

BUILDING AND USING A KNOWLEDGE GRAPH TO COMBAT HUMAN TRAFFICKING

PEDRO SZEKELY

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INFORMATION SCIENCES INSTITUTE, UNIVERSITY OF SOUTHERN CALIFORNIA
COLUMBIA UNIVERSITY, INFERLINK, NEXT CENTURY, NASA JPL



LOOK BENEATH THE SURFACE

**HUMAN TRAFFICKING IS
MODERN-DAY SLAVERY**

A victim of trafficking may look like many of the people you see everyday.

Ask the right questions and look for clues. You are vital because you may be the only outsider with the opportunity to speak with a victim.

There are safe housing, health, immigration, food, income, employment, legal and interpretation services available to victims, but first they must be found.

If you think someone is a victim of trafficking, **call 1.888.3737.888**

For more information about human trafficking visit www.acf.hhs.gov/trafficking.





LOOK
BENEATH
THE SURFACE

PROFITS PER YEAR: \$32 BILLION

AVERAGE AGE OF ENTRY TO PROSTITUTION IN THE US: 14

PIMP'S PROFIT PER VICTIM PER YEAR: \$150,000

ADVERTISING BUDGET ON THE WEB: \$45 MILLION

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LOOK
BEWETH

TH

Find the locations where a potential victim of human trafficking was advertised

HUM
MODERN-DAY SLAVERY

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jessica blue eyes red hair swedish escort



Web Videos Images Shopping News More Search tools

About 1,200,000 results (0.66 seconds)

Jessica Sweden Independent San Diego Fiery Red Escort

san-diego.date-check.com/Ashow-escort-pub.asp?ProID=js2101f

Nice to meet you. My name is **Jessica**. I am from **Sweden** currently living in San Diego. I am 33 years old, fiery **red hair** and ocean **blue eyes**. Petite 130 pounds ...

Highly reviewed Swedish redhead. Upscale incall. - San ...

sandiego.backpage.com > ... > [San Diego escorts](#)

Aug 6, 2013 - My name is **Jessica**. I am from **Sweden** currently living in San Diego. I am 34 years old, fiery **red hair** and ocean **blue eyes**. Petite 130 pounds ...

Jessica Swedish GFE | San Diego Escort Massage Directory

sandiego.sugarnights.com/escorts/jessica-swedish-gfe

I am from Sweden, currently living in San Diego, 33 years old, fiery red hair and

San Diego, where else?

san-diego.south-coast.classivox.com/...escorts/-...jessica...sweden.../1192...

May 14, 2012 - I have fiery **red hair** and ocean **blue eyes**, slim 120 lbs and 5'5 tall w perky D ... Hi , my name is Je - san diego female **escorts** ... xoxo **Jessica**.

Example: Find the locations where a potential victim of human trafficking was advertised

Highly reviewed Swedish Escort visiting Santa Barbara 16-18th April - 34
Posted: Saturday, April 19, 2014 8:23 AM

[Reply](#)

I am from Sweden. [M.Sc.](#) in engineering. Great reviews! Red hair and blue eyes. Perky D breasts and nice nipples.

I am visiting Santa Barbara 16-18th April.

Please check my website www.swedishpleasure.com

Incall
1 hour \$250.00


(Get \$50 off with proof of purchase of any item from www.redheadtoys.com My toys store has over 15 000 different items.)

Call or text me at:
1 619 319 7315

<http://www.adultsearch.com/classifieds/look?id=163535>

Poster's age: 34

- Location: Santa Barbara
- Post ID: 3948285 santabarbara



619-319-7315


n.DC - Escorts - 619-319-7315 • 5184450

[<< Previous Post](#) [Next Post >>](#)

619-319-7315 • Washington DC Female Escort Post ID: 5184450

Highly reviewed Swedish provider visiting, Tysons Corner Washington DC
28th May-3rd June! - 34

[Share/Save](#) • [Send](#) • [Problems](#) • [Spam](#)
[MPReviews](#) • [TnARReview](#) • [TheEroticReview](#) • [BigDoggie](#) • [EPR](#)



[Click for QR Code](#)

Created: Monday, May 20th, 2013
Phone: 619-319-7315

I am from Sweden. M.Sc. in engineering. Great reviews! Red hair and blue eyes. Perky D breasts and nice nipples.

Upscale incall with free parking.

Please check my website www.swedishpleasure.com

Incall

> 100 million pages advertising adult services

Highly reviewed Swedish Escort visiting Santa Barbara 16-18th April - 34

Posted: Saturday, April 19, 2014 8:23 AM

2014-12-07

Reply

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Inca Santa Barbara
1 hour \$250.00

(Get \$50 off with proof of purchase of any item from www.redheadtoys.com My toys store has over 15 000 different items.)

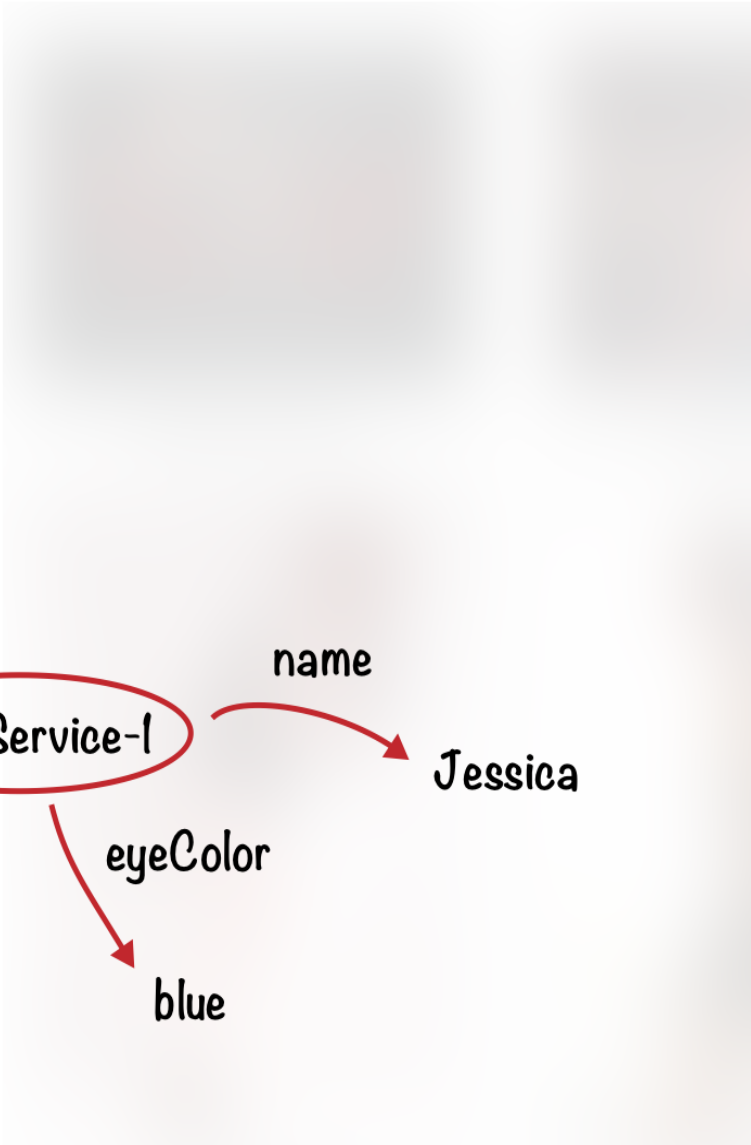
Call or text me at:
1 619 319 7315

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• 619-319-7315

• Post ID: 3948285 santabarbara



619-319-7315

Washington DC > Escorts > 619-319-7315 • 5184450

2014-05-28

<< Previous Post

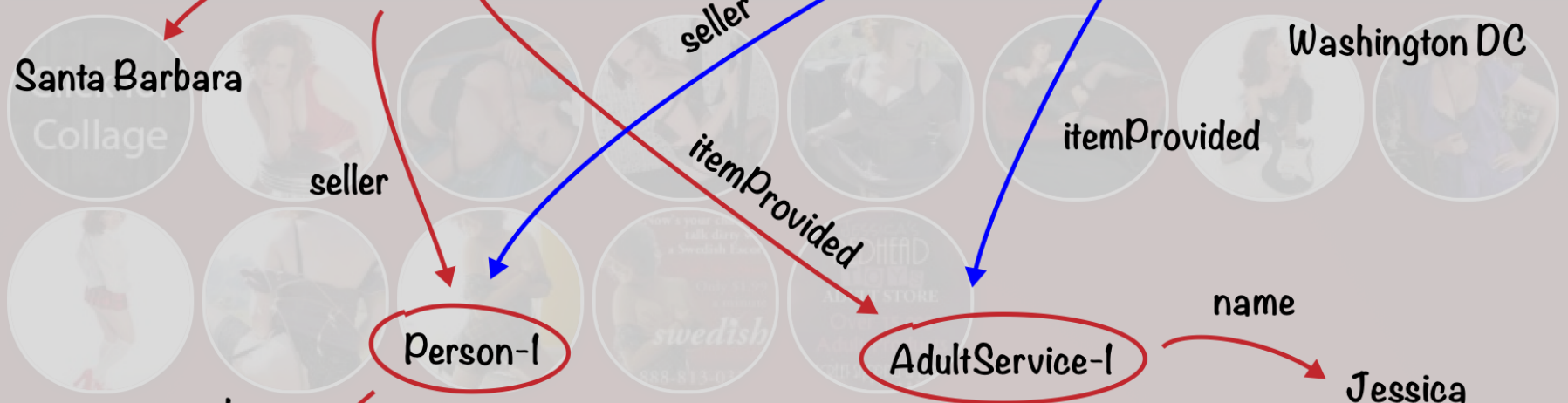
2014-12-07

Next Post >>

250/hour
Post ID: 5184450

619-319-7315 • Washington DC Female Escort
Highly reviewed Swedish provider visiting, Tysons Corner Washington DC
28th May-3rd June! -34

Share/Save • Spams • MPReviews • TnAReview • TheCroucher • Digi • EPR



Created: Monday, May 20th, 2014

Phone: 619-319-7315

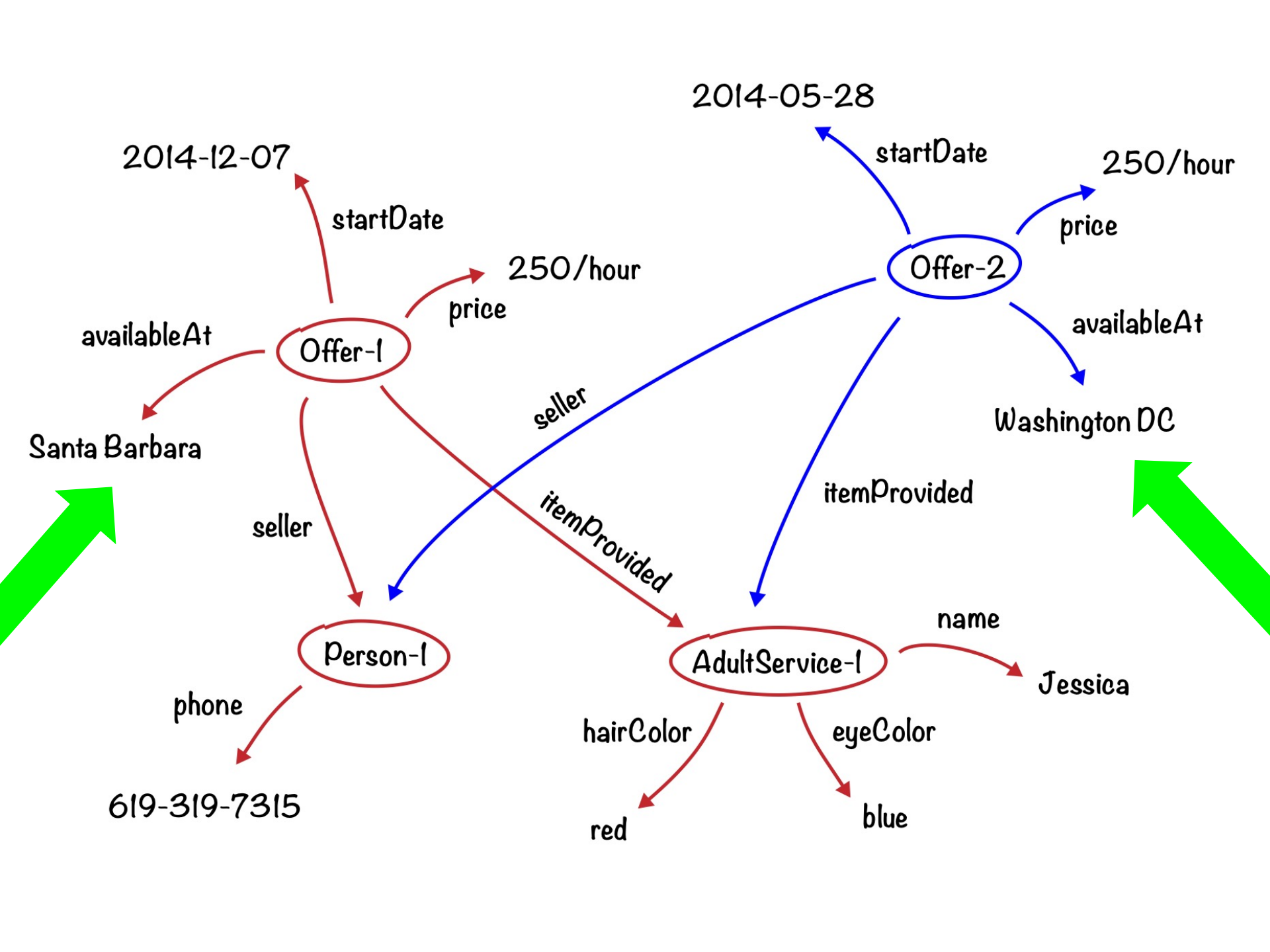
619-319-7315

I am from Sweden. M.Sc. in engineering. Great reviews! Red hair and blue eyes. Perky D breasts and nice nipples.
Upscale incall with free parking.

Please check my website www.swedishpleasure.com

Incall

Click for QR Code





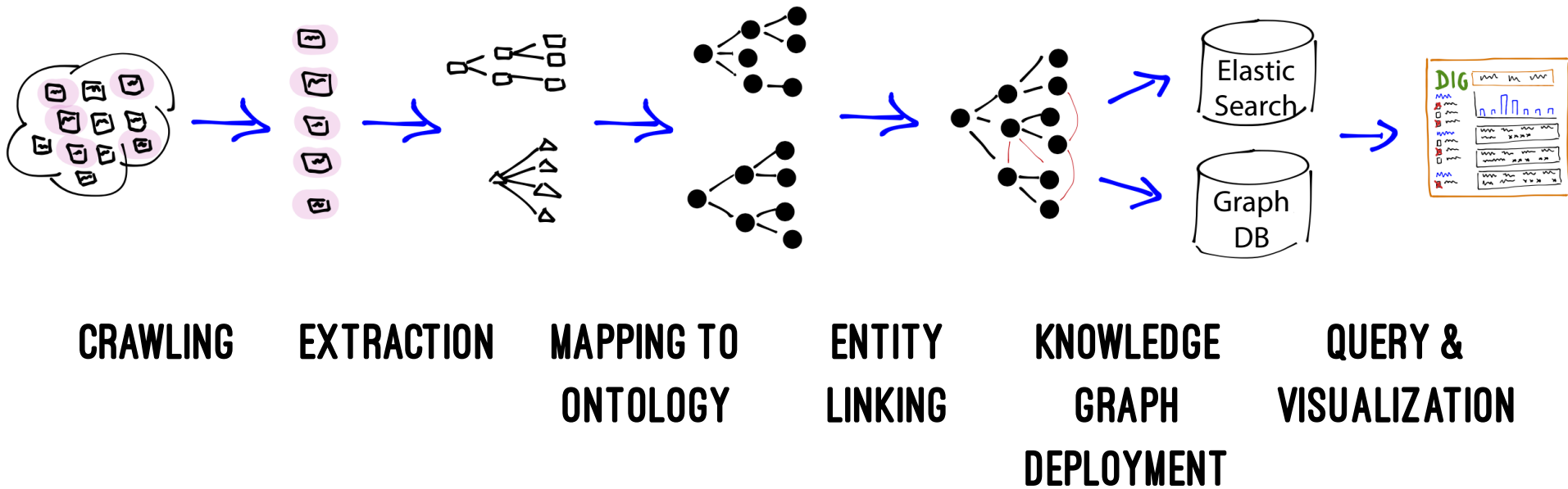
DAVID KARGER,
KEYNOTE ESWC 2013

"... SHOWING HOW THE SEMANTIC WEB CAN SOLVE
PROBLEMS THAT END USERS HAVE RIGHT NOW"

"A SEMANTIC WEB APPLICATION IS ONE WHOSE
SCHEMA IS EXPECTED TO CHANGE"



REUSABLE TECHNOLOGY FOR BUILDING DOMAIN-SPECIFIC SEARCH



WEB CRAWLING

24/7

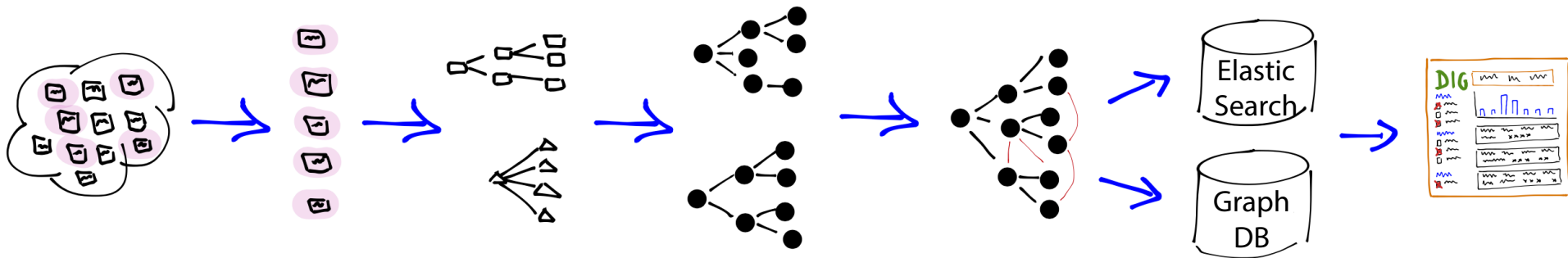
2,000 PAGES/HOUR

68,000,000 PAGES TOTAL

Backpage	26257125
Live Escort Reviews	15781909
EroticMugshots	9356957
Escortphonelist	3569247
Escorts In College	2843699
EscortAds.XXX	2139044
Craigslist	1622389
escortsinthe.us	1485510
Cityxguide	1393208
MyProviderGuide	1293239
Massagetroll	647875
NaughtyReviews	551454
Cityvibe	444240
Just Landed	259463
Escorts Inca	242635
SipSap	164153
Classivox	110066
Rubads	102187
AdultSearch	56773
Redbook	30674



REUSABLE TECHNOLOGY FOR BUILDING DOMAIN-SPECIFIC SEARCH



CRAWLING

EXTRACTION

**MAPPING TO
ONTOLOGY**

**ENTITY
LINKING**

**KNOWLEDGE
GRAPH
DEPLOYMENT**

**QUERY &
VISUALIZATION**



SEMISTRUCTURED EXTRACTION

HTML

JSON

FOR SALE: STOEGER M3500

post id: 4700468

share:    

Price: \$ 500
Seller: Private Party
Account: Registered on 5/9/2013
[Listings by this user](#)

Listed On: Thursday, September 17, 2015
Listed In: Shotguns
Location: Keenesburg, Denver, Colorado [Map](#)
Shipping: No

Manufacturer: Stoeger
Caliber: 12 Gauge
Action: Semi-automatic
Firearm Type: Shotgun

[Flag](#) | [Edit](#) | [Fav](#)

Contact Seller

I have a Stoeger m3500. It is a year old. It has 200 rounds through it from clay shooting. Its in perfect condition. If you have any questions email or text me. 9703427061. I'm asking 500



Contact Seller

```
{
  "description": "Universal M3 .30 carbine in good/very good condition. Functions fla...",
  "title": "For Sale/Trade: Universal M3 .30 carbine",
  "url": "http://www.armslist.com/posts/4189129/lower-peninsula-michigan-rifl_",
  "fields": [
    {
      "value": "Universal Firearms",
      "label": "Manufacturer"
    },
    {
      "value": ".30 Carbine",
      "label": "Caliber"
    },
    {
      "value": "Semi-automatic",
      "label": "Action"
    },
    {
      "value": "Rifle",
      "label": "Firearm Type"
    }
  ],
  "team": "list",
  "vendor_id": "",
  "tikonetdata": {
    "Content-Type": [
      "text/html; charset=UTF-8"
    ],
    "Content-Encoding": [
      "UTF-8"
    ],
    "X-Parsed-By": [
      "org.apache.tika.parser.DefaultParser",
      "org.apache.tika.parser.Html4xParser"
    ]
  },
  "listings": [
    {
      "ANMLIST - For Sale/Trade: Universal M3 .30 carbine"
    },
    {
      "ANMLIST - For Sale/Trade: Universal M3 .30 carbine"
    }
  ],
  "seller": {
    "id": "43321276000",
    "username": "keenesburg",
    "url": "http://www.armslist.com/profile/content/system/100000"
  }
}
```



TEXT EXTRACTION

“YOU don't wanna miss out
on ME :) Perfect lil booty
Green eyes Long curly black
hair Im a Irish,Armenian and
Filipino mixed princess :) ♡

Kim ♡ 707~7two7~7four77

♡ HH 80 roses ♡ Hour 120

roses ♡ 15 mins 60 roses”

NAME: KIM

EYE-COLOR: GREEN

HAIR-COLOR: BLACK

PHONE: 707-727-7477

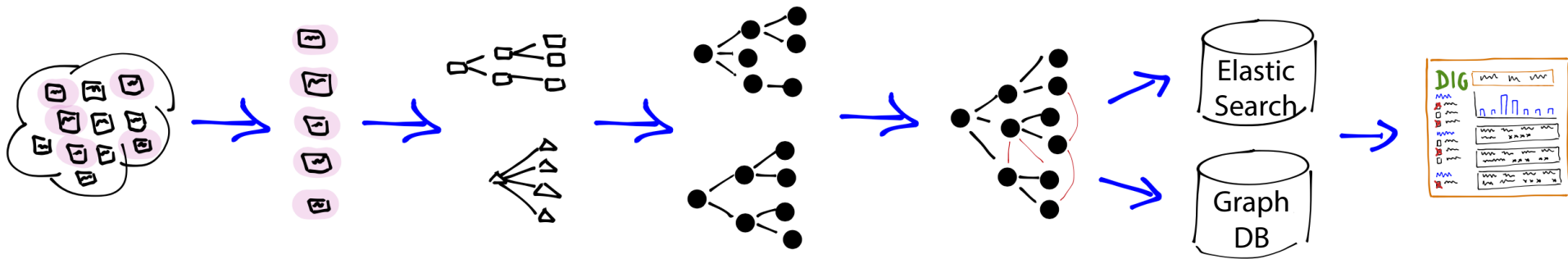
RATE: \$60/15MIN

\$80/30MIN

\$120/60MIN



REUSABLE TECHNOLOGY FOR BUILDING DOMAIN-SPECIFIC SEARCH



CRAWLING

EXTRACTION

**MAPPING TO
ONTOLOGY**

**ENTITY
LINKING**

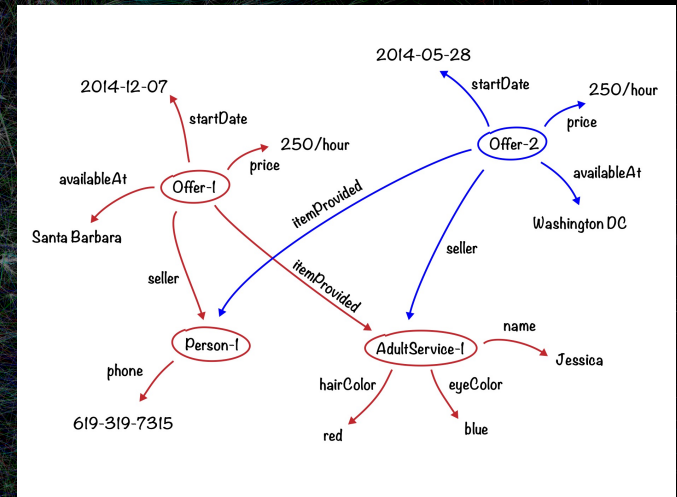
**KNOWLEDGE
GRAPH
DEPLOYMENT**

**QUERY &
VISUALIZATION**



MAPPING TO ONTOLOGY

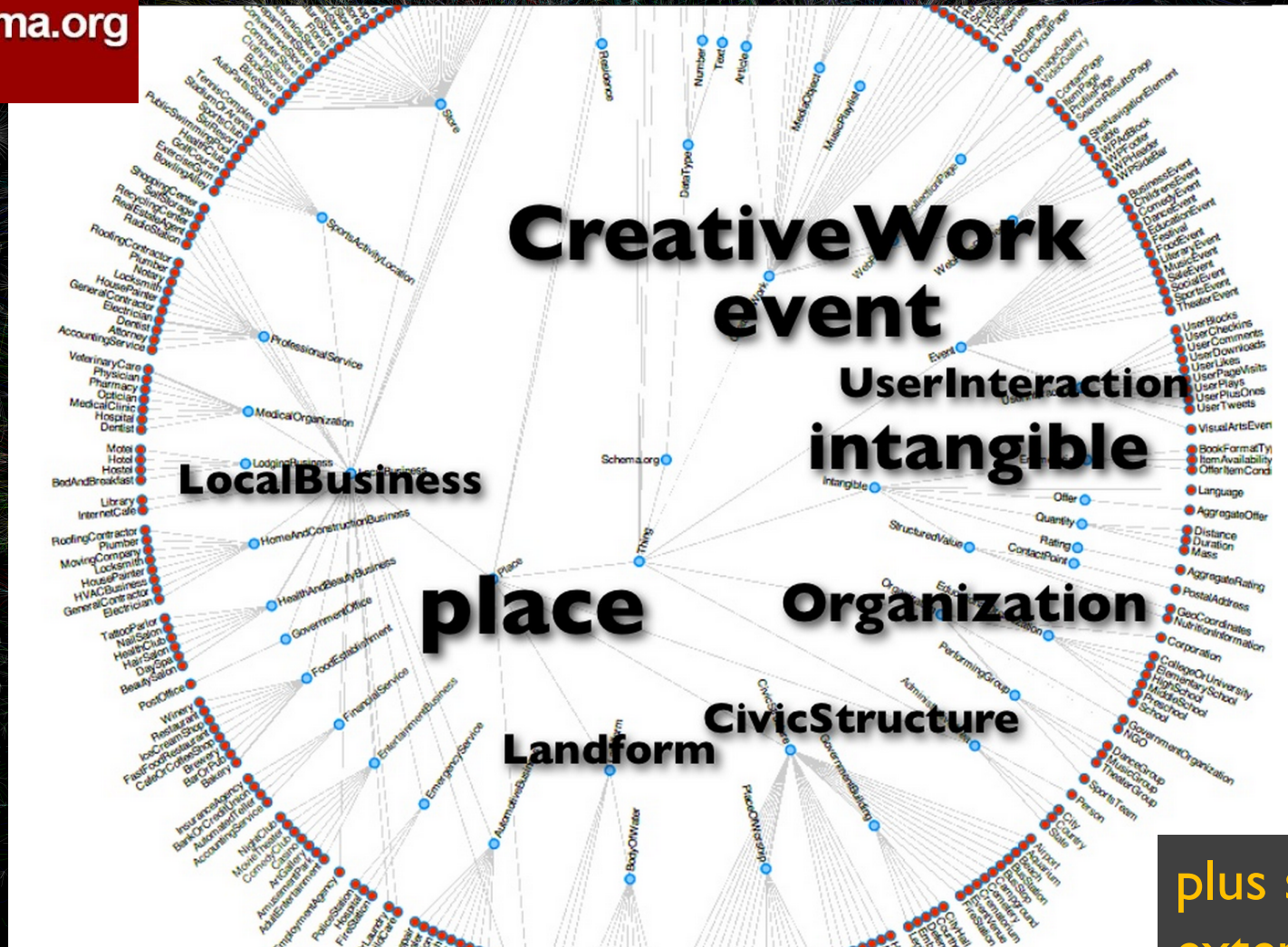
Many
schemas



One
ontology

ONTOLOGY

schema.org



plus some extensions

KARMA: MAPPING DATA TO ONTOLOGIES



Relational Sources



Hierarchical Sources

Services



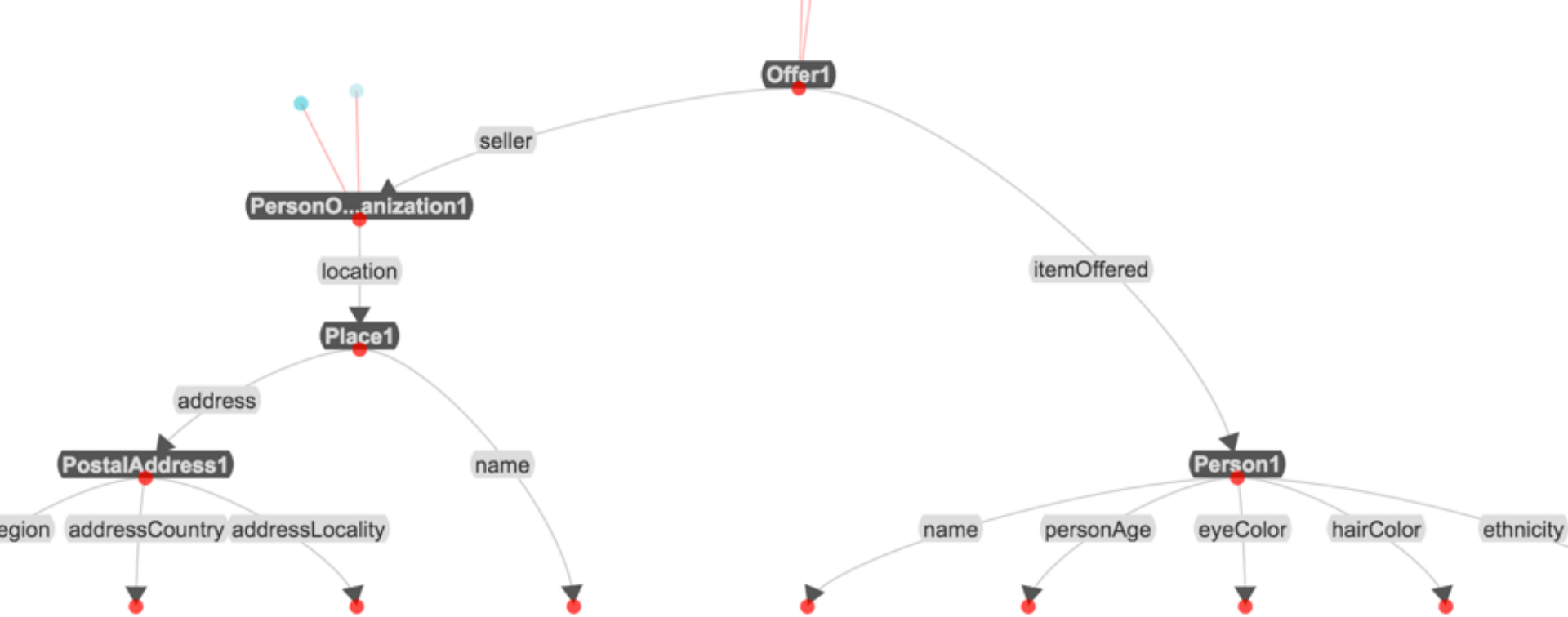
Mapping to Ontology

currency	cleanPrice	title	skypeman	person:f7761-4dda-11e5-bbd2-28cfe91a43c5	organization:f061d4f-4dda-11e5-bd9c-28cfe91a43c5	organizationrole:fefc...4dda-11e5-b0a5-28cfe91a43c5	organization:f9342-4dda-11e5-b053-28cfe91a43c5
USD	5.00	Realty Kings Account [LIFETIME + FREEBIES]					
USD	30.00	1 HOUR 24CPU-65GB RAM-150TB SSD-11TBHMD	ServerMagic	person:f7761-4dda-11e5-bbd2-28cfe91a43c5	organization:f061d50-4dda-11e5-91a8-28cfe91a43c5	organizationrole:fefc...4dda-11e5-b089-28cfe91a43c5	organization:4dda-11e5-b089-28cfe91a43c5

Data

{JSON-LD}

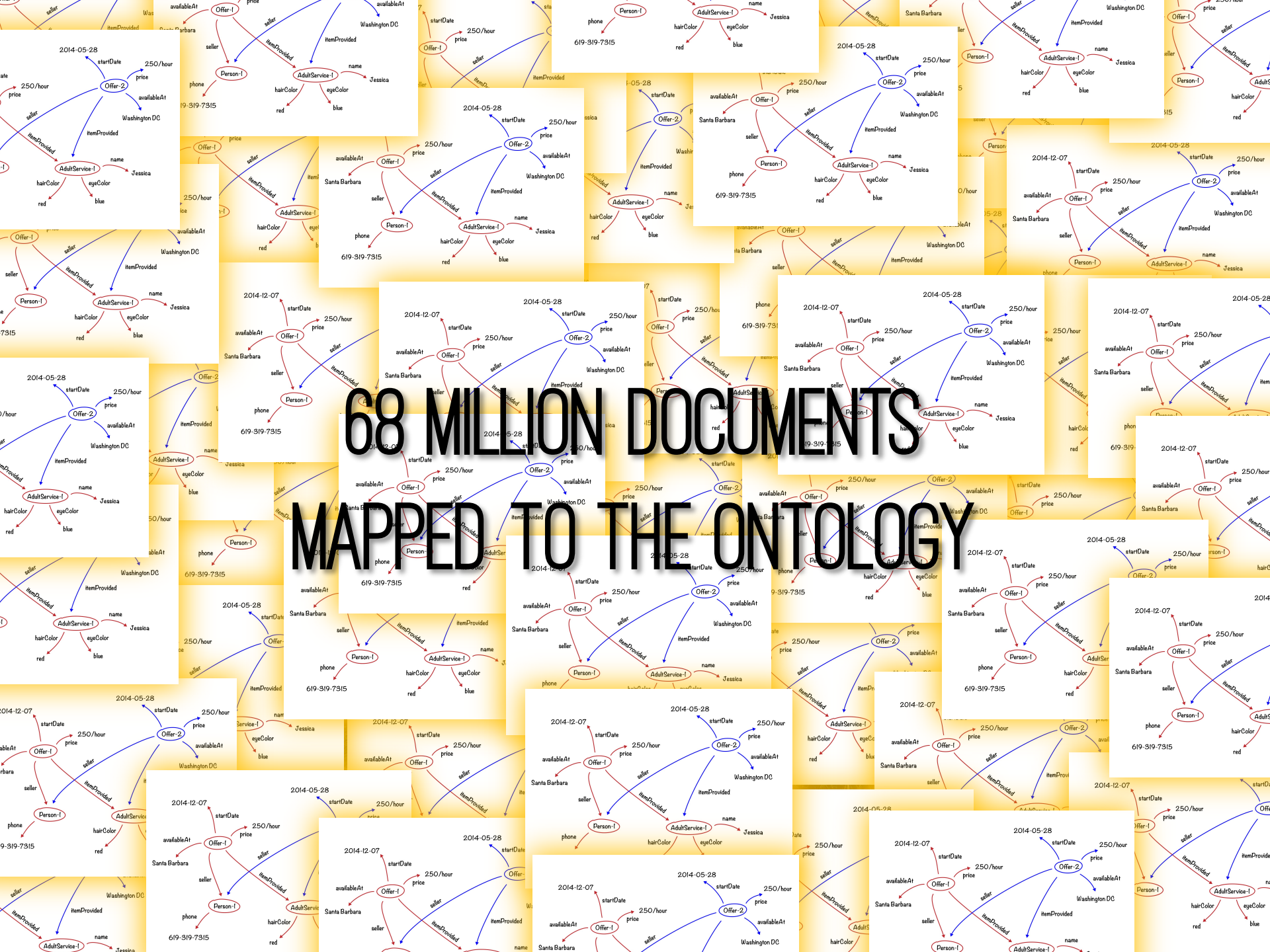




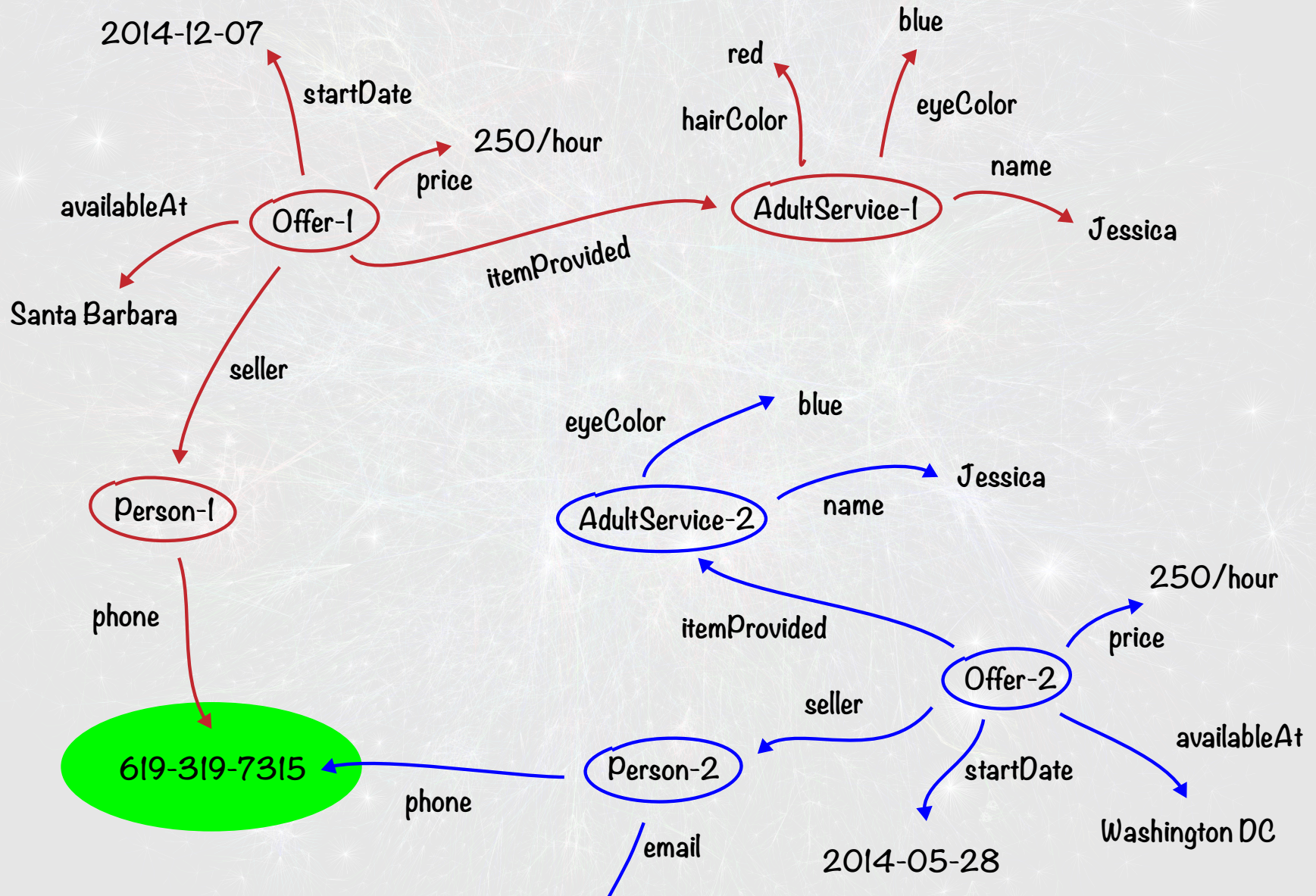
_source ▾						
country ▾	city ▾		name ▾	age ▾	eyes ▾	hair ▾
	values ▾	place_name ▾		values ▾		
United States of America	lawrence	lawrence, kansas, United States of America	Empty		Empty	Empty
Canada	british colu...	british columbia, British Columbia	emily	22	Empty	Empty

```
{
  "@context": "http://localhost:8080/publish/JSON/WSP1WS1-escorts_json-context.json",
  "itemOffered": {
    "personAge": "26",
    "name": "reika",
    "a": "Person",
    "ethnicity": "asian"
  },
  "a": "Offer",
  "identifier": "14558690",
  "seller": {
    "location": {
      "geo": {
        "a": "GeoCoordinates",
        "longitude": "-73.9597",
        "latitude": "40.7903"
      },
      "address": {
        "addressLocality": "manhattan",
        "a": "PostalAddress"
      },
      "name": "manhattan, , ",
      "a": "Place"
    },
    "a": "PersonOrOrganization",
    "telephone": "9178087930"
  },
  "mainEntityOfPage": {
    "text": "<i>HELLO Gentlemen!\nMy name is Reika 26years old, 5'8\" 105lbs, and I",
    "name": "***Sexy Asian model from Tokyo ~~ UPSCALE & ELEGANT&EROTIC BODY RUB ~ -",
    "a": "WebPage",
    "dateCreated": "2014-05-20T11:43:00",
    "url": "http://manhattan.backpage.com/BodyRubs/sexy-asian-model-from-tokyo-upsca"
  }
}
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68 MILLION DOCUMENTS MAPPED TO THE ONTOLOGY

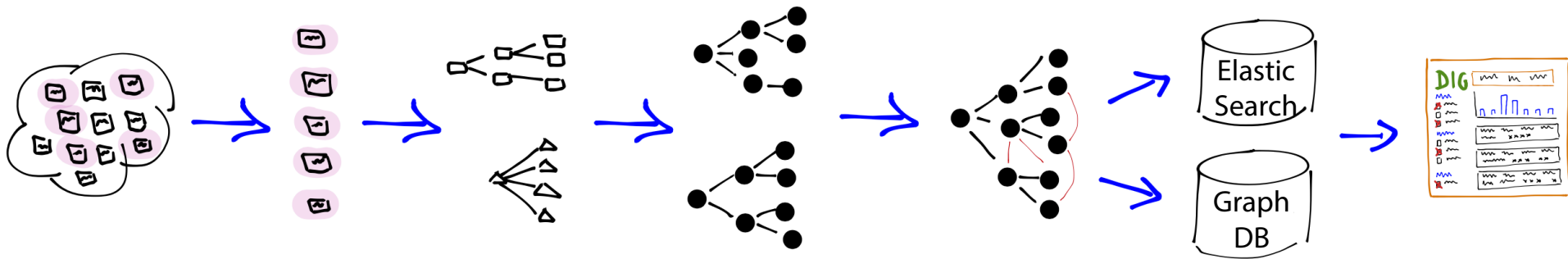


KARMA CONNECTS GRAPHS ON STRONG ATTRIBUTES





REUSABLE TECHNOLOGY FOR BUILDING DOMAIN-SPECIFIC SEARCH



CRAWLING

EXTRACTION

**MAPPING TO
ONTOLOGY**

**ENTITY
LINKING**

**KNOWLEDGE
GRAPH
DEPLOYMENT**

**QUERY &
VISUALIZATION**



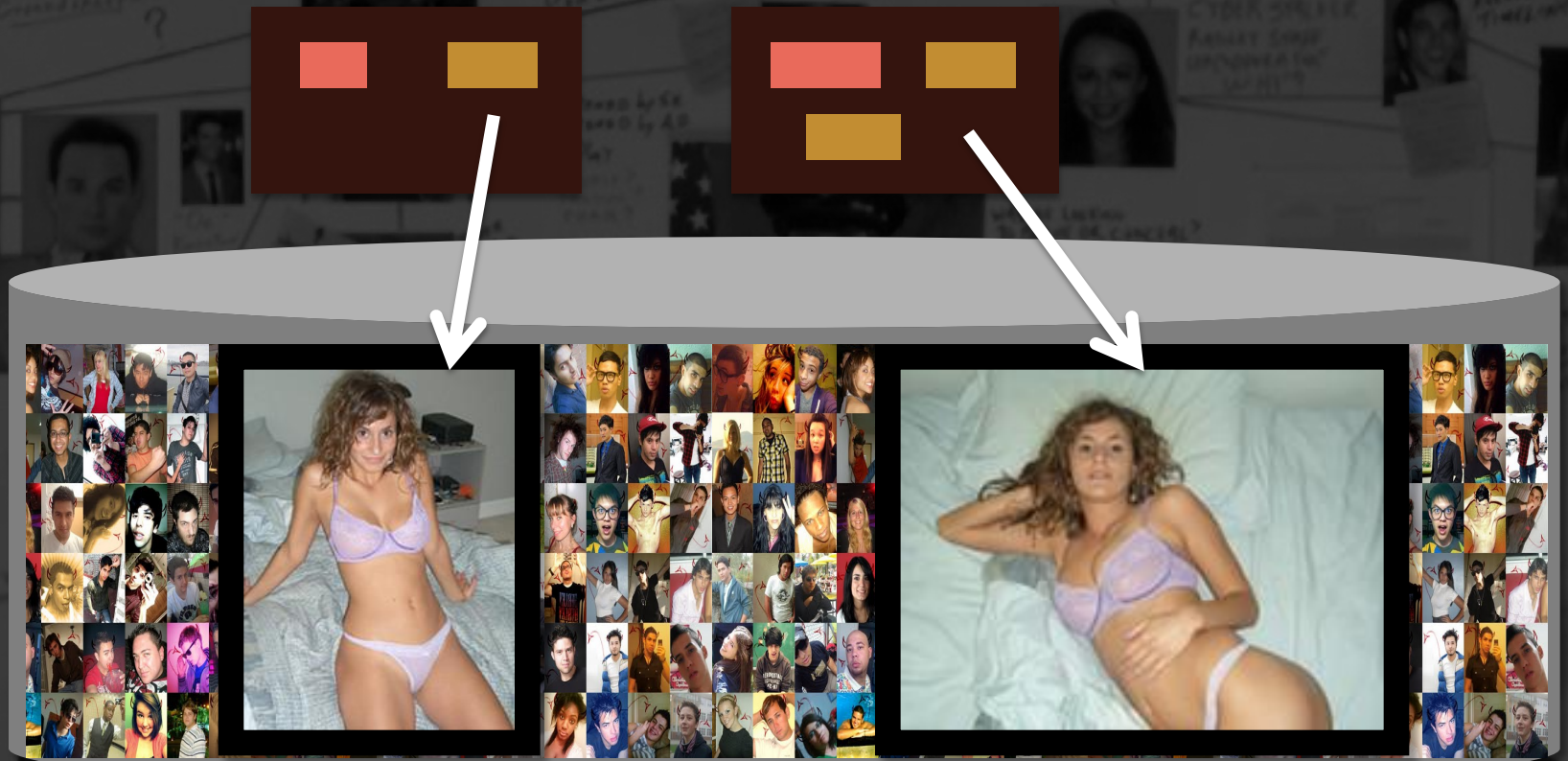
USING TEXT SIMILARITY TO CONNECT THE DOTS

EMILY SEXY. ** wHiTe/IATin girl ** bUsTy SWEET. LoTs Of fUn. Call Me.
O_U_T_C__A__L_L_S

LAYLA SEXY. ** wHiTe girl ** bUsTy SWEET. LoTs Of fUn. Call Me.
O__U__T__C__A__L__L__S

LILA SEXY. ** WhiTe girl ** bUsTy SWEET. LoTs Of fUn. Call Me.
O_U_T_C__A__L_L_S

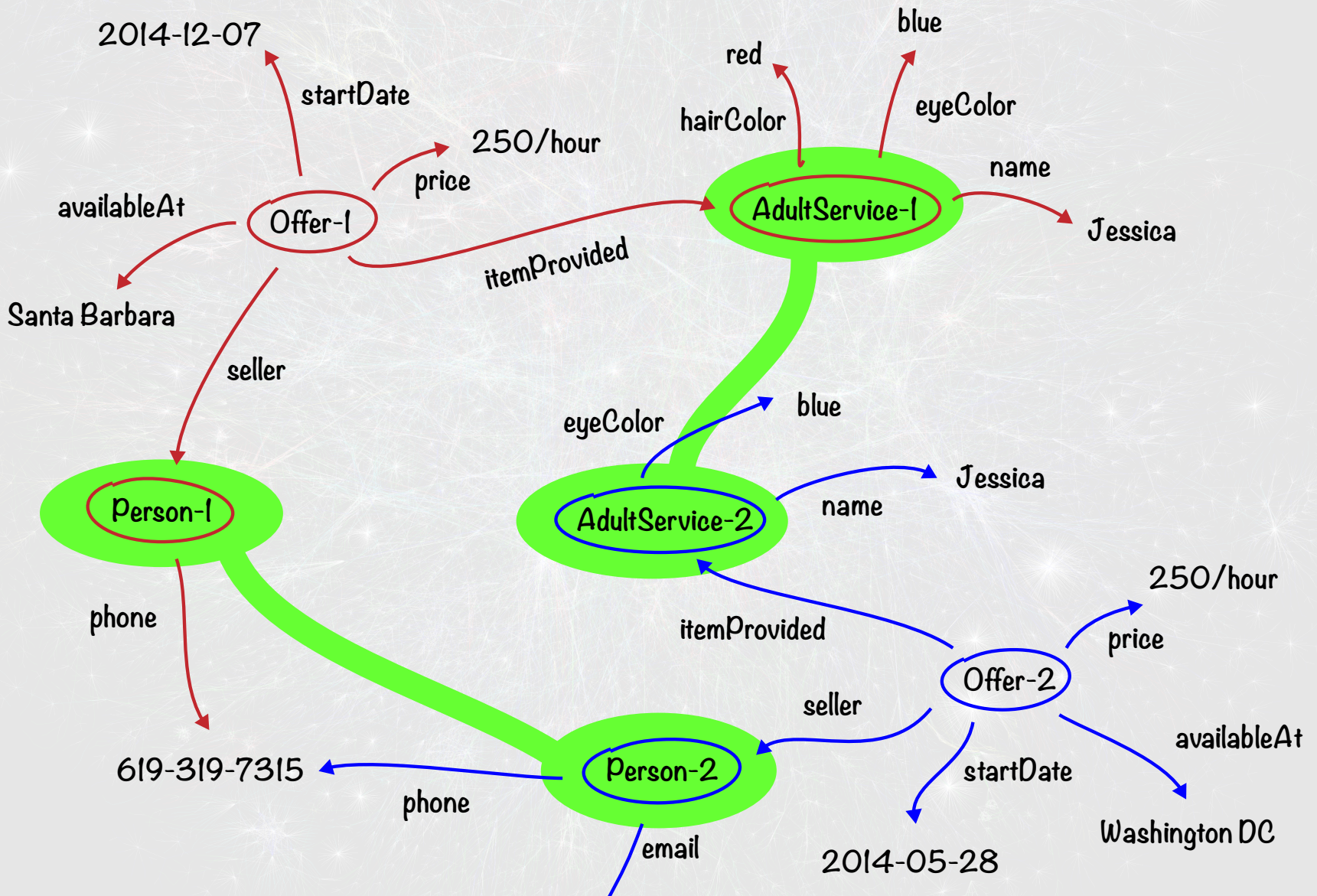
USING IMAGE SIMILARITY TO CONNECT THE DOTS



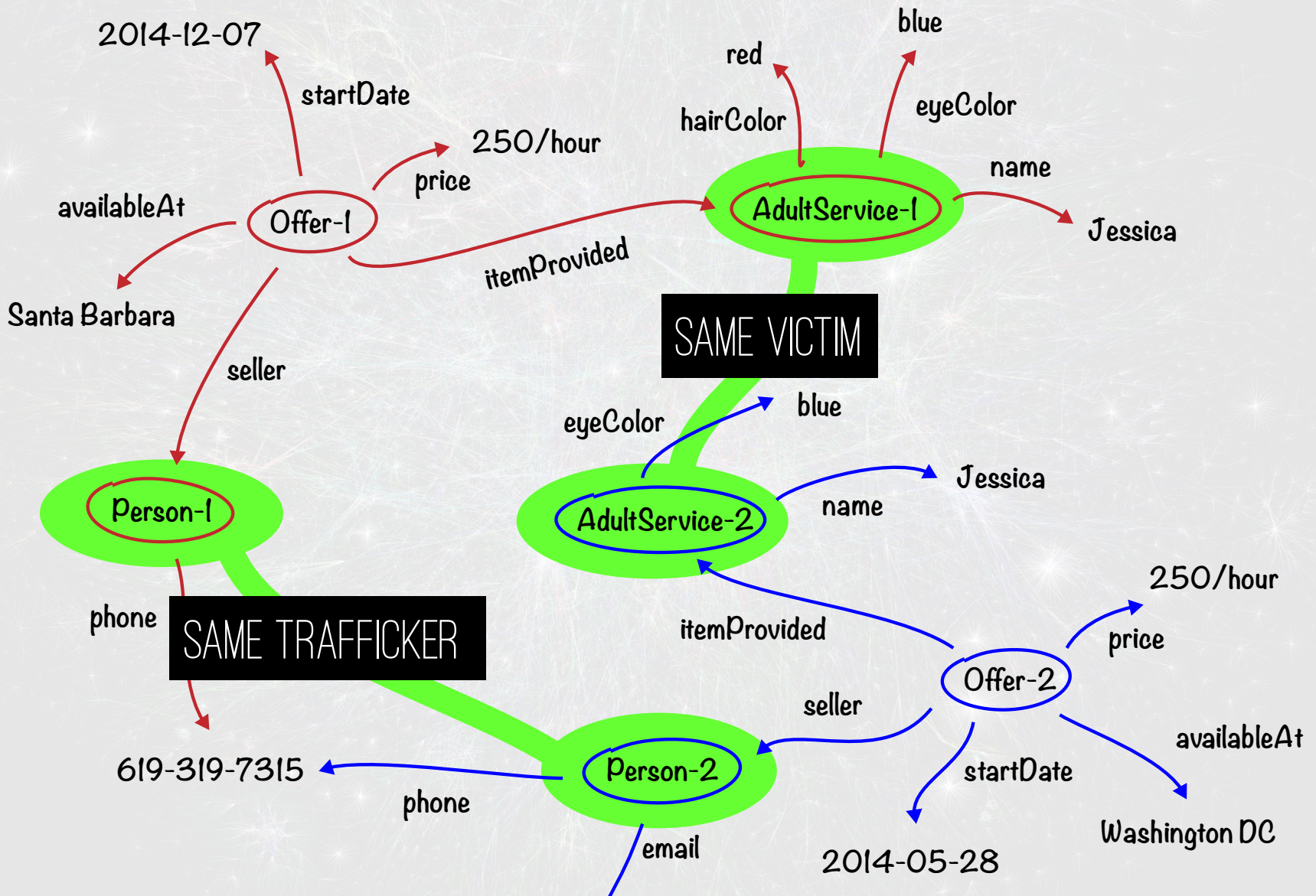
80 MILLION IMAGES

TECHNOLOGY: DEEP LEARNING

CONNECTING NODES USING ALL ATTRIBUTES

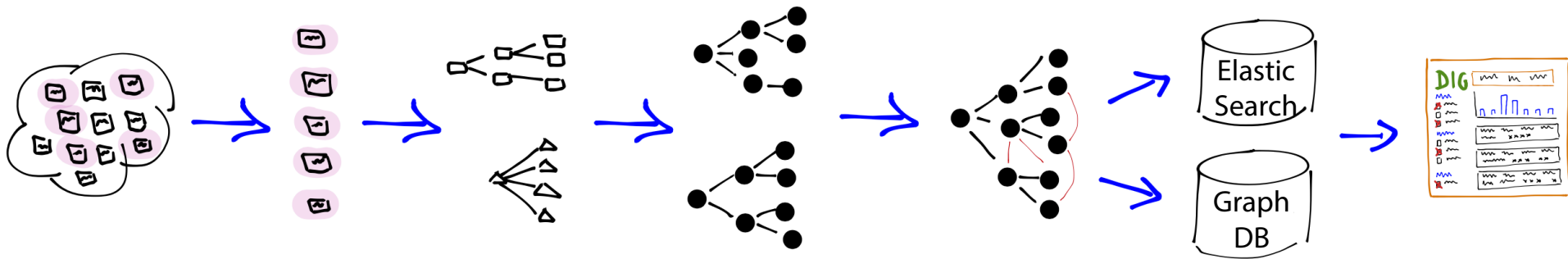


CONNECTING NODES USING ALL ATTRIBUTES





REUSABLE TECHNOLOGY FOR BUILDING DOMAIN-SPECIFIC SEARCH



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**QUERY &
VISUALIZATION**



SPARQL

ELASTICSEARCH

> 100 MILLION DOCS
> 1 BILLION TRIPLES

CHALLENGING

EASY

TEXT +
STRUCTURED QUERY

RESTRICTED

NATIVE SUPPORT

FACETED BROWSING

HARD

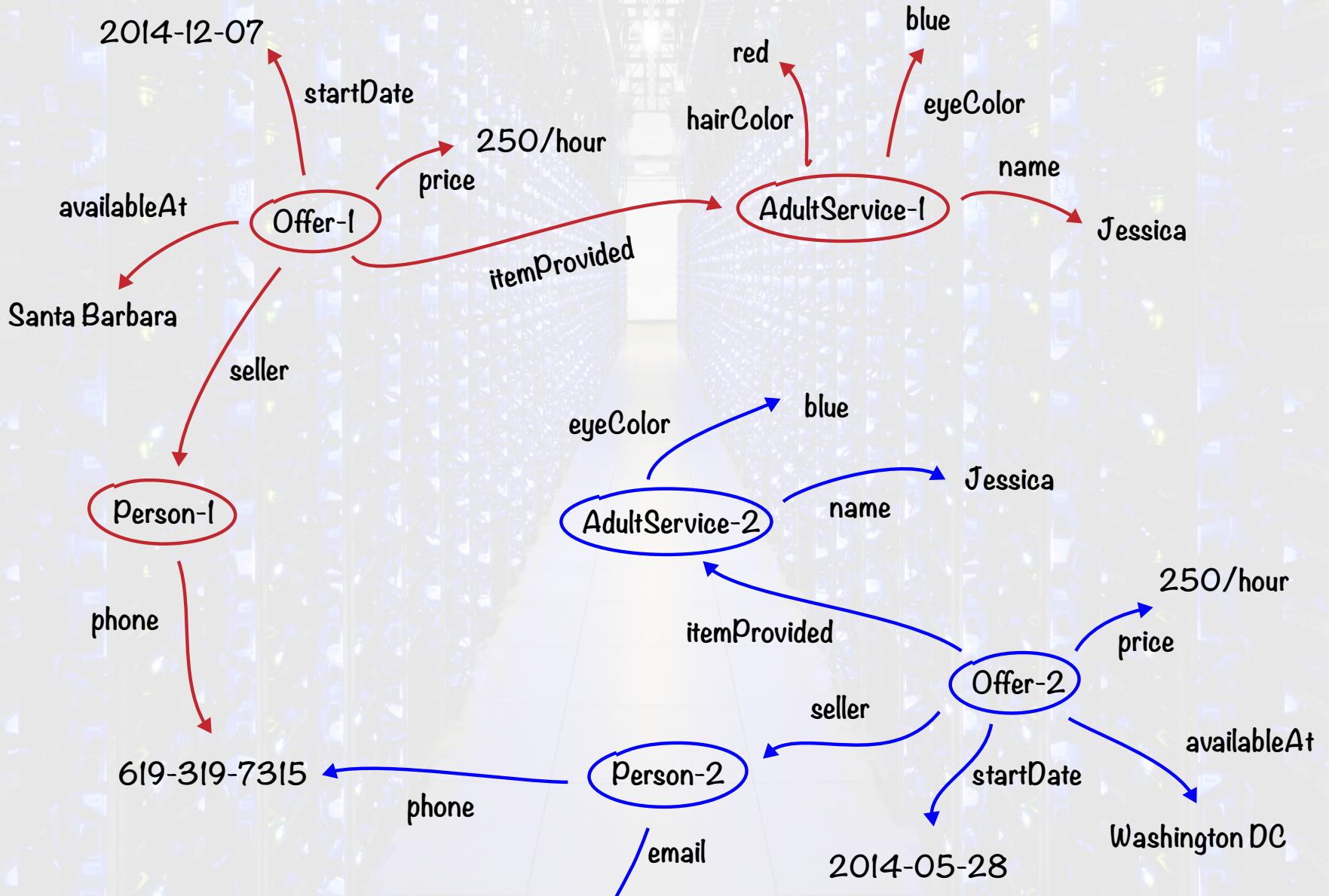
EASY

FAMILIAR TO
DEVELOPERS

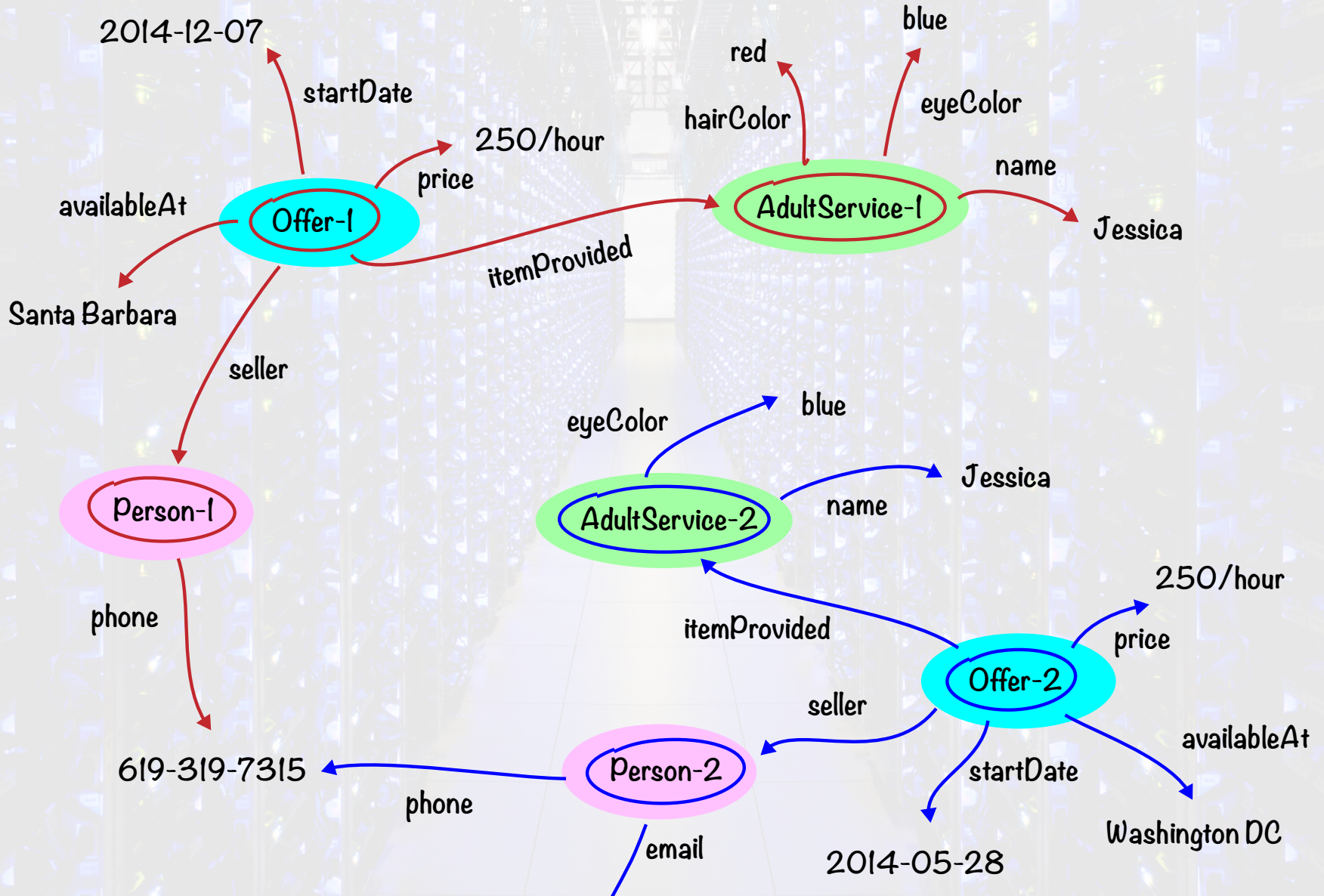
NO

YES

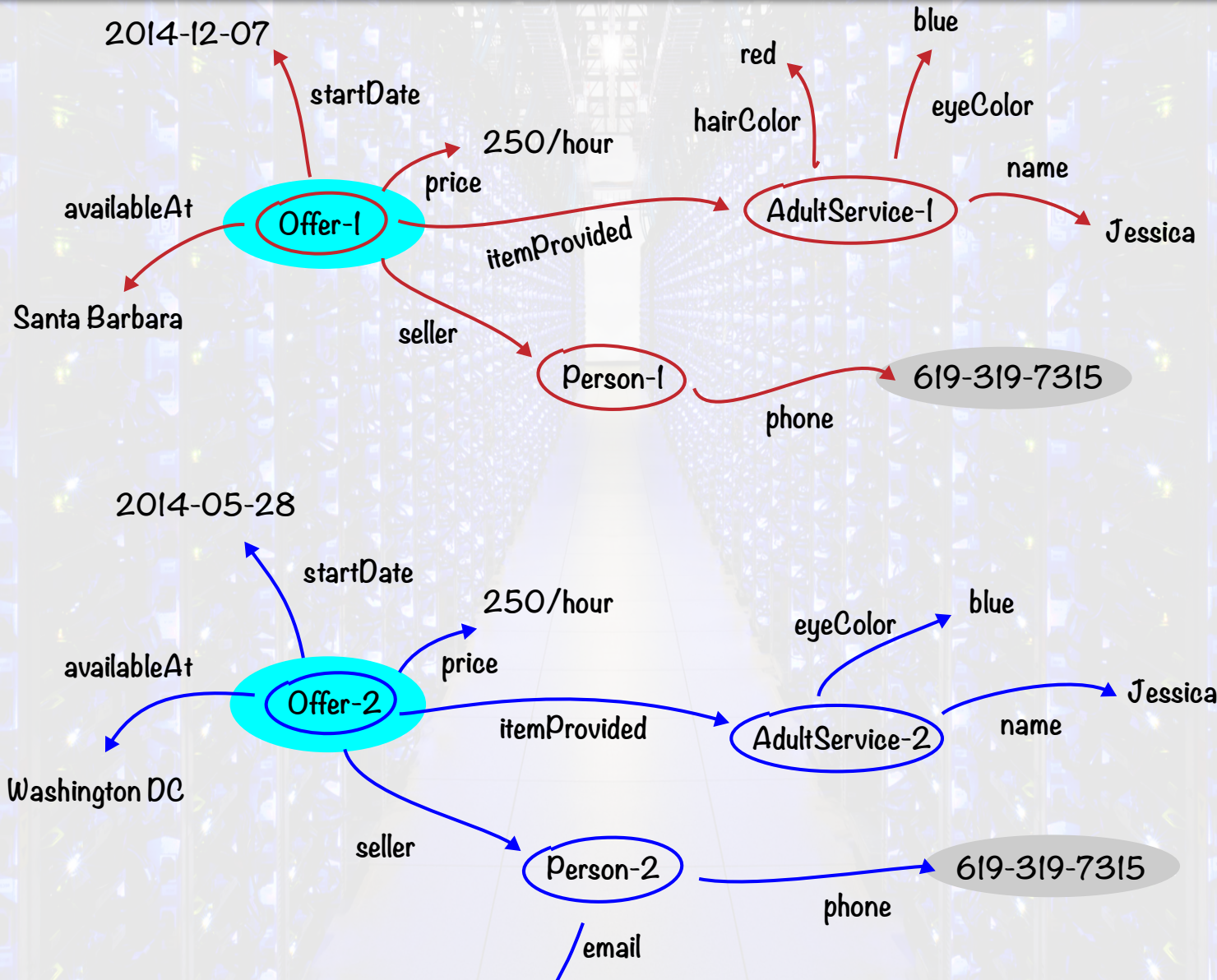
CREATE UNIFIED DATABASE



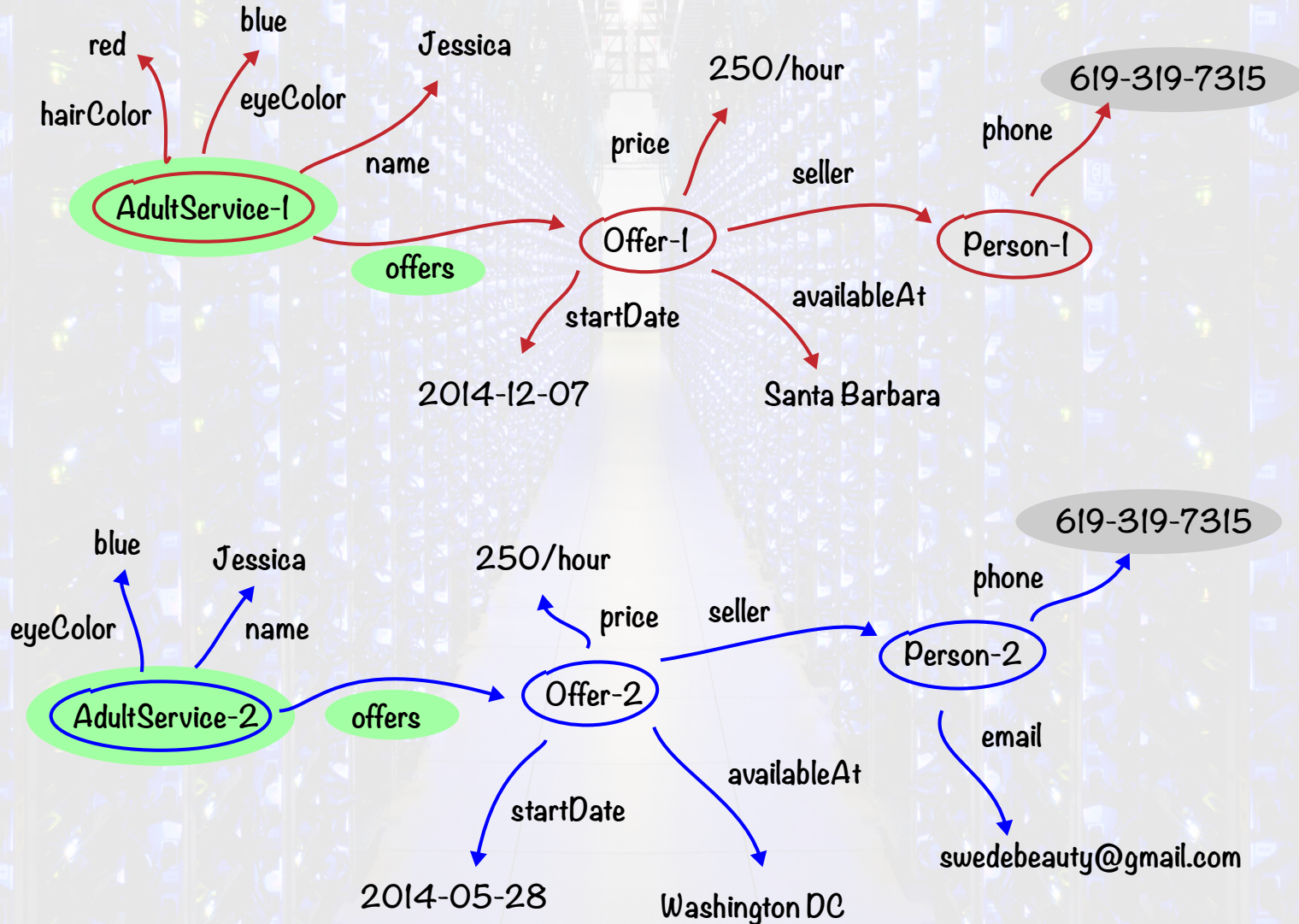
ONE INDEX PER MAIN CLASS



OFFERS AS ROOTS



ADULT SERVICE AS ROOTS



ELASTICSEARCH DATA MODEL

EFFICIENT INDEXING AND QUERY

Adult
Service

Offer

Person

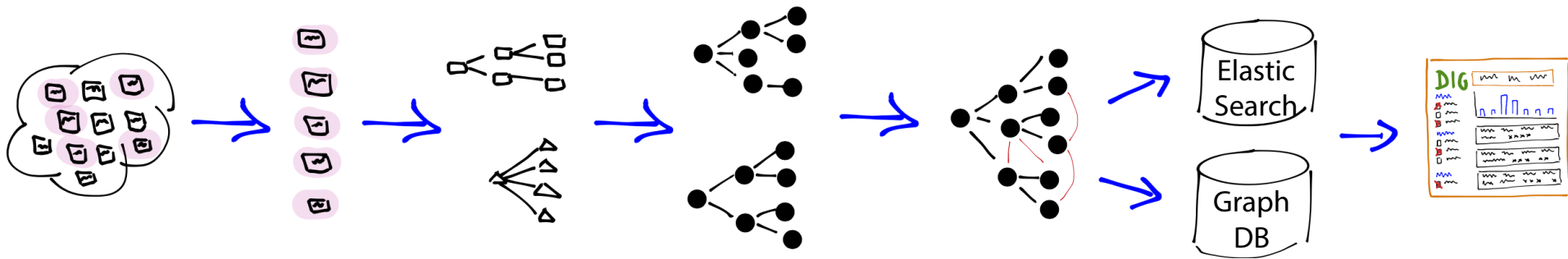
Phone

Web
Page





REUSABLE TECHNOLOGY FOR BUILDING DOMAIN-SPECIFIC SEARCH



CRAWLING

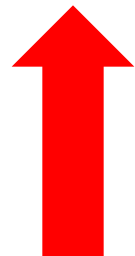
EXTRACTION

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**KNOWLEDGE
GRAPH
DEPLOYMENT**

**QUERY &
VISUALIZATION**



Filter Folders

FROM

TO

▼ CITY/REGION

- Not Specified 663544
- Toronto 111130
- New York 81876
- Ontario 80422
- Los Angeles 54444
- Chicago 54285
- Phoenix 49934
- Montreal 48932
- Denver 48291
- Houston 47814
- Calgary 47480
- Red Deer 46936
- San Jose 46769
- Ottawa 46367
- Dallas 45777
- London 43122
- Orange County 43001
- San Diego 42382
- Boston 42352
- Edmonton 42097
- Atlanta 41958

Display a menu

Q jessica red hair blue eyes swedish X

Search

Clear All

Save

With Images Only



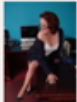
SORT BY **Best Match** ▼

0 item(s) selected X

4,946,783 results

 [San Diego Escorts - Elite Swedish Escort in San Diego 31 - 3518804 - My Provider Guide](#)
 created: 04/11/2011 00:00:00 UTC location: San Diego phone: +1-6193197315
 name: Jessica age: 31

 [1-619-319-7315 - jessica@swedishgfe.com - swedishgfe - San Diego Escorts - Swedish Pleasure from a Real Swede - 3558086 - My Provider Guide](#)
 created: 01/14/2014 00:00:00 UTC location: San Diego phone: +1-6193197315
 name: Jessica age: 33

 [1-619-319-7315 - jessica@swedishgfe.com - swedishgfe - San Diego Escorts - Swedish Pleasure from a Real Swede - 3558086 - My Provider Guide](#)
 created: 01/14/2014 00:00:00 UTC location: San Diego phone: +1-6193197315
 name: Jessica age: 33

 [1-619-319-7315 - jessica@swedishgfe.com - swedishgfe - San Diego Escorts - Swedish Pleasure from a Real Swede - 3558086 - My Provider Guide](#)
 created: 11/01/2013 00:00:00 UTC location: San Diego phone: +1-6193197315
 name: Jessica age: 33

619-319-7315 - Los Angeles Escorts - Horny Swedish Redhead visiting



1-619-319-7315 - jessica@swedishgfe.com - [swedishgfe](#) - San Diego Escorts - [Swedish Pleasure from a Real Swede](#) - 3558086 - My Provider Guide

created: 01/14/2014 00:00:00 UTC location: San Diego phone: +1-6193197315
name: Jessica age: 33



URL

http://www.myproviderguide.com/escorts/san-diego/free-posts/w4m/3558086_swedish-pleasure-from-a-real-s.html

NAME(S)

Jessica

AGE

33

CITY

San Diego

ETHNICITY

HAIR COLOR

red

PHONE NUMBER

+1-6193197315

HEIGHT

+1-6193197315

157

EMAIL

jessica@swedishgfe.com

WEIGHT

54

WEB SITE

[/external/d3d3LnN3ZWRpc2hnZmUuY29t](#)

PROVIDER

MyProviderGuide

CREATED

01/14/2014 00:00:00 UTC

[View Details](#)

20

+ / -

▼ PROVIDER

- Not Specified 2933
- Backpage 2954771
- EroticMugshots 1425744
- Escortphonestlist 609763
- Escorts In College 483456
- NaughtyReviews 471204
- EscortAds.XXX 359567
- Cityxguide 260736
- Live Escort Reviews 258932
- MyProviderGuide 233901
- escortsinthe.us 221848
- Craigslist 130255
- Massagetroll 115994
- Cityvibe 88122
- Escorts Inca 79499
- SipSap 23699
- Rubads 19165
- Classivox 13197
- Just Landed 9004
- Redbook 8742
- AdultSearch 7361
- Alibaba 48
- Gmdu 8

HIPS TYPE

32

CUP SIZE

d

WAIST SIZE

76

BUST BAND SIZE

34

BUILD

slender

IN CALL/OUT CALL

incalloutcall

USERNAME

swedishgfe

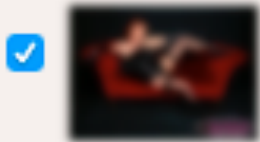
PROVIDER

MyProviderGuide

Hi, my name is Jessica and I am from Sweden now living in San Diego. I am 33 years old, fiery red hair and ocean blue eyes ; slim 120 pounds and 5'5" tall with nice firm breasts. I have an M.Sc (Masters Degree) in Engineering from Sweden. I am a great companion and I speak five languages. I care about our time together and I offer unrushed encounters with pleasure for both of us. I love to laugh, smile, cuddle, kiss and spend quality time, enough for us to connect. If you would like to see more pictures of me and get to know more about me, please check my website www.swedishgfe.com Look at my video: <http://vimeo.com/20795643> Rates: Incall 1 hour \$250.00 2 hours \$400.00 (Get \$50 off with the purchase of any item from my new website: www.redheadtoys.com, show/print receipt) Call or text me at: 1-619-319-7315 I look forward to seeing you soon. xoxo Jessica PS. If you rather talk dirty please call my chat line. Look at www.swedishredhead.com Also, don't forget to check out my new adult sex toy website! www.redheadtoys.com - Great selection of adult sex toys!!

Find the locations where a potential victim of human trafficking was advertised

IMAGE



CITY/REGION

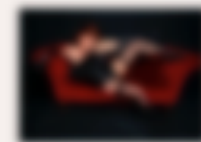
- Not Specified 21
- San Diego 254
- Santa Barbara 56
- Palmdale 42
- Los Angeles 10
- Washington Dc 8
- Chicago 5
- East Bay 3
- Oakland 1

+ / -

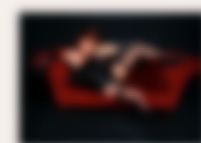
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name: Jessica age:



619-319-7315 - Sa
32 - 3620011 - My
created: 08/04/2011 0
name: Jessica age:



619-319-7315 - Lo
on March 7 10th 32
created: 02/27/2012 0
name: Jessica age:



IMPACT





DEPLOYED TO LAW
ENFORCEMENT AND NGOS

CONCLUSIONS

- Using an ontology to integrate data
- Continuous schema evolution
- Elasticsearch as an RDF store
- Using a JSON-based tool chain
- Deployment of large SemanticWeb app

WE ARE HIRING



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