Introduction to the Semantic Web (tutorial)

3rd Chinese Semantic Web Symposium
Nanjing, China
August 29, 2009

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Introduction

Let's organize a trip to Budapest from Amsterdam using the Web!

You try to find a proper flight with …

… a big, reputable airline, or …

Book flights - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.klm.com/travel/nl_nl/apps/ebt/ebt_home.htm

travel tom

KLM Royal Dutch Airlines

nwa

Stel hier uw vraag (in me

Book flights

You are not logged in

1 Vlucht zoeken | 2 Datum kiezen | 3 Tijd kiezen | 4 Uw gegevens | 5 Bekijken & betalen

Contact KLM Service Center

E-mail een vriend(in) Print deze pagina

Kies uw heen- en terugvlucht.

Vertrek: Amsterdam (Schiphol) naar Boedapest (Ferihegy Airport)

Toon vluchten gebaseerd op Alleen de beste verbindingen (10 van 13)

Alleen rechtstreekse vluchten tonen (5 van 13)

Laagste tarieven (9 van 13)

Alle vluchten (13)

Kies	Prijs	Vertrek	Aankomst	Vlucht
Rechtstreekse vluchten				
◉		10:00 Vr 15 Aug 08 Amsterdam (Schiphol) Totale reistijd: 2 uren 0 minuten Uitgevoerd door MALEV Hungarian Airlines Vliegtuigtype :Boeing 737	12:00 Vr 15 Aug 08 Boedapest (Ferihegy Airport)	KL3201
○		12:20 Vr 15 Aug 08 Amsterdam (Schiphol) Totale reistijd: 2 uren 0 minuten Uitgevoerd door MALEV Hungarian Airlines Vliegtuigtype :Boeing 737	14:20 Vr 15 Aug 08 Boedapest (Ferihegy Airport)	KL3203

Kies tarief

Take Off

RETOUR tarieven per persoon incl. belasting en toeslagen (excl. reserveringskosten)

Take Off (25% FB Miles) 300 Geselecteerd

Take Off 341 Selecteer

Take Off (Flexibel) 383 455 537

… the airline of the target country, or …

Review - Mozilla Firefox

File Edit View History Bookmarks Tools Help

https://booking.malev.com/BookingSite/Review/Review.aspx

travel tom

BOOK YOUR TRIP
FLIGHTS, SCHEDULES
PREPARE FOR FLIGHT
FLYING WITH MALEV
DUNA CLUB
CUSTOMER CARE
CORPORATE INFO

MALEV Hungarian Airlines
ONE MORE REASON TO TRAVEL

English

1 Search 2 Select 3 Review 4 Traveller data 5 Purchase 6 Confirmation

SELECT DELIVERY METHOD

Please select ticket delivery method below!

	Delivery method	Service fee	Address
◉	E-ticket	EUR 10 View service fee breakdown	with e-invoice
○	Airport	EUR 30	KLM ticket office, departure hall 2.
○	Office	EUR 30	KLM ticket office, departure hall 2.
○	Courier		Courier or mail delivery is available only within the country of departure! You will be asked to provide a delivery address on the next page. Please note that in case of courier delivery we will be unable to deliver your ticket(s) to a PO box.
○	Mail	EUR 30	

BOOKING GUIDE
Book Cheap!
Card payment
About ticket pickup
If you are not among the travellers
Online Client Service

Check it!

FLIGHT SUMMARY

Outbound flight
From: Amsterdam, Schiphol (AMS), Netherlands
Budapest, Ferihegy 2A (BUD),

Return flight
From: Budapest, Ferihegy 2A (BUD), Hungary
To: Amsterdam, Schiphol (AMS),

… or a low cost one

Online booking | Select Flights - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://wizzair.com/skylights/cgi-bin/skylights.cgi?step=1

wizzair.com

new destination from London Luton: Timisoara (from 17 December)

online booking | useful information | destinations | travel services | partners

tant changes regarding checked-in baggages - Please click here for more details...

flights
agency login
my account
search bookings
log in

Book a Flight

Round Trip
One Way

From: Eindhoven

To: Budapest-Terminal 1

Depart: 14 Aug

Return: 03 Sep

Passengers: 1 Adult Over 14 years

0 Child 2 to 14 years

search | select | contact | passengers | purchase | confirmation

The flights available for the date(s) that you have selected are shown below. Review and select that you wish to purchase by ticking the dot next to the fare price or use the form to the left ha search for new flights. All times are local.

Fares shown below are for one way flights and per adult, child and infant. The total price include: the taxes and the charges. Payments made with debit and credit cards are subject to a payment Click here to find out the exact amount. The fee depends on the type of card that you wish to u payment.

going out

Eindhoven » Budapest-Terminal 1

date	fareclass	flight	departs	arrives	price excluding tax	taxes and charges
Fri 15 Aug 08	Web	W6 228	13:25	15:20	Adult 94.99 EUR	26.00 EUR
Sun 17 Aug 08	Web	W6 228	13:25	15:20	Adult 73.99 EUR	26.00 EUR

Next Week >

You have to find a hotel, so you look for…

… a really cheap accommodation, or …

Hostels - online booking at Youth Hostels and Backpackers Hostels - instant online reservations and reviews with HostelTraveler.co...

File Edit View History Bookmarks Tools Help

http://www.hosteltraveler.com/index.php

HostelTraveler.com

Hostels Reviews Best deals Top Cities

everything for travelers:

Search Hotels/Cities

Check Reservations

Free Membership

Hostel Traveler ... instant online booking for youth hostels, budget hotels and hostelling the globe

Welcome member travelers !

Sign in

Lodging Sign in

InstantWorldBooking

Find Hostels and Lodging at your destinations.

Look for IWB for instant online booking.

How it Works

Step 1-Find Lodging

Step 2-Make Reservations

Secure online hostel booking at worldwide youth hostels, backpackers, and budget hotels.

Home

Start Over

Members

Lodging Operators

About this Site

Selection Status

3 accommodations have been found matching your criteria.

Select your accommodations and click Make Reservations for rates, availability, and reservations.

Click on names to see photos, reviews, and more information.

Tip: Click Instant for rates and instant secure confirmations.

Sort by: **Price (Lo-Hi)** Price (Hi-Lo) Traveler Rating Hostel Class Hostel Name

View Advanced Display Options

Balaton, Hungary Make Reservations

Unity Hostel Balaton
Rakoczi Ut 268
Hostel 8 Units
Write a Review

unity hostel

Instant Booking

From **€12**

2hours from Budapest,we are located right behind a free beach access to the lake, right opposite a large shopping and dinning court, only few minutes from the best clubs.lots of freebies!!!

… or a really luxurious one, or …

Search Results - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.hilton.com/en/hi/hotels/search/newresults.jhtml?searchType=city&stat

Hilton

Travel should take you places®

Sign in Username or HHonors #: Password or PIN:

Register Forgot password? Remember Me

View Text Only

Customer Support 1-800-HILTONS

Specials & Packages | Reservations | Meetings | Social Gatherings | Hilton HHonors | Things to Do | eBrochures | My Favo

Search Results

Change Your Search

Location

City: Budapest

Search Within: 40 mi km

State/Province: State / Province

Country: Hungary

Brand

Hilton Hotels

All Hilton Family Hotels

Search Results

Print Help

The following locations matched your request.

Rates displayed may be non-refundable.

Please review rate rules and restrictions prior to booking your stay.

Sort by: Brand Show: All Hotels Go View Hotels on a Map >

Hilton Hotels

Hilton Budapest WestEnd

Compare Hotel

Vaci ut 1-3
Budapest, Hungary, 1062
36-1-288-5500

Available

… an intermediate one …

Szállás Utazás Magyarországon - Wellness-Szállás, Nyaralás, Utazás, Programok - Magyarországon - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.travelsinhungary.hu/view_kat.php?katid=1&megye=budapest

TRAVELS IN HUNGARY
www.travelsinhungary.hu

MAGYAR ENGLISH DEUTSCH

Keresés | Az összes kategóriában | OK

TÖRZSVENDÉG KEDVEZMÉNYEK

REGISZTRÁCIÓ

ELÉRHETŐSÉG

VENDÉGKÖNYV

- Szállás (Wellness, Aktív pihenés, Gyógyturizmus)
- Étterem
- Programok, Látnivalók
- Szórakozás (Élményfürdők, Kalandparkok)
- Rendezvényszervezés (konferenciák-tréningek)

AJÁNLATOK

Szálláshely \ Budapest

Válasszon megyét:
Válasszon!

Válasszon várost:
Válasszon!

Ajánlatok száma a kategóriában: **1.**

Airport Hotel Budapest****

★★★★☆

SZÁLLÁSHELY
Budapest(Vecsés)
Ferihegyi repülőtéri szálloda és konferencia központ

részletesen...

W3C Semantic Web

oops, that is no good, the page is in Hungarian that almost nobody understands, but…

… this one could work

Bestwestern.com, the World's Largest Hotel Chain - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://book.bestwestern.com/bestwestern/selectHotel.do?iata=00158210

st western

Best Western

Welcome to bestwestern.com®

Customer Service ↗ Rewards Program ↗ Gift Card ↗ Groups & Meetings ↗

My Profile Email or Member#: Password: SIGN-IN

Forgot Password
Create Password
Enroll Now

HOME | FIND A HOTEL | CHECK RESERVATIONS | TRIP PLANNER | PROMOTIONS & PROGRAMS | PACKAGES

RESERVATIONS | HOTEL LOCATIONS | BEST WESTERN PREMIER HOTELS | NEW HOTELS | QUESTIONS & ANSWERS

Hotel Search Results → Select Occupancy → Select Room → Review & Reserve → Confirmation

Find a Hotel - Select Hotel

Page: 1

Modify Your Search:

City: Budapest

Select State or Province: All

Select Country: Hungary

Check-In: 08/15/2008

Check-Out: 09/03/2008

Features & Amenities:

- High Speed Internet
- Complimentary Breakfast

5 Hotels Found within 50 Mi / 80 Km of the Budapest Area

Show: All Hotels By: Distance

Display Currency In:

Show Hotels on a Map

Best Western Hotel Hungaria

Photo Gallery

Stay at this 4-star Budapest hotel offering guests deluxe accommodations near some of Budapest's popular attractions and business locations. Visitors... More >

Pet Policy

Rákoczi Ut 90,
Budapest, H-1074, Hungary
Distance from City Center: 0.86m / 1.38km

Hotel not available on selected dates.

Check Alternate Dates

W3C Semantic Web

Of course, you could decide to trust a specialized site…

… like this one, or…

Create your package from Amsterdam to Budapest (and vicinity) - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.expedia.com/pub/agent.dll?qscr=cmsh&subm=1&CMBTX_0_rgnm=Bud

travel tom

Expedia

Welcome - Already a

My Itineraries | My Account | Customer S

Search Expedia

Home | Flights | Hotels | Cars | Vacation Packages | Cruises | Activities | DEALS & OFFERS | Maps | Business Travel | Rewards

Start search over

Change your search

Departing: 8/18/2008

Returning: 9/3/2008

Star Rating: Show all

Lodging Type: Show All

Name contains:

Go

Change Travelers

2 Adults
1 Room

Change travelers

Create your package from Amsterdam to Budapest (and vicinity)

Maps: Area map view Hotel map view

Hotel amenities: Narrow your search

Show hotels in this area:

Budapest (and vicinity) (all areas) Go

Not what you're looking for? Choose a different destination

View packages: **1 - 25** 26 - 50 51 - 75 76 - 97

Previous | Next

Sort by: Expedia Picks | Price | Hotel Name | City | Star Rating | Traveler Opinion

Avg/person: $2889

Corinthia Grand Hotel Royal

Impressive landmark building with imposing Neo-classical façade and soaring glass atrium, set on Pest's busy Erzsébet Avenue, and housing shops, a spa, … More lodging info

Hotel promotion - Stay 3 Nights and Save 20% on Your Stay!

Total: Price details $5778

Get ThankYou® Points

Budapest, PEST

Executive Double-Executive lounge usage

Includes: Free Wireless Internet, Spa Credit , Breakfast Buffet

Check in: 8/18/08
Check out: 9/03/08

Traveler Opinion
4.7 out of 5
15+ reviews

Amsterdam (AMS) to Budapest (BUD) Depart: 8/18/08 6:00 PM - 8:00 PM Malev Hungarian Airlines

1-800-55

Call now for the same great deals plus expert advice

W3C Semantic Web

… or this one

Budapest Hotels: Read Budapest Hotel Reviews and Compare Prices - TripAdvisor - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.tripadvisor.com/Hotels-g274887-Budapest-Hotels.html

tripadvisor®
get the truth. then go.®

My TripAdvisor
Register Now!

22,582,888 Travelers from 190 Countries Planned Trips Here This Week!

Home | Destinations | Fun & Games | Just For Members

Search
Go

Budapest Overview
Budapest Hotels
Flights to Budapest
Budapest Deals

More On Budapest
Before You Go
Things to Do
Restaurants
Map
Traveler Photos
Traveler Videos
Forum

Budapest Deals
Discount Hotels

Home → Europe → Hungary → Budapest

Budapest Hotels

ADD TO MY MAP | WRITE A REVIEW | EMA

Hotels (272) | B&Bs / Inns (24) | Specialty Lodging (83)

Find Hotels Travelers Trust

Check-in: Any date mm/dd/yyyy
Check-out: Any date mm/dd/yyyy
My dates are flexible

Price: Any Price | U.S. Dollars
Hotel class: Any Class
Adults: 2

Recommended For: All

Find Hotels

Best deals: Budapest hotels

Budapest: Boek en bespaar tot 75%.
Booking.com Geen reserveringskosten!

Great Budapest Hotels
www.Venere.com/Budapest_Hotels See maps & pics, reac book online. Relax and enjoy your stay!

Budapest easyHotel Deals
www.easyHotel.com City Centre from just €15 per night fror founder of easyJet

Cheap Hotels Budapest
www.otel.com/BudapestHotels Fantastic rates on Budape Huge Savings. Instant Confirmation!

View all deals for Budapest

Spon

Recommended Hotels (1-20 of 272)

Sort by: Popularity next »

Free Budapest Guide

Get the best picks for where to ea and play.

Download pdf

You may want to know something about Budapest; look for some photographs…

… on flickr …

Flickr: Budapest - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.flickr.com/groups/budapest/

flickr

Signed in as Ivan Herman Help Sign Out

Home You Organize Contacts Groups Explore Search this group's pool Search

Share This

Budapest

Group Pool | Discussion | 1,418 Members | Map | Invite Friends

Group Pool (19,017 items | Add photos or video)

NEW From apuc

NEW From André Fromont

NEW From carlogambino

NEW From carlogambino

NEW From Crashbandi

NEW From Crashbandi

NEW From Crashbandi

NEW From Crashbandi

NEW From Crashbandi

NEW From Crashbandi

NEW From Crashbandi

NEW From Crashbandi

» More

Discussion (33 posts | Post a new topic)

… on Google …

budapest - Google Image Search - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://images.google.nl/images?hl=en&q=budapest&btnG=Search+Images&gbv=2

Web **Images** Maps News Video Gmail more ▼ Sign in

Google budapest Search Images Search the Web Advanced Image Search Preferences

Moderate SafeSearch is on

Images Showing: All image sizes Results 1 - 18 of about 19,900,000 for **budapest** [definition]. (0.25 seconds)

E-mail this photo E-mail. **Budapest** 550 x 412 - 40k - jpg www.tripadvisor.com

Budapest, Hungary 450 x 338 - 43k - jpg www.transitionsabroad.com

Budapest looks its most beautiful at … 1024 x 768 - 161k - jpg web.kvif.bgf.hu

Beautiful-**Budapest** 430 x 320 - 34k - jpg www.budapesthotels.com [More from www.budapesthotels.com]

Hotel Victoria **Budapest** 575 x 473 - 92k - jpg www.victoria.hu

Fly to **Budapest** and experienc one … 909 x 682 - 347k - jpg www.sterling.dk

Danube Bridge Elisabeth in **Budapest** … 1024 x 768 - 194k - jpg budapest5.freeblog.hu

Budapest had 2421831 inhabitants in … 422 x 425 - 29k - jpg www.squidoo.com

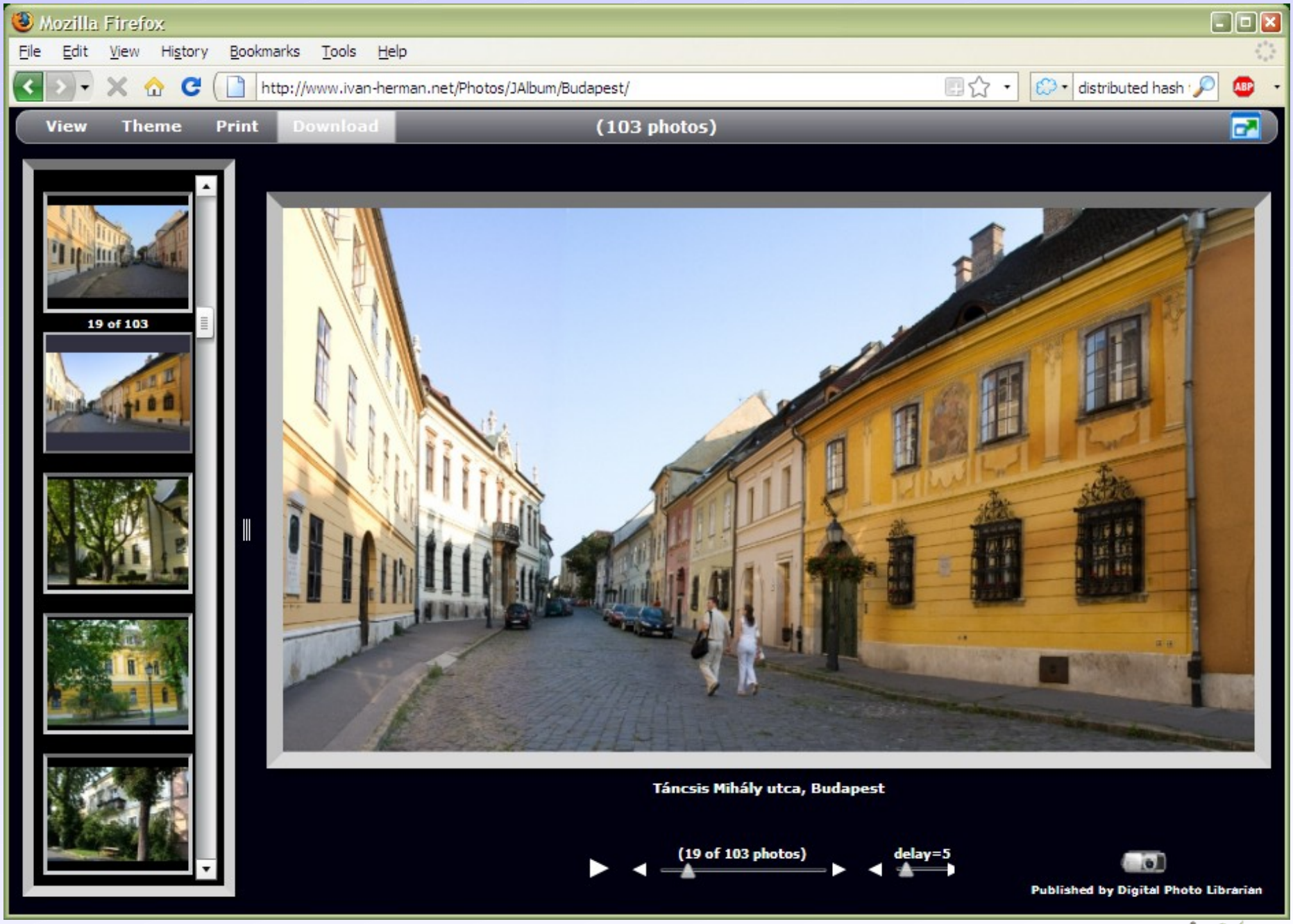
budapest night 575 x 352 - 206k - jpg www.wayfaring.info

Budapest - Things to Do with a Day … 400 x 300 - 32k - jpg cruises.about.com

Jewish Cultural Heritage in **Budapest** 452 x 360 - 67k www.budapesthotels.com

Hungary, **Budapest**, Parliamen 640 x 480 - 199k - jpg www.hungary.travelphotoguide.c

… or you can look at mine



… or a (social) travel site

Budapest Travel Guide | Budapest Tourism - RealTravel - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://realtravel.com/budapest-hungary-travel-guide-d13081-1.html

realtravel™ Real People. Real Advice. Real Experiences.™

Free Travel Blog | Free Trip Planner | Sign

Travel Guides | Hotels | Attractions | Things To Do | Editor's Picks | Deals

Search

You are here: Destinations > Europe > Hungary > Budapest > Travel Guide

BUDAPEST TRAVEL GUIDE AND TOURISM

Introduction | Guides | Trips | Photos | Flights | Hotels | Restaurants | Attractions | Deals

photo by Taisteal

more Budapest photos ▸
Destinations near Budapest ▸

Budapest Travel Guide

This capital city - made up of two parts, Buda and Pest - sits on one of the most beautiful areas of the Danube River and it shows. Often dubbed the "Paris of Eastern Europe", it is a combination of Old World grandeur and a thriving cultural scene. Budapest has a vibrancy and vitality that never slows and the numerous sights can occupy travelers for weeks. With so much history and culture to explore, no traveler leaves unsatisfied.

Price Compare Tool

Search multiple sites for the best rate in Budapest

COMPARE FLIGHTS

COMPARE HOTELS

Travel Guide Information From Our Partners

What happened here?

- You had to consult a large number of sites, all different in style, purpose, possibly language…
- You had to mentally *integrate* all those information to achieve your goals
- We all know that, sometimes, this is a long and tedious process!

- All those pages are only tips of respective icebergs:
  - the real *data* is hidden somewhere in databases, XML files, Excel sheets, …
  - you have only access to what the Web page designers allow you to see

- Specialized sites (Expedia, TripAdvisor) do a bit more:
  - they gather and combine data from other sources (usually with the approval of the data owners)
  - but they still control how you see those sources
- But sometimes you want to personalize: access the original data and combine it yourself!

Here is another example…

CoCoDat - Collation of Cortical Data - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.cocom

CoCoMac DATABASES ORT EXAMPLES

CoCoDat: Collation of Cortical [s
microcircuitry] Data

CoCoDat is a microcircuitry database that
published experimental reports. The data
and cellular compartment), as well as the

- Morphology
- Firing properties
- Ionic currents
- Ionic conductances
- Synaptic currents
- Connectivity

The database is available for download u
data tables but also a Search Board with
manual or automatic relaxation of the sea

- Brain region
- Layer
- Neuron type

http://www.cocomac.org/cocodat/catalyzer/inc

Cell Centered Database - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://ccdb.ucsd.edu/sand/main?event=gallery&action=show&dpl=y

red database

Cell Centered Database™
National Center for Microscopy and Imaging Research
Gallery

Data | Search | Gallery | Dictionary | Publications | MyCCDB | Data Download | Contact us | Help

2D image | Reconstruction | Segmentation | Animation

y 23
: 071202tjd
: P1188
t Brain Maps
t Tom Deerinck
t BioRad RTS 2000MP
: Multiphoton
: montage of cerebellar cortex triple labeled for Hoescht stain (blue), IP3 receptor (green) and GFAP (red)

logged out

NeuronDB - Thalamic relay neuron - Overview (A) () - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://senselab.med.yale.edu

senselab

NeuronDB

Back

Thalamic relay neuron

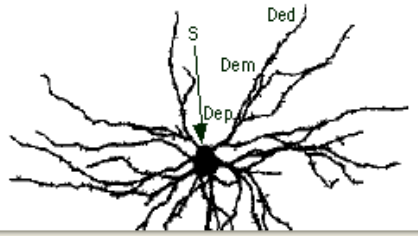
Mode: Overview | Data/Search | plus Connectivity | plus Classical References/Notes | Models

Region: Distal equivalent dendrite | Middle equivalent dendrite | Proximal equivalent dendrite | Soma | Axon hillock | Axon fiber | Axon terminal | All Compartments

Properties: Receptors | Channels | Transmitters | All Properties

Interoperation: Gene and Chromosome | Experimental Data (neurodatabase.org) | Microscopy Data (CCDB)

Neuron type: principal
Organism: Vertebrates



1. Equivalent dendrite — Show other
2. Distal equivalent dendrite — Show other
3. Middle equivalent dendrite — Show other
4. Proximal equivalent dendrite — Show other
5. Soma — Show other

Done

logged out

W3C Semantic Web

Another example: social sites. I have a list of "friends" by…

… Dopplr,

DOPPLR: Ivan Herman's fellow travellers - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.dopplr.com/traveller/IvanHerman/fellows

DOPPLR FOR IVAN

Find and Invite | Your connections | Your trips | Your account | Sign out

Visit our blog for updates

Where Next? { Gent, Boston, Vienna…

+ Add a trip

Type the name of a city or a traveller

Find people and places

Welcome, Ivan

In the last 2 weeks,
one of your fellow travellers added a trip that coincides with you.

Find out more in your journal...

You are at home in Amsterdam.

You can invite people to Dopplr to see your trips, find them on other networks you use
or look for travellers you already know to encourage more coincidences.
You have a public profile. Edit it?

You can now create a public profile to display to the whole internet if you want, not just Dopplr users — and take any of the information to embed on your own website. Give it a try!

Your trips | Fellow travellers | Your journal | Your carbon

List or Map

- Peter Brown is in Montréal until August 16th. Boston soon. Montréal later.
- Daniel Appelquist is in Washington until August 23rd. Aspen soon. Washington later.
- Eva Méndez is in Maraña until August 17th. Santo Domingo later.
- Danny Weitzner is in Bergen until September 5th. Los Angeles later.
- Charlton Barreto is in Vienna until August 18th. Sacramento soon. Vienna later.

… Twine,

My Connections | Twine - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.twine.com/user/ivanherman/connections

BETA INVITE-ONLY twine

Home | My Items ▾ | My Twines ▾ | My Connections | Explore ▾ | Start a Twine

Ivanherman | Logout | Account

My Connections

Search within My Connections...

View All | Sort by Most Recent

Refine your view by...

You can also filter by selecting from the following categories.

related twines

Dean Allemang
at home
Oakland, CA
3 Twines | 4 Items
Send Message | Disconnect

78

David Provost
Breathing
Boston
20 Twines | 15 Items
Send Message | Disconnect

Attila Gardos
Hungary, Budapest
9 Twines | 8 Items
Send Message | Disconnect

Connect with Peop

Invite People to Tw

Recommended M

jim
got my
san fra
83 Twi

Steve
Seattle
38 Twi

James
living l
95008
122 Tw

Chris
All rea
Mill Val
73 Twi

… LinkedIn,

LinkedIn: My Contacts: Connections - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.linkedin.com/connections?trk=hb_side_cnts

easy jet

Account & Settings | Help | Sign Out Language

LinkedIn

People | Jobs | Answers | Companies | Advanced Search People Search

Home
Groups
Profile
Contacts
Inbox (19)

Add Connections

Ivan Herman

Semantic Web Activity Lead, World Wide Web Consortium

What are you working on?

Your profile is 80% complete [Edit]

Contacts

Connections | Imported Contacts | Network Statistics

Add Connections

Connections

Show contacts with new connections

advanced options

Showing 311 of 311 connections.

15 outstanding sent invitations

A B C D E F G H I J K L M N O P Q R S T

A

Aasman, Jans ja@franz.com View & edit details »	CEO at Franz Inc	252
Abramatic, Jean-François jfa@ilog.fr View & edit details »	Chief Product Officer at ILOG	163
Adida, Ben ben@adida.net View & edit details »	Software Security Researcher and Entrepreneur	148
Allemang, Dean dino-link@happydino.com View & edit details »	Chief Scientist at TopQuadrant Inc.	179
Allison, Kevin kevin.allison@ft.com View & edit details »	San Francisco Correspondent at The Financial Times	152
Alonso, Jose Manuel jalonso@w3.org View & edit details »	eGovernment Lead at W3C	106

W3C Semantic Web

… and, of course, Facebook

Facebook | All Friends - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.new.facebook.com/friends/#/friends/?flid=0&view=everyone&

Welcome to the new Facebook

Send feedback | Back to the old Facebook

facebook Ivan Herman Friends Applications Inbox Home Settings Logout Search

All Friends

Friend Lists

- All Friends
- CWI
- Family
- IW3C2
- W3C Team

Make a New List

Find Friends

Find people you know who are already on Facebook

Invite your friends to join Facebook

Showing: Status Updates Recently Updated Phonebook Everyone Search Friends

Show: Choose an option...

You have 137 friends.

1 2 3 Next

Shadi Abou-Zahra

Ross Ackland

Ben Adida

Anupriya Ankolekar

Daniel Appelquist is hanging out in Aspen.
15 hours ago

Lora Aroyo

Advertise

Make mo

Discover Ali world n°1 o marketplace

Do You T Photos?

Make your c book, from

More Ads

- I had to type in and connect with friends again and again for each site independently ☹
- This is even worse then before: *I* feed the icebergs, but I still do not have an easy access to data…

What would we like to have?

- Use the data on the Web the same way as we do with documents:
  - be able to link to data (independently of their presentation)
  - use that data the way I want (present it, mine it, etc)
  - agents, programs, scripts, etc, should be able to *interpret* part of that data

Put it another way…

- We would like to *extend* the current Web to a "*Web of data*":
  - allow for applications to exploit the data directly

But wait! Isn't what mashup sites are already doing?

A “mashup” example:

TripIt | Organize your travel - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.tripit.com/trip/show/id/858966

Trip Details

Summary View | Expanded View | View Change Log

Thursday, July 24, 2008 — Budapest, Hungary (Edit) Avg: Sunny / Hi 28°C / Lo 14°C — Add Plans

FLIGHT 14:55 CEST

Flight from Amsterdam (AMS) to Zurich (ZRH)

edit | delete | copy | move

Swiss International Airlines 729

Depart: Amsterdam (AMS), 14:55 CEST

Arrive: Zurich (ZRH), 16:20 CEST

nonstop
1h 25min
aircraft Airbus A320-100/200
374 miles

Conf. # JFFRAL

Connects to: LX 2258 at 17:20 CEST

Passengers
Ivan Herman
Eva Boka ep Herman

Booking Information
Booked on 18/4/2008
http://www.swiss.com

FLIGHT 17:20 CEST

Flight from Zurich (ZRH) to Budapest (BUD)

edit | delete | copy | move

Swiss International Airlines 2258

Depart: Zurich (ZRH), 17:20 CEST

Arrive: Budapest (BUD), 18:55 CEST

nonstop
1h 35min
aircraft Fokker 100
500 miles

Conf. # JFFRAL

Passenger(s): Ivan Herman, Eva Boka ep Herman.

MAPS 19:05 CEST

Map of Budapest, Hungary

delete |

Budapest, Hungary

- In some ways, yes, and that shows the huge power of what such Web of data provides
- But mashup sites are forced to do very ad-hoc jobs
  - various data sources expose their data via Web Services
  - each with a different API, a different logic, different structure
  - these sites are forced to reinvent the wheel many times because there is no standard way of doing things ☹

Put it another way (again)…

- We would like to extend the current Web to a *standard* way for a “Web of data”

But what does this mean?

- What makes the current (document) Web work?
  - people create different documents
  - they give an address to it (ie, a URI) and make it accessible to others on the Web

Steven's site on Amsterdam (done for some visiting friends)

The Internet Guide to Amsterdam - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://homepages.cwi.nl/~steven/amsterdam.html

The Internet Guide to Amsterdam

Contents

Designed to be printed out and taken with you.

Written by Steven Pemberton, CWI, Amsterdam, and Astrid Kerssens, Amsterdam.

Linked to by more than 450 other sites; more than 3,500,000 gruntled readers!

The top Amsterdam travel guide according to Google. If you know how Google works, you know that that says something about this site!

See also London.

A Review of this Guide

The Internet Guide To Amsterdam:
WebUser Gold Award
Rating: ★★★★★
Reviewed By: Jane Hoskyn
Sometimes, it's the simple things in life that make your heart skip a beat.
This is especially true when you're abroad and you need a guide that loads really fast on your mobile phone or PDA (check), doesn't involve clicking from page to page to find what you want (check), isn't written in fluffy tourist-board-speak (check), has all the links you need and none of the ones you don't (check), and is put together by someone who loves your destination and knows it better than the insides of his own eyelids (check). Step forward Steven Pemberton, creator of this exemplary guide to having a damn good time in the 'Dam.

Introduction

Amsterdam is an unusual city in that it has all the advantages of a big city – culture, history, food, entertainment, good

Then some magic happens…

- Others discover the site and they link to it
- The more they link to it, the more important and well known the page becomes
  - remember, this is what, eg, Google exploits!
- This is the "Network effect": some pages become important, and others begin to rely on it *even if the author did not expect it…*

This could be expected…

WWW9 Organizers - Opera

File Edit View Bookmarks Widgets Feeds Chat Tools Help

QuickP… Diigolet Pyt… Boo… W3… Sem… RDF… Validate! Mobical Favikis Twi… Netvibes World …

WWW9 Organizers

http://www9.org/w9-organizers.html

ido-masochism website

WWW9 Organizers

May 15-19, 2000, Amsterdam

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120%

but this one, from the other side of the Globe, was not…

Netherlands - Spring Break Information - Mozilla Firefox

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http://msass.case.edu/international/SPNetherlandFAQ.html

CASE.EDU: HOME | DIRECTORIES | SEARCH

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International Courses

- General Information
- Descriptions by Country
- Passport Application
- Dutch Visa Application
- Previous Trips
- Testimonials

Netherlands - Spring Break Information

Please also see the following links for information on the trip to the Netherlands

- General FAQ
- Appling for a Dutch Visa
- A Students Photo Journal of the Netherlands

What Forms do I need for this Program?

All of the forms you will need are linked from the Forms page.

More information? Check out these links:

Amsterdam Links
Spring Break Trip participants to Amsterdam may familiarize themselves with Amsterdam by visiting the following web sites. On website address nl refers to the Netherlands.
Information on travel outside the United States , including instructions on getting a passport: http://travel.state.gov
A must see website http://homepages.cwi.nl/~steven/amsterdam.html
United States Consulate, Amsterdam: http://www.usemb.nl
Virtual Tour of Amsterdam: http://www.channels.nl

W3C Semantic Web

What would that mean for a Web of Data?

- Lessons learned: we should be able to:
  - "publish" the data to make it known on the Web
    - standard ways should be used instead of ad-hoc approaches
    - the analogous approach to documents: *give URI-s to the data*
  - make it possible to "link" to that URI from *other* sources of data (not only Web pages)
    - ie, applications should not be forced to make targeted developments to access the data
    - generic, standard approaches should suffice
  - and let the network effect work its way…

But it is a little bit more complicated

- On the traditional Web, humans are implicitly taken into account
- A Web link has a “context” that a person may use

Eg: address field on my page:

Ivan Herman - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.w3.org/People/Ivan/

Ivan Herman

My Work at W3C | Contact information | Short CV | Upcoming trips | Public presentations

My Work at W3C

I am Semantic Web Activity Lead; that is my main work at W3C. I am member of IW3C2 (International World Wide Web Conference Committee) (the committee coordinating the yearly WWW conference series), serving as a liaison for W3C, and of SWSA (Semantic Web Science Association), the committee responsible for the International Semantic Web Conferences series.

As part of my work, I also participate in lots of outreach activities, and I regularly make presentations, tutorials, etc. You can consult my list of presentations for further details.

Contact information

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Phone numbers:
phone: +31-20-5924163
mobile phone: +31-641044153
fax: +31-20-5924312
PGP/GPG:
My GnuPGP key and signature is available on-line.
FOAF:
You can either extract a short FOAF information from this page, of consult my more complete, public FOAF file.
Misc:

… leading to this page

Centrum Wiskunde & Informatica | CWI - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.cwi.nl/

CWI

Centrum Wiskunde & Informatica

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Centrum Wiskunde & Informatica

Centrum Wiskunde & Informatica (CWI) performs fundamental scientific research in mathematics and computer science. CWI transfers the acquired knowledge to society and industry. The institute's strategy for the period up to 2012 is to concentrate research on four broad, societally relevant themes:

News

13-10-08

PhD defence Jarek Byrka

22-09-08

Best Paper Award for SMIL State research

At the ACM DocEngineering Symposium in Sao Paulo, Brazil, from 16 till 19 September, CWI researchers Jack Jansen and Dick Bulterman received the Best Paper Award.

read more

Agenda

18-10-08

Science Day at the Science Park Amsterdam

At Science Day the Science Park Amsterdam will be open for

This year the theme of Science Day is 'Crack the code'. CWI workshops en demonstrations within this theme for every age

read more

21-10-08

MAS Seminar, speaker Svetlana Dubinkina

Two speaker session

Tea starting at 10.00

Room: M279

Speakers:

1. Svetlana Dubinkina, CWI MAS 1, tba

2. James Glazier, University of Indiana Bloomington, tba

read more

28-10-08

MAS Seminar, speaker Peter Sonneveld

W3C Semantic Web

- A human understands that this is my institution's home page
- He/she knows what it means (realizes that it is a research institute in Amsterdam)
- On a Web of Data, something is missing; machines can't make sense of the link alone

- New lesson learned:
  - extra information (“label”) must be added to a link: “this links to my institution, which is a research institute”
  - this information should be machine readable
  - this is a *characterization* (or “classification”) of *both* the link *and* its target
  - in some cases, the classification should allow for some limited “reasoning”

Let us put it together

- What we need for a Web of Data:
  - use URI-s to publish data, not only full documents
  - allow the data to link to other data
  - characterize/classify the data and the links (the “terms”) to convey some extra meaning
  - and use standards for all these!

So what is the Semantic Web?

It is, essentially, the Web of Data.

"Semantic Web Technologies" is a collection of standard technologies to realize a Web of Data

- It is that simple…
- Of course, the devil is in the details
  - a common model has to be provided for machines to describe, query, etc, the data and their connections
  - the “classification” of the terms can become *very* complex for specific knowledge areas: this is where ontologies, thesauri, etc, enter the game…

W3C GRDDL

W3C SPARQL

W3C SKOS

W3C POWDER

W3C OWL

W3C RDF

W3C RDFa

W3C Semantic Web

In what follows…

- We will use a simplistic example to introduce the main technical concepts
- The details will be for later during the course

The rough structure of data integration

1. Map the various data onto an abstract data representation
   - make the data independent of its internal representation…
2. Merge the resulting representations
3. Start making queries on the whole!
   - queries that could not have been done on the individual data sets

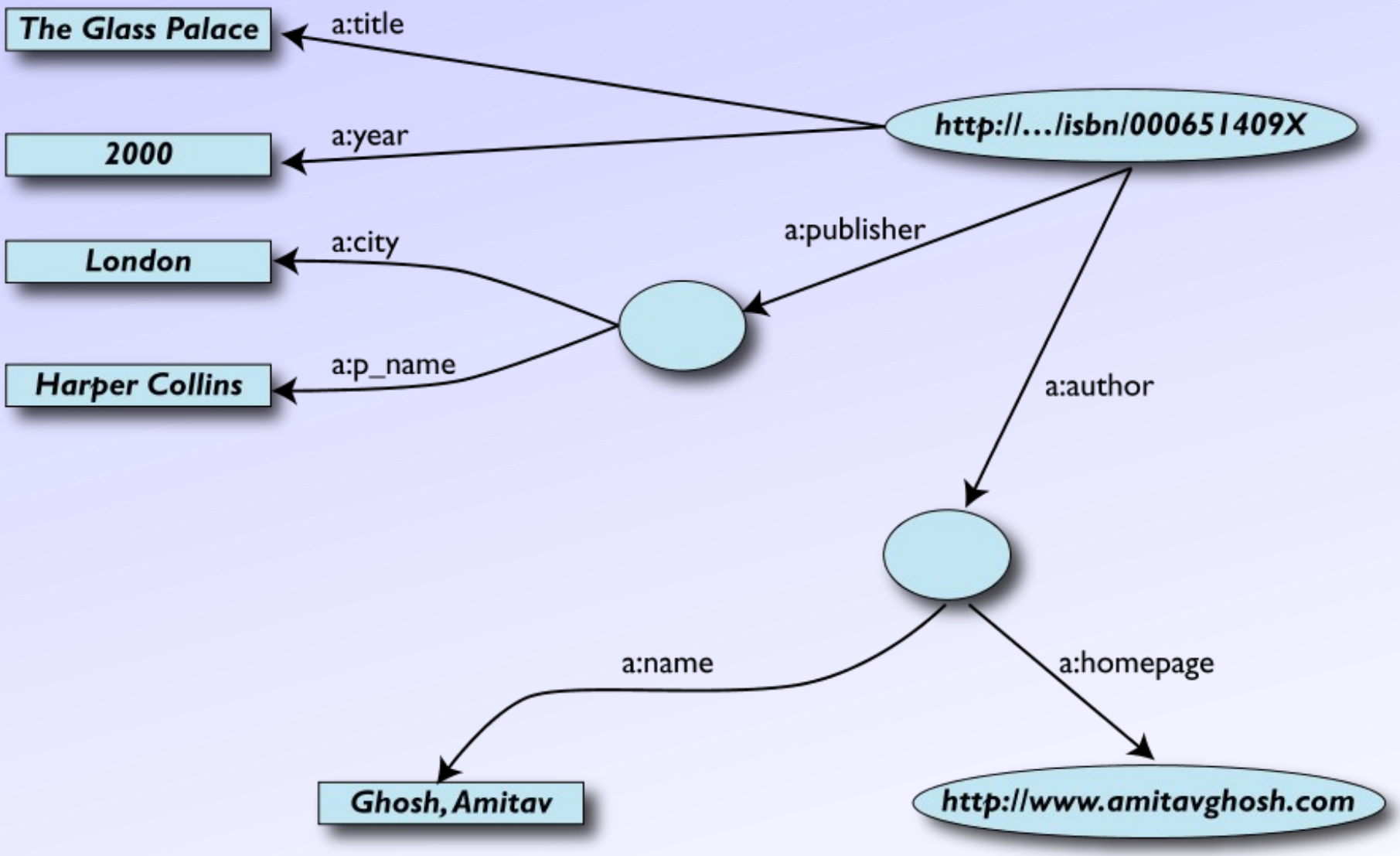
A *simplified* bookstore data (dataset "A")

ID	Author	Title	Publisher	Year
ISBN0-00-651409-X	id_xyz	The Glass Palace	id_qpr	2000

ID	Name	Home Page
id_xyz	Ghosh, Amitav	http://www.amitavghosh.com

ID	Publ. Name	City
id_qpr	Harper Collins	London

1st: export your data as a set of relations



Some notes on the exporting the data

- Relations form a graph
  - the nodes refer to the “real” data or contain some literal
  - how the graph is represented in machine is immaterial for now
- Data export does *not* necessarily mean physical conversion of the data
  - relations can be generated on-the-fly at query time
    - via SQL “bridges”
    - scraping HTML pages
    - extracting data from Excel sheets
    - etc.
- One can export *part* of the data

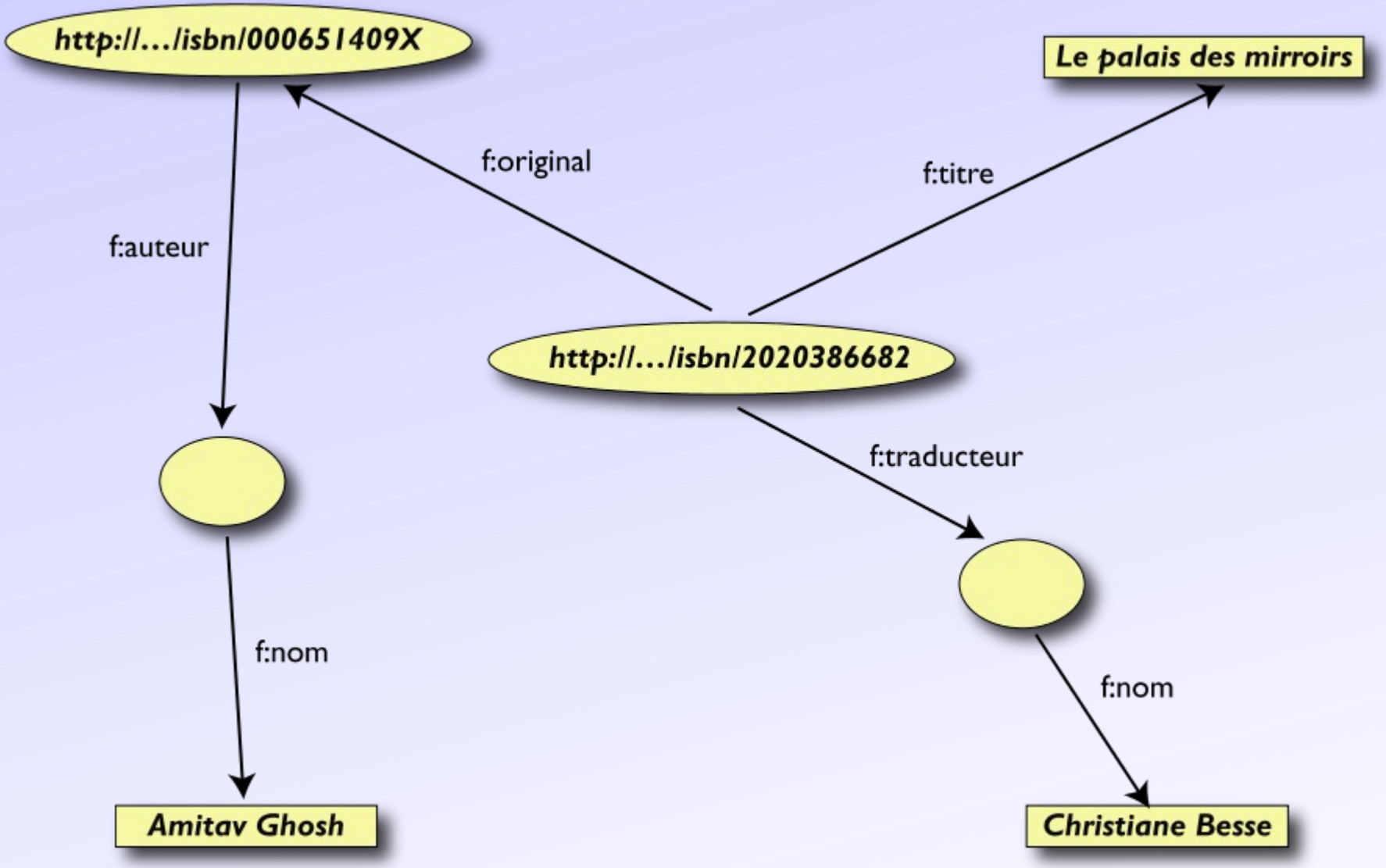
Another *bookstore data (dataset "F")*

	A	B	D	E
1	**ID**	**Titre**	**Traducteur**	**Original**
2	ISBN0 2020386682	Le Palais des miroirs	A13	ISBN-0-00-651409-X
3				

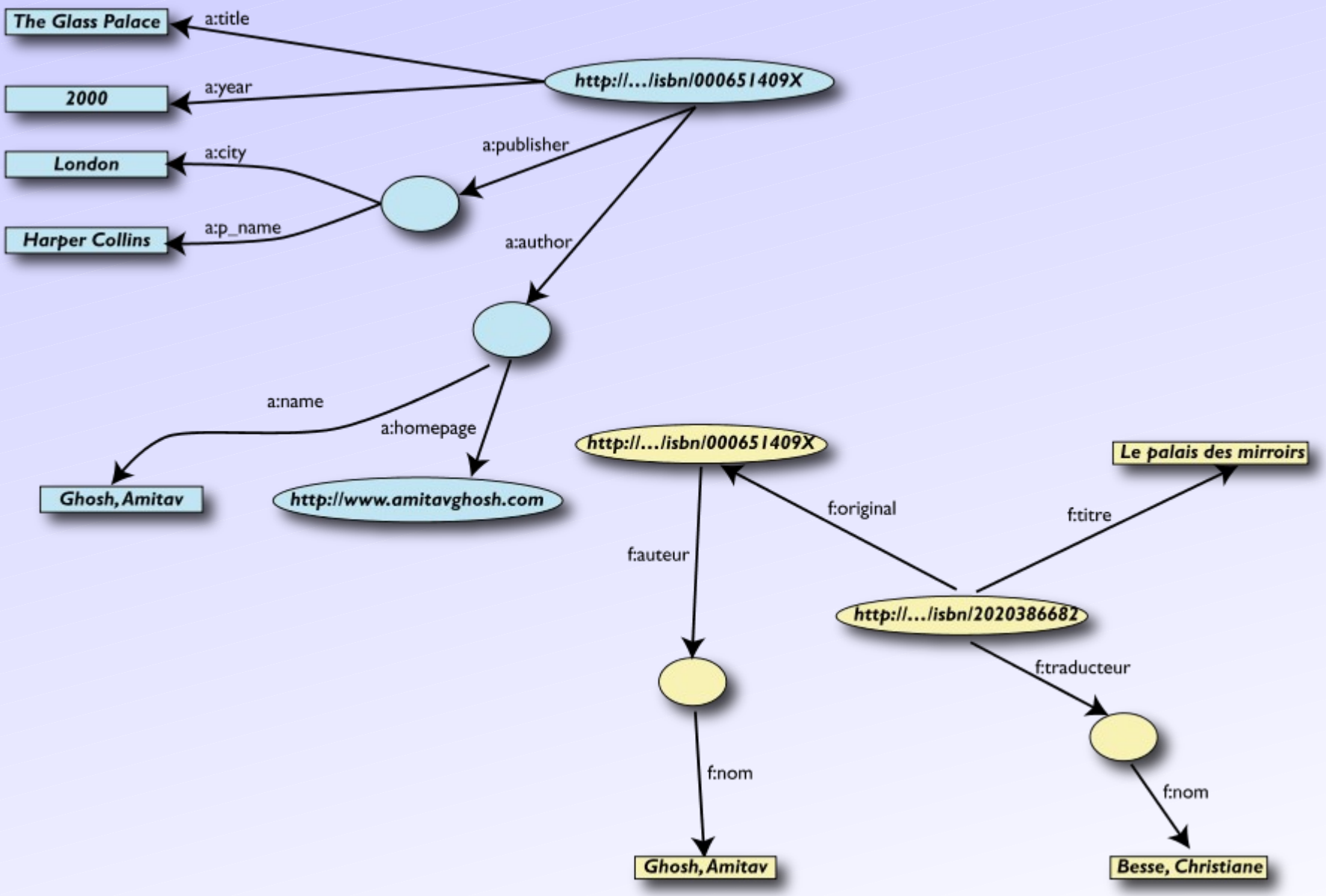
6	**ID**	**Auteur**
7	ISBN-0-00-651409-X	A12

11	**Nom**
12	Ghosh, Amitav
13	Besse, Christianne

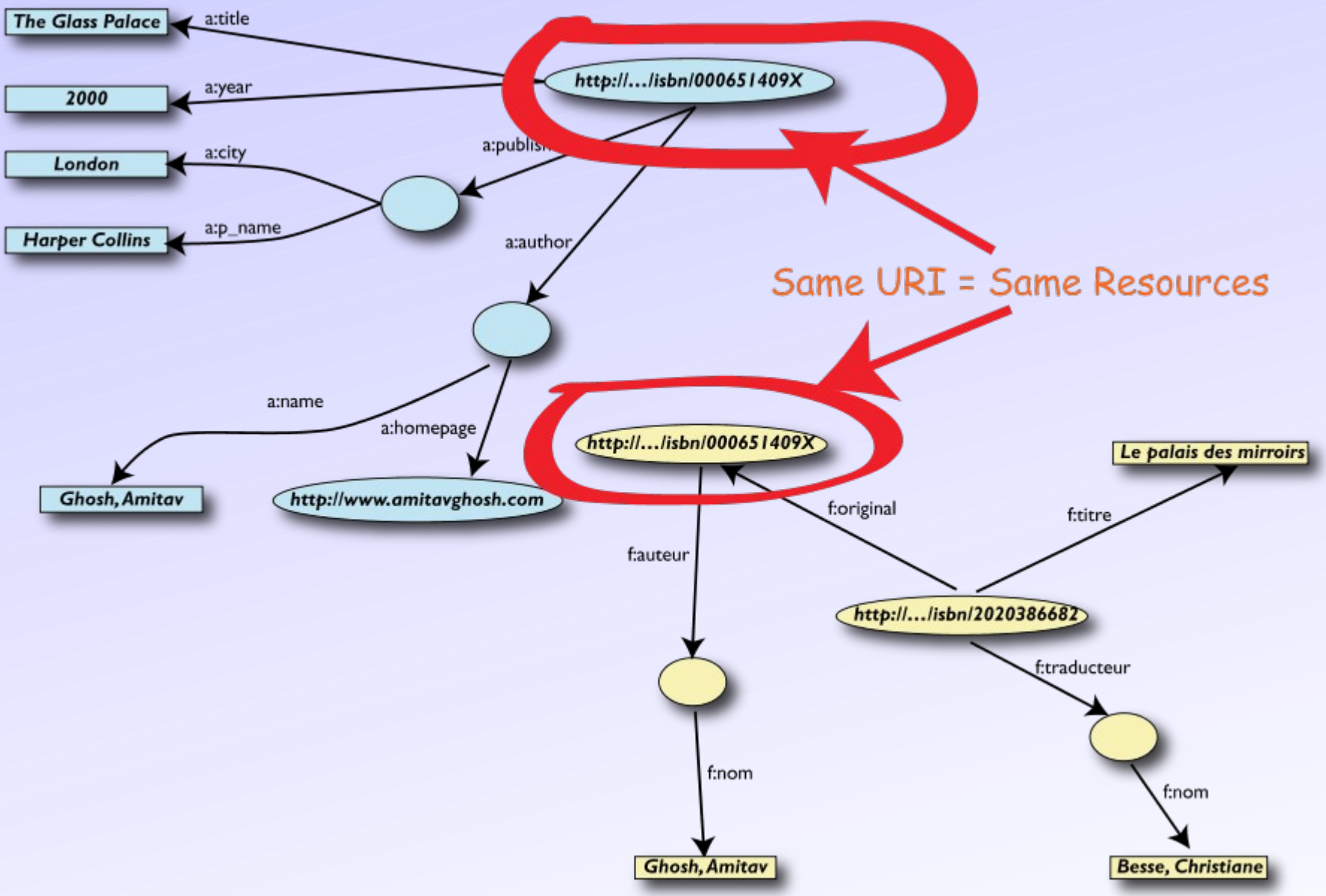
2nd: export your second set of data



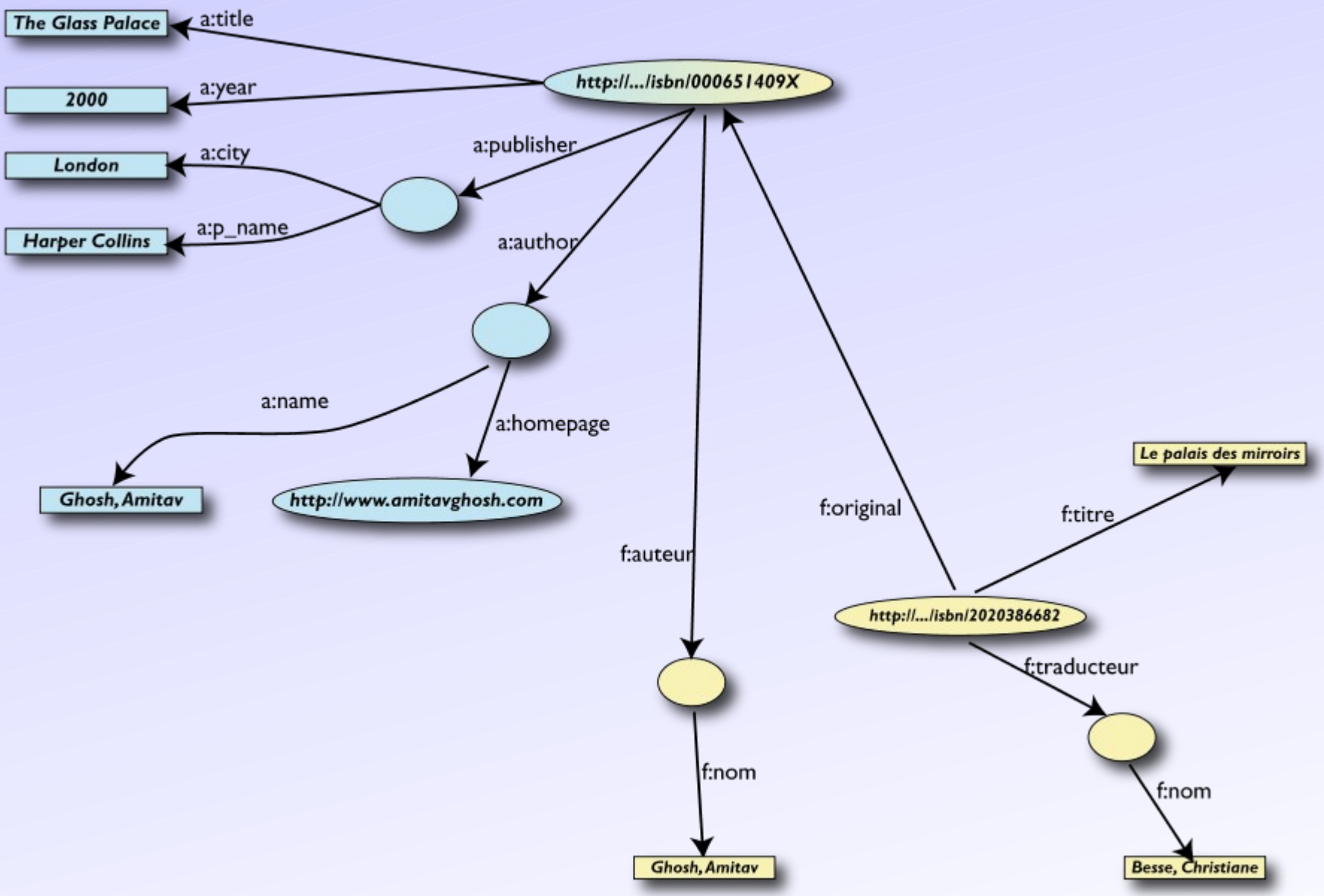
3rd: start merging your data



3rd: start merging your data (cont.)

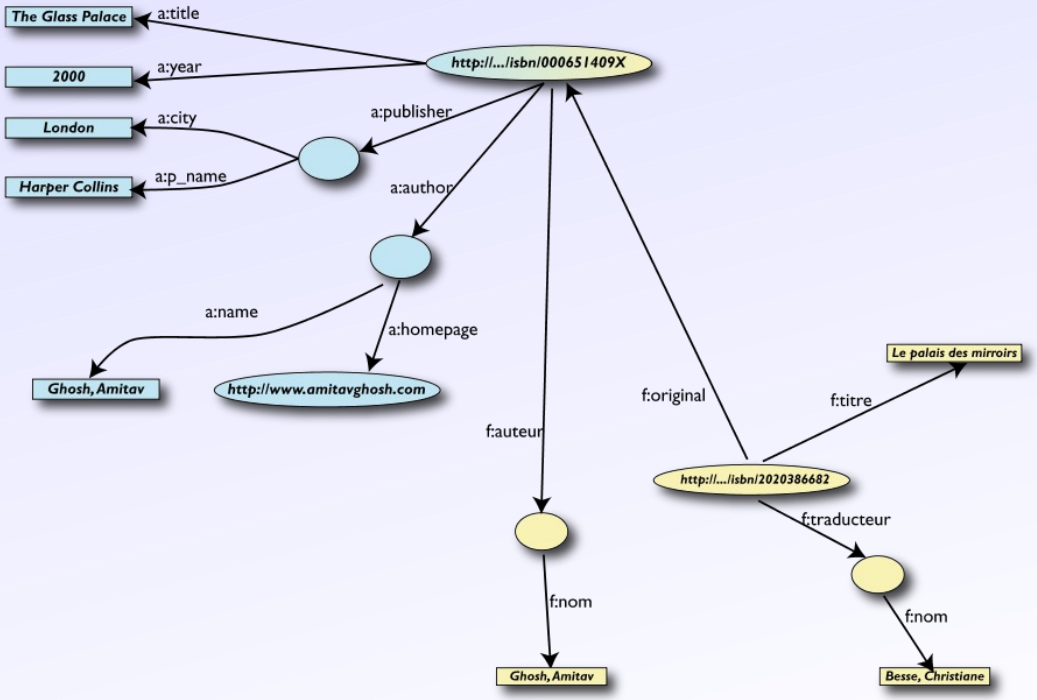


3rd: merge identical resources



Start making queries…

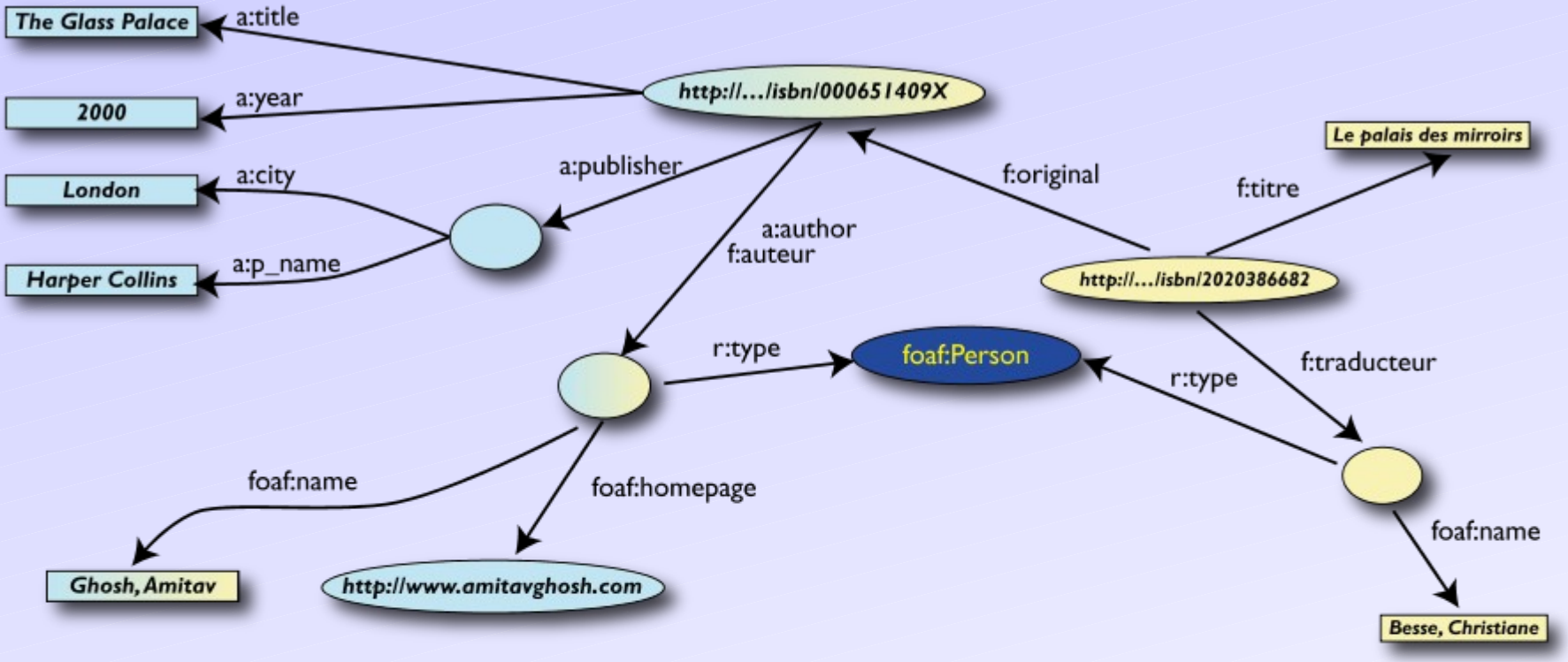
- User of data “F” can now ask queries like:
  - “give me the title of the original”
    - well, … « donnes-moi le titre de l’original »
- This information is not in the dataset “F”…
- …but can be retrieved by merging with dataset “A”!

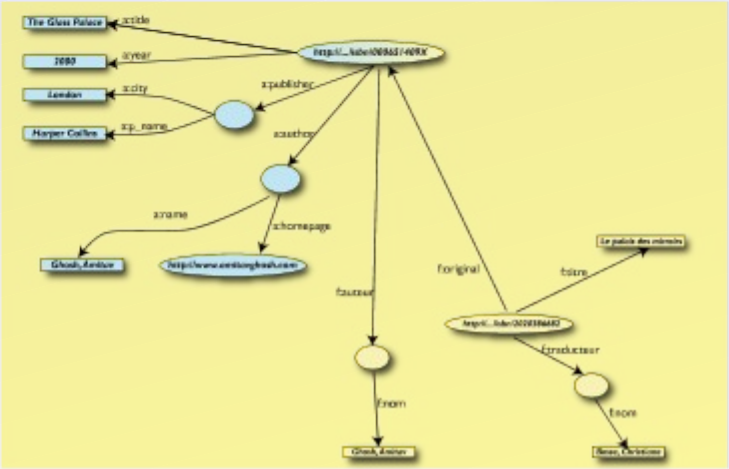


However, more can be achieved…

- We “feel” that **`a:author`** and **`f:auteur`** should be the same
- But an automatic merge doest not know that!
- Let us add some extra information to the merged data:
  - **`a:author`** same as **`f:auteur`**
  - both identify a “Person”
  - a term that a community may have already defined:
    - a “Person” is uniquely identified by his/her name and, say, homepage
    - it can be used as a “category” for certain type of resources

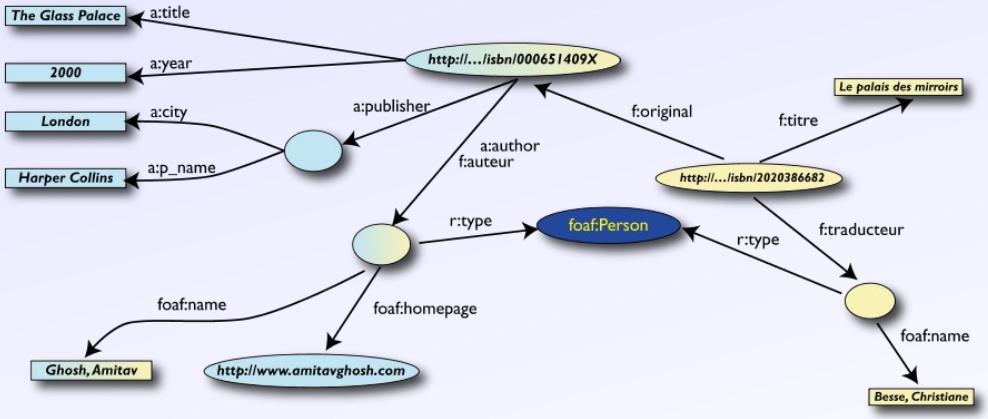
3rd revisited: use the extra knowledge





Start making richer queries!

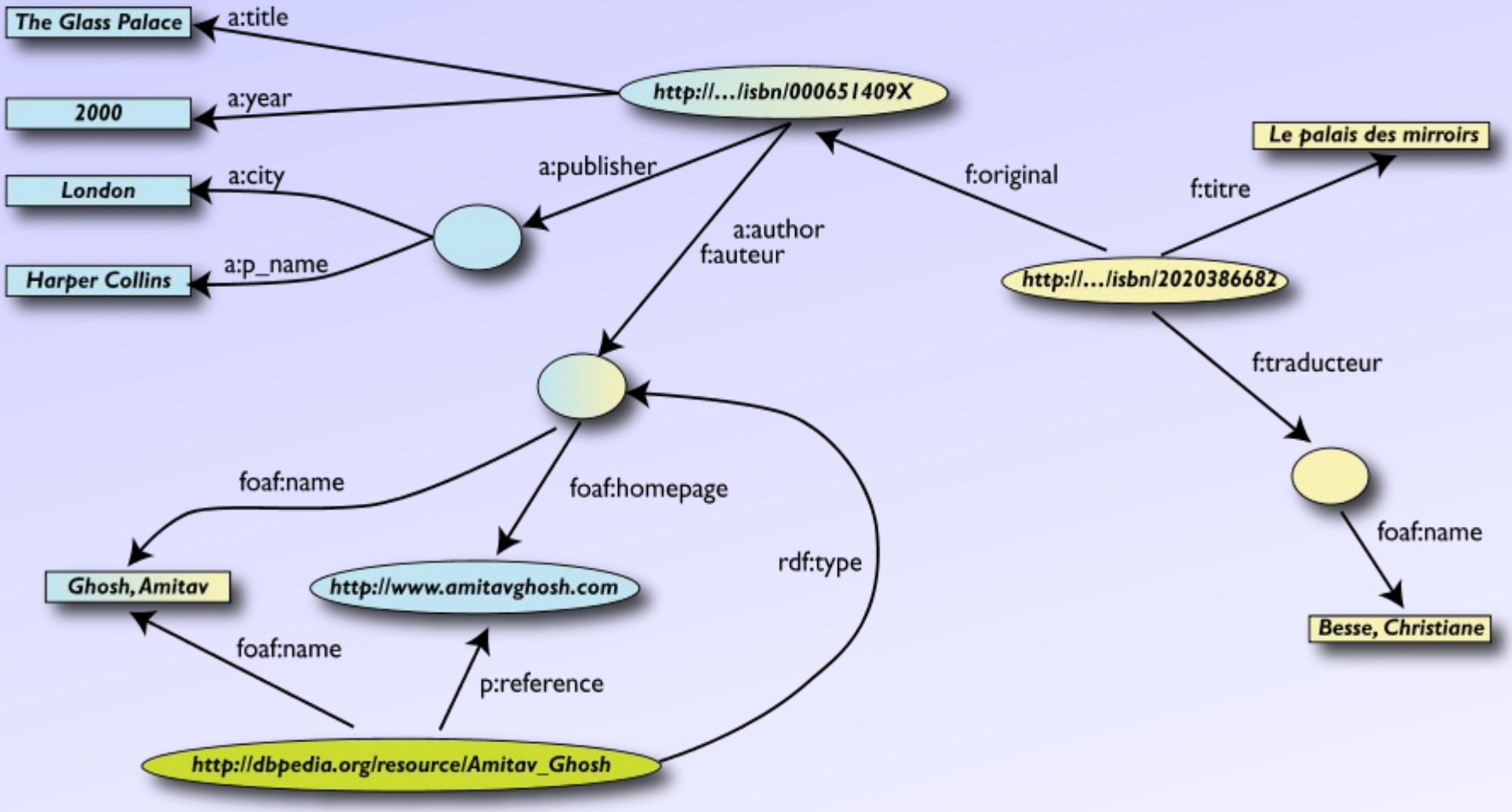
- User of dataset “F” can now query:
  - “donnes-moi la page d’accueil de l’auteur de l’originale”
    - well… “give me the home page of the original’s ‘auteur’”
- The information is not in datasets “F” or “A”…
- …but was made available by:
  - merging datasets “A” and datasets “F”
  - adding three simple extra statements as an extra “glue”



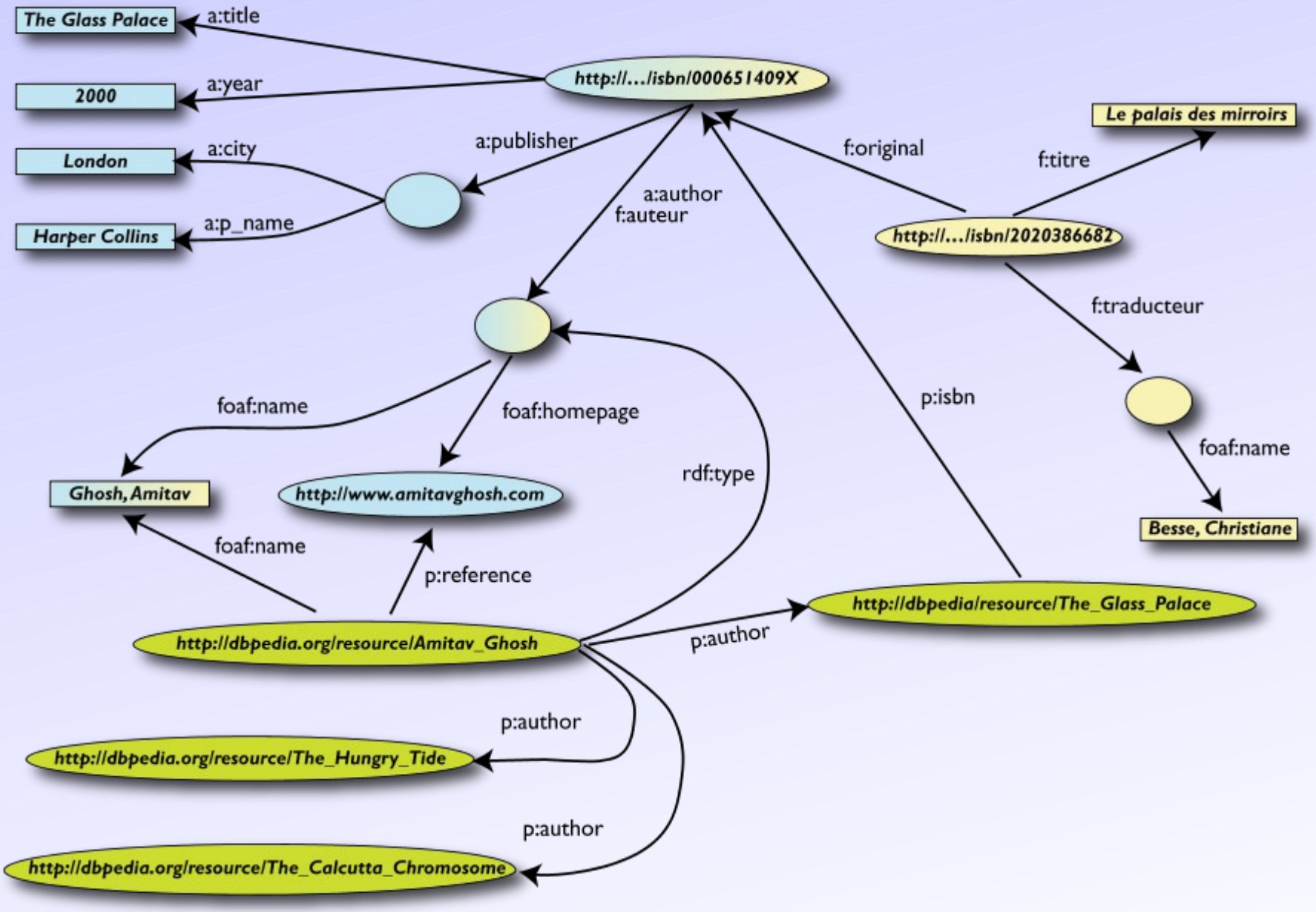
Combine with different datasets

- Using, e.g., the “Person”, the dataset can be combined with other sources
- For example, data in Wikipedia can be extracted using dedicated tools
  - e.g., the “dbpedia” project can extract the “infobox” information from Wikipedia already…

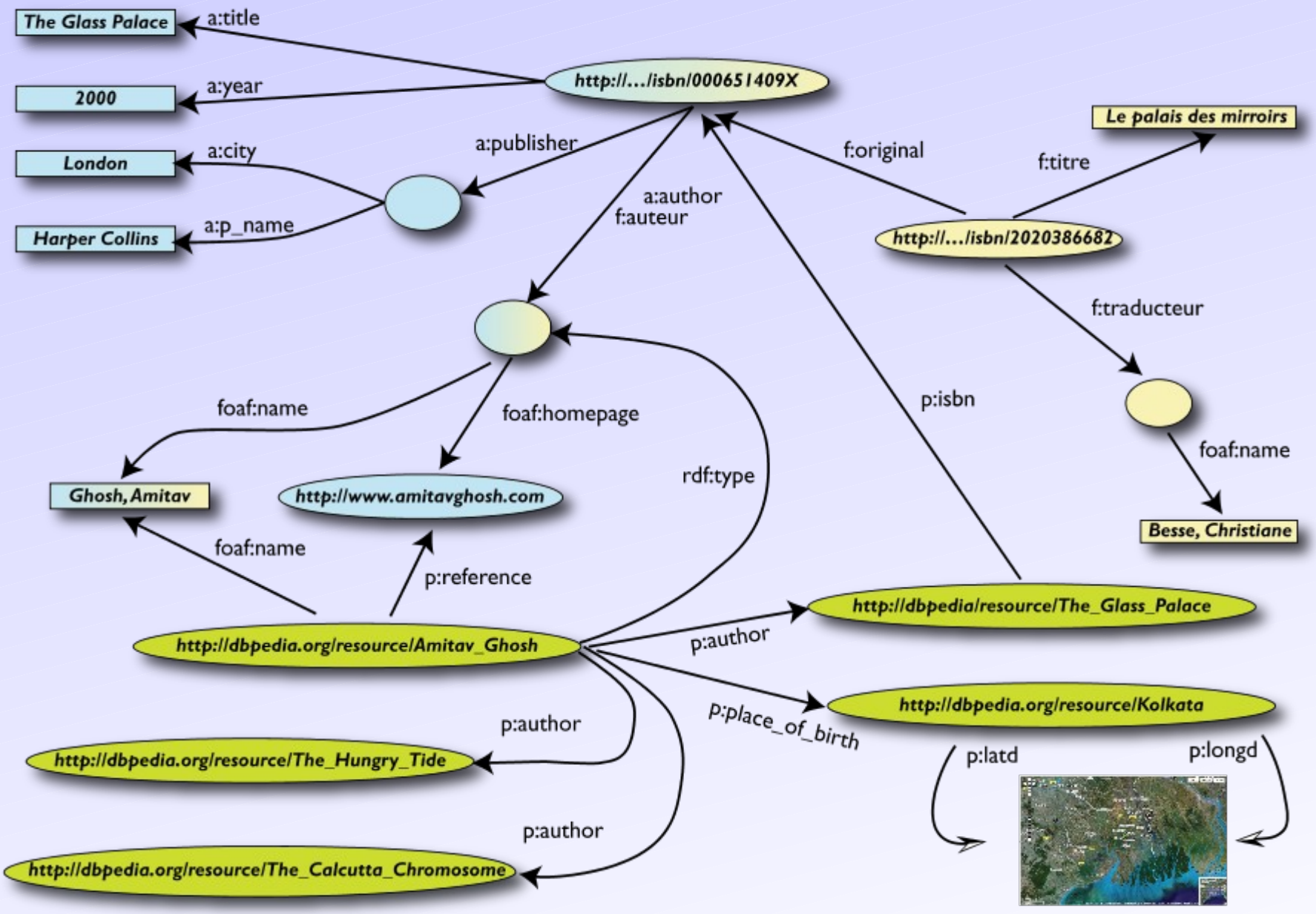
Merge with Wikipedia data



Merge with Wikipedia data



Merge with Wikipedia data



Is that surprising?

- It may look like it but, in fact, it should not be…
- What happened via automatic means is done every day by Web users!
- The difference: a bit of extra rigour so that machines could do this, too

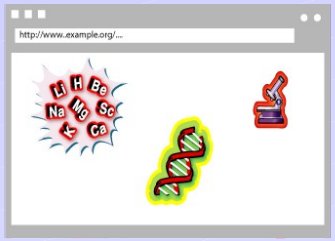
What did we do?

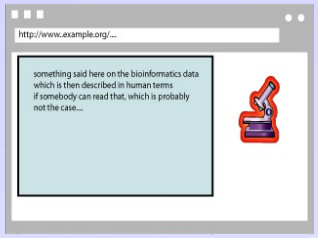
- We combined different datasets that
  - are somewhere on the web
  - are of different formats (mysql, excel sheet, XHTML, etc)
  - have different names for relations
- We could combine the data because some URI-s were identical (the ISBN-s in this case)
- We could add some simple additional information (the “glue”), possibly using common terminologies that a community has produced
- As a result, new relations could be found and retrieved

It could become even more powerful

- We could add extra knowledge to the merged datasets
  - e.g., a full classification of various types of library data
  - geographical information
  - etc.
- This is where *ontologies*, extra *rules*, etc, come in
  - ontologies/rule sets can be relatively simple and small, or huge, or anything in between…
- Even more powerful queries can be asked as a result

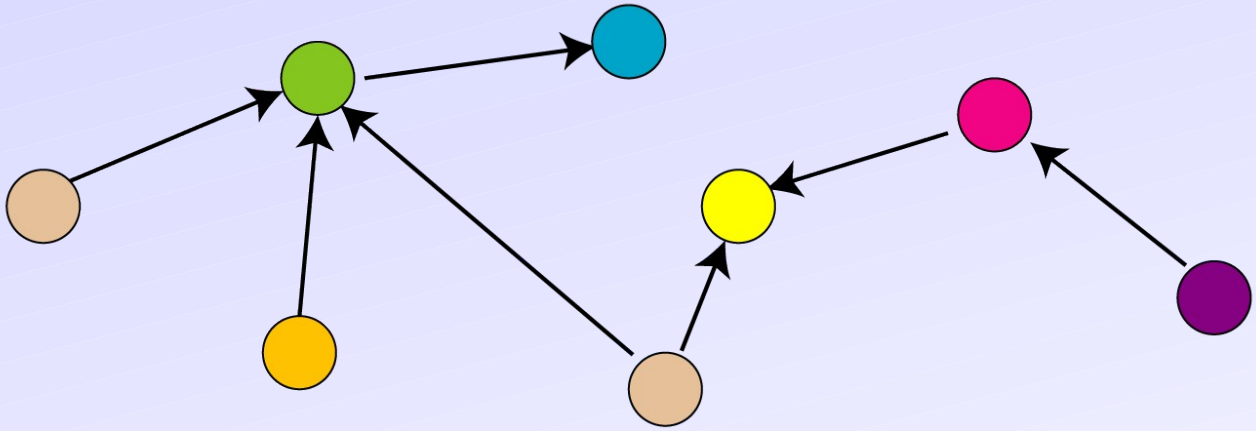
What did we do? (cont)





Applications

Query, Manipulate, etc.



Data represented in abstract format

Map, Expose, etc.

Data in various formats

The Basis: RDF

RDF triples

- Let us begin to formalize what we did!
  - we “connected” the data…
  - but a simple connection is not enough… data should be named somehow
  - hence the RDF Triples: *a labelled connection between two resources*

RDF triples (cont.)

- An RDF Triple **(s,p,o)** is such that:
  - "**s**", "**p**" are URI-s, ie, resources on the Web; "**o**" is a URI or a literal
    - "**s**", "**p**", and "**o**" stand for "subject", "property", and "object"
  - here is the complete triple:

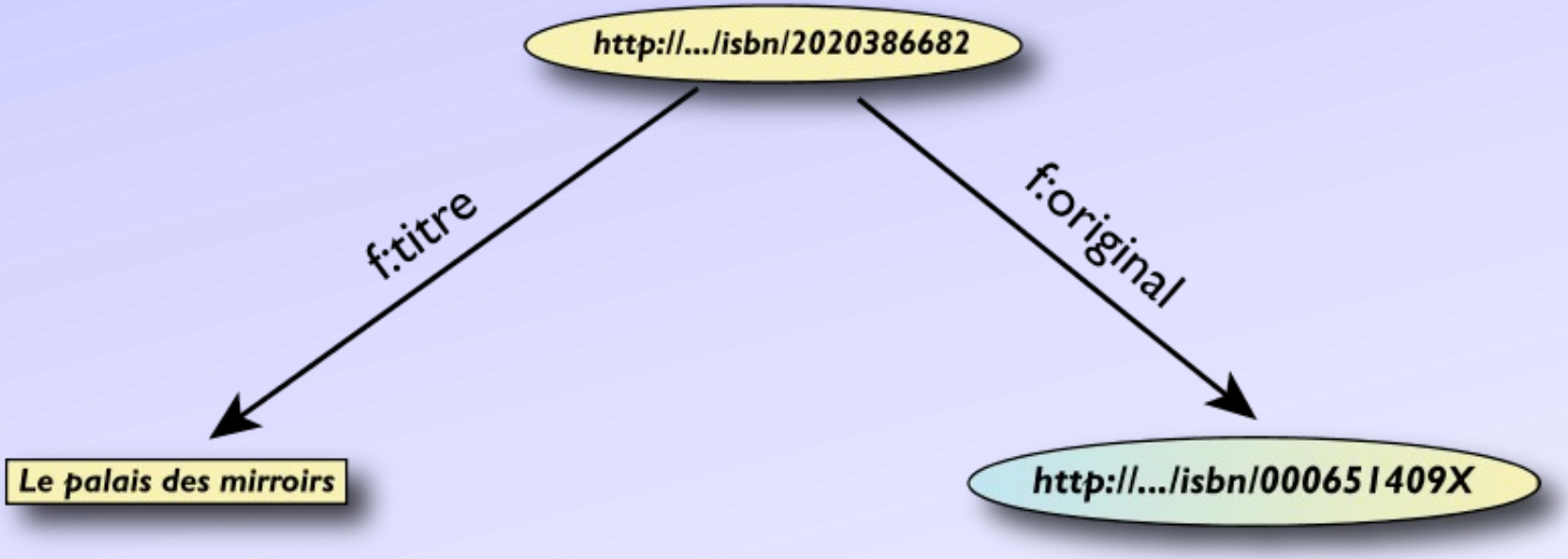
```
(<http://…isbn…6682>, <http://…/original>, <http://…isbn…409X>)
```

- *RDF* is a general model for such triples (with machine readable formats like RDF/XML, Turtle, N3, RXR, …)

RDF triples (cont.)

- Resources can use *any* URI, e.g.:
  - `http://www.example.org/file.xml#element(home)`
  - `http://www.example.org/file.html#home`
  - `http://www.example.org/file2.xml#xpath1(//q[@a=b])`
- URI-s can also denote non Web entities:
  - **`http://www.ivan-herman.net/me`** is me
  - not my home page, not my publication list, but *me*
- RDF triples form a directed, labelled graph

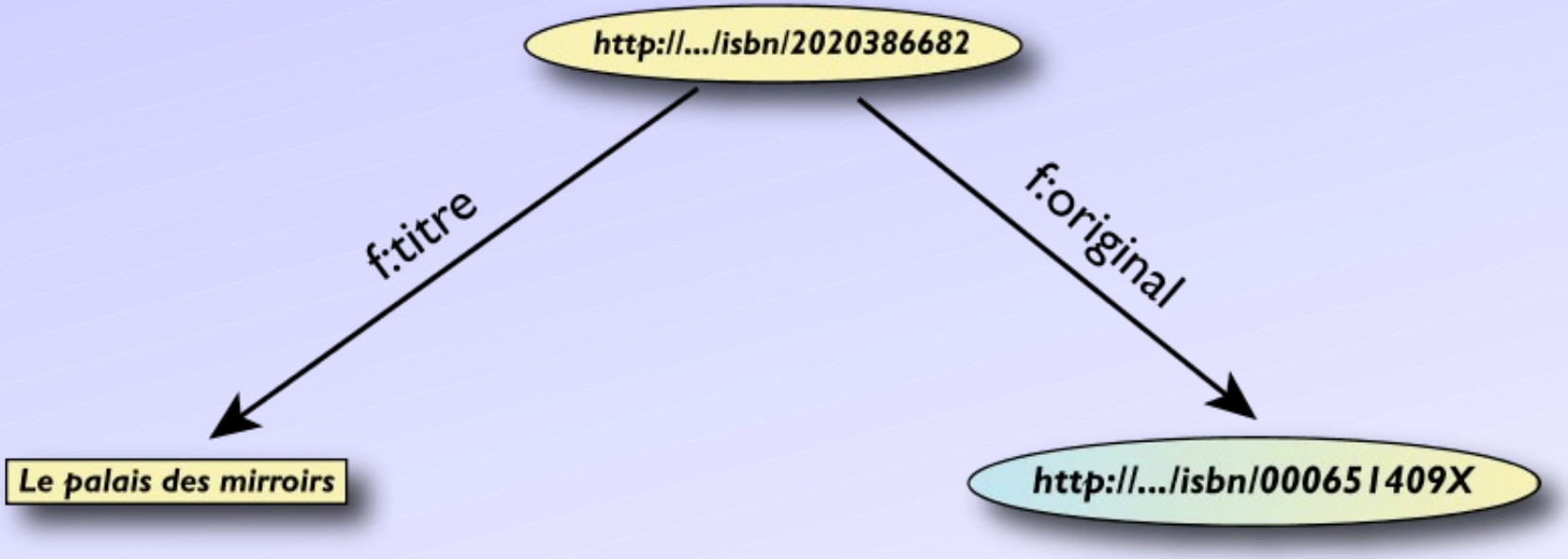
A simple RDF example (in RDF/XML)




```
<rdf:Description rdf:about="http://…/isbn/2020386682">
    <f:titre xml:lang="fr">Le palais des mirroirs</f:titre>
    <f:original rdf:resource="http://…/isbn/000651409X"/>
</rdf:Description>
```

(Note: namespaces are used to simplify the URI-s)

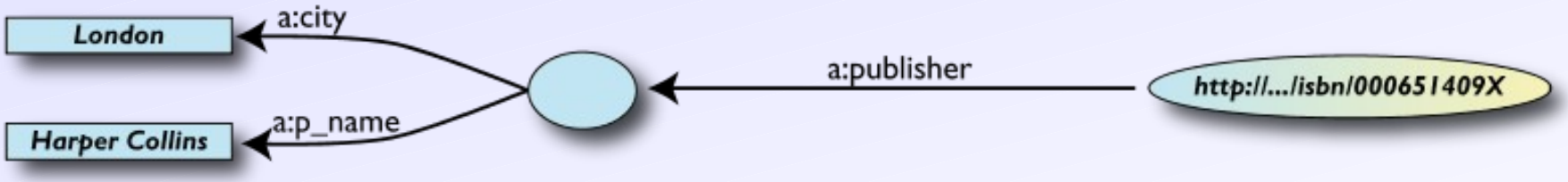
A simple RDF example (in Turtle)




```
<http://…/isbn/2020386682>
    f:titre "Le palais des mirroirs"@fr ;
    f:original <http://…/isbn/000651409X> .
```

"Internal" nodes

- Consider the following statement:
  - "the publisher is a «thing» that has a name and an address"
- Until now, nodes were identified with a URI. But…
- …what is the URI of «thing»?



Internal identifier (“blank nodes”)

```
<rdf:Description rdf:about="http://…/isbn/000651409X">
   <a:publisher rdf:nodeID="A234"/>
</rdf:Description>
<rdf:Description rdf:nodeID="A234">
   <a:p_name>HarpersCollins</a:p_name>
   <a:city>HarpersCollins</a:city>
</rdf:Description>
```

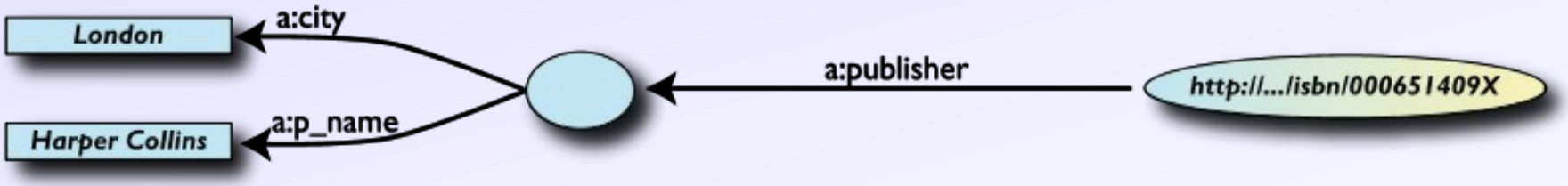
```
<http://…/isbn/2020386682> a:publisher _:A234.
_:A234 a:p_name "HarpersCollins".
```

- Syntax is serialization dependent
- A234 is invisible from outside (it is not a “real” URI!); it is an internal identifier for a resource

Blank nodes: the system can also do it

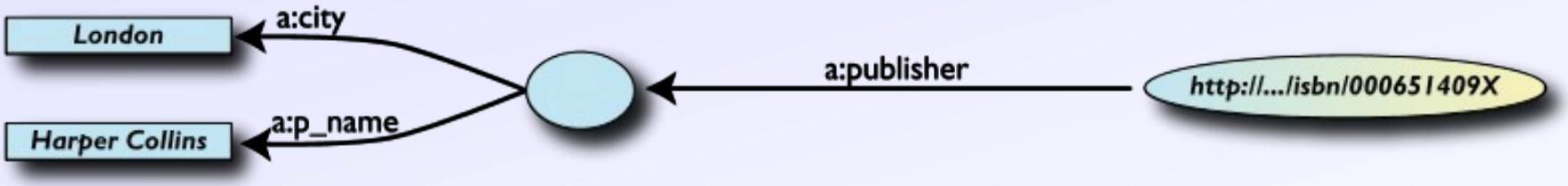
- Let the system create a “nodeID” internally (you do not really care about the name…)

```
<rdf:Description rdf:about="http://…/isbn/000651409X">
  <a:publisher>
      <rdf:Description>
          <a:p_name>HarpersCollins</a:p_name>
          …
      </rdf:Description>
  </a:publisher>
</rdf:Description>
```



Same in Turtle

```
<http://…/isbn/000651409X> a:publisher [
    a:p_name "HarpersCollins";
    …
].
```



Blank nodes: some more remarks

- Blank nodes require attention when merging
  - blanks nodes with identical nodeID-s in *different* graphs are *different*
  - implementations must be careful…
- Many applications prefer not to use blank nodes and define new URI-s “on-the-fly”

RDF in programming practice

- For example, using Java+Jena (HP's Bristol Lab):
  - a "Model" object is created
  - the RDF file is parsed and results stored in the Model
  - the Model offers methods to retrieve:
    - triples
    - (property,object) pairs for a specific subject
    - (subject,property) pairs for specific object
    - etc.
  - the rest is conventional programming…
- Similar tools exist in Python, PHP, etc.

Jena example

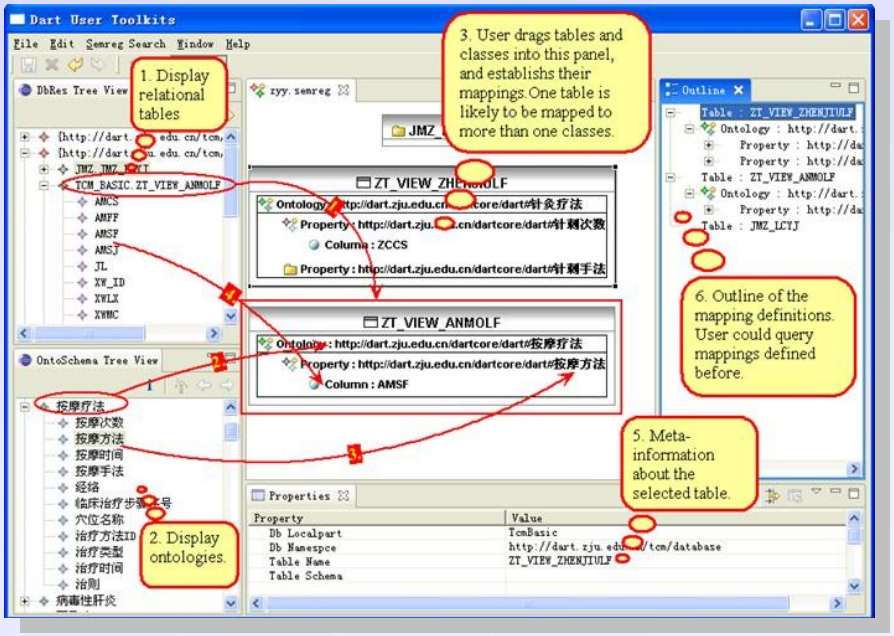
```
// create a model
Model model=new ModelMem();
Resource subject=model.createResource("URI_of_Subject")
// 'in' refers to the input file
model.read(new InputStreamReader(in));
StmtIterator iter=model.listStatements(subject,null,null);
while(iter.hasNext()) {
   st = iter.next();
   p = st.getProperty();
   o = st.getObject();
   do_something(p,o);
}
```

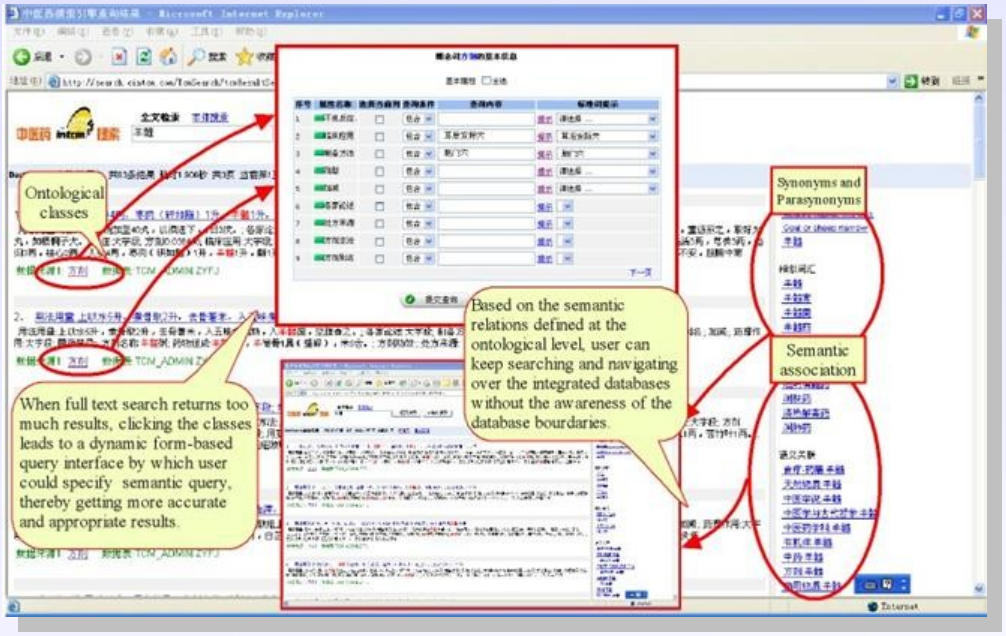
Merge in practice

- Environments merge graphs automatically
  - e.g., in Jena, the Model can load several files
  - the load merges the new statements automatically

Integrate knowledge for Chinese Medicine

- Integration of a large number of TCM databases
  - around 80 databases, around 200,000 records each
- Form based query interface for end users





Courtesy of Huajun Chen, Zhejiang University, (SWEO Case Study)

One level higher up

(RDFS, Datatypes)

Need for RDF schemas

- First step towards the “extra knowledge”:
  - define the terms we can use
  - what restrictions apply
  - what extra relationships are there?
- Officially: “RDF Vocabulary Description Language”
  - the term “Schema” is retained for historical reasons…

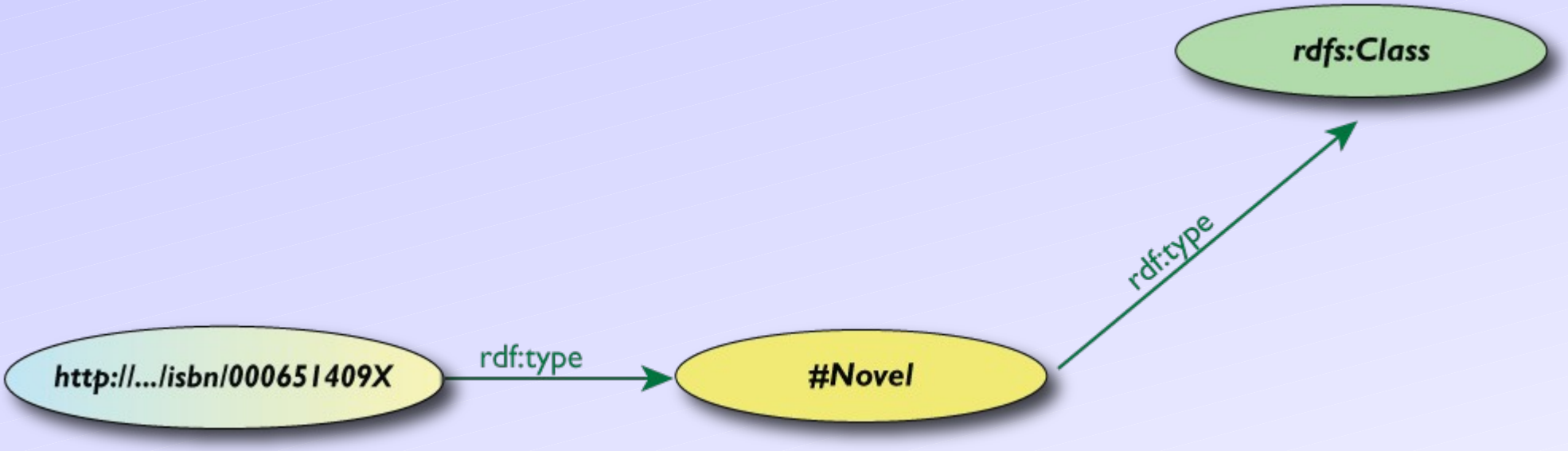
Classes, resources, …

- Think of well known traditional ontologies or taxonomies:
  - use the term “novel”
  - “every novel is a fiction”
  - “«The Glass Palace» is a novel”
  - etc.
- RDFS defines resources and classes:
  - everything in RDF is a “resource”
  - “classes” are also resources, but…
  - …they are also a collection of possible resources (i.e., “individuals”)
    - “fiction”, “novel”, …

Classes, resources, … (cont.)

- Relationships are defined among classes and resources:
  - "typing": an individual belongs to a specific class
    - "«The Glass Palace» is a novel"
    - to be more precise: "«http://.../**000651409X**» is a novel"
  - "subclassing": *all* instances of one are also the instances of the other ("every novel is a fiction")
- *RDFS formalizes these notions in RDF*

Classes, resources in RDF(S)



- RDFS defines the meaning of these terms
  - (these are all special URI-s, we just use the namespace abbreviation)

Schema example in RDF/XML

- The schema part:

```
<rdf:Description rdf:ID="Novel">
  <rdf:type
      rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
</rdf:Description>
```

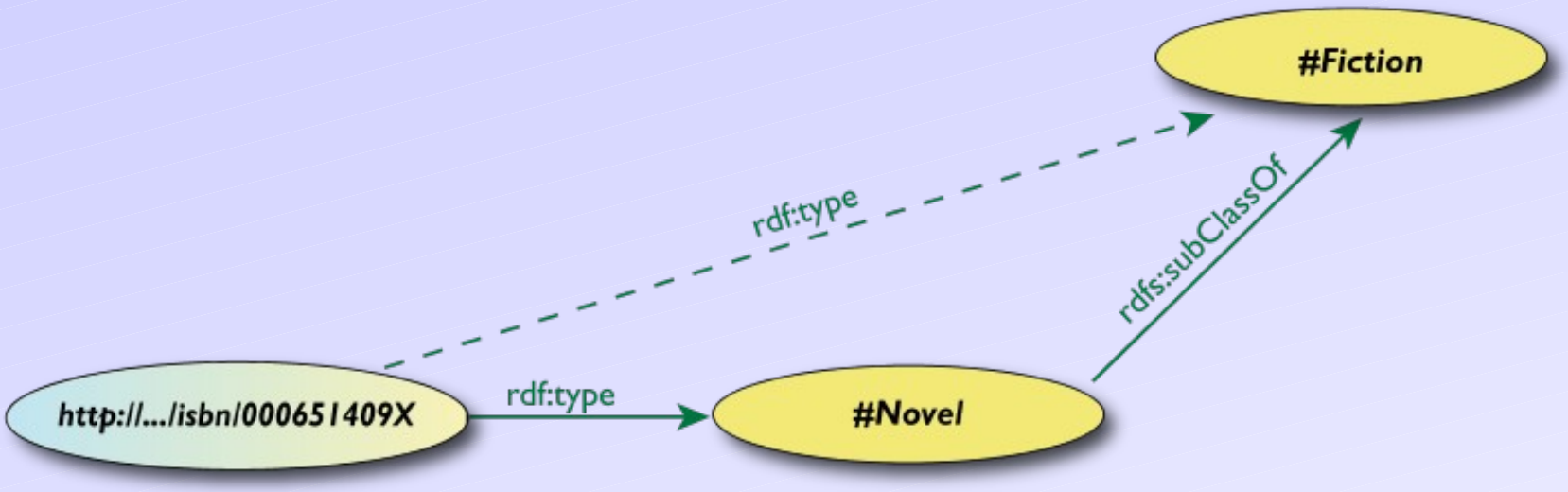
- The RDF data on a specific novel:

```
<rdf:Description rdf:about="http://…/isbn/000651409X">
   <rdf:type rdf:resource="http://…/bookSchema.rdf#Novel"/>
</rdf:Description>
```

Further remarks on types

- A resource may belong to several classes
  - rdf:type is just a property…
    - "«The Glass Palace» is a novel, but «The Glass Palace» is also an «inventory item»…"
  - i.e., it is *not* like a datatype!
- The type information may be very important for applications
  - e.g., it may be used for a categorization of possible nodes
  - probably the most frequently used RDF property…
    - (remember the "Person" in our example?)

Inferred properties




```
(<http://…/isbn/000651409X> rdf:type #Fiction)
```

- is not in the original RDF data…
- …but can be inferred from the RDFS rules
- RDFS environments return that triple, too

Inference: let us be formal…

- The RDF Semantics document has a list of (33) *entailment rules*:
  - "if such and such triples are in the graph, add this and this"
  - do that recursively until the graph does not change
- The relevant rule for our example:

```
If:
  uuu rdfs:subClassOf xxx .
  vvv rdf:type uuu .
Then add:
  vvv rdf:type xxx .
```

Properties

- Property is a special class (`rdf:Property`)
  - properties are also resources identified by URI-s
- There is also a possibility for a “sub-property”
  - all resources bound by the “sub” are also bound by the other
- Range and domain of properties can be specified
  - i.e., what type of resources serve as object and subject

Property specification serialized

- In RDF/XML:

```
<rdf:Property rdf:ID="title">
  <rdfs:domain rdf:resource="#Fiction"/>
  <rdfs:range rdf:resource="http://...#Literal"/>
</rdf:Property>
```

- In Turtle:

```
:title
  rdf:type     rdf:Property;
  rdfs:domain  :Fiction;
  rdfs:range   rdfs:Literal.
```

What does this mean?

- Again, new relations can be deduced. Indeed, if

```
:title
  rdf:type     rdf:Property;
  rdfs:domain  :Fiction;
  rdfs:range   rdfs:Literal.

<http://…/isbn/000651409X> :title "The Glass Palace" .
```

- then the system can *infer* that:

```
<http://…/isbn/000651409X> rdf:type :Fiction .
```

Literals

- Literals may have a data type
  - floats, integers, booleans, etc, defined in XML Schemas
  - full XML fragments
- (Natural) language can also be specified

Examples for datatypes

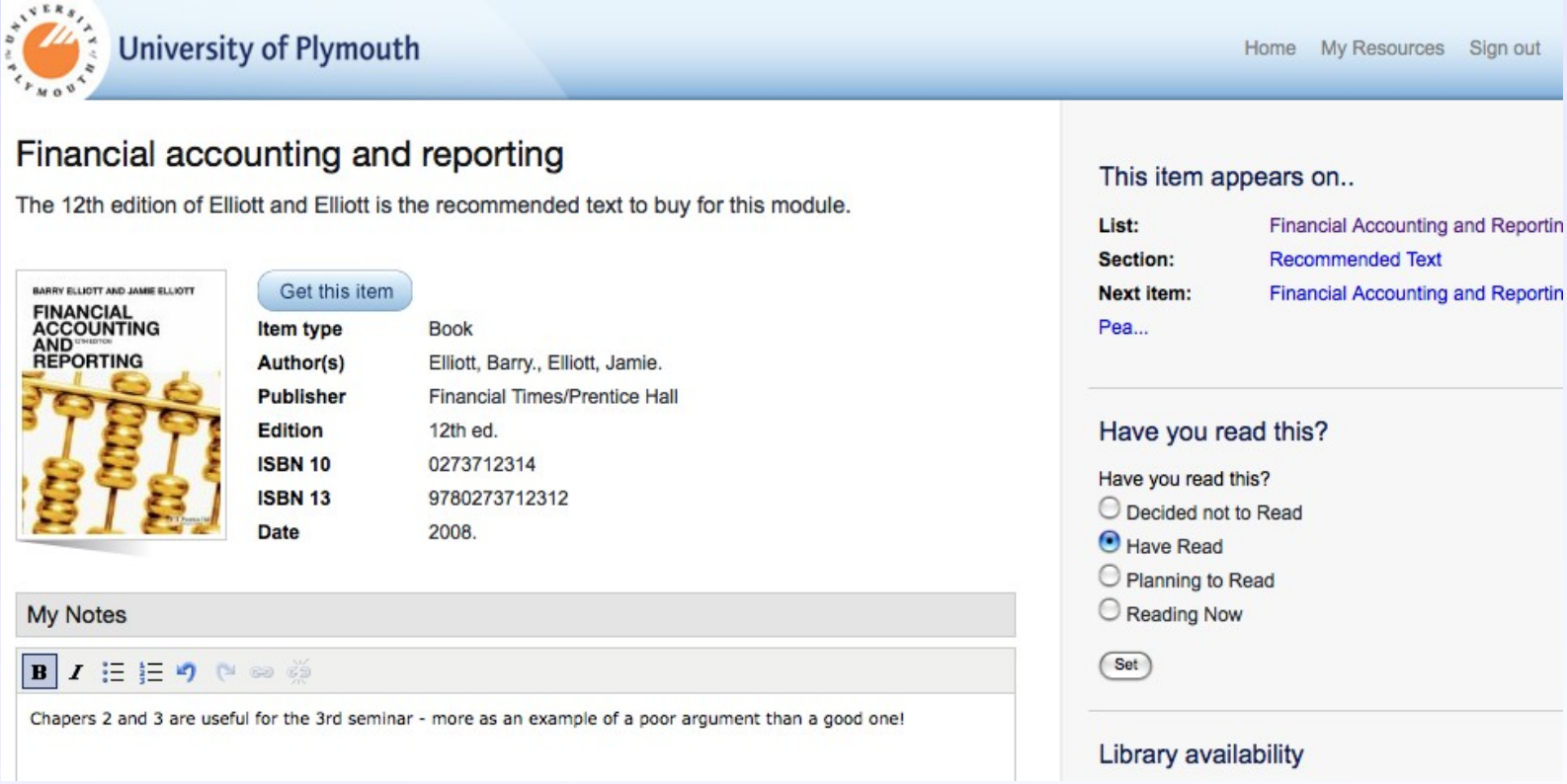
```
<http://…/isbn/000651409X>
      :page_number "543"^^xsd:integer ;
      :publ_date   "2000"^^xsd:gYear ;
      :price       "6.99"^^xsd:float .
```

A bit of RDFS can take you far…

- Remember the power of merge?
- We could have used, in our example:
  - **`f:auteur`** is a subproperty of **`a:author`** and vice versa (although we will see other ways to do that…)
- Of course, in some cases, more complex knowledge is necessary (see later…)

Univ. of Plymouth's resource management

- Manages teaching materials for students (including instructor annotations, bookmarks, A/V,…)
  - quickly adapts to changes (eg, library subscriptions)
  - uses simple (public) vocabularies to bind data
  - links to external datasets



Courtesy of Chris Clarke, Talis, and Fiona Greig, University of Plymouth (SWEO Case Study)

How to get RDF Data?

(Microformats, GRDDL, RDFa)

Simple approach

- Write RDF/XML or Turtle “manually”
- In some cases that is necessary, but it really does not scale…

RDF with XHTML

- Obviously, a huge source of information
- By adding some “meta” information, the same source can be reused for, eg, data integration, better mashups, etc
  - typical example: your personal information, like address, should be readable for humans *and* processable by machines
- Two solutions have emerged:
  - extract the structure from the page and convert the content into RDF
  - add RDF statements directly into XHTML via RDFa

Extract RDF

- Use intelligent “scrapers” or “wrappers” to extract a structure (hence RDF) from a Web pages or XML files…
- … and then generate RDF automatically (e.g., via an XSLT script)

Formalizing the scraper approach: GRDDL

- GRDDL formalizes the scraper approach. For example:

```
<html xmlns="http://www.w3.org/1999/">
  <head profile="http://www.w3.org/2003/g/data-view">
    <title>Some Document</title>
    <link rel="transformation" href="http:…/dc-extract.xsl"/>
    <meta name="DC.Subject" content="Some subject"/>
    ...
  </head>
  ...
  <span class="date">2006-01-02</span>
  ...
</html>
```

- yields, through **dc-extract.xsl**:

```
<>
   dc:subject "Some subject";
   dc:date "2006-01-02" .
```

GRDDL

- The transformation itself has to be provided for each set of conventions
- A more general syntax is defined for XML formats in general (e.g., via the namespace document)
  - a method to get data in other formats to RDF (e.g., XBRL)

Example for "structure": microformats

- *Not* a Semantic Web specification, originally
  - there is a separate microformat community
- Approach: re-use (X)HTML attributes and elements to add "meta" information
  - typically **`@abbr`**, **`@class`**, **`@title`**, …
  - different community agreements for different applications

RDFa

- RDFa extends (X)HTML a bit by:
  - defining general attributes to add metadata to any elements
  - provides an almost complete “serialization” of RDF in XHTML
- It is a bit like the microformats/GRDDL approach but fully generic

RDFa example

- For example:

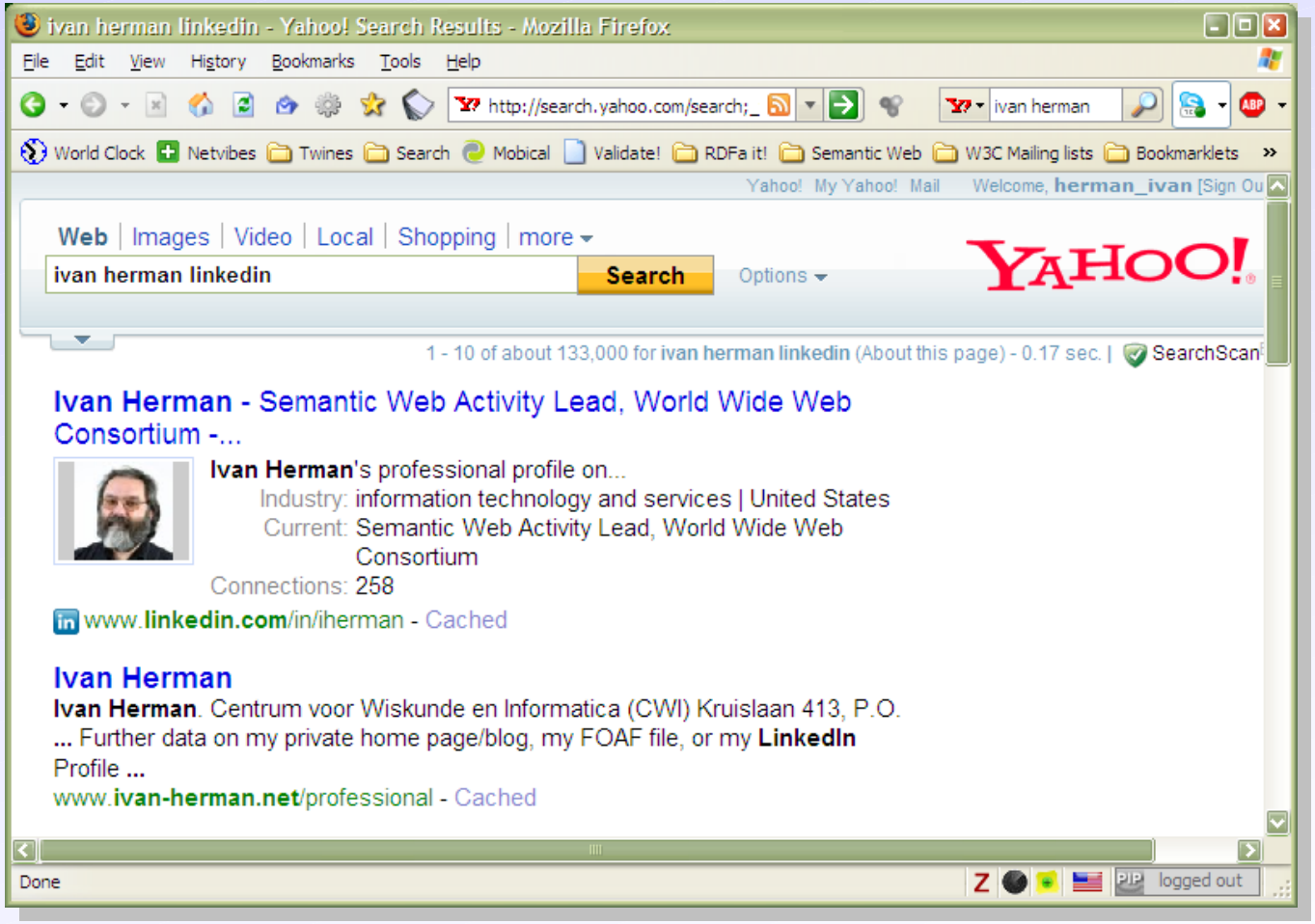
```
<div about="http://uri.to.newsitem">
  <span property="dc:date">March 23, 2004</span>
  <span property="dc:title">Rollers hit casino for £1.3m</span>
  By <span property="dc:creator">Steve Bird</span>. See
  <a href="http://www.a.b.c/d.avi" rel="dcmtype:MovingImage">
  also video footage</a>…
</div>
```

- yields, through an RDFa processor:

```
<http://uri.to.newsitem>
  dc:date              "March 23, 2004";
  dc:title             "Rollers hit casino for £1.3m;
  dc:creator           "Steve Bird";
  dcmtype:MovingImage <http://www.a.b.c/d.avi>.
```

Example: Yahoo's SearchMonkey

- Search based results may be customized via small applications
- Metadata in pages (in RDFa, microformats etc) are reused



Courtesy of Peter Mika, Yahoo! Research, (SWEO Case Study)

Example: Google's rich sniplet

- Embedded metadata (in microformat or RDFa) is used to improve search result page
  - at the moment only a few vocabularies are recognized, but that will evolve over the years

Example: RDFa data by the London Gazette

Search Results - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.gazettes-online.co.uk/ViewGazetteDocument.aspx?atdocid=5437822&Ge

Wikia Search

The London Gazette

Change edition: Edinburgh / Belfast

- Home
- About the Gazette
- Browse
- Search Tools
- My Account
- My Notices
- Services
- Placing a Notice
- Help

Search archive | Enter keyword | Search | Advanced Se

Search Results

Results 0 of 14 gazette documents

Back to results

Documents: Previous 10 11 12 13 14 Next

Date: 31 October 2008 Issue Number: 58870 Page number: 16858

Publication Date: *Friday, 31 October 2008*

Notice Code: *1901*

Water Resources

Environment Agency

Done

RDFa

Example: RDFa data by the London Gazette

http://www.w3.org/2007/08/pyRdfa/extract?uri=http://www.gazettes-online.co.uk/ViewGazetteDocument.aspx?atdocid=5437822&GeoType...

File Edit View History Bookmarks Tools Help

http://www.w3.org/2007/08/pyRdfa/extract?uri=http%3A//www.gazettes-online.co.uk/Vie

Wikia Search

Search Results | http://www.w3.org/2007/08/pyRdfa/e...

http://www.w3.org/2007/08/pyRdfa/extract?uri=http://www.gazettes-online.co.uk/ViewGazetteDocument.aspx?atdocid=5437822&

GeoType=London&categorydocids=144&lastissuecount=10

http://www.gazettes-online.co.uk/ViewGazetteDocument.aspx?atdocid=5437822&GeoType=London&categorydocids=144&lastissuecount=10	stylesheet	http://www.gazettes-online.co.uk/Styles/gazettes.css
London Gazette: Issue dated 31 October 2008: Notice 650554	Creator	TSO (The Stationery Office)
	Identifier	http://www.london-gazette.co.uk/issues/2008-10-31/notices/650554
	Language	Member Of: ISO 639-2
		value: eng
	Publisher	TSO (The Stationery Office), St Crispins, Duke Street, Norwich, NR3 1PD, 01603 622211, customer.services@tso.co.uk
	Subject	Member Of: IPSV
		value: Water Resources
	Title	London Gazette: Issue dated 31 October 2008: Notice 650554
	Date Issued	2008-10-31
	Date Modified	2008-08-20
	Administrator	Grant Wilson
	Authority	Environment Agency
	Category Code	1901
	Notice Number	650554
	Publication Date	2008-10-31
	is In Issue	http://www.london-gazette.co.uk/issues/2008-10-31
	type	Water Resources Notice
http://www.london-gazette.co.uk/issues/2008-10-31	Issue Number	58870
	Publication Date	2008-10-31
Environment Agency	is Known As	Environment Agency
	type	Authority
		Public Institution
Grant Wilson	Forename	Grant
	Surname	Wilson
	type	Person

Done

Bridge to relational databases

- Data on the Web are mostly stored in databases
- “Bridges” are being defined:
  - a layer between RDF and the relational data
    - RDB tables are “mapped” to RDF graphs, possibly on the fly
    - different mapping approaches are being used
  - a number RDB systems offer this facility already (eg, Oracle, OpenLink, …)
- A survey on mapping techniques has been published at W3C
- A charter is under review for a W3C group, to start in September

Linking Data

Linking Open Data Project

- Goal: “expose” open datasets in RDF
- *Set RDF links among the data items* from different datasets
- Set up query endpoints
- Altogether billions of triples, millions of links…

LINKINGOPENDATA
W3C SWEO Community Project

W3C Semantic Web

Example data source: DBpedia

- DBpedia is a community effort to
  - extract structured (“infobox”) information from Wikipedia
  - provide a query endpoint to the dataset
  - interlink the DBpedia dataset with other datasets on the Web

Freie Universität Berlin

UNIVERSITÄT LEIPZIG

OPENLINK SOFTWARE

Extracting Wikipedia structured data

Amsterdam

The Keizersgracht at dusk

Location of Amsterdam

Coordinates: 52°22'23"N 4°53'32"E

Country	Netherlands
Province	North Holland
Government	
- Type	Municipality
- Mayor	Job Cohen[1] (PvdA)
- Aldermen	Lodewijk Asscher Carolien Gehrels Tjeerd Herrema Maarten van Poelgeest Marijke Vos
- Secretary	Erik Gerritsen
Area [2][3]	
- City	219 km² (84.6 sq mi)
- Land	166 km² (64.1 sq mi)
- Water	53 km² (20.5 sq mi)
- Urban	1,003 km² (387.3 sq mi)
- Metro	1,815 km² (700.8 sq mi)
Elevation [4]	2 m (7 ft)
Population (1 October 2008)[5][6]	
- City	755,269
- Density	4,459/km² (11,548.8/sq mi)
- Urban	1,364,422
- Metro	2,158,372
- Demonym	Amsterdammer
Time zone	CET (UTC+1)
- Summer (DST)	CEST (UTC+2)
Postcodes	1011 – 1109
Area code(s)	020

Website: www.amsterdam.nl

```
@prefix dbpedia <http://dbpedia.org/resource/>.
@prefix dbterm  <http://dbpedia.org/property/>.

dbpedia:Amsterdam
  dbterm:officialName "Amsterdam" ;
  dbterm:longd "4" ;
  dbterm:longm "53" ;
  dbterm:longs "32" ;
  ...
  dbterm:leaderTitle "Mayor" ;
  dbterm:leaderName dbpedia:Job_Cohen ;
  ...
  dbterm:areaTotalKm "219" ;
  ...
dbpedia:ABN_AMRO
  dbterm:location dbpedia:Amsterdam ;
  ...
```

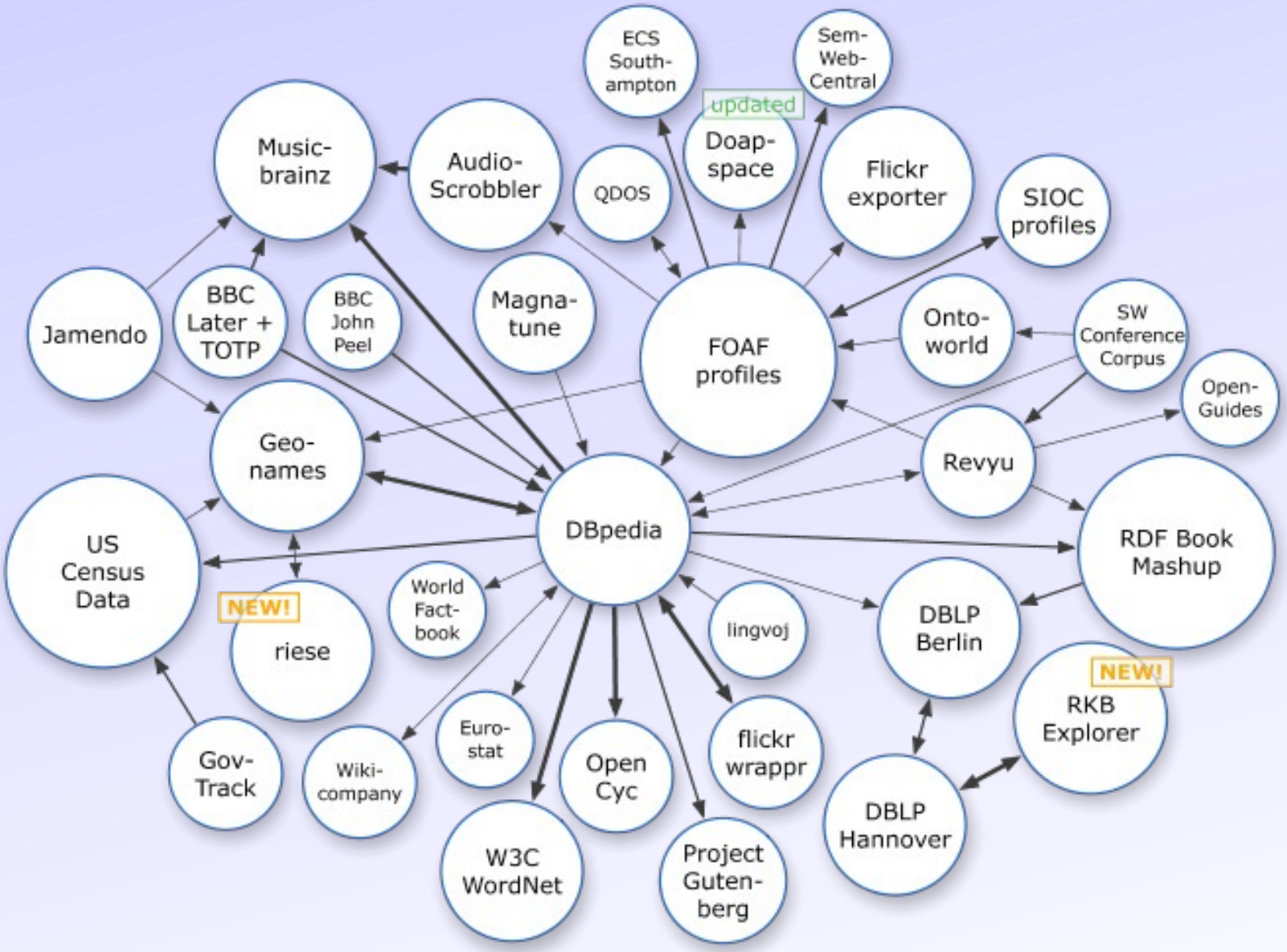
Automatic links among open datasets

```
<http://dbpedia.org/resource/Amsterdam>
  owl:sameAs <http://rdf.freebase.com/ns/...> ;
  owl:sameAs <http://sws.geonames.org/2759793> ;
  ...
```

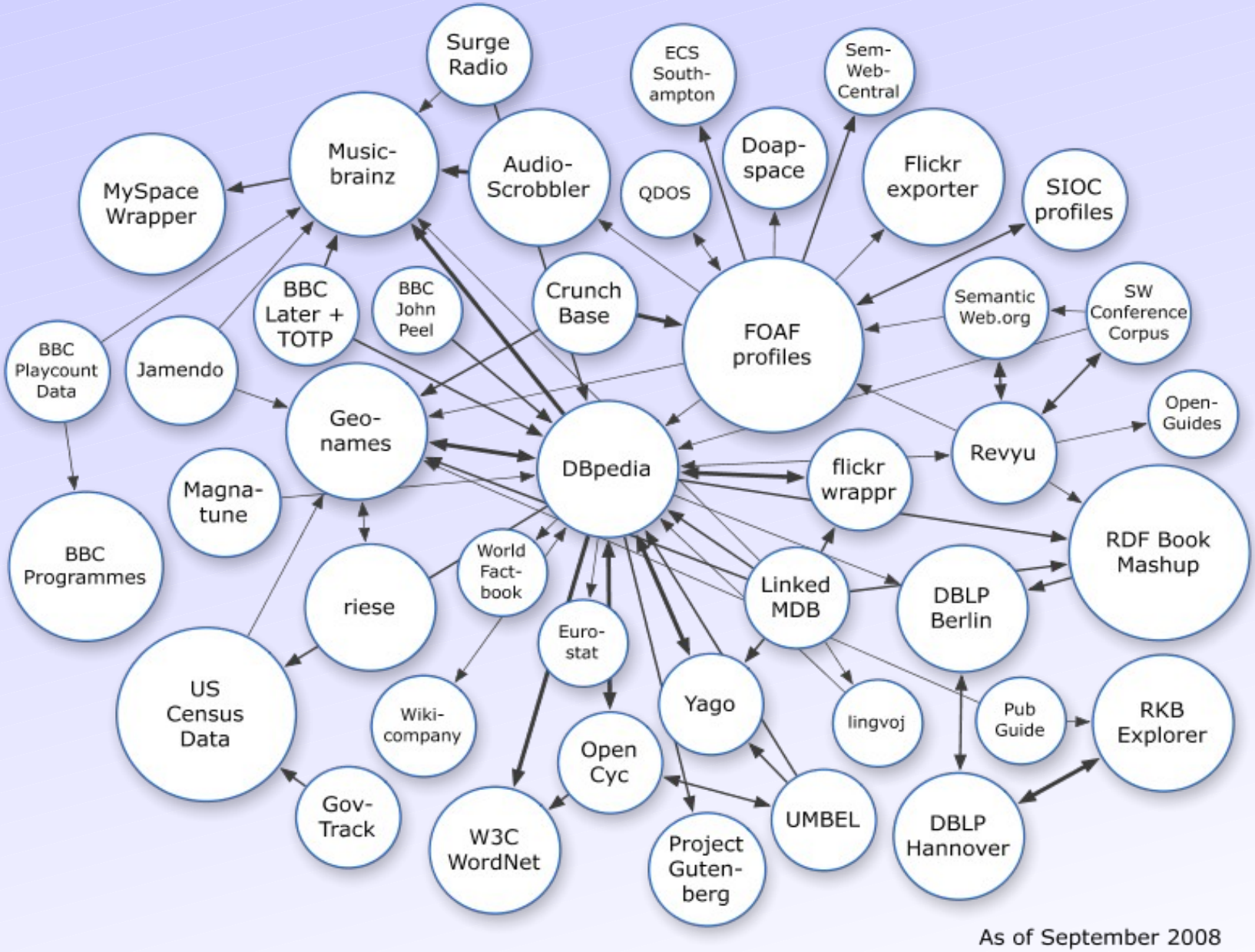
```
<http://sws.geonames.org/2759793>
  owl:sameAs <http://dbpedia.org/resource/Amsterdam>
  wgs84_pos:lat "52.3666667" ;
  wgs84_pos:long "4.8833333" ;
  geo:inCountry <http://www.geonames.org/countries/#NL> ;
 ...
```

Processors can switch automatically from one to the other…

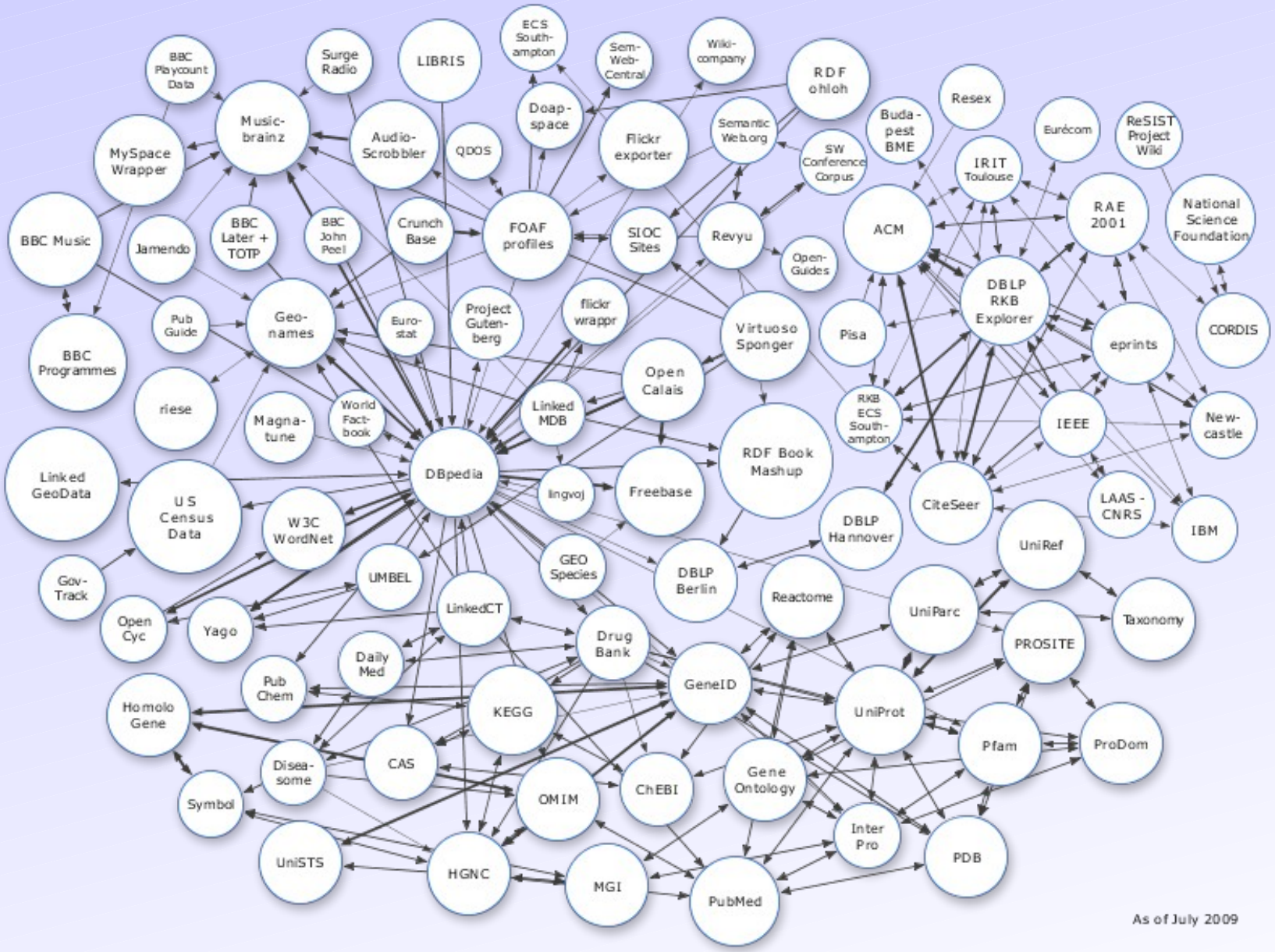
The LOD "cloud", March 2008



The LOD "cloud", September 2008



The LOD "cloud", July 2009



Using the LOD to build Web site: BBC

BBC - Music - Eric Clapton - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.bbc.co.uk/music/artists/618b6900-0618-4f1e-b835-bccb17f84294.html

BBC - Music - Eric Clapton

Music BETA

BBC Music > Artists > Eric Clapton

Eric Clapton

Born 30 March 1945.

MOST PLAYED ON BBC RADIO 2

Played By

Since December 2008

Steve Wright in the Afternoon

BBC Radio 2

Steve Wright's afternoon show with special g host of other features

Ken Bruce

BBC Radio 2

The best in music every weekday with Ken B sessions

Chris Hawkins

BBC 6 Music

Join Chris for regular great music and a new show

Done

Using the LOD to build Web site: BBC

BBC - Music - Eric Clapton - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.bbc.co.uk/music/artists/618b6900-0618-4f1e-b835-bccb17f84294.html

BBC - Music - Eric Clapton

...this hits the spot nicely and underlines just why Clapton is so revered amongst...

More Eric Clapton Releases »

Credits

ROLE	ARTIST	RELEASE
Instrument	George Harrison	All Things Must Pass (1987)
Instrument	Roger Waters	The Pros and Cons of Hitch Hiking (1984)
Performer	T.D.F.	Retail Therapy

Credits comes from MusicBrainz. You can add or edit information about Eric Clapton at musicbrainz.org. Find out more about our use of this data .

More Eric Clapton Credits »

Blind Faith

Cream

Derek and the Dominos

John Mayall & The Bluesbreakers

The Yardbirds

Information about group members comes from MusicBrainz. You can a about Eric Clapton at musicbrainz.org. Find out more about our use of

Connected Artists

COLLABORATED ON

J.J. Cale & Eric Clapton

Eric Clapton & The Immediate All Stars

Eric Clapton & The Impressions

Connected artists information comes from MusicBrainz. You can add or edit info at musicbrainz.org. Find out more about our use of this data .

More Eric Clapton Connected Artists

Links

Official homepage at ericclapton.com

Fanpage at whereseric.com

Wikipedia article on Eric Clapton

MySpace at myspace.com/ericclapton

Last.fm page on Eric Clapton

MusicBrainz entry on Eric Clapton

Done

Using the LOD to build Web site: BBC

Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.bbc.co.uk/music/artists/618b6900-0618-4f1e-b835-bccb17f84294.rdf

http://www.bbc.co...bccb17f84294.rdf


```
<foaf:homepage rdf:resource="http://www.ericclapton.com/"/>
<mo:fanpage rdf:resource="http://www.whereseric.com/"/>
<mo:wikipedia rdf:resource="http://en.wikipedia.org/wiki/Eric_Clapton"/>
<mo:myspace rdf:resource="http://www.myspace.com/ericclapton"/>
<mo:member_of rdf:resource="/music/artists/53fa91ca-a2b9-463d-b78e-daca9894082a#artist"/>
<mo:member_of rdf:resource="/music/artists/04cd0cfd-bfd1-4c36-bc38-95c35e2c045f#artist"/>
<mo:member_of rdf:resource="/music/artists/2155a81a-f0c6-417a-9b16-2f86f98bb8bc#artist"/>
<mo:member_of rdf:resource="/music/artists/4756395c-57ed-4a63-afb2-01117f14dff6#artist"/>
<mo:member_of rdf:resource="/music/artists/191de76f-a224-445d-b041-54df16d65bf7#artist"/>
- <foaf:made>
  - <mo:Record>
      <dc:title>Me and Mr. Johnson</dc:title>
      <mo:musicbrainz rdf:resource="http://musicbrainz.org/release/cf83ac25-374f-4cd4-9872-c6c00aaced92.html"/>
      <rev:hasReview rdf:resource="/music/reviews/5dqv#review"/>
    </mo:Record>
  </foaf:made>
- <foaf:made>
  - <mo:Record>
      <dc:title>Martin Scorsese Presents the Blues: Eric Clapton</dc:title>
      <mo:musicbrainz rdf:resource="http://musicbrainz.org/release/a36c1d21-5669-44d6-969c-179fb6039359.html"/>
      <rev:hasReview rdf:resource="/music/reviews/6jxm#review"/>
    </mo:Record>
  </foaf:made>
</mo:MusicArtist>
- <mo:MusicArtist rdf:about="/music/artists/53fa91ca-a2b9-463d-b78e-daca9894082a#artist">
    <foaf:name>Blind Faith</foaf:name>
  </mo:MusicArtist>
- <mo:MusicArtist rdf:about="/music/artists/04cd0cfd-bfd1-4c36-bc38-95c35e2c045f#artist">
    <foaf:name>Cream</foaf:name>
  </mo:MusicArtist>
- <mo:MusicArtist rdf:about="/music/artists/2155a81a-f0c6-417a-9b16-2f86f98bb8bc#artist">
```


Done

Query RDF Data
(SPARQL)

RDF data access

- How do I *query* the RDF data?
  - e.g., how do I get to the DBpedia data?

Querying RDF graphs

- Remember the Jena idiom:

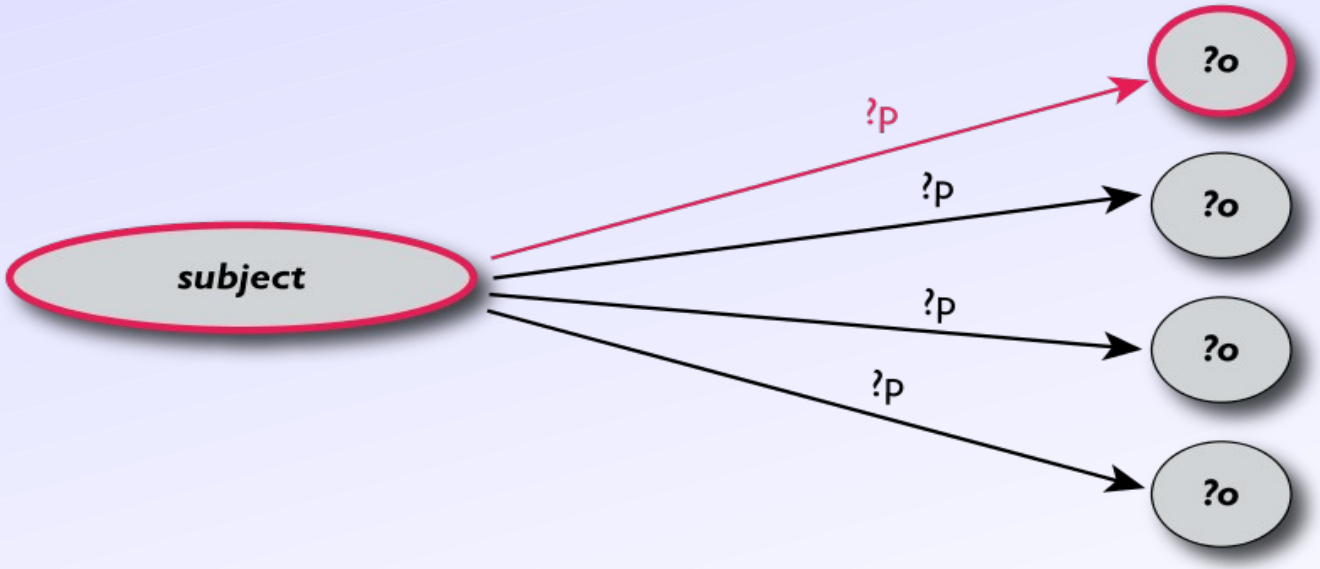
```
StmtIterator iter=model.listStatements(subject,null,null);
while(iter.hasNext()) {
    st = iter.next();
    p = st.getProperty(); o = st.getObject();
    do_something(p,o);
```

- In practice, more complex queries into the RDF data are necessary
  - something like: “give me the (a,b) pair of resources, for which there is an x such that (x parent a) and (b brother x) holds” (ie, return the uncles)
  - these rules may become quite complex
- The goal of SPARQL (Query Language for RDF)

Analyse the Jena example

```
StmtIterator iter=model.listStatements(subject,null,null);
while(iter.hasNext()) {
    st = iter.next();
    p = st.getProperty(); o = st.getObject();
    do_something(p,o);
```

- The **(subject,?p,?o)** is a *pattern* for what we are looking for (with **?p** and **?o** as "unknowns")



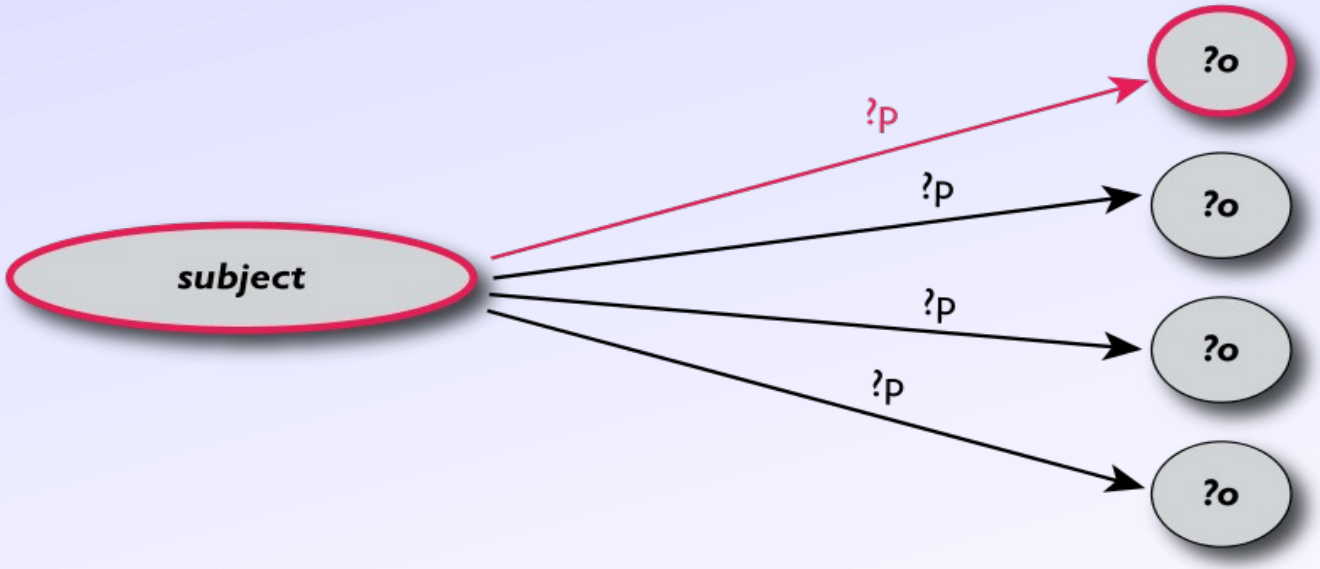
General: graph patterns

- The fundamental idea: use graph patterns
  - the pattern contains unbound symbols
  - by binding the symbols, subgraphs of the RDF graph are selected
  - if there is such a selection, the query returns bound resources

Our Jena example in SPARQL

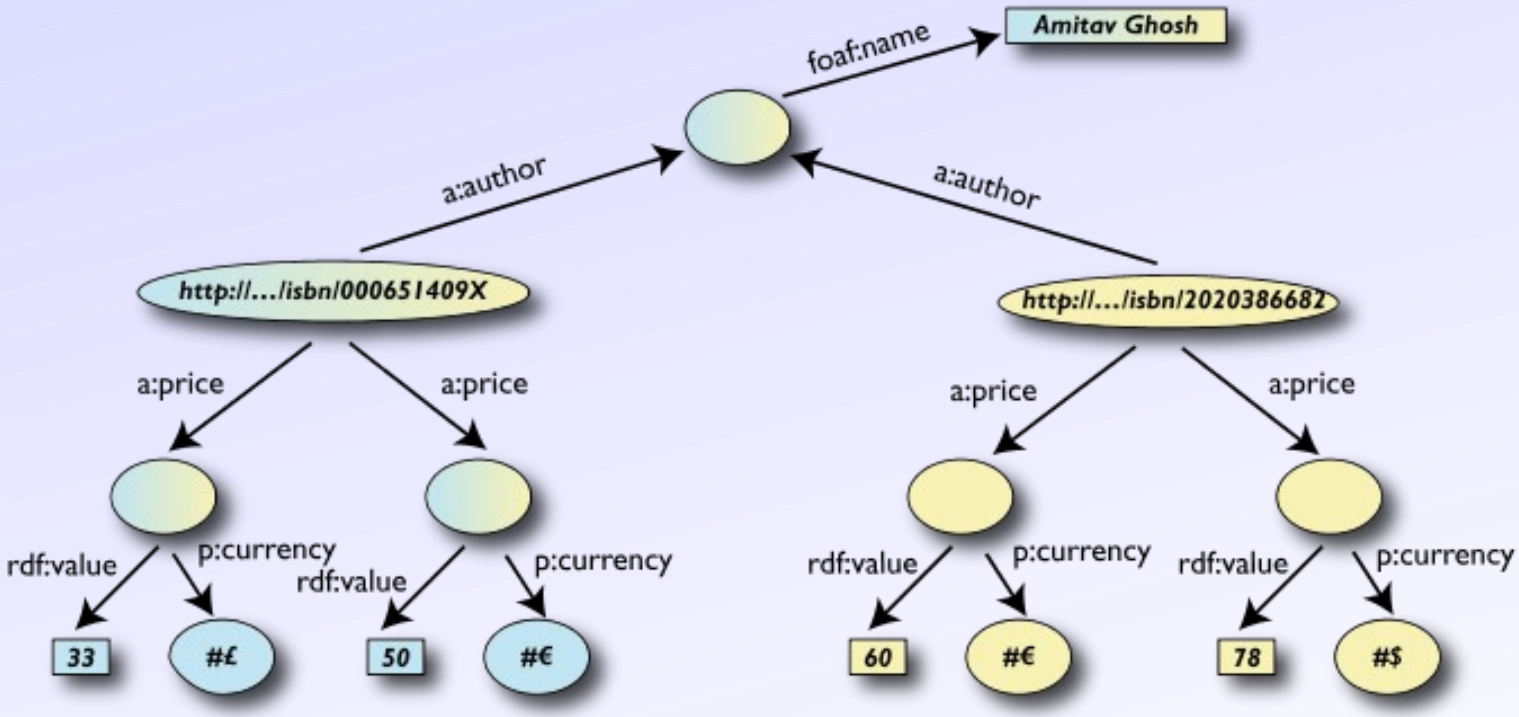
```
SELECT ?p ?o
WHERE {subject ?p ?o}
```

- The triples in **WHERE** define the graph pattern, with **?p** and **?o** "unbound" symbols
- The query returns *all* **p**,**o** pairs



Simple SPARQL example

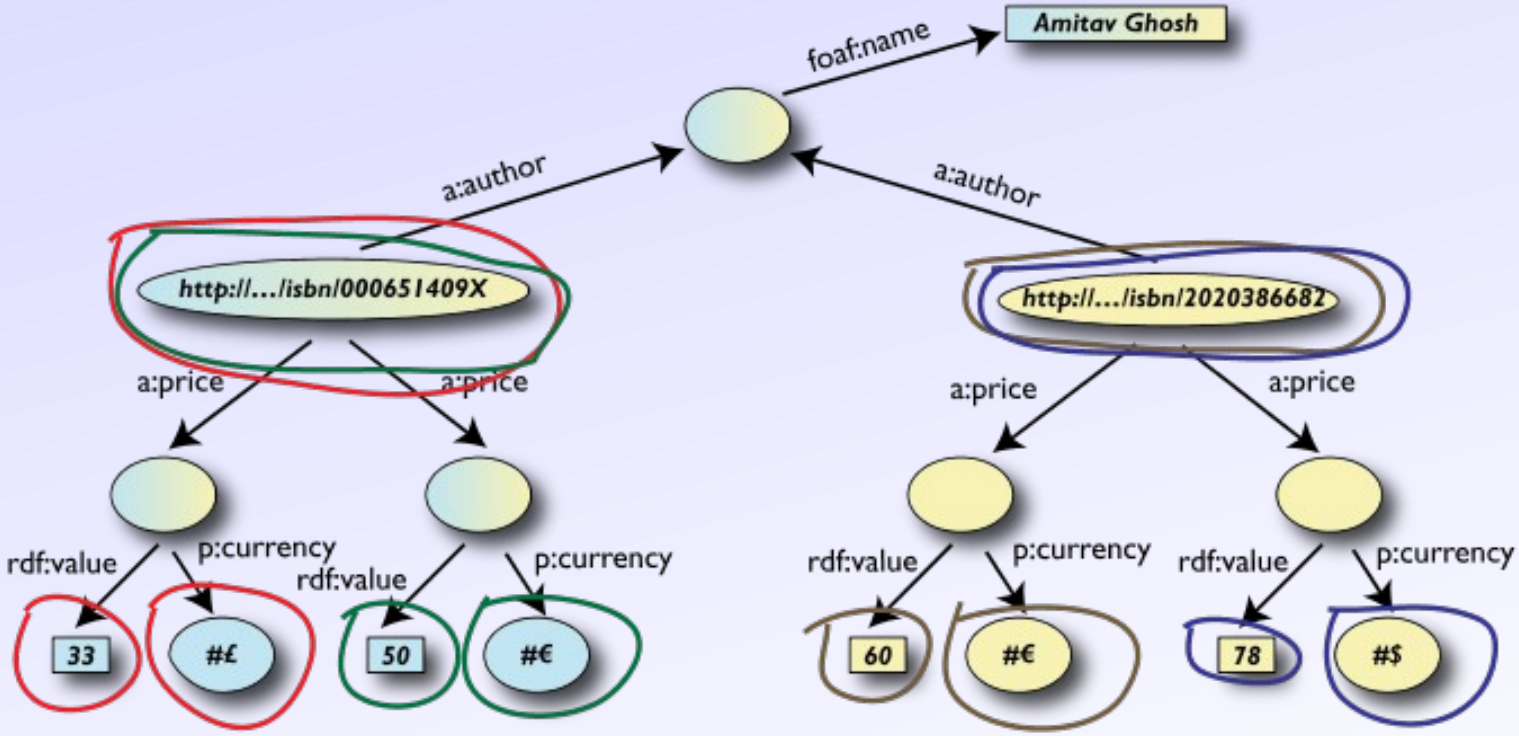
```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```



Simple SPARQL example

```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE {?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.}
```

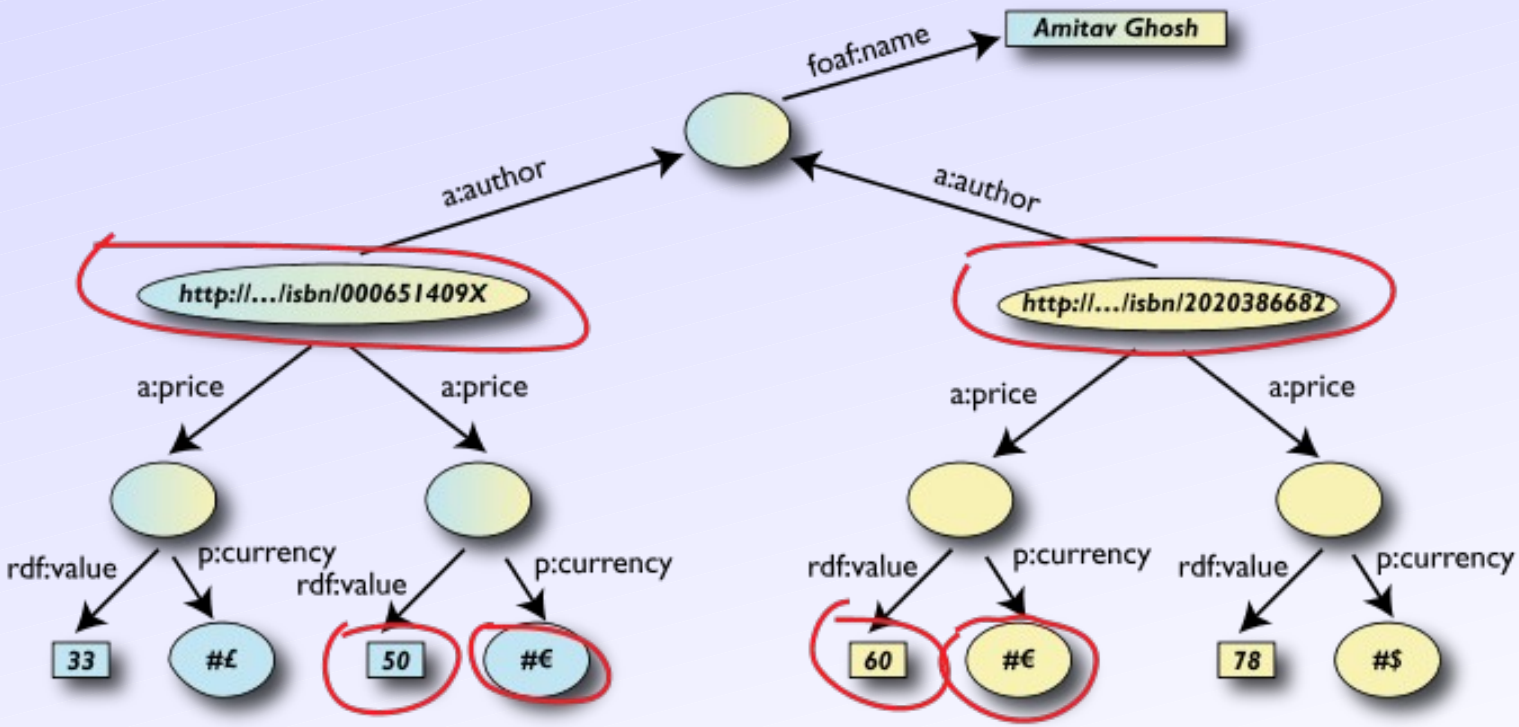
- Returns:
  [[<..49X>,33,£], [<..49X>,50,€], [<..6682>,60,€], [<..6682>,78,$]]



Pattern constraints

```
SELECT ?isbn ?price ?currency # note: not ?x!
WHERE { ?isbn a:price ?x. ?x rdf:value ?price. ?x p:currency ?currency.
        FILTER(?currency == € }
```

- Returns: [[<..409X>,50,€], [<..6682>,60,€]]



Other SPARQL features

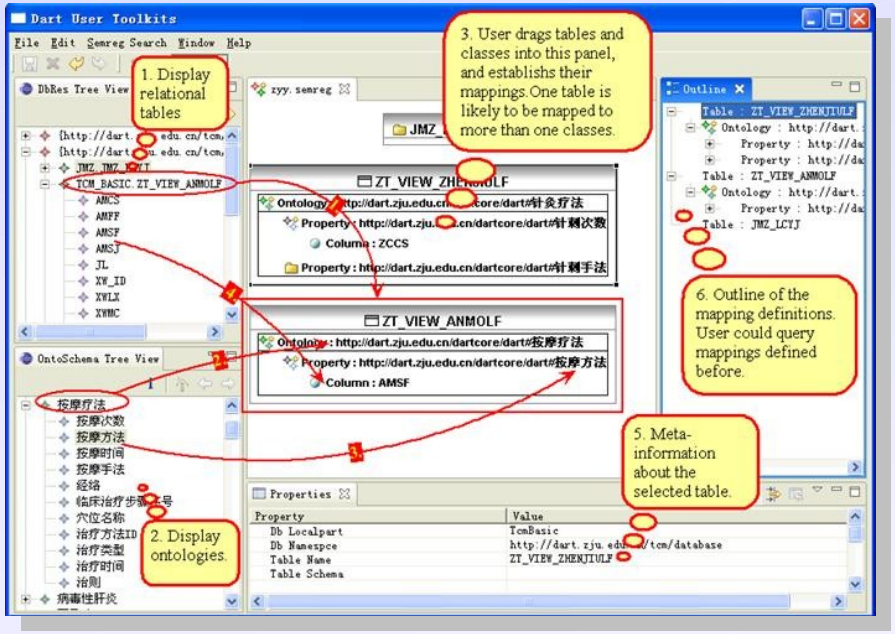
- Limit the number of returned results; remove duplicates, sort them, …
- Optional branches in the query
- Specify several data sources (via URI-s) within the query (essentially, a merge!)
- *Construct* a graph combining a separate pattern and the query results
- Use datatypes and/or language tags when matching a pattern

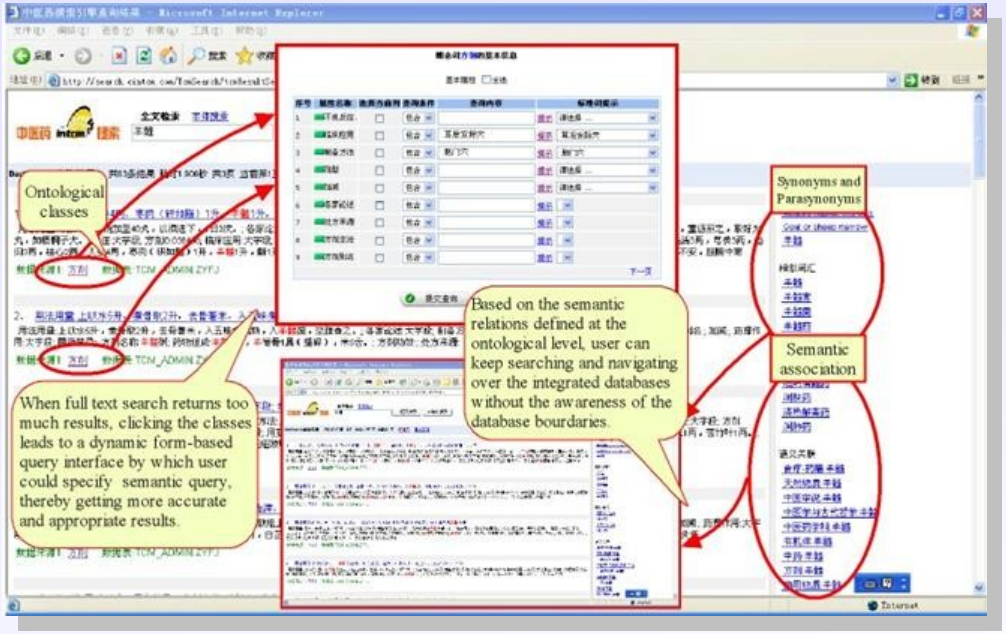
SPARQL usage in practice

- SPARQL is usually used over the network
  - separate documents define the protocol and the result format
  - SPARQL Protocol for RDF with HTTP and SOAP bindings
  - SPARQL results in XML or JSON formats
- Big datasets usually offer “SPARQL endpoints” using this protocol
  - typical example: SPARQL endpoint to DBpedia

Remember this example?

- The access to all the data is based on SPARQL queries





Courtesy of Huajun Chen, Zhejiang University, (SWEO Case Study)

Ontologies

(OWL)

Ontologies

- RDFS is useful, but does not solve all possible requirements
- Complex applications may want more possibilities:
  - characterization of properties
  - identification of objects with different URI-s
  - disjointness or equivalence of classes
  - construct classes, not only name them
  - can a program reason about some terms? E.g.:
    - “if «Person» resources «A» and «B» have the same «**`foaf:email`**» property, then «A» and «B» are identical”
  - etc.

Ontologies (cont.)

- The term *ontologies* is used in this respect:

"defines the concepts and relationships used to describe and represent an area of knowledge"

- RDFS can be considered as a simple ontology language
- Languages should be a compromise between
  - rich semantics for meaningful applications
  - feasibility, implementability

Web Ontology Language = OWL

- OWL is an extra layer, a bit like RDF Schemas
  - own namespace, own terms
  - it relies on RDF Schemas
- It is a separate recommendation
  - actually… there is a 2004 version of OWL (“OWL 1”)
  - and there is an update (“OWL 2”) that should be finalized in a few weeks

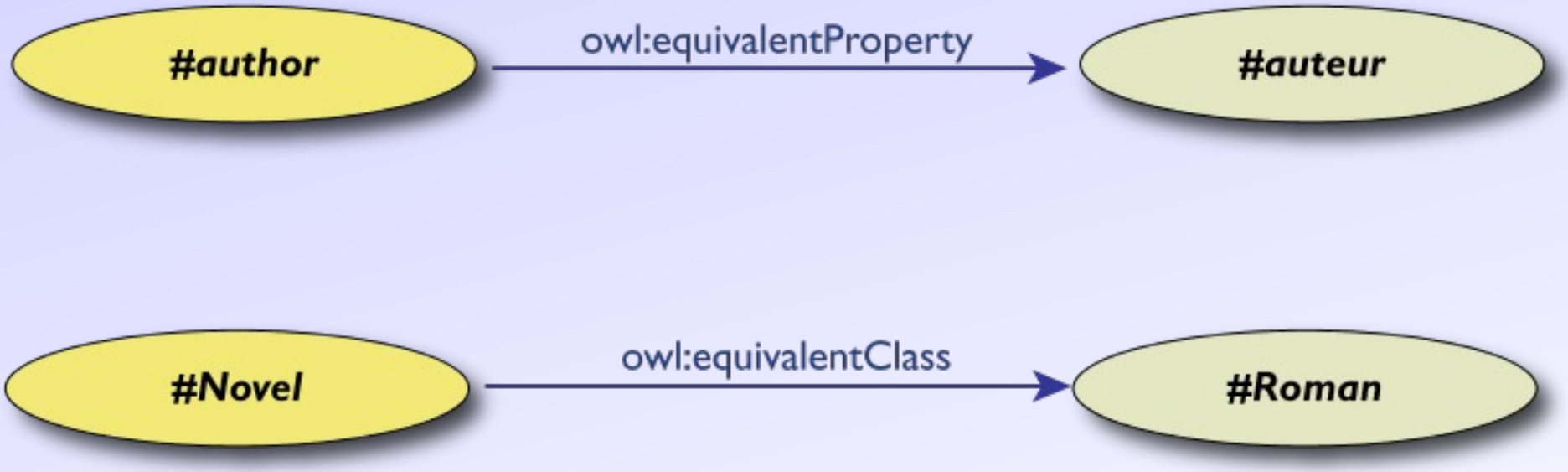
OWL is complex…

- OWL is a large set of additional terms
- We will not cover the whole thing here…

Term equivalences

- For classes:
  - **`owl:equivalentClass`**: two classes have the *same* individuals
  - **`owl:disjointWith`**: no individuals in common
- For properties:
  - **`owl:equivalentProperty`**
    - remember the **`a:author`** vs. **`f:auteur`**
  - **`owl:propertyDisjointWith`**
- For individuals:
  - **`owl:sameAs`**: two URIs refer to the same concept (“individual”)
  - **`owl:differentFrom`**: negation of **`owl:sameAs`**

Connecting to French…



Typical usage of `owl:sameAs`

- Linking our example of Amsterdam from one data set (DBpedia) to the other (Geonames):

```
<http://dbpedia.org/resource/Amsterdam>
  owl:sameAs <http://sws.geonames.org/2759793>;
```

- This is the main mechanism of “Linking” in the Linking Open Data project

Property characterization

- In OWL, one can characterize the behaviour of properties (symmetric, transitive, functional, inverse functional…)
- One property may be the inverse of another
- OWL also separates *data* and *object* properties
  - “datatype property” means that its range are typed literals

What this means is…

- If the following holds in our triples:

```
:email rdf:type owl:InverseFunctionalProperty.
<A> :email "mailto:a@b.c".
<B> :email "mailto:a@b.c".
```

then, processed through OWL, the following holds, too:

```
<A> owl:sameAs <B>.
```

- I.e., *new relationships* were discovered again (beyond what RDFS could do)

Classes in OWL

- In RDFS, you can subclass existing classes… that's all
- In OWL, you can *construct* classes from existing ones:
  - enumerate its content
  - through intersection, union, complement
  - Etc

Classes in OWL (cont)

- OWL makes a stronger conceptual distinction between *classes* and *individuals*
  - there is a separate term for **`owl:Class`**, to make the difference (a specialization of the RDFS class)
  - individuals are separated into a special class called **`owl:Thing`**
- Eg, a precise classification would be:

```
ex:Person rdf:type owl:Class.

<uri-for-Amitav-Ghosh>
    rdf:type owl:Thing;
    rdf:type owl:Person .
```

Classes contents can be enumerated

```
:£ rdf:type owl:Thing.
:€ rdf:type owl:Thing.
:¥ rdf:type owl:Thing.
:Currency
    rdf:type owl:Class;
    owl:oneOf (:€ :£ :¥).
```

- I.e., the class consists of *exactly* of those individuals

Union of classes can be defined

```
:Novel            rdf:type owl:Class.
:Short_Story      rdf:type owl:Class.
:Poetry           rdf:type owl:Class.
:Literature rdf:type owl:Class;
   owl:unionOf (:Novel :Short_Story :Poetry).
```

- Other possibilities: **`complementOf`**, **`intersectionOf`**, …

For example…

If:

```
:Novel            rdf:type owl:Class.
:Short_Story      rdf:type owl:Class.
:Poetry           rdf:type owl:Class.
:Literature rdf:type owl:Class;
   owl:unionOf (:Novel :Short_Story :Poetry).

<myWork> rdf:type :Novel .
```

then the following holds, too:

```
<myWork> rdf:type :Literature .
```

It can be a bit more complicated…

If:

```
:Novel            rdf:type owl:Class.
:Short_Story      rdf:type owl:Class.
:Poetry           rdf:type owl:Class.
:Literature rdf:type owlClass;
   owl:unionOf (:Novel :Short_Story :Poetry).

fr:Roman owl:equivalentClass :Novel .

<myWork> rdf:type fr:Roman .
```

then, through the *combination* of different terms, the following still holds:

```
<myWork> rdf:type :Literature .
```

What we have so far…

- The OWL features listed so far are already fairly powerful
- E.g., various databases can be linked via **`owl:sameAs`**, functional or inverse functional properties, etc.
- Many inferred relationship can be found using a traditional rule engine

However… that may not be enough

- Very large vocabularies might require even more complex features
  - typical usage example: definition of all concepts in a health care environment
  - a major issue: the way classes (i.e., “concepts”) are defined
- OWL includes those extra features but… the inference engines become (much) more complex ☹

Property value restrictions

- Classes are created by *restricting* the property values on its individuals
- For example: how would I characterize a "listed price"?
  - it is a price (which may be a general term), but one that is given in one of the "allowed" currencies (say, €, £, or ¥)
  - more formally:
    - the value of "**`p:currency`**", when applied to a resource on listed price, *must* be of one of those values…
    - …thereby defining the class of "listed price"

Restrictions formally

- Defines a class of type **`owl:Restriction`** with a
  - reference to the property that is constrained
  - definition of the constraint itself
- One can, e.g., subclass from this node when defining a particular class

```
:Listed_Price rdfs:subClassOf [
      rdf:type              owl:Restriction;
      owl:onProperty        p:currency;
      owl:allValuesFrom     :Currency.
    ].
```

Possible usage…

If:

```
:Listed_Price rdfs:subClassOf [
      rdf:type              owl:Restriction;
      owl:onProperty        p:currency;
      owl:allValuesFrom     :Currency.
    ].

:price rdf:type :Listed_Price .

:price p:currency <something> .
```

then the following holds:

```
<something> rdf:type :Currency .
```

Other restrictions

- **`allValuesFrom`** could be replaced by:
  - **`someValuesFrom`**
    - e.g., I could have said: there should be a price given in *at least one* of those currencies
  - **`hasValue`**, when restricted to *one specific value*
- Cardinality restrictions: instead of looking at the values of properties, their number is considered
  - eg, a specific property should occur exactly once

But: OWL is hard!

- The combination of class constructions with various restrictions is extremely powerful
- What we have so far follows the same logic as before
  - extend the basic RDF and RDFS possibilities with new features
  - define their semantics, ie, what they “mean” in terms of relationships
  - expect to infer new relationships based on those
- However… a full inference procedure is hard ☹
  - not implementable with simple rule engines, for example

OWL "species"

- OWL species comes to the fore:
  - restricting *which* terms can be used and *under what circumstances (restrictions)*
  - if one abides to those restrictions, then simpler inference engines can be used
- They reflect compromises: expressibility vs. implementability

Unrestricted OWL (a.k.a. "OWL Full")

- No constraints on any of the constructs
  - **`owl:Class`** is just syntactic sugar for **`rdfs:Class`**
  - **`owl:Thing`** is equivalent to **`rdfs:Resource`**
  - this means that:
    - Class can also be an individual, a URI can denote a property as well as a Class
      - e.g., it is possible to talk about class of classes, apply properties on them
      - etc
  - etc.
- Extension of RDFS in all respects
- But: no system may exist that infers everything one might expect

OWL Full usage

- Nevertheless OWL Full is essential
  - it gives a generic framework to *express* many things with precise semantics
  - some application actually just need to express and interchange terms (even with possible scruffiness)
- Applications may control what terms are used and how
  - in fact, they may define their own sub-language via, eg, a vocabulary
    - thereby ensuring a manageable inference procedure

OWL DL

- A number of restrictions are defined
  - classes, individuals, object and datatype properties, etc, are fairly strictly separated
  - object properties must be used with individuals
    - i.e., properties are really used to create relationships *between individuals*
  - no characterization of *datatype* properties
  - …
- But: *well known inference algorithms exist!*

Examples for restrictions

- The following is not “legal” OWL DL:

```
<q> rdf:type <A>.          # A is a class, q is an individual

<r> rdf:type <q>.          # error: q cannot be used for a class, too

<A> ex:something <B>.      # error: properties are for individuals only

<q> ex:something <s>.      # error: same property cannot be used as
<p> ex:something “54”.     #   object and datatype property
```

OWL DL usage

- Abiding to the restrictions means that very large ontologies can be developed that require precise procedures
  - eg, in the medical domain, biological research, energy industry, financial services (eg, XBRL), etc
  - the number of classes and properties described this way can go up to the many thousands
- OWL DL has become a language of choice to define and manage formal ontologies in general
  - even if their usage is not necessarily on the Web

OWL 2 defines further species a.k.a. "profiles"

- Further restrictions on how terms can be used and what inferences can be expected
  - Classification and instance queries in polynomial time: *OWL-EL*
  - Implementable on top of conventional relational database engines: *OWL-QL*
  - Implementable on top of traditional rule engines: *OWL-RL*

Ontology development

- The hard work is to *create* the ontologies
  - requires a good knowledge of the area to be described
  - some communities have good expertise already (e.g., librarians)
  - *OWL is just a tool to formalize ontologies*
  - large scale ontologies are often developed in a community process
- Ontologies should be *shared* and *reused*
  - can be via the simple namespace mechanisms…
  - …or via explicit import

Must I use large ontologies?

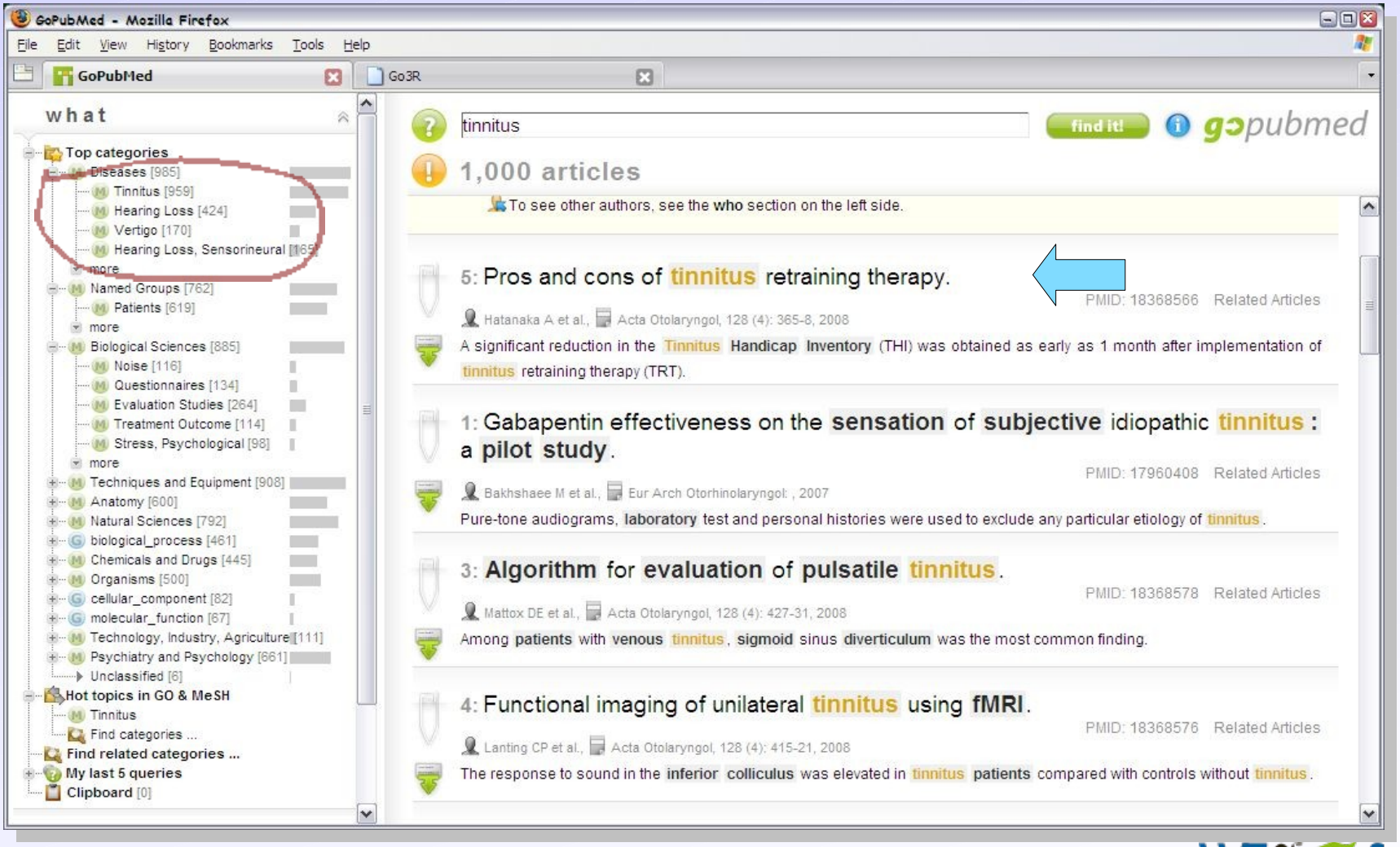
- NO!!!
- Many applications are possible with RDFS and a just a little bit of OWL
  - a few terms, whose meaning is defined in OWL, and that application can handle directly
  - OWL RL is a step to create such a generic OWL level
- Big ontologies can be expensive (both in time and money); use them only when really necessary!

Ontologies examples

- eClassOwl: eBusiness ontology for products and services, 75,000 classes and 5,500 properties
- National Cancer Institute's ontology: about 58,000 classes
- Open Biomedical Ontologies Foundry: a collection of ontologies, including the Gene Ontology to describe gene and gene product attributes in any organism or protein sequence and annotation terminology and data (UniProt)
- BioPAX: for biological pathway data

Example: improved search via ontology

- Search results are re-ranked using ontologies
- Related terms are highlighted, usable for further search



Example: improved search via ontology

- Same dataset, different ontology
  - (ontology is on non-animal experimentation)

Go3R - Mozilla Firefox

File Edit View History Bookmarks Tools Help

GoPubMed | Go3R

what

- 3R Relevance Filters (Beta)
- Top categories
  - Diseases & Symptoms [601]
    - Tinnitus [547]
    - Hearing Loss [248]
    - Vertigo [98]
    - Disease [118]
    - Hearing Loss, Sensorineural [95]
    - more
  - Methodology [408]
  - Life Sciences [503]
  - Body Systems & Structures [401]
  - Bioethics [102]
    - Reduction [90]
    - more
  - Statistics [125]
  - Substances, Preparations & Products [277]
  - Biological Material & Organisms for Animal U
  - Method Specification [36]
  - Animal Species [40]
  - Product Properties & Effects [62]
  - Product Testing & Assessment [20]
  - 3Rs Methods in the Life Sciences [6]
  - Animal Experiment [6]
  - 3Rs Relevant [5]
  - In Vitro Experimental Design [20]
  - In Vivo Experimental Design [5]
  - Animal Condition, Physiological or Psycholog
  - Animal Care & Handling [3]
  - Toxic Actions of Substances [7]
  - Unclassified [390]
- Find related categories ...
- My last 5 queries
- Clipboard [0]

tinnitus | find it! | go3R

1,000 articles

differences (P > 0.05).

2: Microvascular decompression of cochleovestibular nerve.
PMID: 18389269 Related Articles
Yap L et al., Eur Arch Otorhinolaryngol: , 2008
This report provides a review of all the published studies on MVD of the eighth (8th) nerve in alleviating cochleovestibular symptoms and presents three additional patients who underwent MVD of the eighth nerve for tinnitus or vertigo.

3: Algorithm for evaluation of pulsatile tinnitus.
PMID: 18368578 Related Articles
Mattox DE et al., Acta Otolaryngol, 128 (4): 427-31, 2008
Among patients with arterial tinnitus, carotid atherosclerotic disease was the most common.

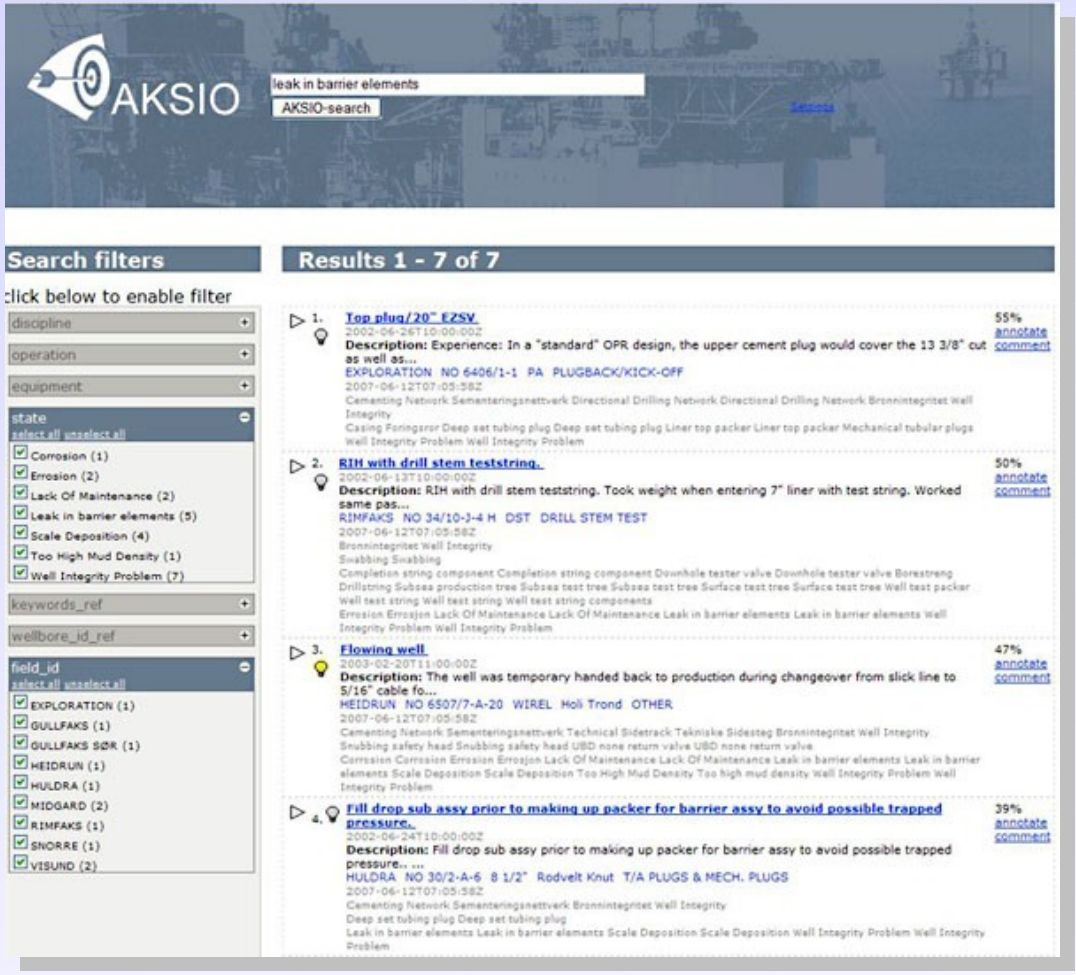
4: Functional imaging of unilateral tinnitus using fMRI.
PMID: 18368576 Related Articles
Lanting CP et al., Acta Otolaryngol, 128 (4): 415-21, 2008
This article shows that the inferior colliculus plays a key role in unilateral subjective tinnitus.

5: Pros and cons of tinnitus retraining therapy.
PMID: 18368566 Related Articles
Hatanaka A et al., Acta Otolaryngol, 128 (4): 365-8, 2008
A significant reduction in the Tinnitus Handicap Inventory (THI) was obtained as early as 1 month after implementation of tinnitus retraining therapy (TRT).

6: Mass casualty incident management, triage, injury distribution of casualties and

Help for deep sea drilling operations

- Integration of experience and data in the planning of deep sea drilling processes
- Discover relevant experiences
  - uses an ontology backed search engine



Courtesy of David Norheim and Roar Fjellheim, Computas AS (SWEO Use Case)

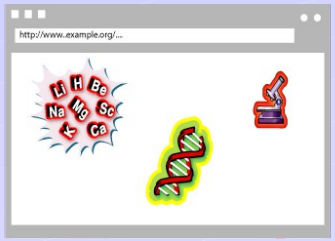
What have we achieved?

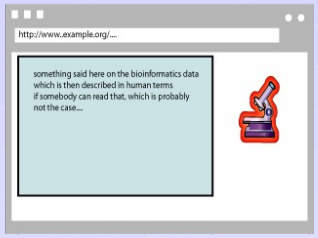
(putting all this together)

Other SW technologies

- There are other technologies that we do not have time for here
  - find RDF data associated with general URI-s: POWDER
  - bridge to thesauri, glossaries, etc: SKOS
  - use Rule engines on RDF data

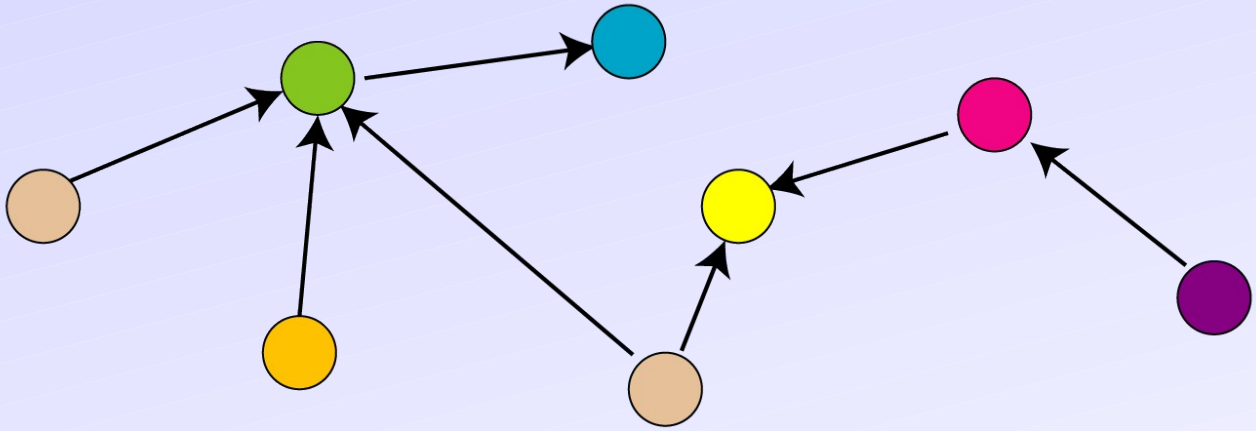
Remember the integration example?





Applications

Query, Manipulate, etc.

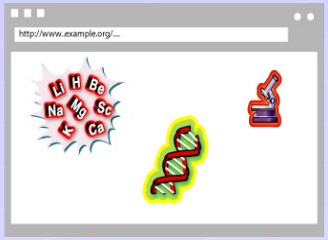


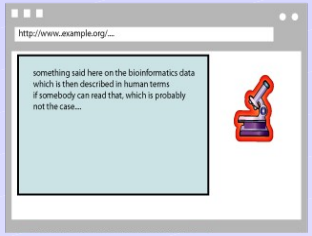
Data represented in abstract format

Map, Expose, etc.

Data in various formats

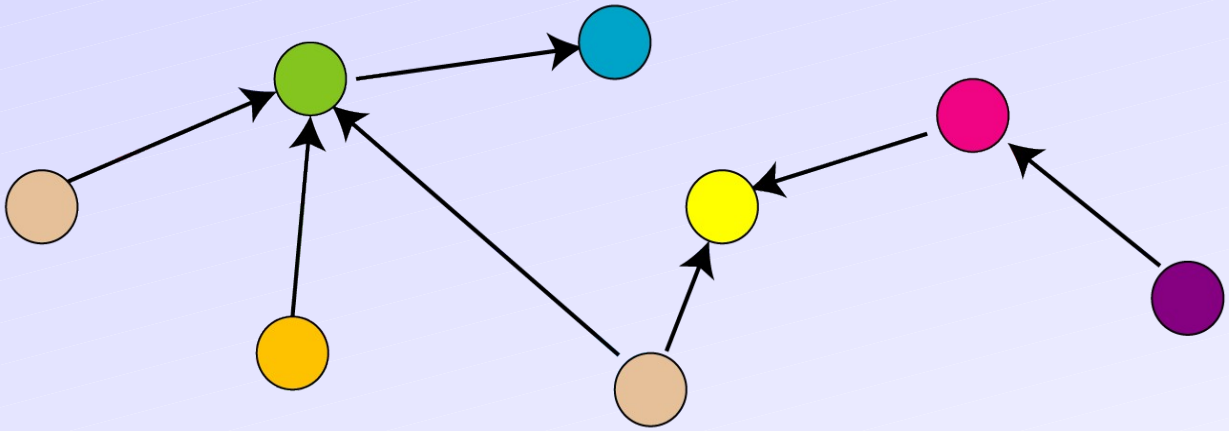
Same with what we learned





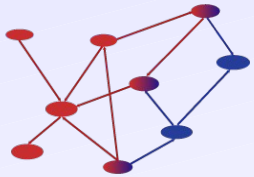
Applications

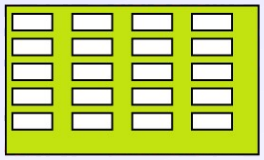
SPARQL,
OWL inferences,
etc.

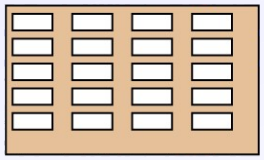


Data represented in RDF, possibly with extra knowledge (RDFS, OWL, SKOS, Rules, …)

SQL <=> RDF,
GRDDL, RDFa
etc.

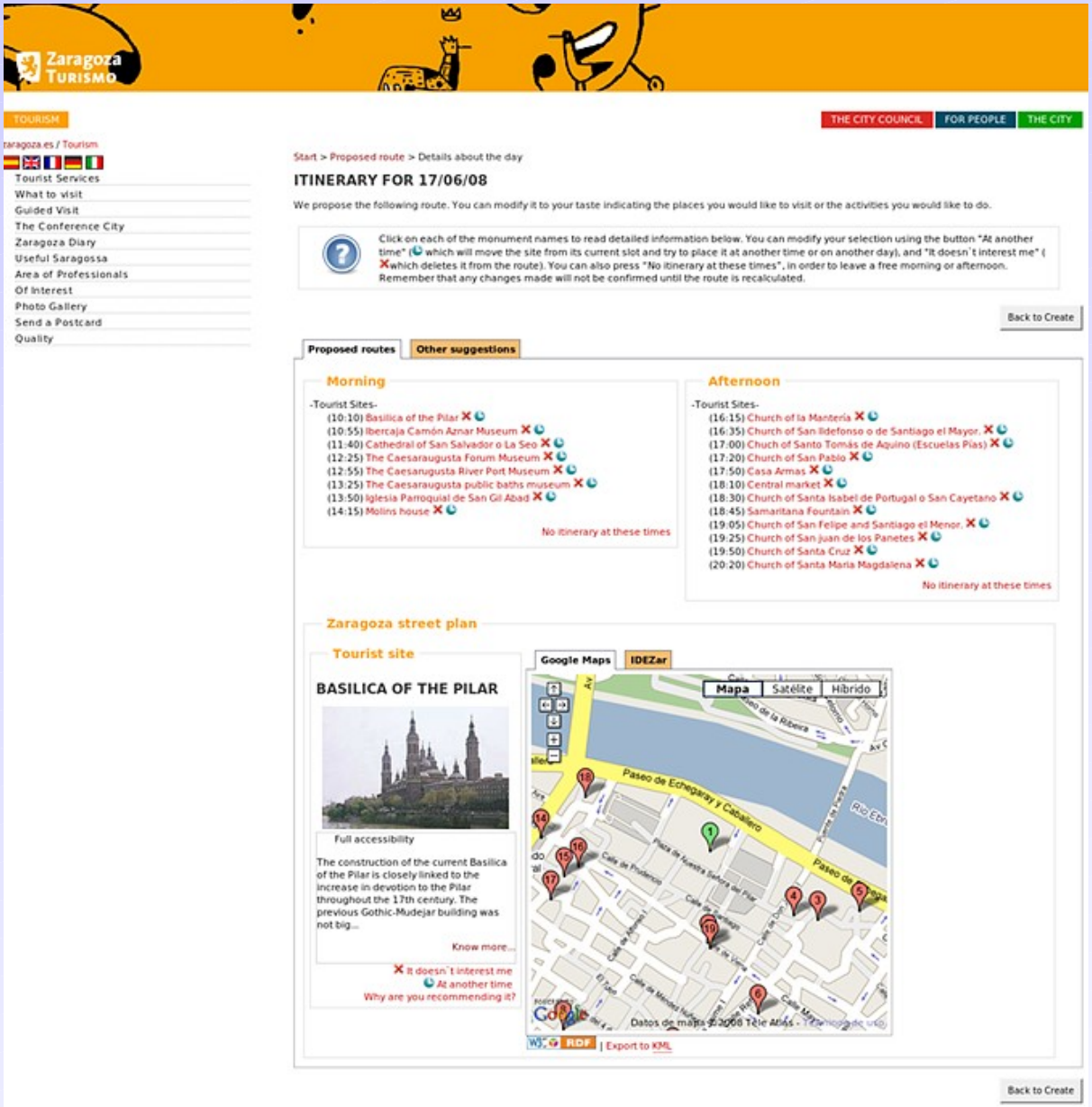






Data in various formats

Example: personalized tourist itinerary



Integration of relevant data in Zaragoza (using RDF and ontologies)

Use rules on the RDF data to provide a proper itinerary

Courtesy of Jesús Fernández, Mun. of Zaragoza, and Antonio Campos, CTIC (SWEO Use Case)

Available documents, resources

Available specifications: Primers, Guides

- The “RDF Primer” and the “OWL Guide” give a formal introduction to RDF(S) and OWL
- GRDDL and RDFa Primers have also been published
- The W3C Semantic Web Activity Homepage has links to all the specifications and guides:
  - http://www.w3.org/2001/sw/

"Core" vocabularies

- There are also a number widely used "core vocabularies"
  - Dublin Core: about information resources, digital libraries, with extensions for rights, permissions, digital right management
  - FOAF: about people and their organizations
  - DOAP: on the descriptions of software projects
  - SIOC: Semantically-Interlinked Online Communities
  - vCard in RDF
  - …
- One should never forget: ontologies/vocabularies must be shared and reused!

Some books

- G. Antoniu and F. van Harmelen: Semantic Web Primer, 2nd edition in 2008
- D. Allemang and J. Hendler: Semantic Web for the Working Ontologist, 2008
- Jeffrey Pollock: Semantic Web for Dummies, 2009
- 语义网简明教程，Wei Song, Ming Zhang, Higher Education Press, Beijing, 2004
- …

See the separate Wiki page collecting book references: http://esw.w3.org/topic/SwBooks

Further information and Fora

- Planet RDF aggregates a number of SW blogs:
  - http://planetrdf.com/
- Semantic Web Interest Group
  - a forum developers with archived (and public) mailing list, and a constant IRC presence on freenode.net#swig
    - anybody can sign up on the list:
      - http://www.w3.org/2001/sw/interest/
  - there are also similar list for Linked Open Data, OWL developers, etc
    - contact me for details if you cannot find them

Further information and Fora

- There is also a Chinese bulletin board
  - http://semweb.cn/
  - contact Han Xu <hanxu@w3china.org> or Huajun Chen <huajunsir@gmail.com> for further details
    - both should be around at the conference…

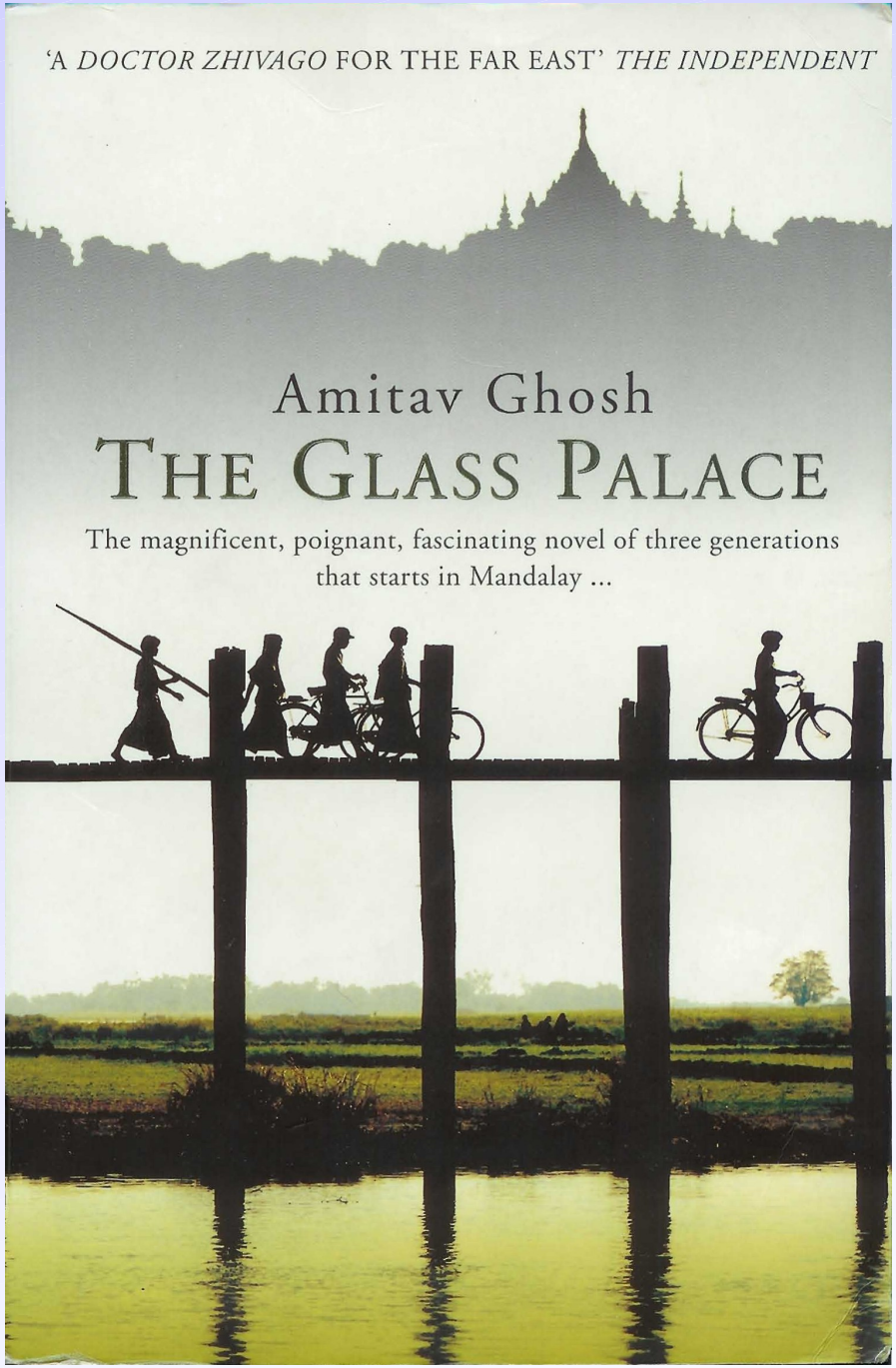
Lots of Tools (not an exhaustive list!)

- Categories:
  - Triple Stores
  - Inference engines
  - Converters
  - Search engines
  - Middleware
  - CMS
  - Semantic Web browsers
  - Development environments
  - Semantic Wikis
  - …
- Some names:
  - Jena, AllegroGraph, Mulgara, Sesame, flickurl, …
  - TopBraid Suite, Virtuoso environment, Falcon, Drupal 7, Redland, Pellet, …
  - Disco, Oracle 11g, RacerPro, IODT, Ontobroker, OWLIM, Tallis Platform, …
  - RDF Gateway, RDFLib, Open Anzo, DartGrid, Zitgist, Ontotext, Protégé, …
  - Thetus publisher, SemanticWorks, SWI-Prolog, RDFStore…
  - …

Conclusions

- The Semantic Web is about creating a Web of Data
- There is a great and very active user and developer community, with new applications

By the way: the book is real



Thank you for your attention!

These slides are also available on the Web:

http://www.w3.org/2009/Talks/0829-Nanjing-IH/