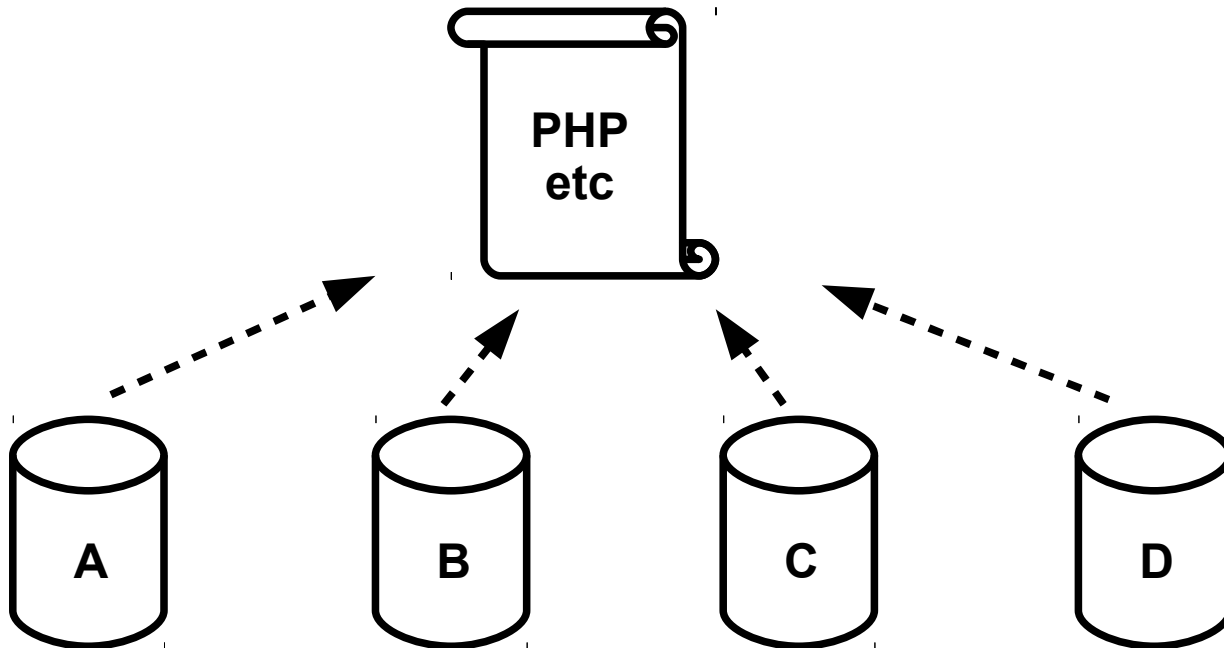




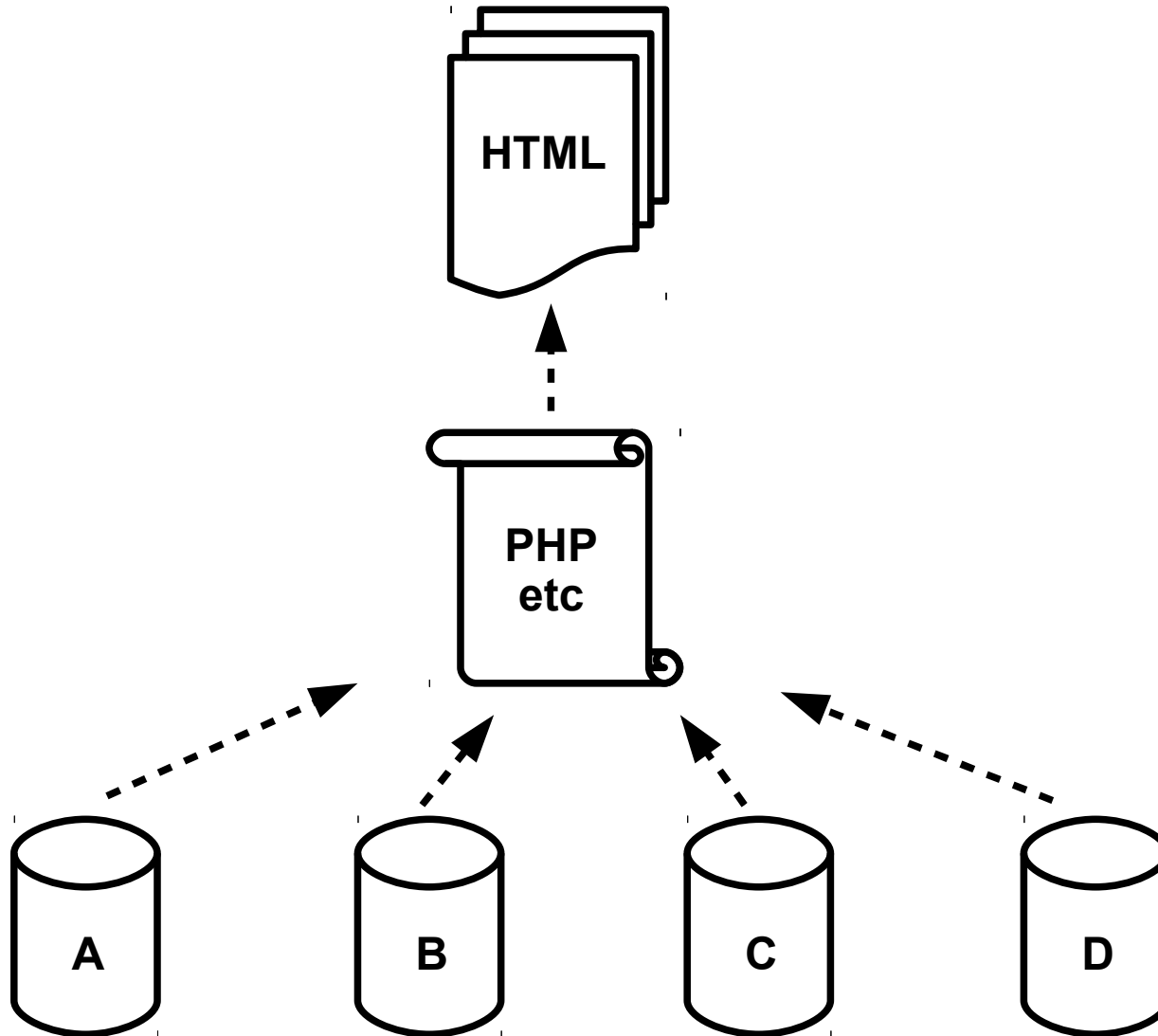
# The Mechanics of a Mashup



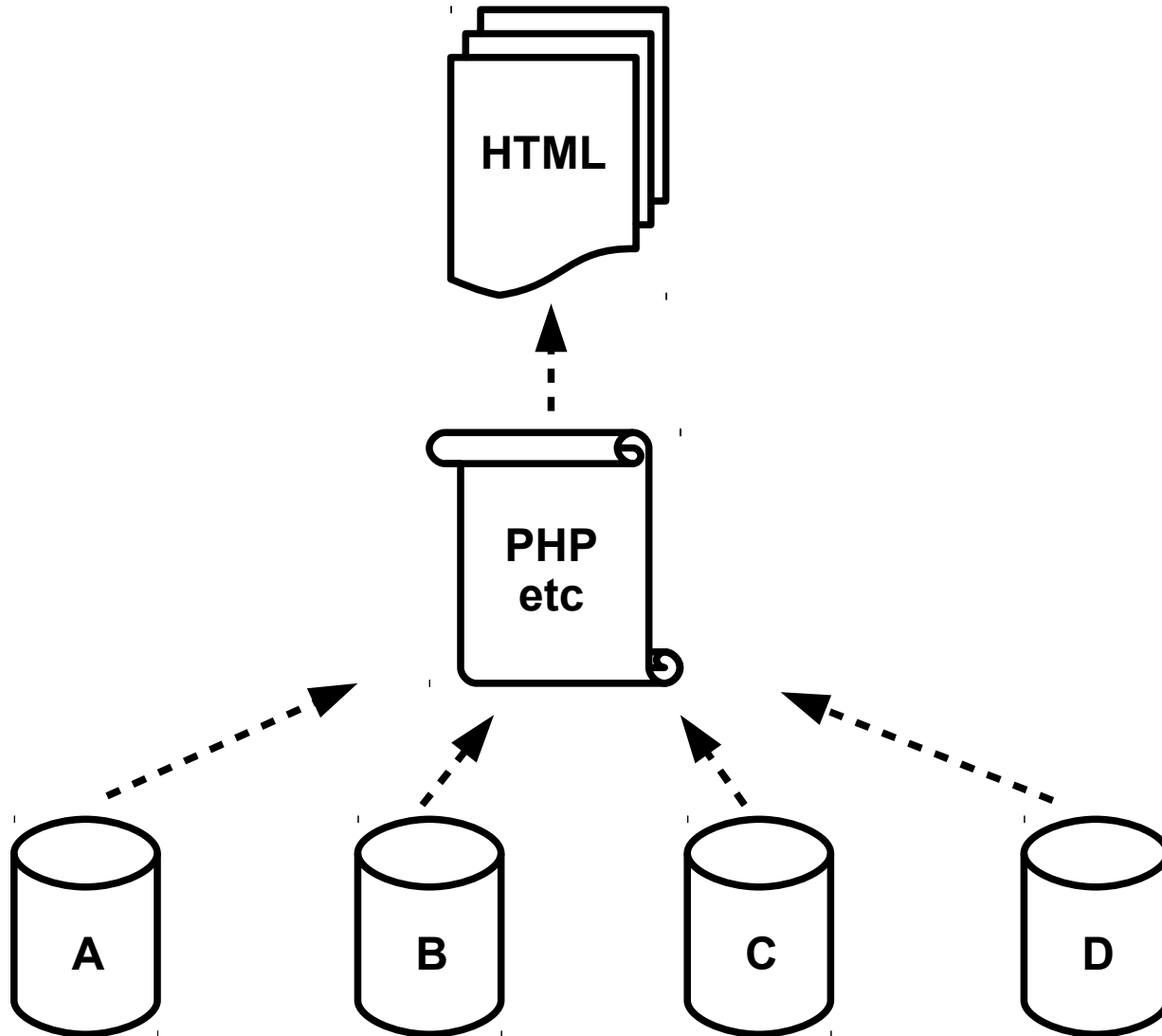
# The Mechanics of a Mashup



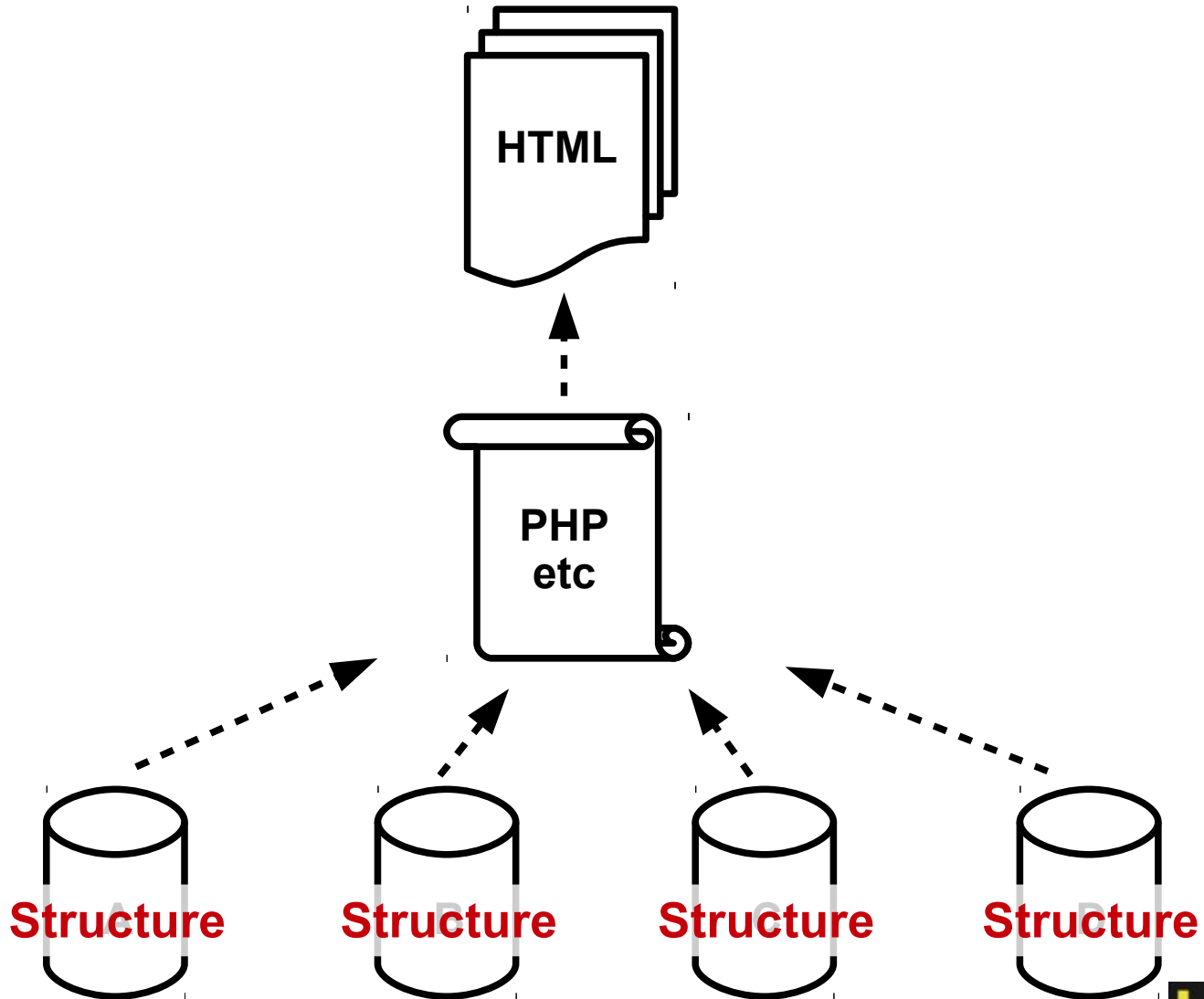
# The Mechanics of a Mashup



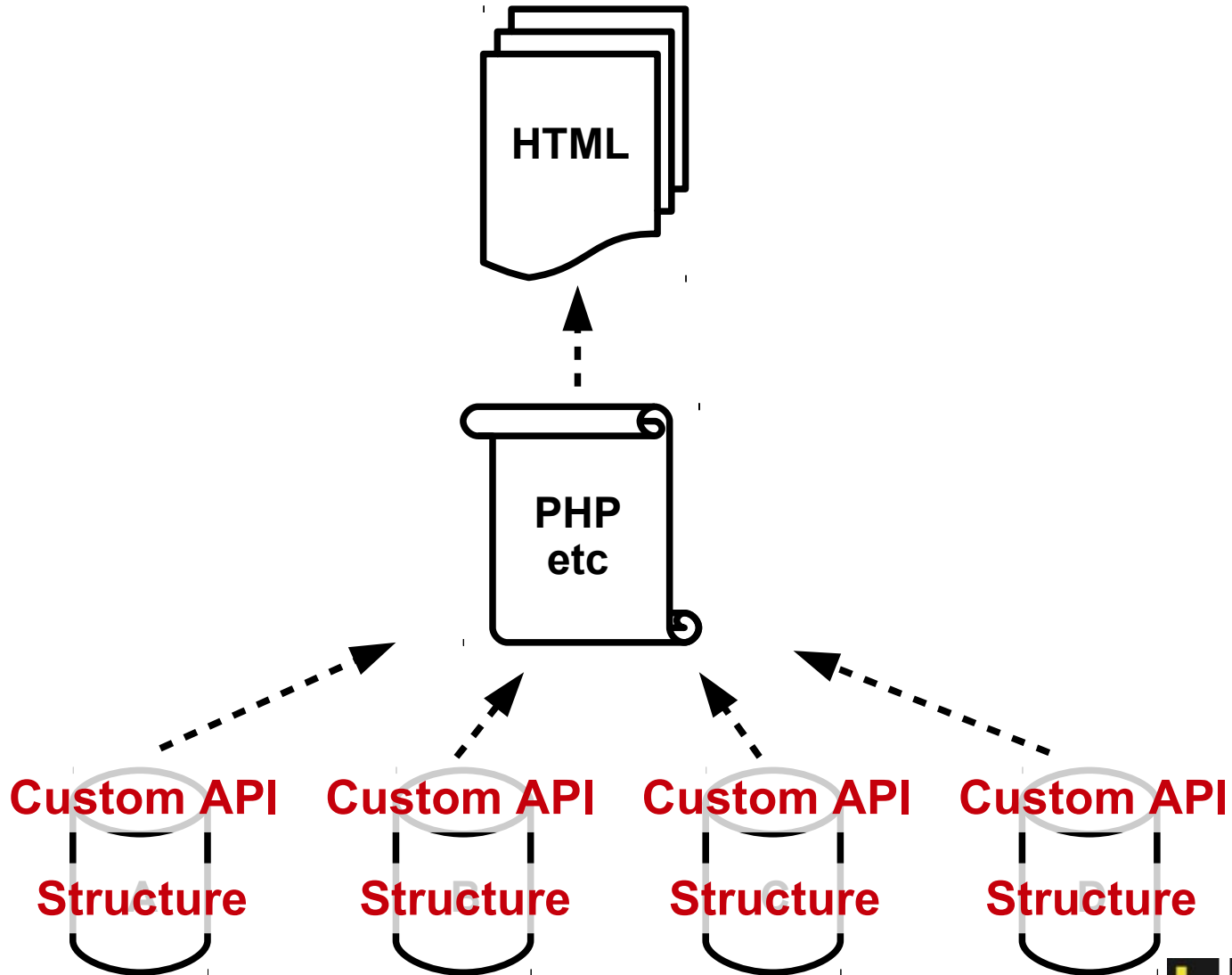
# What's Wrong with This?



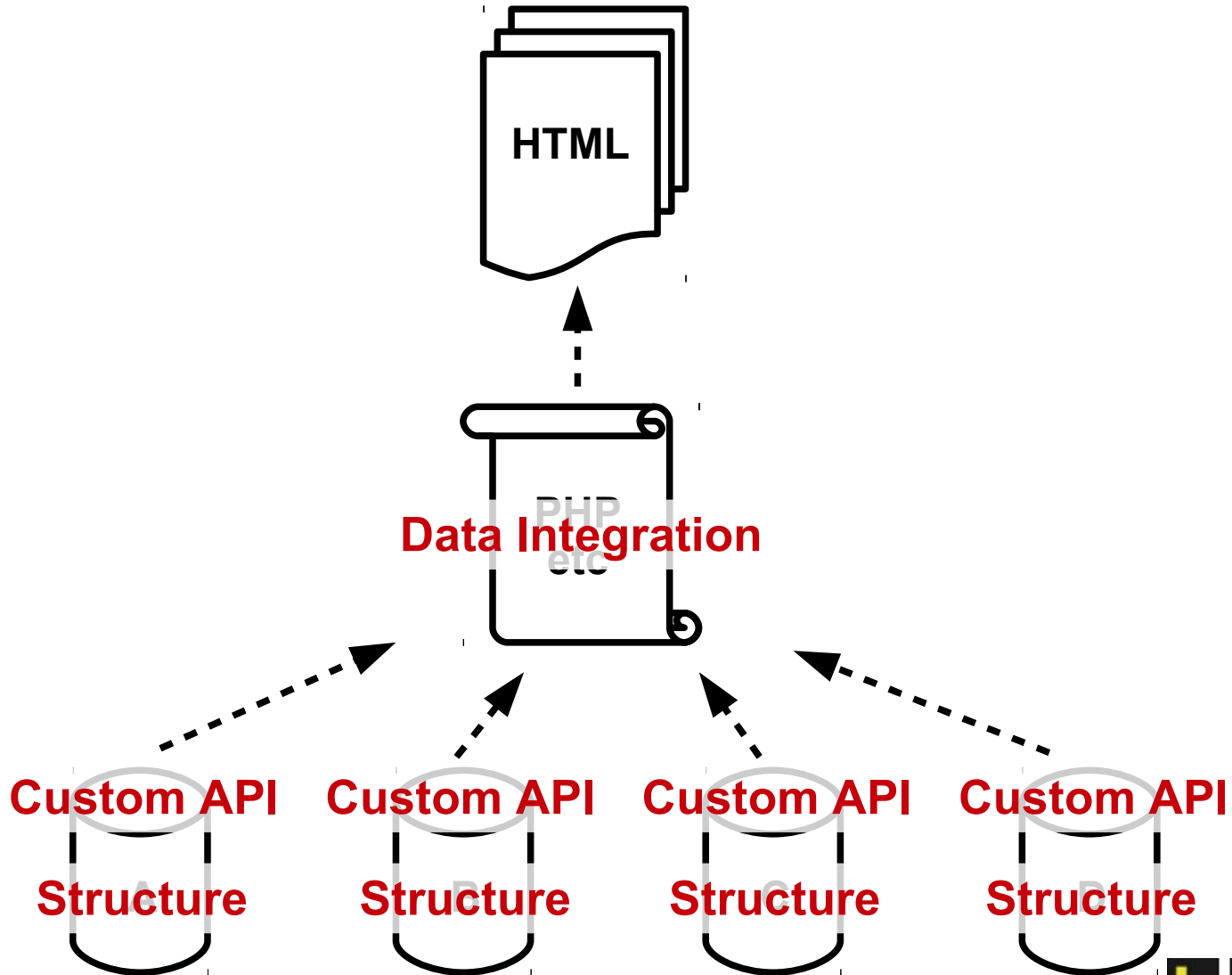
# What's Wrong with This?



# What's Wrong with This?

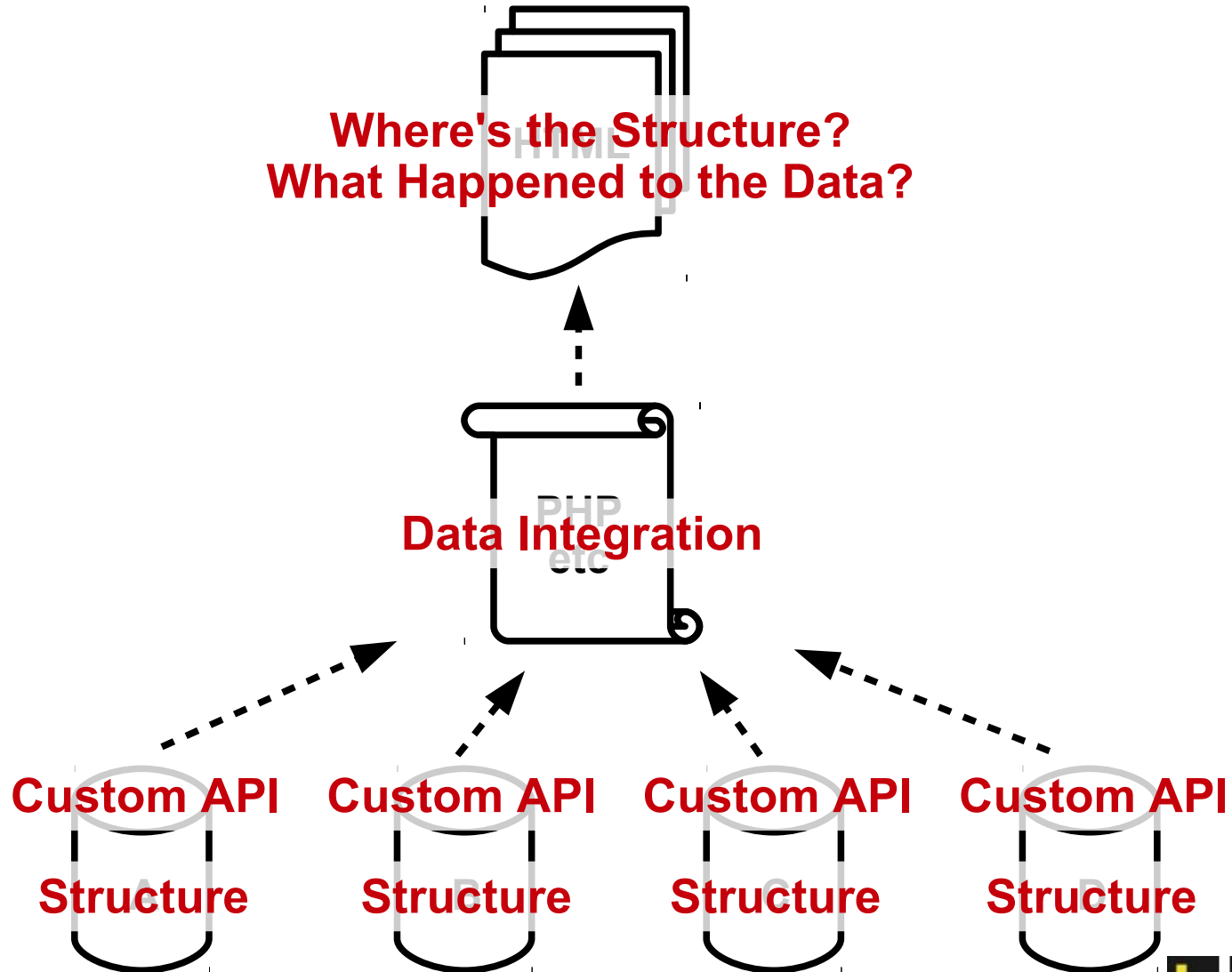


# What's Wrong with This?

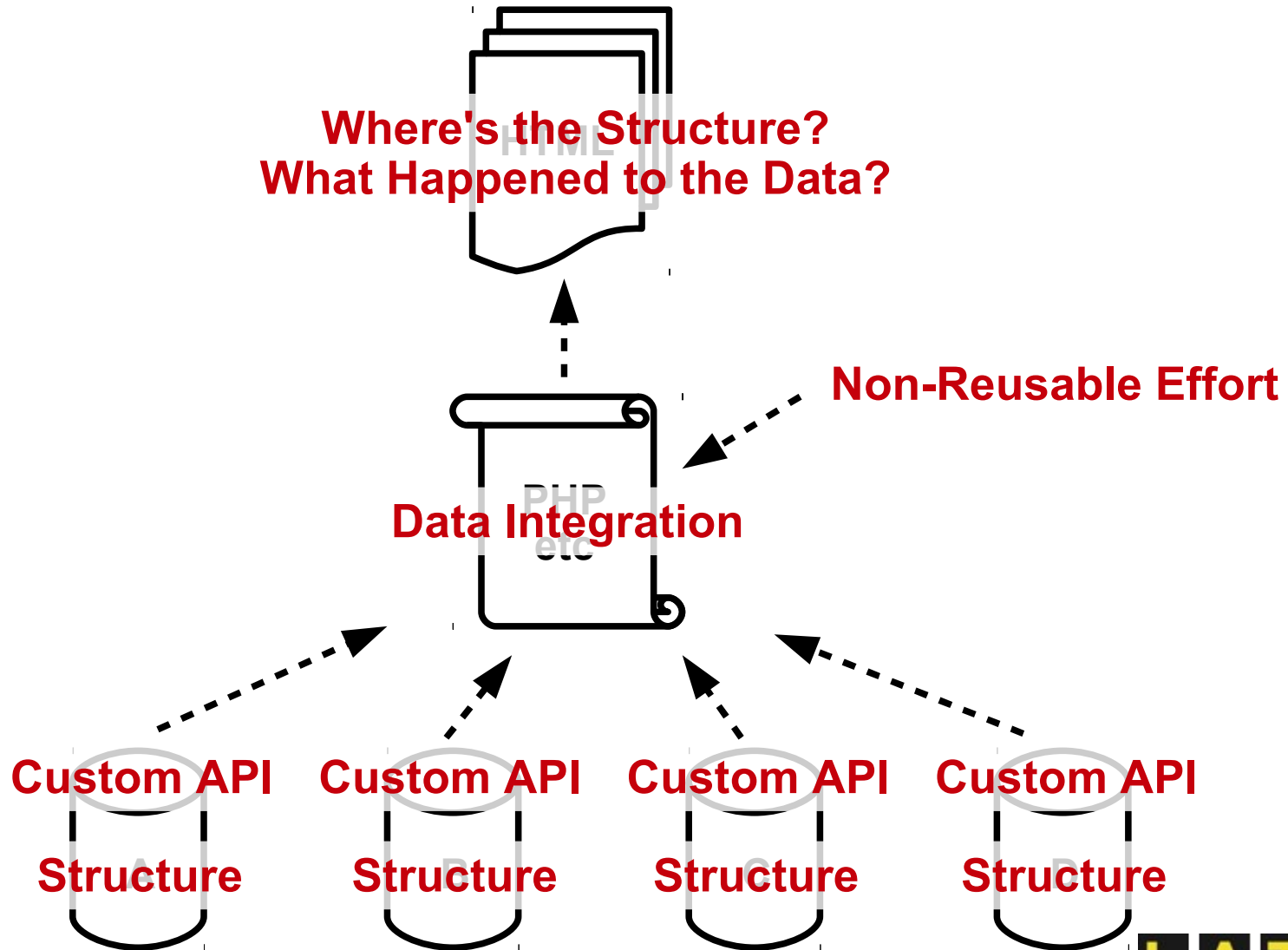




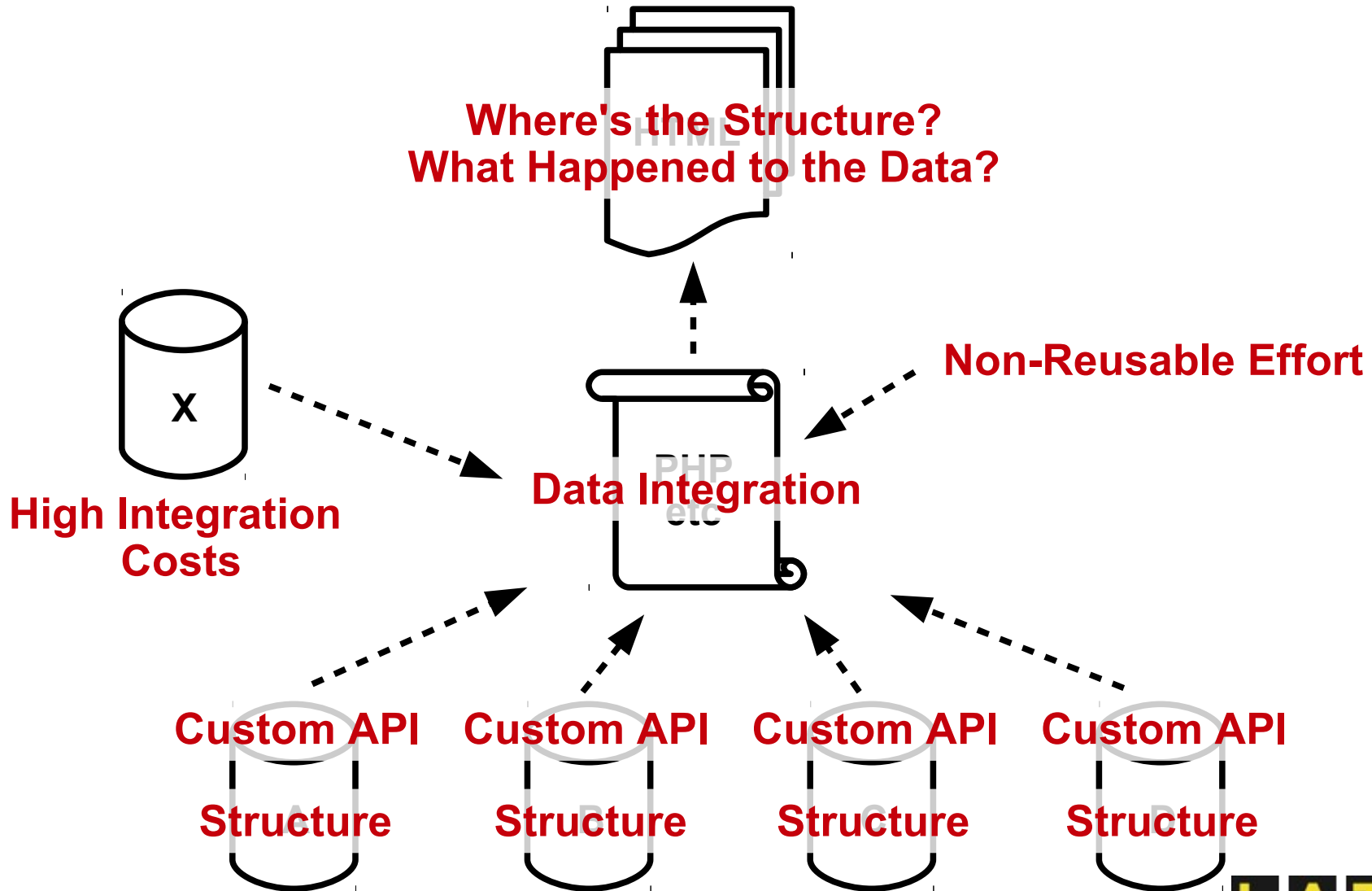
# What's Wrong with This?



# Data Integration Down the Pan



# What about all the other Data?



# A History Lesson



## About Me (In A Nutshell)



## About Me (In A Nutshell)

Tom lives in Bristol

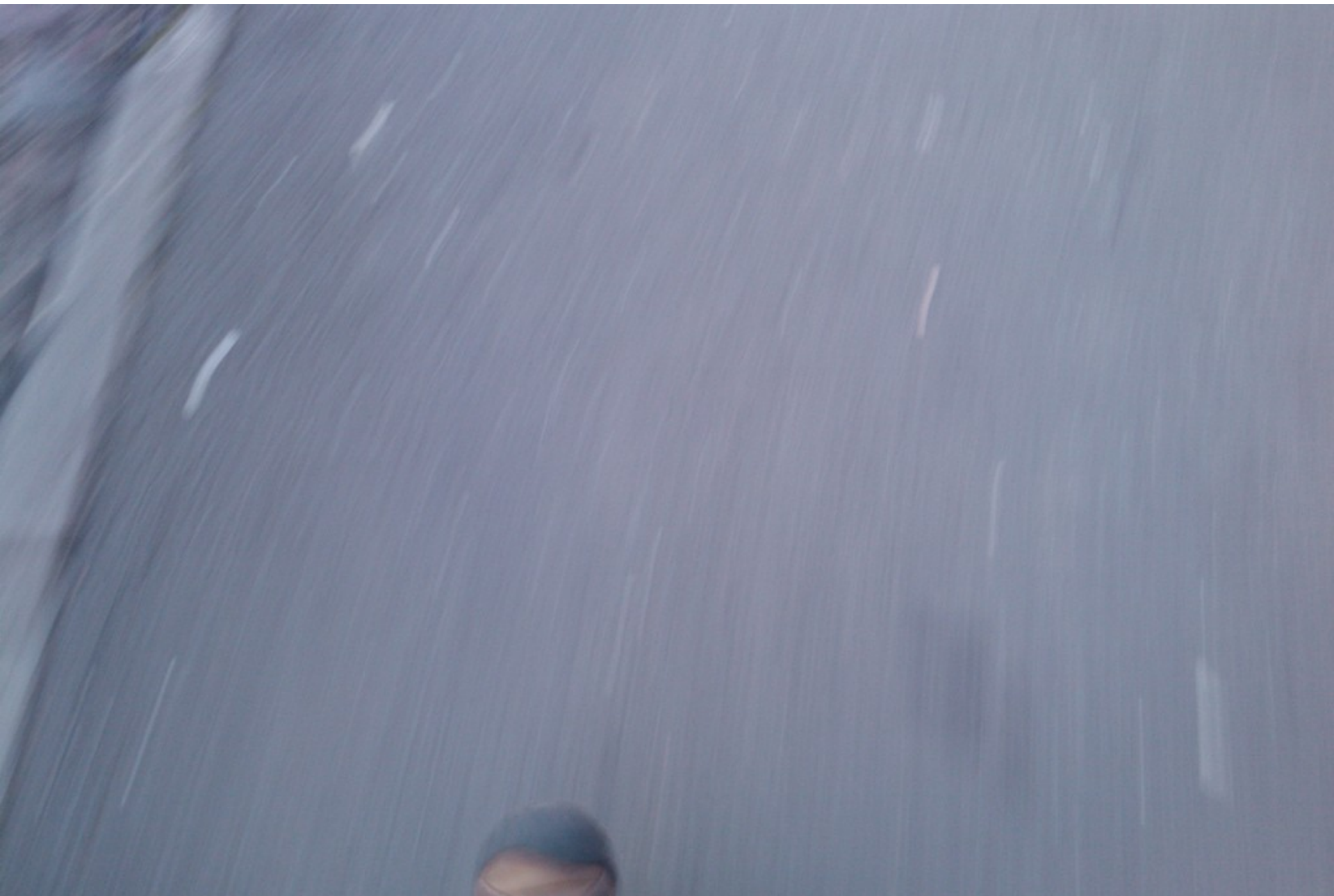
Tom works for Talis

Talis is based in Birmingham



Let's go to Work!





**Edward W. Godwin**  
**1833 - 1886**

---

Bristol born architect, furniture  
and fabric designer. His work  
includes the Carriageworks,  
Stokes Croft and Highbury  
Chapel, St. Michael's Hill.

Lived here from 1862 to 1865



































<http://www.flickr.com/photos/apenguincalledelvis/>









talis®

About Talis

Careers

Corporate Overview

Board Members

Management Team

Contact Us

Location

Talis Intranet

Site Map

Legal



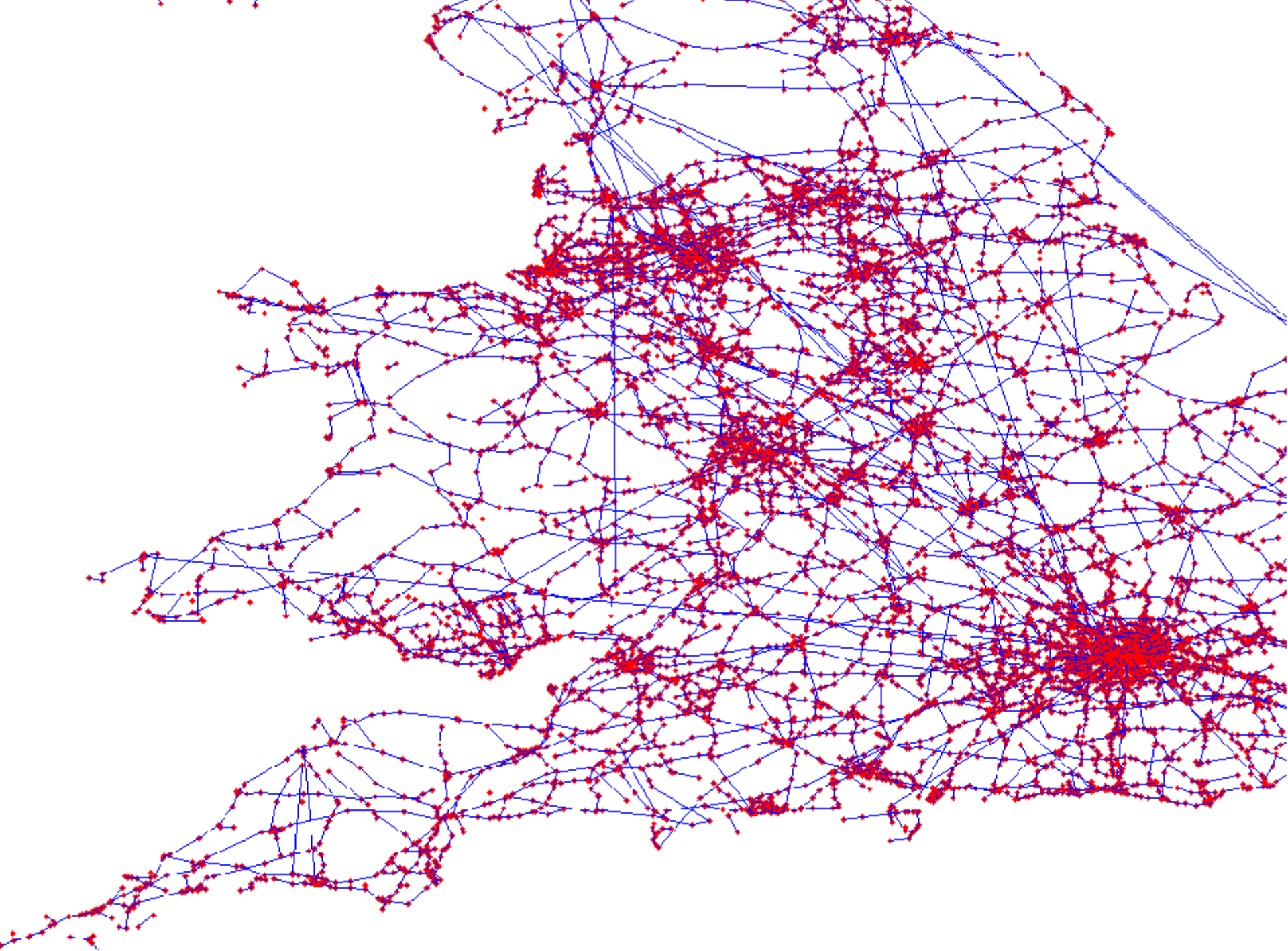
## How to find Talis

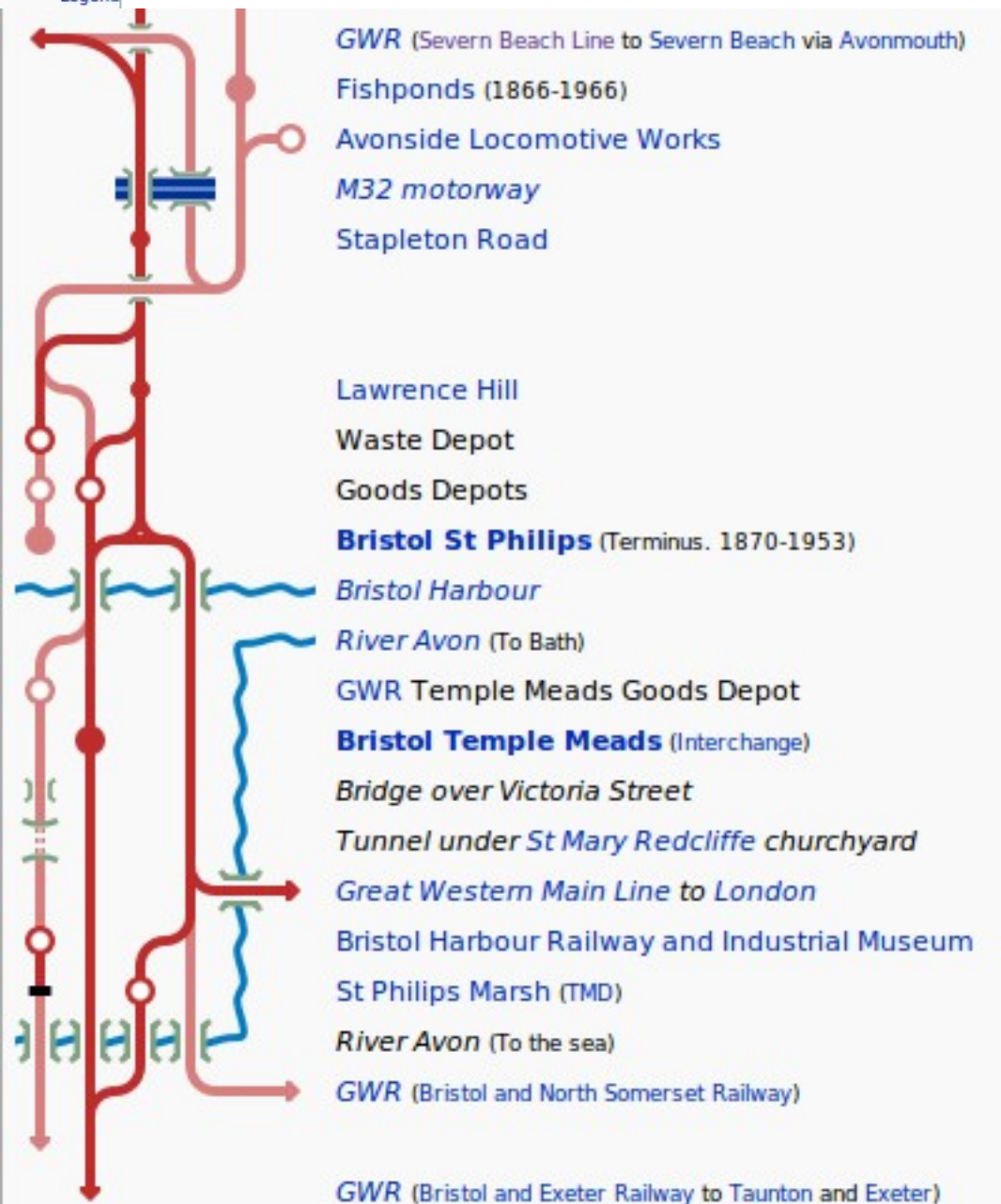
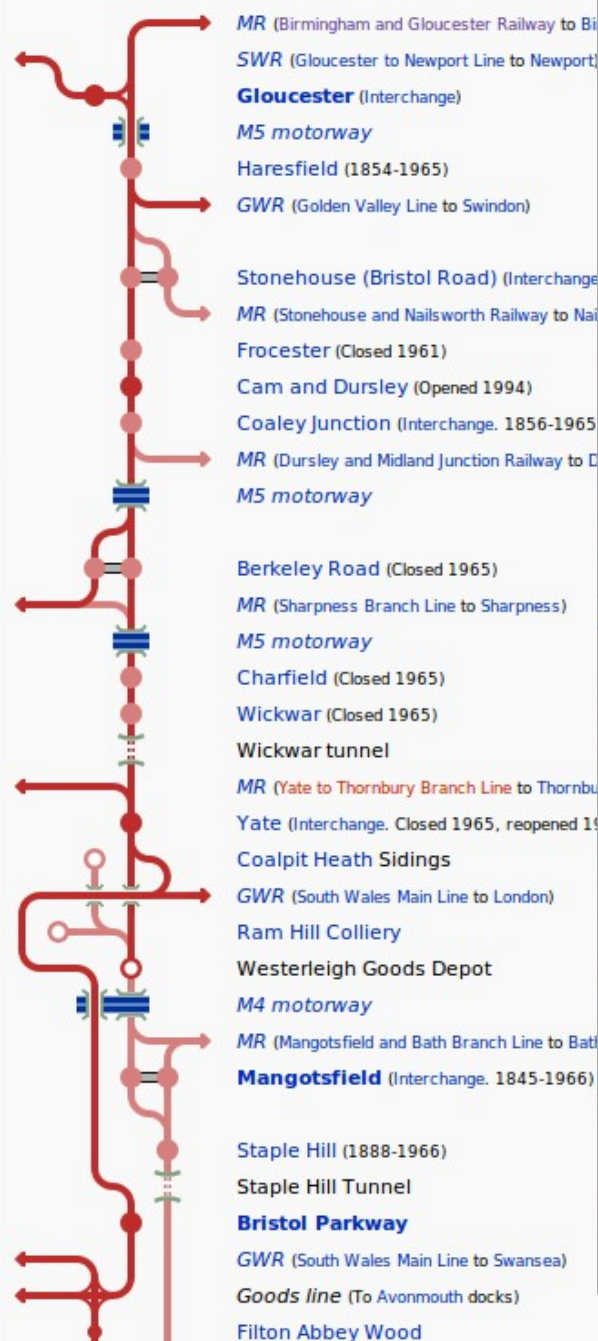




## What Makes This Possible?











# The Historical Perspective

## The Historical Perspective

“At that time, the **canal journey** from Birmingham to Bristol took **almost a week**, and the **road journey**, which due to **expense** and **road quality** was only really suitable for passengers, took the **best part of four days**.”

[http://en.wikipedia.org/wiki/Birmingham\\_and\\_Gloucester\\_Railway](http://en.wikipedia.org/wiki/Birmingham_and_Gloucester_Railway)





The Free Wiki World Map

OpenStreetMap is a free editable map of the whole world. It is made by people like you.

OpenStreetMap allows you to view, edit and use geographical data in a collaborative way from anywhere on Earth.

OpenStreetMap's hosting is kindly supported by the [UCL VR Centre](#) and [bytemark](#). Other supporters of the project are listed in the [wiki](#).

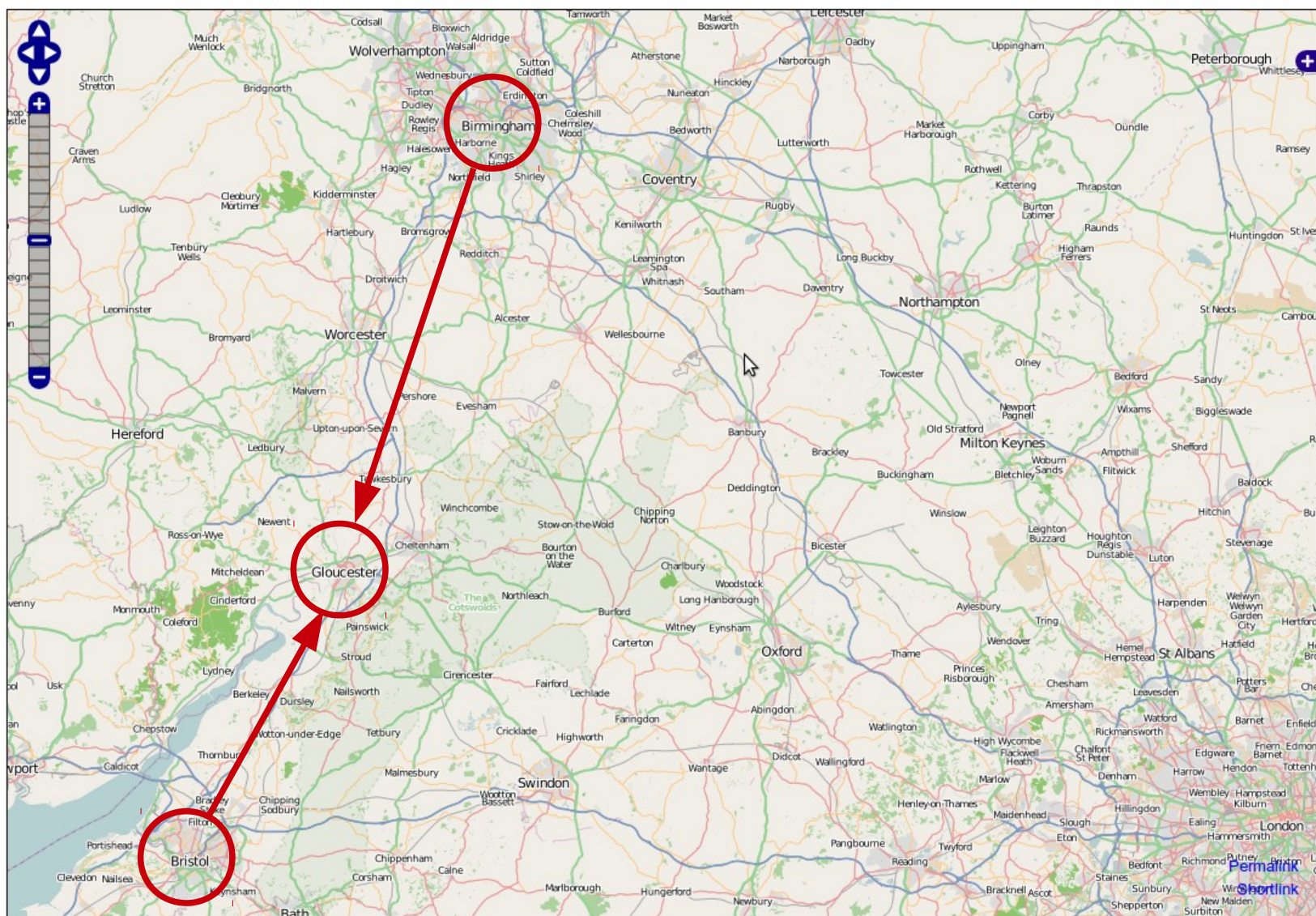
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examples: 'Alkmaar', 'Regent Street, Cambridge', 'CB2 5AQ', or 'post offices near Lünen'  
[more examples...](#)

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## The Historical Perspective

“At that time, the **canal journey** from Birmingham to Bristol took **almost a week**, and the **road journey**, which due to **expense** and **road quality** was only really suitable for passengers, took the **best part of four days**.”

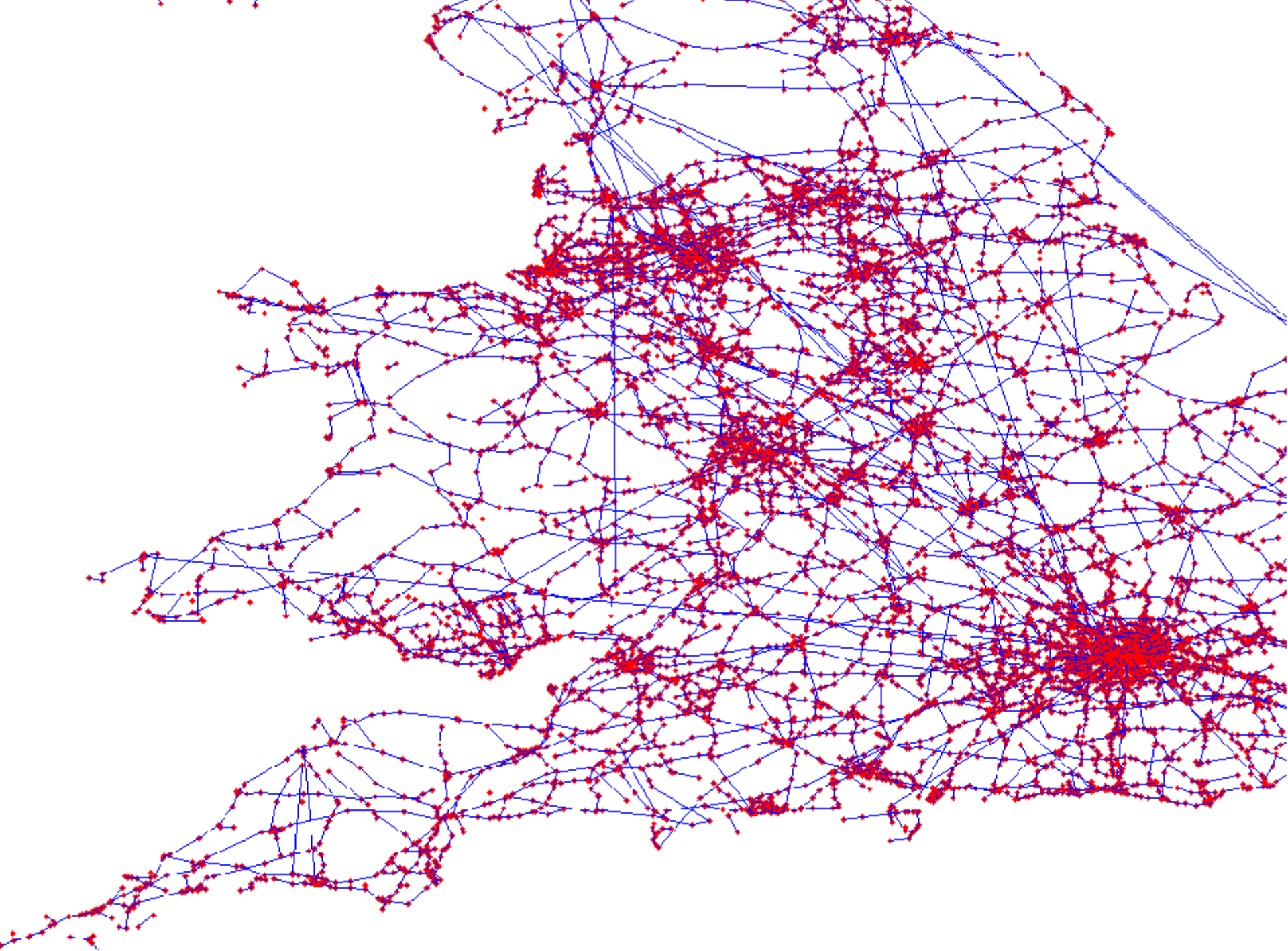
[http://en.wikipedia.org/wiki/Birmingham\\_and\\_Gloucester\\_Railway](http://en.wikipedia.org/wiki/Birmingham_and_Gloucester_Railway)

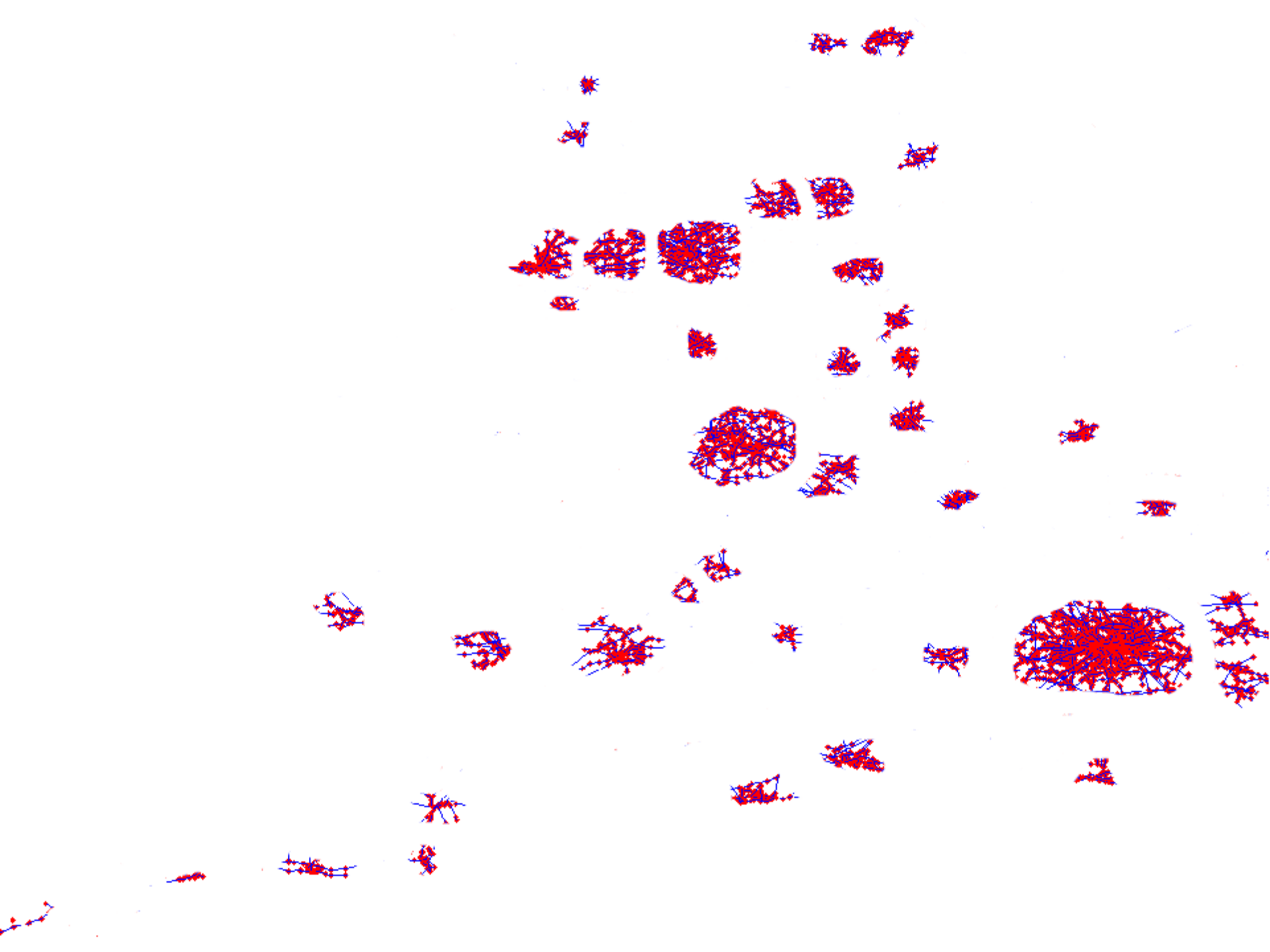
“The '**break-of-gauge**' at **Gloucester** was a **major problem**. It caused **pandemonium** as **whole trainloads** of passengers, and their luggage, **changed from one to another**, together with the transshipment of goods.”

[http://en.wikipedia.org/wiki/Birmingham\\_and\\_Bristol\\_Railway](http://en.wikipedia.org/wiki/Birmingham_and_Bristol_Railway)

# If Cities Were Data









Films, Actors  
and Directors

Cinemas and  
Showing Times



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OSCARS® '10[Oscar Photos](#)[List of Winners](#)[Show Recap](#)

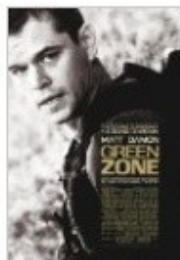
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## Green Zone

**Director:** [Paul Greengrass](#)**Stars:** [Matt Damon](#), [Jason Isaacs](#), [Greg Kinnear](#) ([Full Cast](#))**Studio:** Universal Pictures**The Plot:** Discovering covert and faulty intelligence causes a U.S. Army officer (Damon) to go rogue as he hunts for Weapons on Mass Destruction in an unstable region.**Photos** ([see all 31](#) | [slideshow](#))**Videos** ([see all 7](#))

Trailer



Featurette

**THE BUZZ:** Entertainment writers are worked up about (1) Universal's box-office slump and (2) the studio's decision to move *Green Zone* out of the 2009 Oscar zone. To me, this is a sign that the movie *actually might be*

### Movie Showtimes

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### Coming Soon

**MARCH 19th:**[The Bounty Hunter](#)





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categorized ▾

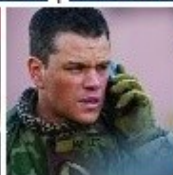
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# Matt Damon

[More at IMDbPro »](#)[Photos](#) ([see all 468](#) | [slideshow](#) | [add photos](#))[Videos](#) ([see all 101](#))[Full Movie](#)

## Overview

**Date of Birth:** [8 October 1970](#), [Boston, Massachusetts, USA](#) [more»](#)**Contact:** View [agent](#), [publicist](#) and [legal](#) contact info on [IMDbPro](#).**Mini Biography:** Matt Damon was born in 1970. His father, [Kent Damon](#), a tax preparer... [more»](#)**Trivia:** Lives with his family in Florida (2007). [more»](#)**STARmeter:** [Up 72%](#) in popularity this week. See [why](#) on [IMDbPro](#).**Awards:** Won Oscar. Another 19 wins & 53 nominations [more»](#)**NewsDesk:** [2010 Academy Awards: The Show, The Winners](#)  
(From [GossipCenter](#), 8 March 2010, 2:05 AM, PST)  
['The Hurt Locker' Tops the 2010 Oscars Taking Home Six Awards](#)  
(From [Rope Of Silicon](#), 8 March 2010, 1:35 AM, PST)



# Motherhood



Ents24 Rating: ★★★★★

Shot entirely on location in New York's West Village, this bittersweet comedy distills the dilemmas of the maternal state (marriage, work, self, and...

» [More Info](#)

## New Releases



Motherhood



Chloe



Alice In Wonderland (2010)



Case 39



Legion

## Bristol Cinema Showtimes » [change town](#)

### Cinemas closest to you

#### Odeon Bristol

0.1 miles from your location

Union Street, Bristol, BS1 2DS

#### Showcase Cinema De Lux (CDL Bristol)

0.2 miles from your location

Cabot Circus, Bristol, BS1 3AG

#### The Cube

0.3 miles from your location

4 Princess Row, King Square, Bristol, Avon, BS2 8NQ

### Top Films

- ▶ A Single man
- ▶ Alice In Wonderland (2010)
- ▶ Alvin And The Chipmunks 2: The Squeakquel
- ▶ An Education
- ▶ Astro Boy
- ▶ Avatar
- ▶ Blind Side with Have A Heart, The
- ▶ Capitalism: A Love Story
- ▶ Case 39
- ▶ Chloe
- ▶ Crazies, The
- ▶ Crazy Heart
- ▶ Did You Hear About the Morgans?

## This Week's Top 5



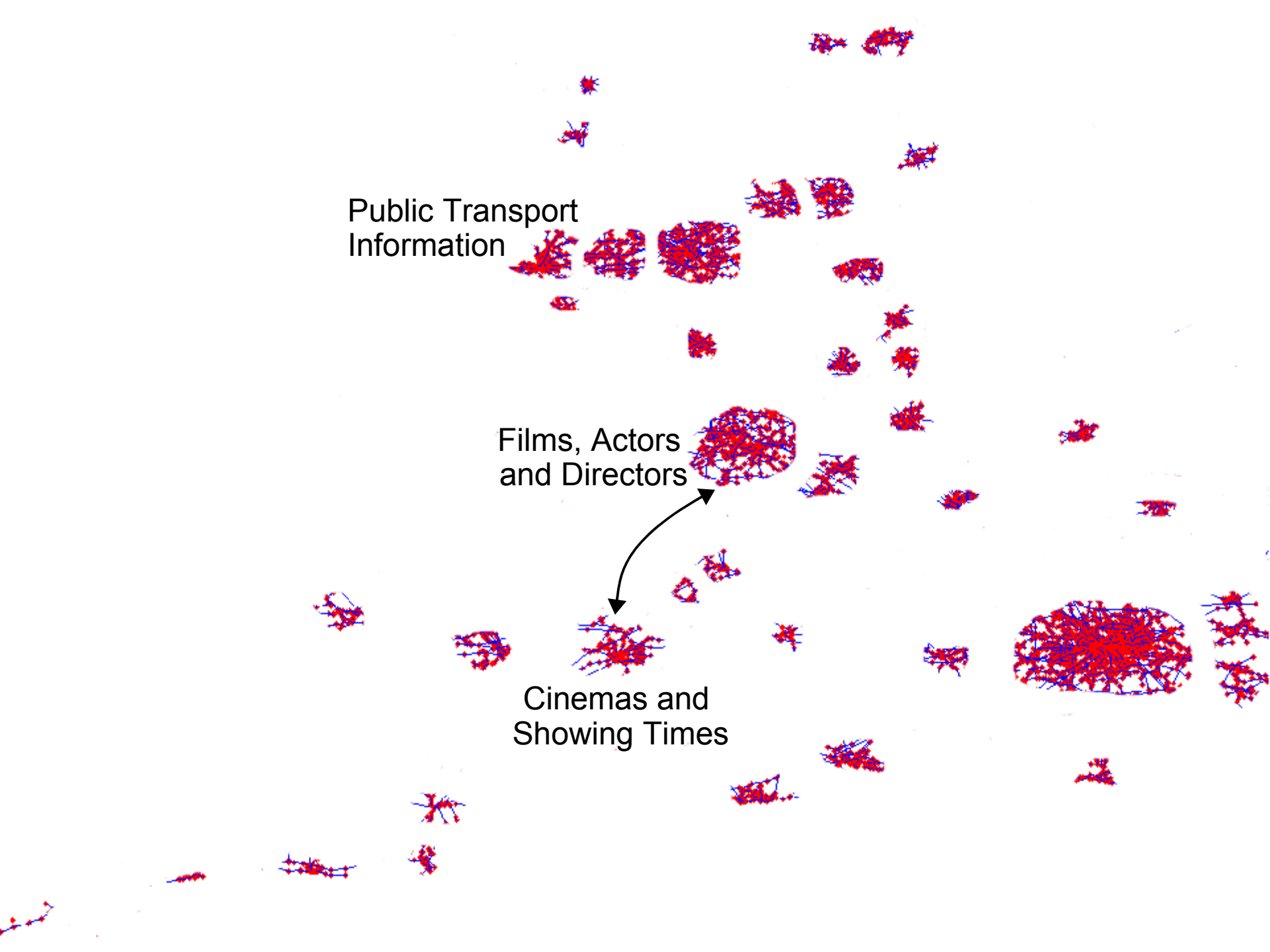
Avatar (12A)

1. Avatar (12A)
2. The Lovely Bones (12A)

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Information

Films, Actors  
and Directors

Cinemas and  
Showing Times

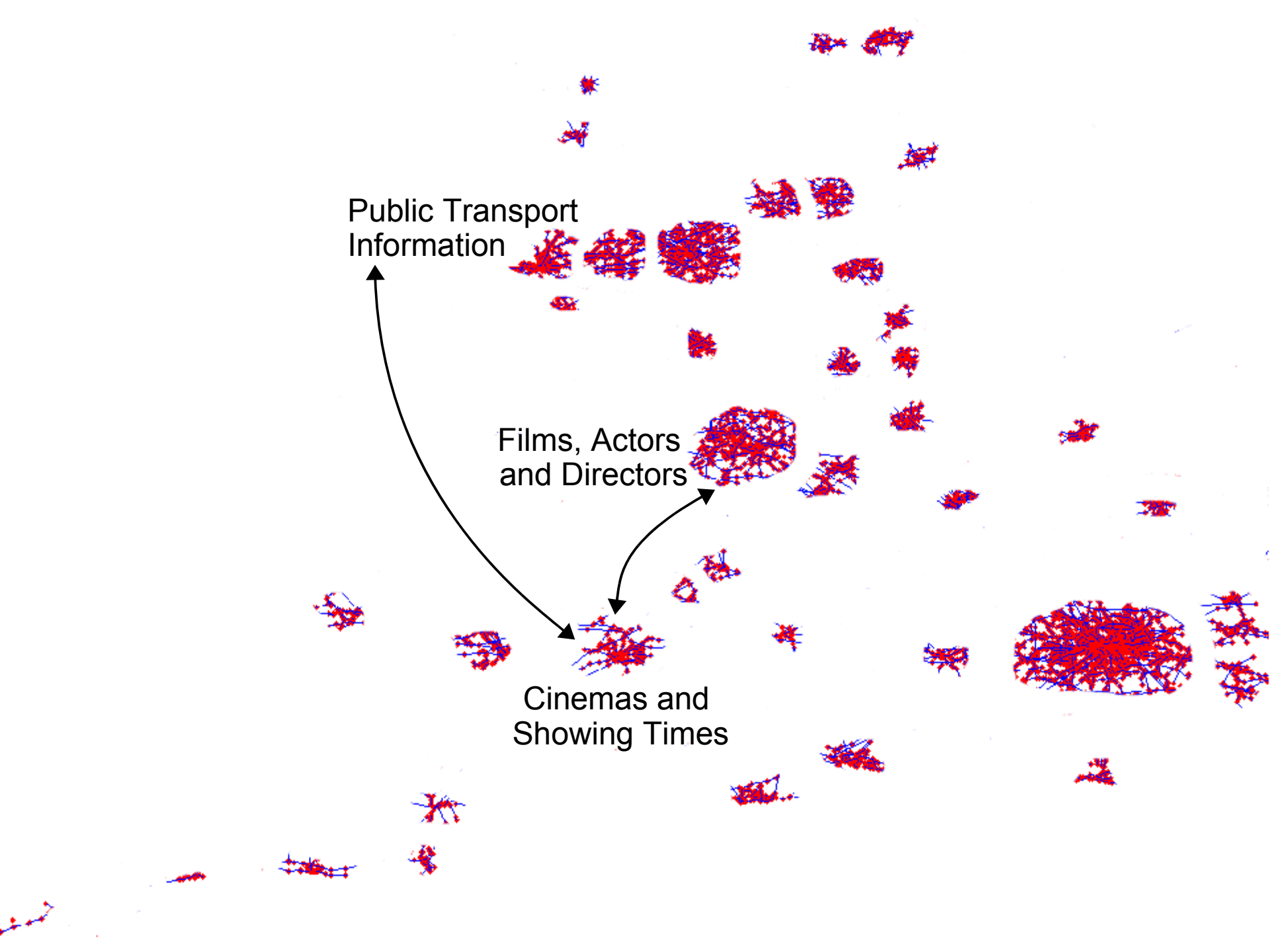




Public Transport  
Information

Films, Actors  
and Directors

Cinemas and  
Showing Times





## Gloucester was a Mashup

(everyone incurred the cost of 'integrating' the different gauges, every time they travelled)

# Linked Data: Web-Scale Data Integration



# Web-Scale Data Integration: Requirements

- Unique identifiers with global scope, yet under devolved ownership



# Web-Scale Data Integration: Requirements

**HTTP URIs**

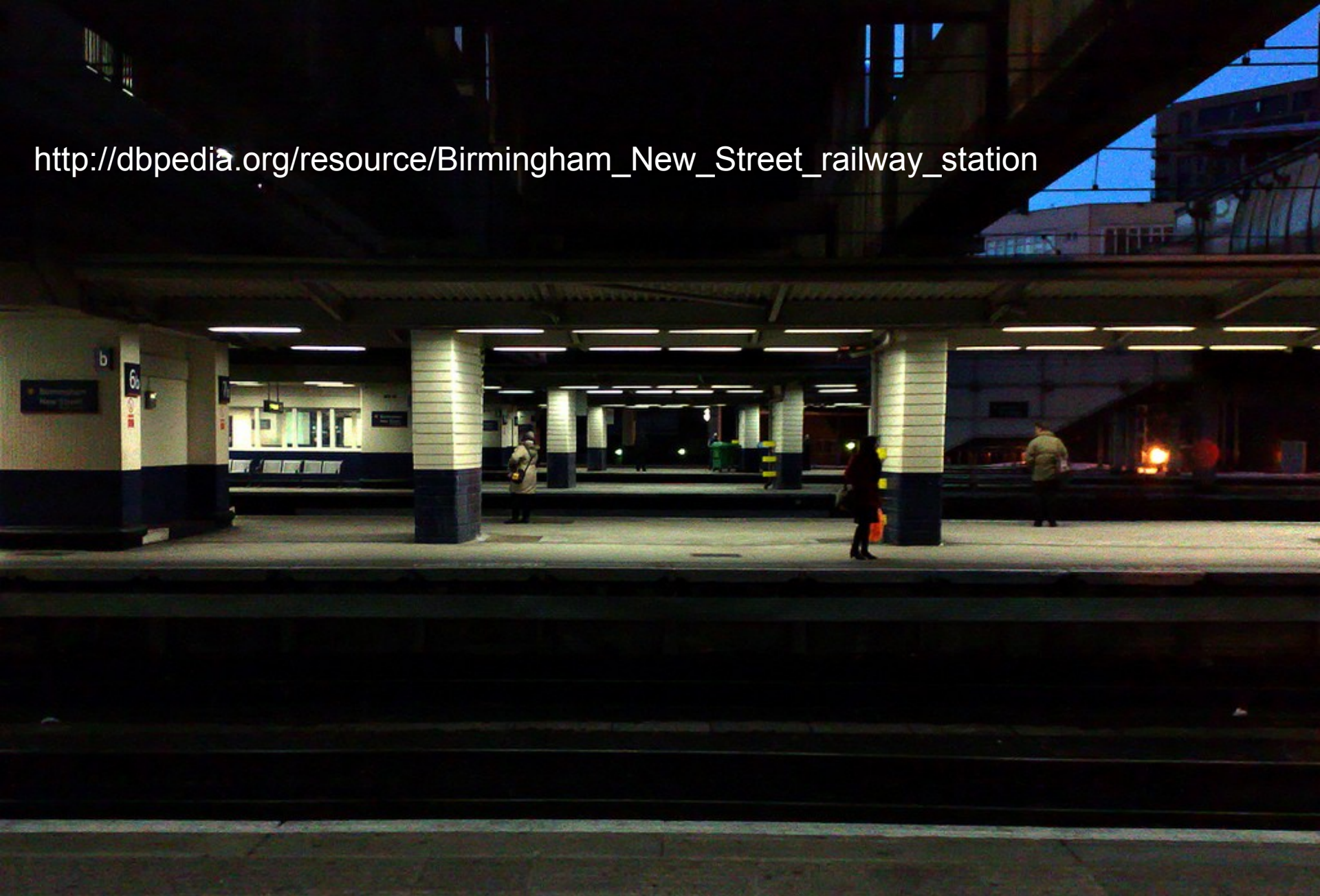
- Unique identifiers with global scope, yet under devolved ownership



## HTTP URIs

- globally unique, distributed ownership
- anyone can look them up
- not just for documents
  - [http://dbpedia.org/resource/Talis\\_Group](http://dbpedia.org/resource/Talis_Group)

[http://dbpedia.org/resource/Birmingham\\_New\\_Street\\_railway\\_station](http://dbpedia.org/resource/Birmingham_New_Street_railway_station)



<http://www.flickr.com/photos/apenguincalledelvis/>





[http://dbpedia.org/resource/Lickey\\_Incline](http://dbpedia.org/resource/Lickey_Incline)



[http://www.flickr.com/photos/\\_mia/](http://www.flickr.com/photos/_mia/)



[http://dbpedia.org/resource/Bristol\\_Temple\\_Meads\\_railway\\_station](http://dbpedia.org/resource/Bristol_Temple_Meads_railway_station)







[http://dbpedia.org/resource/Cabot\\_Circus](http://dbpedia.org/resource/Cabot_Circus)





[http://dbpedia.org/resource/Portland\\_Square%2C\\_Bristol](http://dbpedia.org/resource/Portland_Square%2C_Bristol)

# HTTP URI House-Rules

- You are not your homepage
  - <http://tomheath.com/id/me> (me, not my homepage)
- If two people refer to the same URI they are referring to the same thing
- The owner of the URI defines what it identifies
- If you disagree (or have lots to say), create your own URI (in your own namespace)



# Web-Scale Data Integration: Requirements

**HTTP URIs**

- Unique identifiers with global scope, yet under devolved ownership
- A flexible data model that allows:
  - anyone to say anything about anything
    - using whatever terms they like
  - anyone to link anything to anything
  - arbitrary merging of data fragments



# Web-Scale Data Integration: Requirements

**HTTP URIs**

- Unique identifiers with global scope, yet under devolved ownership

**RDF  
(+ RDFS & OWL)**

- A flexible data model that allows:
  - anyone to say anything about anything
    - using whatever terms they like
  - anyone to link anything to anything
  - arbitrary merging of data fragments

# Key Properties of RDF

- RDF data can refer to URIs from many different namespaces
- RDF data can use terms from many different vocabularies/ontologies
- Two RDF documents that refer to the same URI(s) merge effortlessly
  - Reusable data integration
- Look up URIs to find out more information
  - Repeat ad infinitum

## “Talis is Based Near Birmingham”

<[http://dbpedia.org/resource/Talis\\_Group](http://dbpedia.org/resource/Talis_Group)>

<[http://xmlns.com/foaf/0.1/Person#based\\_near](http://xmlns.com/foaf/0.1/Person#based_near)>

<<http://sws.geonames.org/3333125/>>



# Linked Data Principles (TimBL, 2006)

- Use URIs as names for things
- Use HTTP URIs
- Provide useful information in RDF
  - when someone looks up a URI
- Include RDF links to other URIs
  - to enable discovery of related information

## Linked Data...

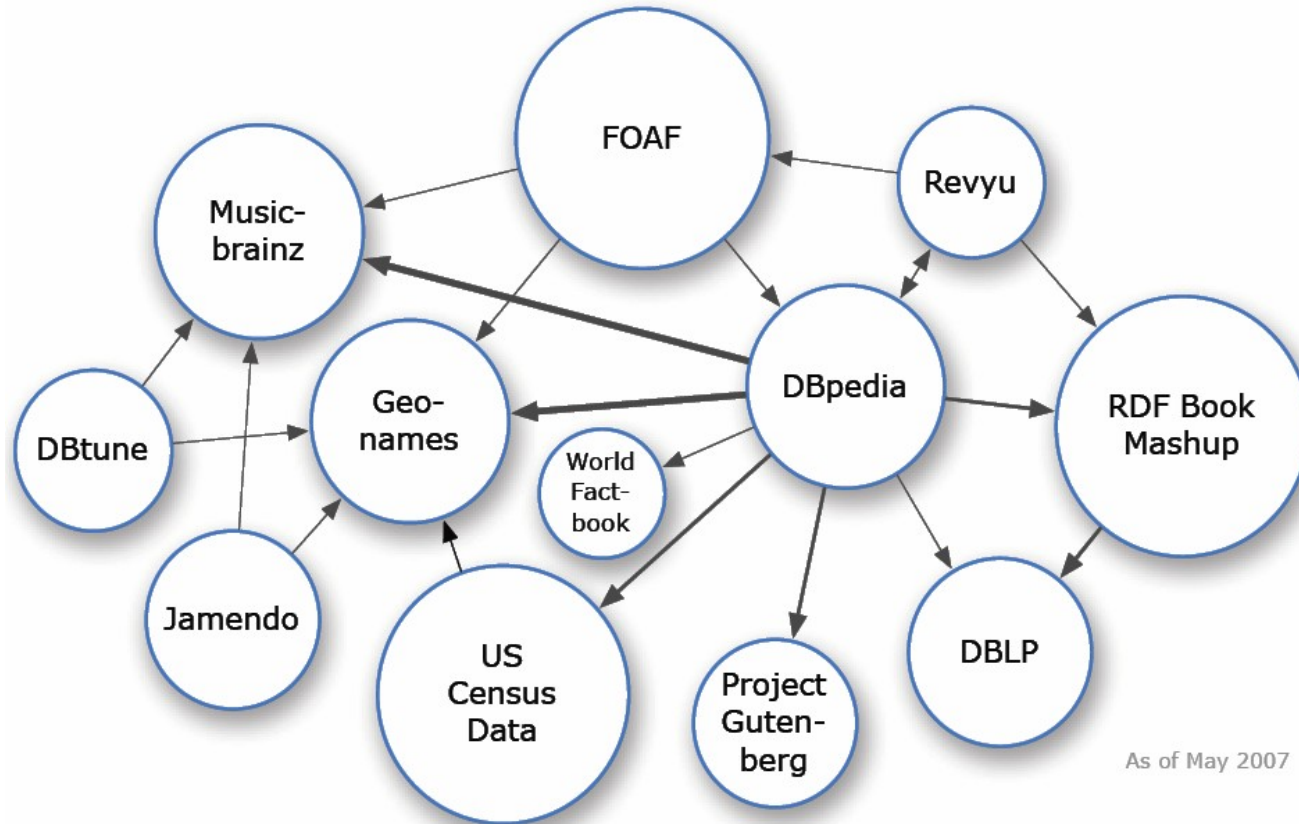
- ...is not just structured data published on the Web
  - not equivalent to CSV files, (plain) XML, database dumps
- ...is a way of putting data *into* the Web
  - i.e. with links
- ...adds value
  - building physical networks adds value to the places which get connected
  - building data networks adds value to the connected data sets
    - less redundancy, greater discoverability, network effects
- ...is based on well-established Web standards
  - avoids the 'break of gauge' at Gloucester
  - cheaper, faster journeys between data sets

# Linked Data: State of the Art

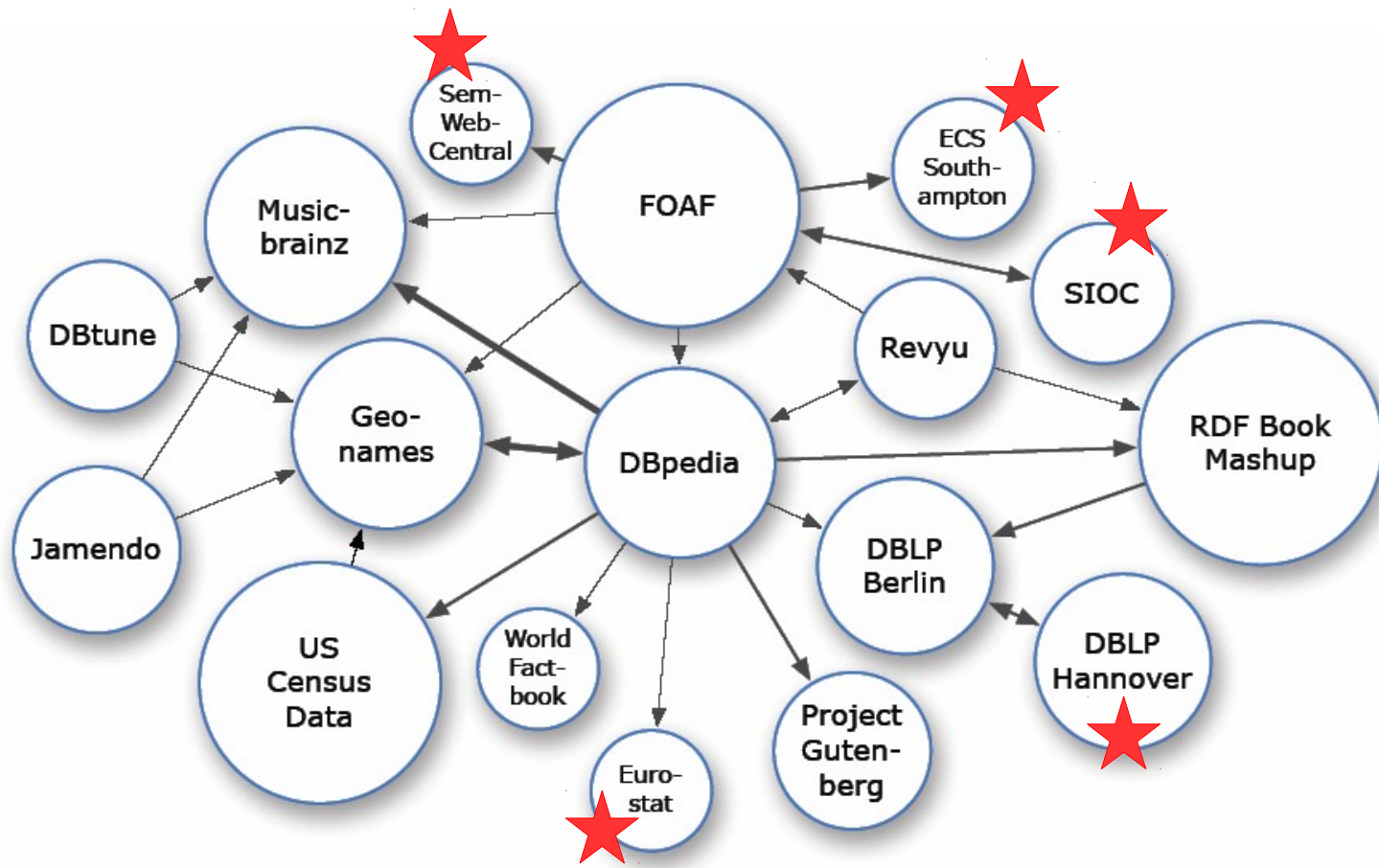




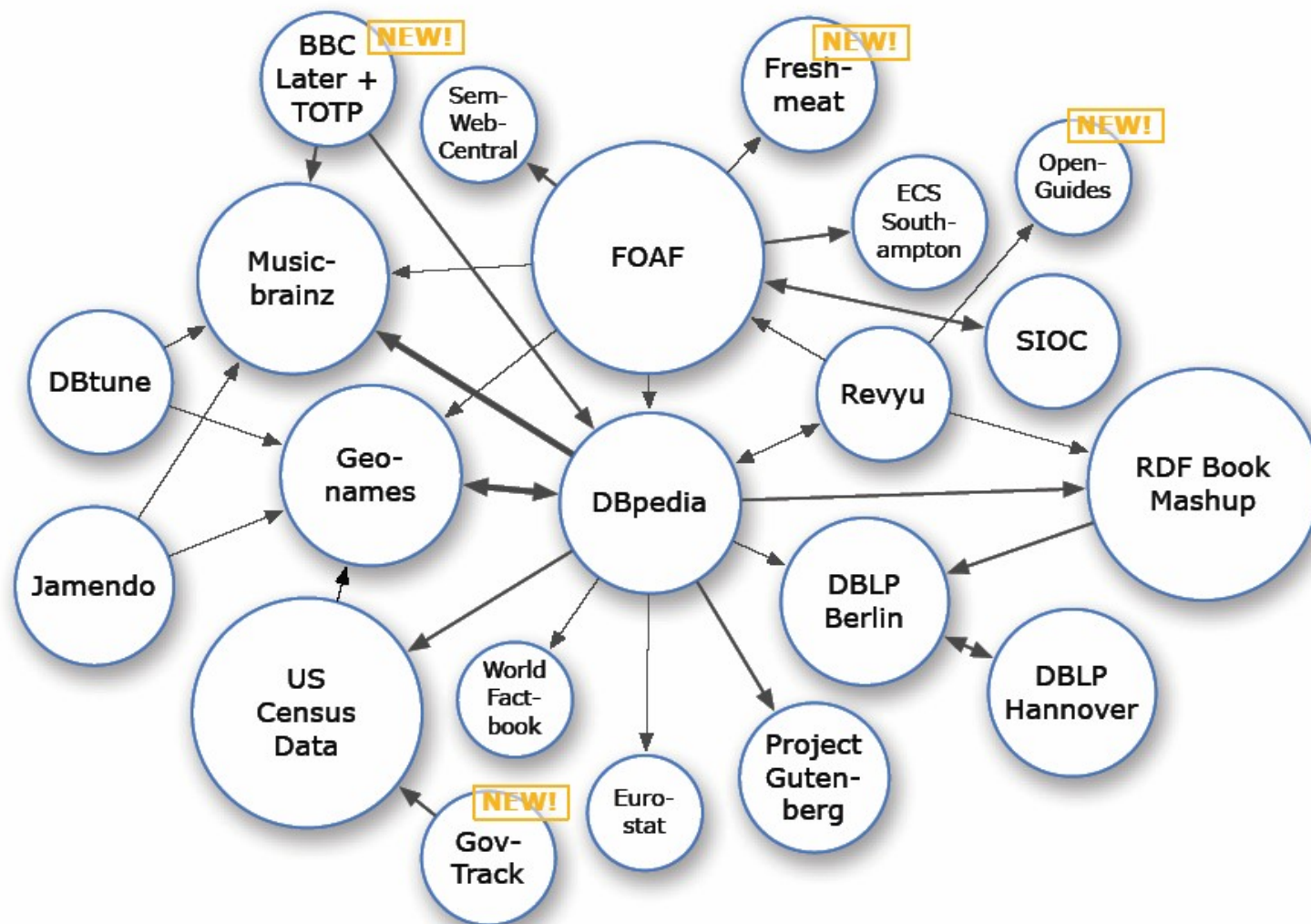
# The LOD "Cloud" - May 2007



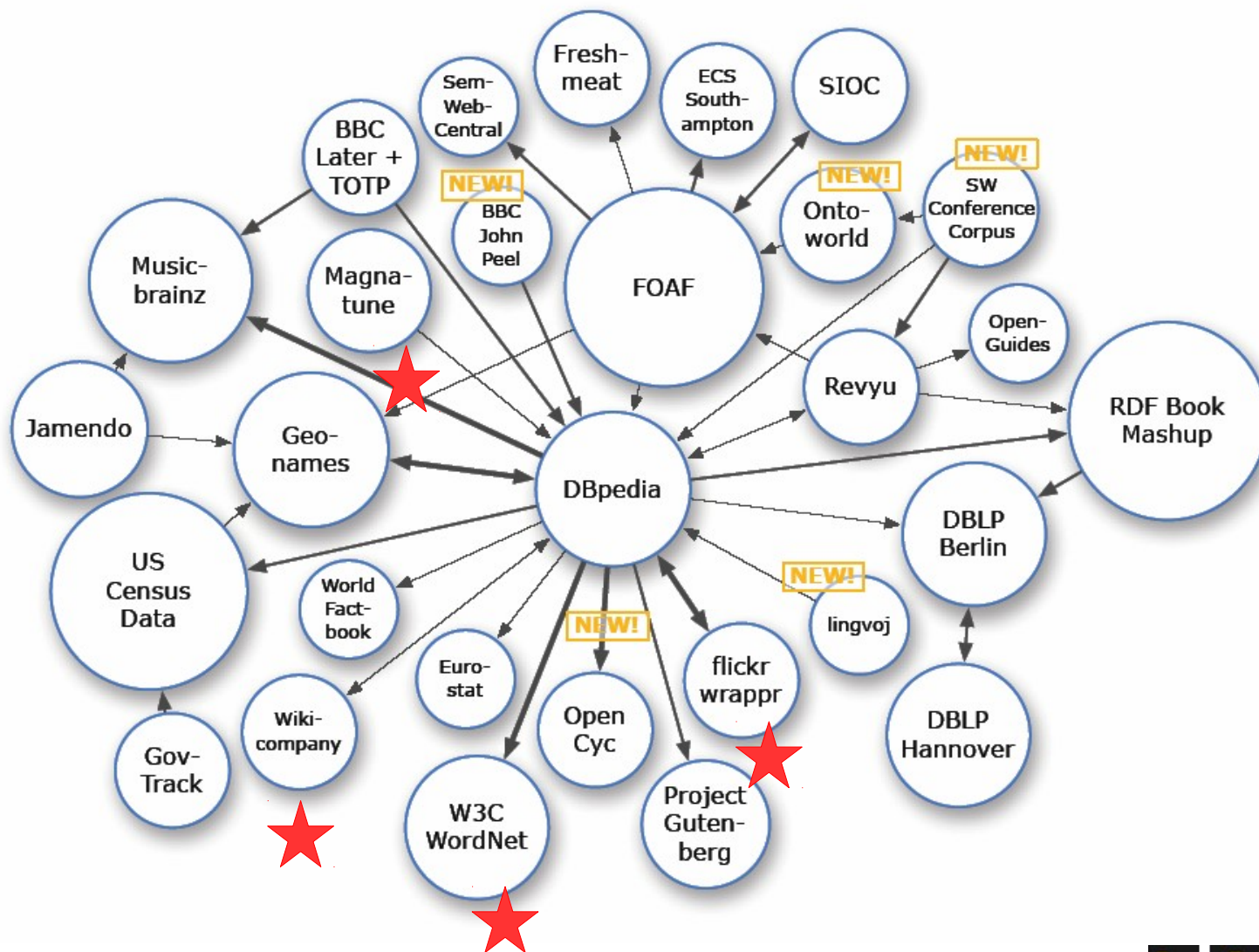
# The LOD "Cloud" - July 2007



# The LOD "Cloud" - August 2007

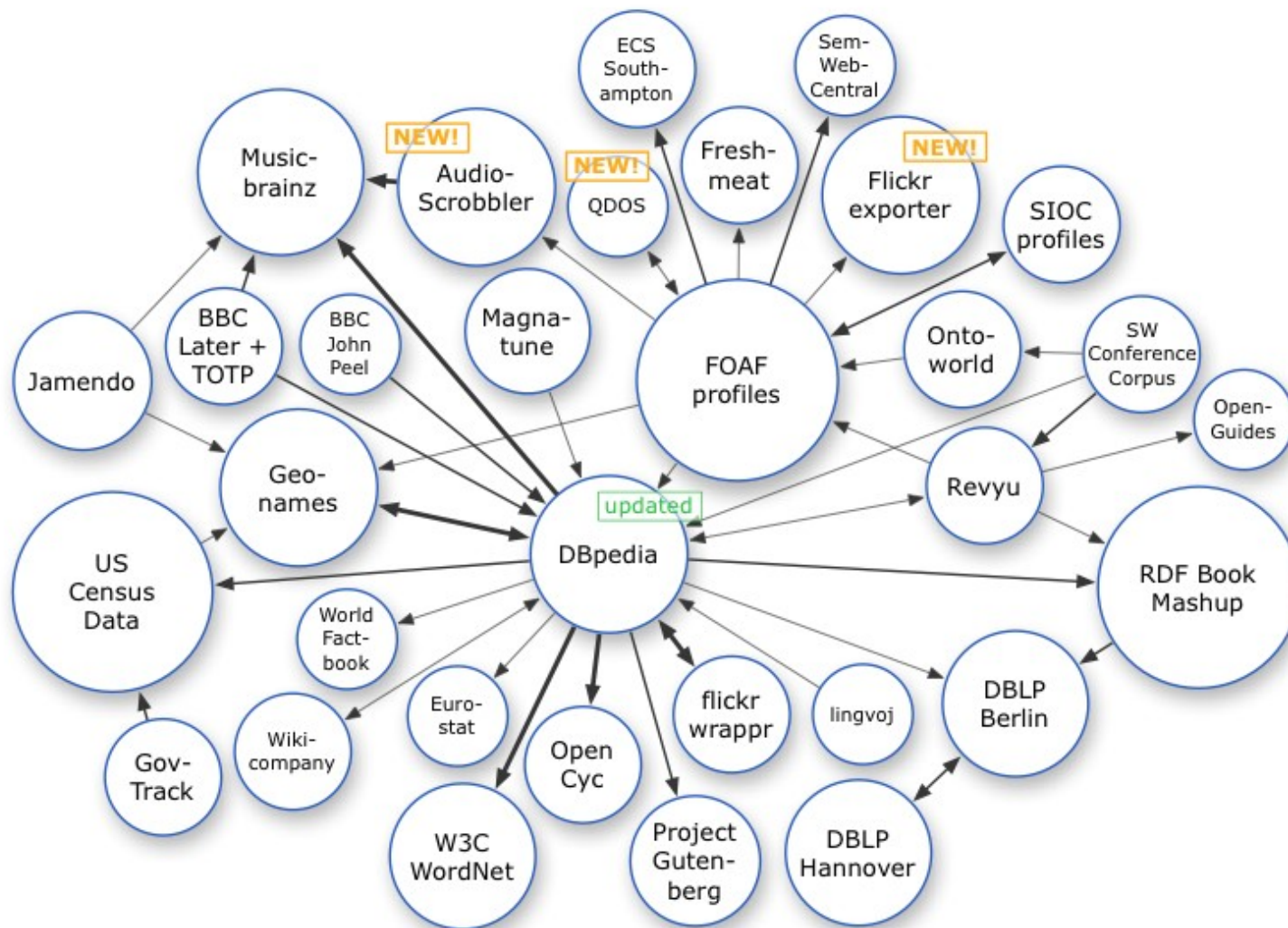


# The LOD "Cloud" - November 2007

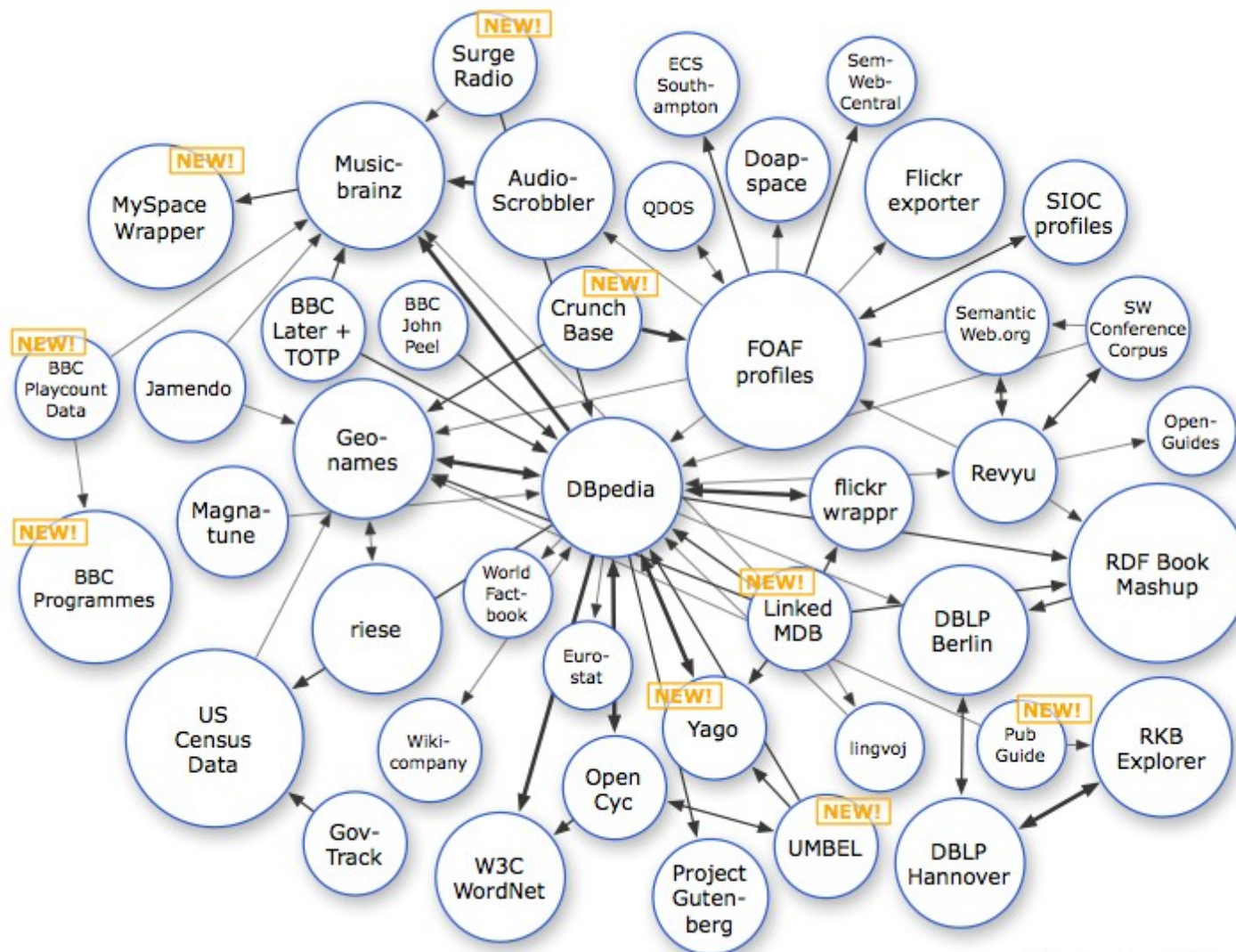




# The LOD "Cloud" – Feb 2008



# The LOD "Cloud" – Sept 2008



As of September 2008

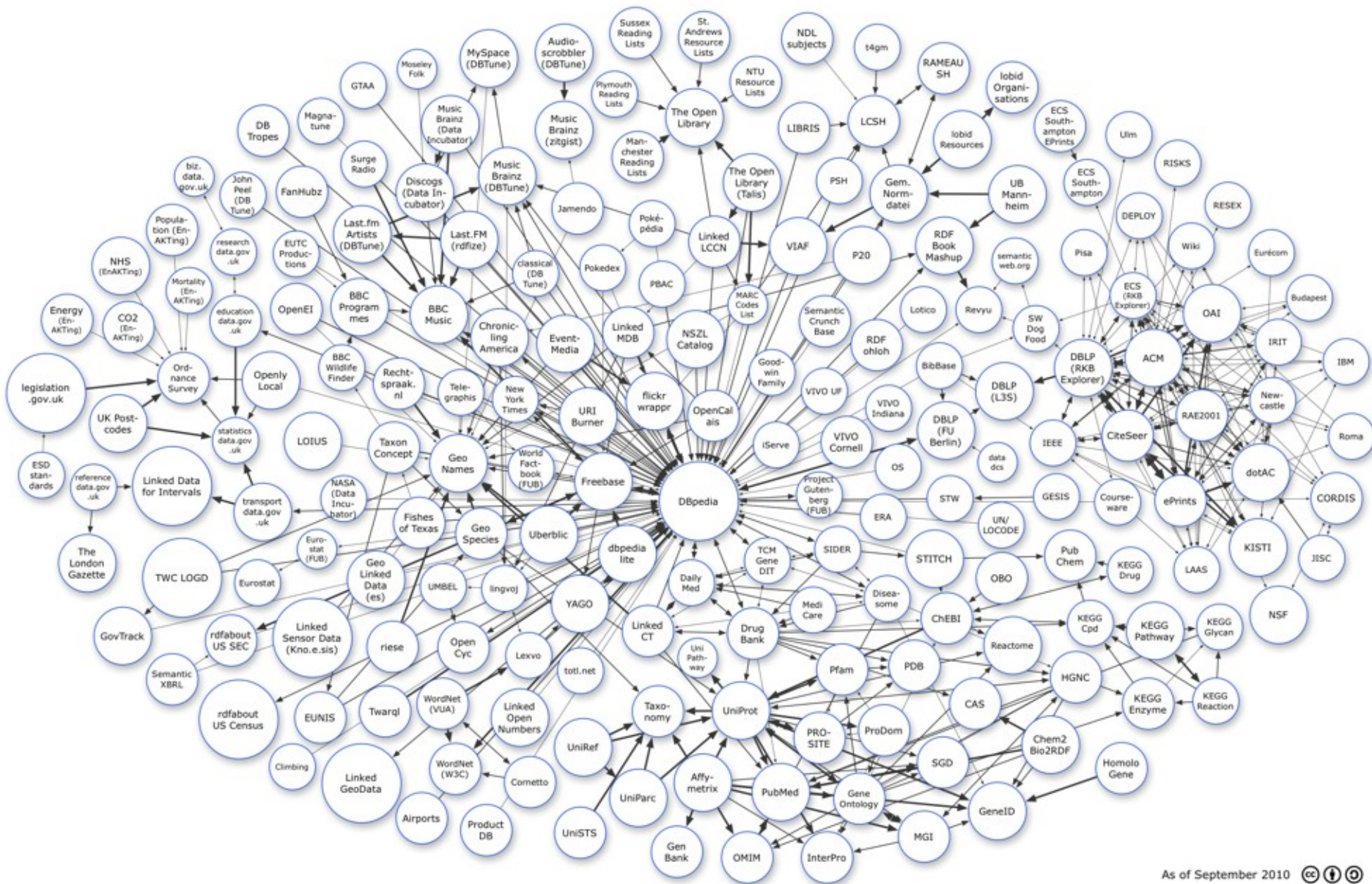












one

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## The Sky at Night



Reporting on the latest cosmological events and the people who observe them

WEBSITE: [Go to the homepage for 'The Sky at Night'](#)

PREVIOUS PROGRAMMES: [by year](#) (78)

## Coming up

Sorry, no programmes coming up.

## More from BBC One

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## Last on



## Star Birth

MORE: [programme information](#) | [related links](#)

Broadcast **Saturday, 14:10** on **BBC Two** (except Northern Ireland (Analogue), Wales (Analogue)) but **no longer available** on BBC iPlayer.

A look at new images of star-forming areas of our galaxy from the Herschel telescope.





ROBYN | BBC RADIO 1

### Robyn In The Live Lounge

Robyn brought a touch of heartbreak to the Live Lounge as she performed her new single, 'Dancing On My Own', and a cover of Alicia Keys' 'Sleeping With A Broken Heart'.

MORE MUSIC ON THE BBC 1-3 OF 20

ROBYN IN THE LIVE  
LOUNGEDOVES - ROCKNESS  
PERFORMANCENERINA PALLOT:  
WEEKEND WOGAN  
PERFORMANCE

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## Most Played Artists On The BBC

14-20 JUNE 2010



Information displayed about artists played on BBC programmes is incomplete at present. [Find out more about this artist play count information.](#)

[More Artists »](#)

# WILDLIFE FINDER

WATCH THE MOST AMAZING ANIMALS IN THE WORLD

BBC  
Nature

LATEST WILDLIFE



1 video 3 programmes  
At this point, they perch upright

16 June 2010

## Gharial

Gharials are once again on the verge of extinction in the wild. After 30 years of conservation effort and restocking, there may still be fewer than 200 breeding adults left in the wild.

1 sound

1 programme

16 June 2010

## Mute swan

Mute swans are a familiar sight in parks and other urban areas.



## COLLECTIONS

Collections offer a new perspective on the vast catalogue of clips showcasing presenter favourites, aspects of wildlife film-making, and gathering content together in illuminating ways.

### BRILLIANT BEES



#### Brilliant bees

Bees are amazing - not only do they fulfil a vital role in our ecosystem, they are one of the most complex and sophisticated living things in the history of evolution.

Wildlife wind-ups

## EDITOR'S CHOICE

Spotted any ravens lately? Or a black red fox? Take a look at who's featuring on Springwatch.



Raven 3 videos



Otter 11 videos



## WELCOME TO WILDLIFE FINDER

Explore a wealth of video, sounds, stories and breaking news on your favourite animals, and find out more about how and where they live.

Wildlife Finder gives you access to an ever growing catalogue of BBC natural history programmes, with video clips from series such as: Planet Earth, Blue Planet, Life on Earth, Natural World, Life and many more.

## WHAT'S NEW?

10 June 2010



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WORLD CUP 2010

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FIXTURES &amp; RESULTS

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BBC COVERAGE



HIGHLIGHTS

Ivory Coast 0-0 Portugal


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Brazil 2-1 North Korea


[Highlights and report](#)

Honduras 0-1 Chile


[Highlights and report](#)

Spain 0-1 Switzerland


[Highlights and report](#)

COMING UP

## Blogs

James Pearce



## Beckham grafts for England

But ex-captain keen to remain away from World Cup spotlight

Phil McNulty



## Is Beckenbauer right about England?

## Swiss secure shock win over Spain



Switzerland provide the first surprise result of the 2010 World Cup by beating 2008 European champions Spain 1-0 in Group H.

[World Cup day six photos](#)
[Enhanced match stats](#)

## Wednesday's matches

<a href="#">Honduras 0-1 Chile</a>	Full-time
<a href="#">Spain 0-1 Switzerland</a>	Full-time
<a href="#">South Africa v Uruguay</a>	19:30 BST

## Group tables

A	B	C	D	E	F	G	H	
GROUP H TEAMS				W	D	L	GD	PTS
	Chile			1	0	0	1	3
	Switzerland			1	0	0	1	3
	Honduras			0	0	1	-1	0
	Spain			0	0	1	-1	0

## Video choice


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### APPS



With so much government data to work with, developers are creating a wide variety of applications, mashups, and visualizations. From crime statistics by neighborhood to the best towns to find a job to seeing the environmental health of your community—these applications arm citizens with the information they need to

### COMMUNITY

Data.gov is leading the way in democratizing public sector data and driving innovation. The data is being surfaced from many locations making the Government data stores available to researchers to perform their own analysis. Developers are finding good uses for the datasets, providing interesting and useful applications that allow for new views and public analysis. This is a work in progress, but this movement is spreading to cities, states, and other countries. After just one year a community is born around open government data.

#### Just look at the numbers:

6 Other nations establishing open data  
8 States now offering data sites

### SEMANTIC WEB

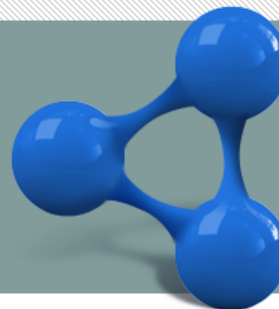
As the Web of linked documents evolves to include the Web of linked data, we're working to maximize the potential of Semantic Web technologies to realize the promise of Linked Open Government Data.



Thanks to our collaboration with the **Tetherless World Constellation** at the **Rensselaer Polytechnic Institute**, Data.gov is now hosting one of the largest open collections of RDF datasets in the world! Check out some of their

## Unlocking innovation

Working with UK Public  
Sector information and data



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Community  
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Local Data Panel

### Latest datasets

- 14 June** More [COINS](#) public spending data: now covers 2005 to 2010
- 10 June** Lists of [all Special Advisers](#) and [Cabinet Office staff](#)
- 4 June** [COINS database](#) of Public Spending
- 2 June** NHS Weekly [MRSA](#) and [C-Difficile](#) dataset
- 1 June** [Senior Civil Servants with salaries over £150,000](#)

### What we do

data.gov.uk is a key part of the Government's [Transparency programme](#) for the UK public sector as a whole. Working with Sir Tim Berners-Lee, Professor Nigel Shadbolt and Tom Steinberg and other members of the Cabinet Office Minister's new [Public Sector Transparency Board](#) this site seeks to give a way into the wealth of government data becoming available. It's under constant development and we want to work with you to make it better.

### What is the Semantic Web?

Combining different data sources has never been easy but the Semantic Web will enable data to be joined easily across boundaries.

[Read more](#)

### Digital Engagement Twitter stream



RT



## Keyword search

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## Current search

[x] energy

## Guided search

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### Nation

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[Scotland \(106\)](#)  
[Wales \(105\)](#)  
[Northern Ireland \(93\)](#)

### Public body

[Department of Energy and Climate Change \(45\)](#)  
[Department for Business \(13\)](#)  
[Innovation and Skills \(13\)](#)  
[Scottish Government \(9\)](#)  
[Northern Ireland Executive \(5\)](#)  
[Department for Communities and Local Government \(4\)](#)  
[Department for Environment \(2\)](#)  
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[business-and-enerav \(91\)](#)

## Results 1 - 10 of 128

### Energy Consumption in the UK

This publication brings together **energy** consumption data for previous year from a variety of different sources in order to give a comprehensive view of how **energy** has been used in the UK since the 1970s. The publication is divided ...

**Tags:** [energy](#) [transport](#)

### UK Energy Sector Indicators: key and supporting indicators

... of the gas and electricity markets; the structure of the **energy** market; and fuel poverty. Supporting indicators, explain in more detail ... by the key indicators, as well as covering carbon and **energy** intensity; gas and electricity capacity; the diversity of fuels used in ...

**Tags:** [electricity](#) [emissions](#) [energy](#) [fuel](#) [gas](#) [green](#) [greenhouse-gas](#) [housing](#)

### High Level Indicators of Energy Use at Regional and Local Authority Level

Indicators of regional **energy** use compared with a variety of socio-economic variables Source agency: **Energy** and Climate Change Designation: Official Statistics not designated ... Language: English Alternative title: Regional **energy** high level indicators Overview ...

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### Energy Trends

Provides statistics on **energy** in the United Kingdom which provides a

## Local Data Panel



## What is the Semantic Web?

Combining different data sources has never been easy but the Semantic Web will enable data to be joined easily across boundaries.

[Read more](#)

## Digital Engagement Twitter stream



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[@RosslynAnalytic](#) We'll have #COINS ready in web analytics for everyone in hours.  
[bit.ly/9Z5Etp](#) <-and they did: well done

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## Ordnance Survey Linked Data

A description of the resource identified by <http://data.ordnancesurvey.co.uk/>

<b>Title</b>	Ordnance Survey Linked Data
<b>Description</b>	Ordnance Survey is Great Britain's national mapping agency, providing the most accurate and up-to-date geographic data, relied on by government, business and individuals. OS OpenData is the opening up of Ordnance Survey data as part of the drive to increase innovation and support the "Making Public Data Public" initiative. As part of this initiative Ordnance Survey has published a number of its products as Linked Data. Linked Data is a growing part of the Web where data is published on the Web and then linked to other published data in much the same way that web pages are interlinked using hypertext. The term Linked Data is used to describe a method of exposing, sharing, and connecting data via URIs on the Web. To find more Linked Data published as part of this initiative please go to <a href="http://data.gov.uk">data.gov.uk</a> . If you are not familiar with Linked Data, OS OpenData products are also available in alternative formats from the OS OpenData website. Ordnance Survey can provide support for the Ordnance Survey OpenData products, but cannot give advice or support on using RDF, SPARQL or SPARQL Endpoints. Ordnance Survey has published two separate linked data resources: the 1:50 000 Scale Gazetteer and the administrative gazetteer for Great Britain.
<b>Creator</b>	<a href="#">Ordnance Survey</a>
<b>Date issued</b>	2010-04-01
<b>Example resource</b>	<a href="#">Southampton</a> <a href="#">Portsmouth</a> <a href="#">Southampton, Itchen</a> <a href="#">The County of Hampshire</a> <a href="#">The City of Southampton</a> <a href="#">Southampton Common</a>
<b>SPARQL endpoint</b>	<a href="#">Sparql</a>
<b>URI lookup point</b>	<a href="#">Meta?about=</a>
<b>Vocabulary used</b>	<a href="#">Spatial Relations Ontology</a> <a href="#">Administrative Geography Ontology</a> <a href="#">WGS84 Geo Positioning</a> <a href="#">FOAF</a> <a href="#">OWL</a> <a href="#">Gazetteer Ontology</a>
<b>URI regex pattern</b>	<a href="http://data.ordnancesurvey.co.uk/id/.+">http://data.ordnancesurvey.co.uk/id/.+</a>
<b>See also</b>	<a href="#">data.gov.uk</a>

# The Open Graph Protocol



## Introduction

The [Open Graph protocol](#) enables any web page to become a rich object in a social graph. For instance, this is used on Facebook to enable any web page to have the same functionality as a Facebook Page.

While many different technologies and schemas exist and could be combined together, there isn't a single technology which provides enough information to richly represent any web page within the social graph. The Open Graph protocol builds on these existing technologies and gives developers one thing to implement. Developer simplicity is a key goal of the Open Graph protocol which has informed many of [the technical design decisions](#).

---

## Basic metadata

To turn your web pages into graph objects, you need to add basic metadata to your page. We've based the initial version of the protocol on [RDFa](#) which means that you'll place additional `<meta>` tags in the `<head>` of your web page. The four required properties for every page are:

- **og:title** - The title of your object as it should appear within the graph, e.g., "The Rock".
- **og:type** - The [type](#) of your object, e.g., "movie". Depending on the type you specify, other properties may also be required.
- **og:image** - An image URL which should represent your object within the graph.

# Linked Data: In Practice



## Introducing “Tom's Travels”

- A low-budget Linked Data mashup
  - A few hours from concept to creation



# Toms Travels

[Athens, Georgia](#)

[Austin](#)

[Banff](#)

[Beijing](#)

[Busan](#)

[Datong](#)

[Manchester](#)

[Raleigh](#)

[Seoul](#)

[Shanghai](#)

# Toms Travels: Athens, Georgia

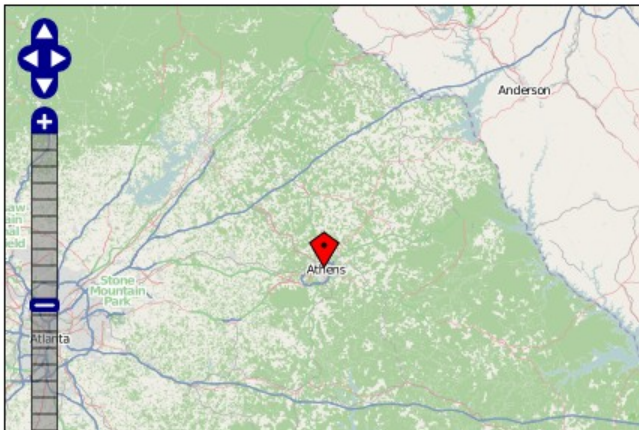
Population: 45734 (GeoNames), 113398 (DBpedia)

Athens-Clarke County is a unified city-county in Georgia, U.S. , in the northeastern part of the state. The University of Georgia is located in this college town and is responsible for the initial creation of Athens and its subsequent growth. In 1991, after a vote the preceding year, the original city abandoned its charter in order to form a unified government with Clarke County, referred to collectively as Athens-Clarke County.



## Location

33.96095/-83.383056640625



## Famous Sons and Daughters

Andy Johnson (American football) Blake Camp Bob McWhorter Bob Woodruff  
(American football) Cincinnati Red Derek Dooley (American football coach) Frank H.  
Brumby Gillian Bonner Henry Woodfin Grady Horace King Janelle Taylor Jeff  
Daniels Jonathan Leathers Keith Wiggins Madeleine Peyroux Marcus Foster Ricky  
Wilson (American musician) Stephen Kendrick Willie Green (American  
football) henry r. jackson leo kottke Đ ĐuĐ<sup>(001)</sup>Đ Đ½Đ³ĐuŊ, ĐšĐ Đ¼

## Bands

[Bain Mattox](#) [Beyond Tomorrow \(band\)](#) [Brent Cash](#) [Bubba Sparxxx](#) [Chris McKay & the Critical Darlings](#) [Cindy Wilson](#) [Colt Ford](#) [Drive-By Truckers](#) [Dromedary \(band\)](#) [Entertainment](#) [Filet of Soul](#) [Harvey Milk](#) [Hindu Love Gods \(band\)](#) [I Am the World Trade Center](#) [James Husband](#) [Japancakes](#) [Jucifer](#) [Keith Strickland](#) [Liz Durrett](#) [Maserati \(band\)](#) [Of Montreal](#) [Pacific UV](#) [Packway Handle](#) [Band](#) [Phosphorescent](#) [Pylon](#) [R.E.M.](#) [Ravenstone](#) [Servotron](#) [Slackdaddy](#) [The B-52's](#) [The Mendoza Line](#) [The Method Actors](#) [The Olivia Tremor Control](#) [The Whigs](#) [Twin](#)



# Toms Travels: Athens, Georgia

Population: 45734 (GeoNames), 113398 (DBpedia)

**DBpedia**

**DBpedia**

**Geonames** Athens is a city in Georgia, U.S. , in the northeastern part of the state. The University of Georgia is located in this college town and is responsible for the creation of Athens and its subsequent growth. In 1991, after a vote the preceding year, the original city abandoned its charter in order to form a unified government with Clarke County, referred to collectively as Athens-Clarke County.

**FlickrWrapp**



**Location Geonames**

33.96095/-83.383056640625



**OpenStreetMap**

**Famous Sons and Daughters**

**DBpedia**

[Andy Johnson \(American football\)](#) [Blake Camruff](#) [\(American football\)](#) [Cincinnati Red](#) [Derek Dooley \(American football coach\)](#) [Frank H. Brumby](#) [Gillian Bonner](#) [Henry Woodfin](#) [Grady Horace](#) [King Janelle Taylor](#) [Jeff Daniels](#) [Jonathan Leathers](#) [Keith Wiggans](#) [Madeleine Peyroux](#) [Marcus Foster](#) [Ricky Wilson \(American musician\)](#) [Stephen Kendrick](#) [Willie Green \(American football\)](#) [henry\\_r.\\_jackson](#) [leo\\_kottke](#)  $\text{D}^{\circ}\text{D}^{\circ}\text{N}^{\circ}\text{D}^{\circ}$   $\text{D}^{\circ}\text{D}^{\circ}\text{D}^{\circ}\text{D}^{\circ}\text{N}^{\circ}\text{D}^{\circ}$   $\text{D}^{\circ}\text{D}^{\circ}\text{D}^{\circ}\text{D}^{\circ}\text{N}^{\circ}\text{D}^{\circ}$

**Bands**

**DBpedia**

[Bain Mattox](#) [Beyond Tomorrow \(band\)](#) [Brent Cash](#) [Bubba Sparxxx](#) [Chris McKay & the Critical Darlings](#) [Cindy Wilson](#) [Colt Ford](#) [Durrett Maserati \(band\)](#) [Entertainment Filet of Soul](#) [Harvey Milk](#) [I Am the World Trade Center](#) [James Husband](#) [Japancakes](#) [Jucifer](#) [Keith Strickland](#) [Liz Durrett](#) [Maserati \(band\)](#) [Of Montreal](#) [Pacific UV](#) [Packway](#) [Handle Band](#) [Phosphorescent](#) [Pylon](#) [R.E.M.](#) [Ravenstone](#) [Servotron](#) [Slackdaddy](#) [The B-52's](#) [The Mendoza Line](#) [The Method Actors](#) [The Olivia Tremor Control](#) [The Whigs](#) [Twin](#)

# Toms Travels: Banff, Alberta

Population: 7502 (GeoNames), 6700 (DBpedia)

Banff is the largest town in Banff National Park, in Alberta's Rockies, Canada. It is the first incorporated municipality located within a Canadian national park, and at 1,463 m (4,800 ft), it is the town with the second highest elevation in Canada, the highest being Lake Louise. It is surrounded by mountains, notably Mount Rundle, Sulphur Mountain, Mount Norquay, and Cascade Mountain, and is situated above Bow Falls near the junction of the Bow and Spray Rivers.



## Location

51.17622/-115.5719451904297



## Famous Sons and Daughters

[John Robarts](#) [Ryan Smyth](#)

## Bands

[Mico \(band\)](#)

<http://sws.geonames.org/5892532/>



# Toms Travels: Busan

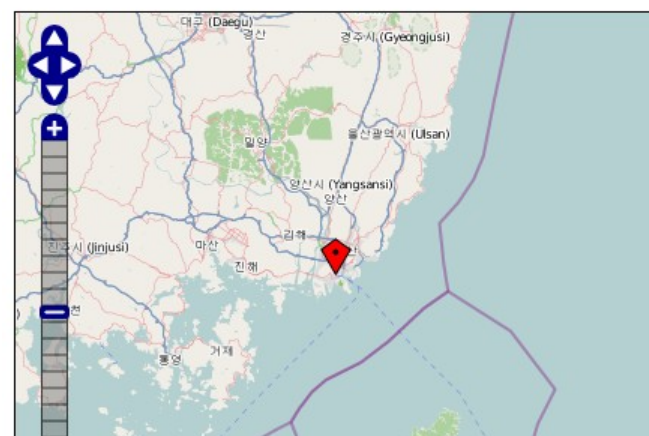
Population: 3678555 (GeoNames), 3596063 (DBpedia)

Busan Metropolitan City, also known as Pusan is South Korea's second largest metropolis after Seoul, with a population of around 3.6 million. It is the largest port city in South Korea and the fifth largest port in the world. The city is located on the Southeasternmost tip of the Korean Peninsula and faces the Korea Strait.



## Location

35.10278/129.03333333333333



## Famous Sons and Daughters

[Ahn Cheol-Soo](#) [Chae Jung An](#) [Chang Jung-Koo](#) [Choi Yong-Soo](#) [Daniel Dae Kim](#) [Ha Gil-jong](#) [Hahn Dae-soo](#) [Heo Jeong Jang](#) [Hyuk Jeong Ga-eun](#) [Jeong Hyeong-don](#) [Kim Jee-Hyuk](#) [Kim Ji-mee](#) [Kim Sung-Jun](#) [Lee Jun Ki](#) [Moon Hee Nam](#) [Tae-Hee Park](#) [Si-yeon Roh](#) [Hoe-chan Sandara](#) [Park Sang-Hyun](#) [Kim Yoon Jeong-hee](#) [choi\\_hyun\\_ha\\_jung-eun](#) [jung\\_hae-seong](#) [moon\\_ki-han](#) [song\\_yoo-geol](#) [usun\\_yoon\\_ã.-ãfãf»ãf\\_ã.¹ëf'èf'ã%¤é«~ã±±\(ã®fã®™éf>eiCEé-cãz,è€...\)](#)

## Bands

[Kim Gun-mo](#) [Pia \(band\)](#) [Sandara Park](#)

<http://sws.geonames.org/1838524/>

# Toms Travels: Beijing

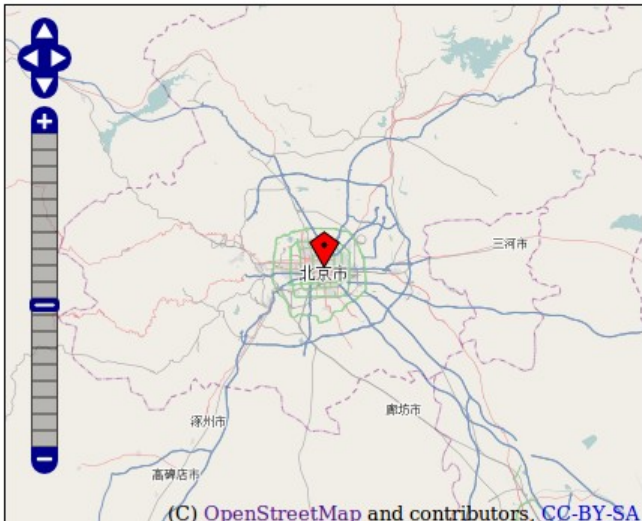
Population: 7480601 (GeoNames), 4 (DBpedia)

Beijing, also known as Peking, is a metropolis in northern China and the capital of the People's Republic of China. Governed as a municipality under direct administration of the central government, Beijing borders Hebei Province to the north, west, south, and for a small section in the east, and Tianjin Municipality to the southeast. Beijing is one of the Four Great Ancient Capitals of China.



## Location

39.9075/116.39166666666667



## Famous Sons and Daughters

Bingyi Bo Xilai Cheng Yuelel Du Wenhui Duo Duo Fu Szeto Gao Leilei Ge You Gong Lei Gu Cheng Jason Hu Jin Zhiyang John Cox (Royal Navy officer) John Liu Fugh Kangxi Emperor Li Baodong Li Dawei Li Kun Li Leilei Li Wei (footballer born 1985) Li Wei (scientist) Liang Shih-chiu Lou Jiwei Lu Bofei Lu Jiang LÁ¼ Zheng Nian Weisi Nien Cheng Nora (Neng Yee) Lam Pujie Puyi Shan Sa Shao Jiayi Tang Jing Tao Wei Tatsuya Fuji Terence Koh Wan Houliang Wang Dulu Wang Wanning Wang Xiaolong Wanli Emperor Wu Hao Xie Xuejing Xu Yunlong Xuefei Yang Yang Lan Yang Mi Yang Pu (footballer) Yansong Ma Yixuan, 1st Prince Chun Yoshiko Kawashima Yuja Wang Zaifeng, 2nd Prince Chun Zhang Jingna Zhang Shuo (footballer) Zhang Si Zhang Xinxin (footballer) Zhang Yuan (footballer) Zhu Yifan jia\_hongsheng ren\_jiaging xiao\_gang\_wen Đ•Đ»ÑŽĐ¹ ĐŚŦfŦĐ•Đ¹ ä¹ ec'ä¹³ ä''ä¹¹³³ ä¹µæ%œäç— æœ™™ æ²°ç¥¥ç;œžžč·éä²ä¹ èèèè ç± è-©æ"-ä¹¹³³ è™³3é¹™ æç... é«-æ²æ³ç (è¹³çœœ fèçœœ äš~ä¹)

## Bands

Dennis Charter Dou Wei Gemini (Chinese band) Liu Liyang (singer) Tang Dynasty (band) The Flowers Yaksa (band) carsick cars

<http://sws.geonames.org/1816670/>





## Tom's Travels

- A low-budget Linked Data mashup
  - A few hours from concept to creation
- ~700 lines of PHP code
  - Including new caching layer for image information

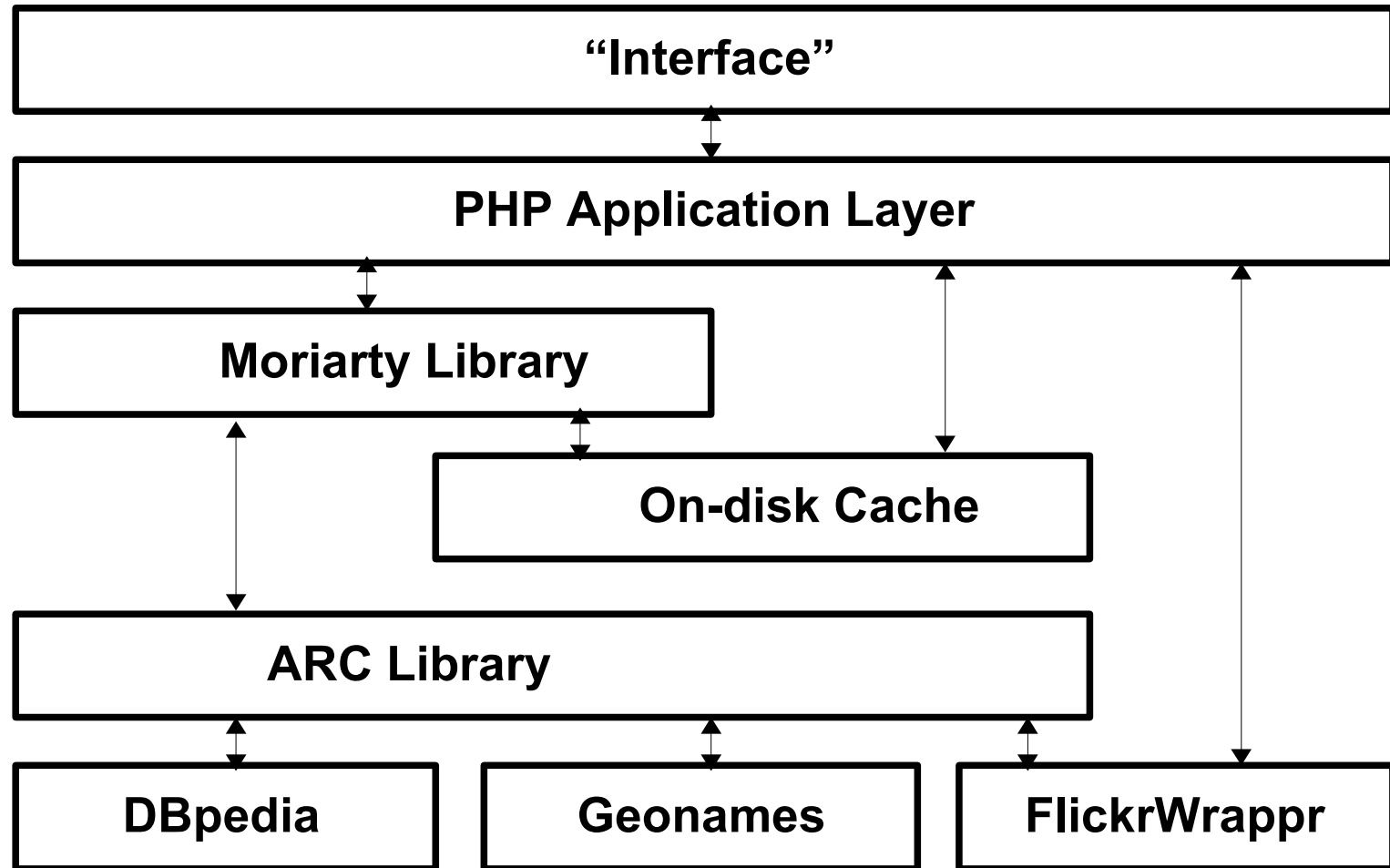




## Tom's Travels

- A low-budget Linked Data mashup
  - A few hours from concept to creation
- ~700 lines of PHP code
  - Including new caching layer for image information
- Integrates Linked Data from 3 sources
  - DBPedia, Geonames, FlickrWrappr
  - Adding more is very low cost

# Tom's Travels: Architecture



## Tom's Travels: Workflow

```

city = new Graph()
city → read_data(dbpediaUri)
geonamesUri = city → getGeonamesUri()
    city → read_data(geonamesUri)
    latlong = city → getLatLong()
photoSetUri = city → getPhotoSetUri()
    city → read_data(photoSetUri)
    photos = city → getPhotos()
    for each photo (getPhotoInfo(); selectOrReject())
city → getChildren()
    for each child (city → read_data(childUri))
city → getBands()
    for each band (city → read_data(bandUri))
page = new Page(city)
    
```



# Challenges (Specific and Generic)

- Performance
  - Real-time Link Traversal vs Pre-Fetching vs Replication

# Challenges (Specific and Generic)

- Performance
  - Real-time Link Traversal vs Pre-Fetching vs Replication
- Trust
  - Spurious Links
    - Is dbpedia:Manchester really same as geonames:2643123 ?
  - Contradictory Information

# Toms Travels: Beijing

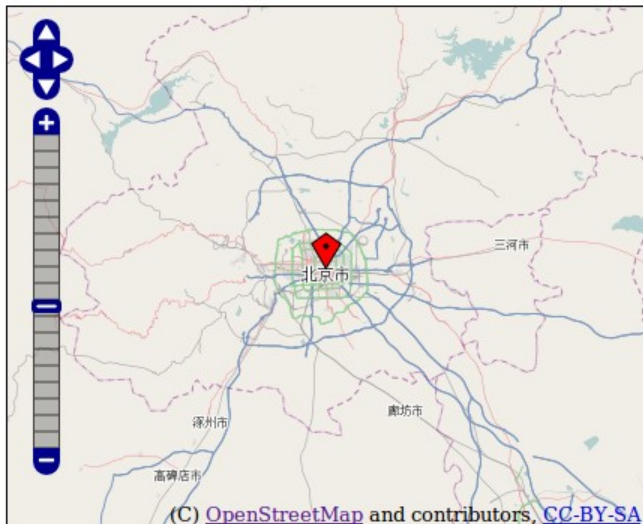
Population: 7480601 (GeoNames), 4 (DBpedia)

Beijing, also known as Peking, is a metropolis in northern China and the capital of the People's Republic of China. Governed as a municipality under direct administration of the central government, Beijing borders Hebei Province to the north, west, south, and for a small section in the east, and Tianjin Municipality to the southeast. Beijing is one of the Four Great Ancient Capitals of China.



## Location

39.9075/116.39166666666667



## Famous Sons and Daughters

Bingyi Bo Xilai Cheng Yuelel Du Wenhui Duo Duo Fu Szeto Gao Leilei Ge You Gong  
Lei Gu Cheng Jason Hu Jin Zhiyang John Cox (Royal Navy officer) John Liu  
Fugh Kangxi Emperor Li Baodong Li Dawei Li Kun Li Leilei Li Wei (footballer born  
 1985) Li Wei (scientist) Liang Shih-chiu Lou Jiwei Lu Bofei Lu Jiang LA¼ Zheng Nian  
Weisi Nien Cheng Nora (Neng Yee) Lam Pujie Puyi Shan Sa Shao Jiayi Tang Jing Tao  
Wei Tatsuya Fuji Terence Koh Wan Houliang Wang Dulu Wang Wanxing Wang  
Xiaolong Wanli Emperor Wu Hao Xie Xuejing Xu Yunlong Xuefei Yang Yang Lan Yang  
Mi Yang Pu (footballer) Yansong Ma Yixuan, 1st Prince Chun Yoshiko  
Kawashima Yuja Wang Zaifeng, 2nd Prince Chun Zhang Jingga Zhang Shuo  
 (footballer) Zhang Si Zhang Xinxin (footballer) Zhang Yuan (footballer) Zhu Yifan jia\_  
hongsheng ren\_jiaqing xiao- gen Đ•Đ•ÑŽĐ¹  
ĐSNfNtĐ•Đ¹ ä¹ èc'ä¹³ ä¹ "ä¹ ä¹¼µæ%öçäç— æ000 "æ™™™ æ²°ç¥¥ç; çŽ·é·çä¹² èèèè  
± è-©æ™™ ä¹ æ™³ 3é!™ æç... é«~æ¹æ³ç (è¹çfèç(ä¹ä¹ ä¹ ä¹)

## Bands

Dennis Charter Dou Wei Gemini (Chinese band) Liu Liyang (singer) Tang Dynasty (band) The Flowers Yaksa (band) carsick cars

<http://sws.geonames.org/1816670/>

# Challenges (Specific and Generic)

- Performance
  - Real-time Link Traversal vs Pre-Fetching vs Replication
- Trust
  - Spurious Links
    - Is dbpedia:Manchester really same as geonames:2643123 ?
  - Contradictory Information
- Reconciling Terminological Differences
  - You say <http://yourvocab.eg/Tomato> , I say <http://myvocab.eg/Tomayto>



# Conclusions

## Conclusions

- Conventional mashups are an ad-hoc and expensive approach to data integration
- Linked Data enables reusable, Web-scale data integration (the data owner pays, just once)
- Building Linked Data mashups is quick and easy
- Challenges remain around architectures, trust/quality, and terminology

## Further Reading and Events

- Bizer, Heath and Berners-Lee (2009) Linked Data – The Story So Far, IJSWIS, 5(3), 1-22.
  - available from <http://tomheath.com/publications>
- Tutorial on Publishing Linked Data
  - <http://linkeddata.org/docs/how-to-publish>
- Synthesis e-Book on Linked Data
  - coming early 2011
- Tools
  - Moriarty: <http://code.google.com/p/moriarty/>
  - ARC: <http://arc.semsol.org/>

# Questions?

- Contact Info
  - [tom.heath@talis.com](mailto:tom.heath@talis.com)
  - <http://tomheath.com/id/me>
  - <http://www.talis.com/>
  - @tommyh (twitter)
- Slides
  - <http://tomheath.com/slides/2010-12-manchester-linked-data.pdf>



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