

Cell Phone Mart

CSCI 586 Project Report

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1. Background

“There is a revolution occurring and it’s all about making the Web meaningful, understandable, and machine-readable, whether it is based on an intranet, extranet or, Internet. This is called Semantic Web and it will transition us towards a knowledge-centric viewpoint of everything.” The Semantic Web provides an infrastructure that enables not just Web pages, but databases, services, programs, sensors, personal devices and even household appliances to both consume and produce data on the Web [1]. URIs are a fundamental component of the current Web and are in turn a foundation for the Semantic Web. URIs, a fundamental component of Semantic Web provides the ability for uniquely identifying resources, RDF leverages URIs and the Web to provide a powerful means of expressing and representing the relationships and their meaning and Ontologies can be used to power advanced services such as more accurate Web search, intelligent software agents and knowledge management.

In our project titled Cell Phone Mart, we apply the concepts of Semantic Web and, by using Ontologies, integrate data from various sources to provide a unified view to the user. The data can be queried and used to extract information required by the user. We have provided queries that analyses various cellphone brands.

2. Problem Statement

There are many sources on the Internet that provide diverse set of disjoint information about Mobile Phones. **Kaggle**, one of the most comprehensive platforms that provides public datasets. The datasets on Kaggle are consistently accessible, and the forums helps to understand the nuances of the data. The data that we acquired from Kaggle had the information about unlocked mobile phones reviews from Amazon with attributes like – product name, brand name, price, rating, reviews, and review votes.

Similarly, **DeviceSpecifications & GSM Arena**, a comprehensive source that provides information about full specifications and features of various mobile devices such as – standard mobile phones and smartphones with attributes such as – dimensions, weight, SoC, CPU, Cores, RAM, Storage, Display, Battery, OS, Camera, SIM Card, Wi-Fi, USB, Bluetooth and positioning. **Wikipedia**, the most common and extensively used online source for anything contributed to the third data source to extract information about the Brand with attributes such as – type, founded in, headquarters, area served, other products, number of employees and its website link.

With data scattered around at multiple data sources, the user can’t get an integrated piece of information about a mobile phone of his choice at one place. For example, if a user wants to know which mobile phone had the highest rating with a certain screen size, he would have to sieve through all the sources. Likewise, identifying which mobile brand had the highest selling rate based on a key feature a user is interested in, becomes time-consuming otherwise.

In our project, we try to implement a few such key performance indices. We gather information about mobile phones from various data sources, unite and shape them, and provide a SPARQL endpoint. The results of the SPARQL queries are displayed on the browser using HTML and JavaScript. A provision for visualization is also provided which uses High charts to display charts and tables to display the query results.

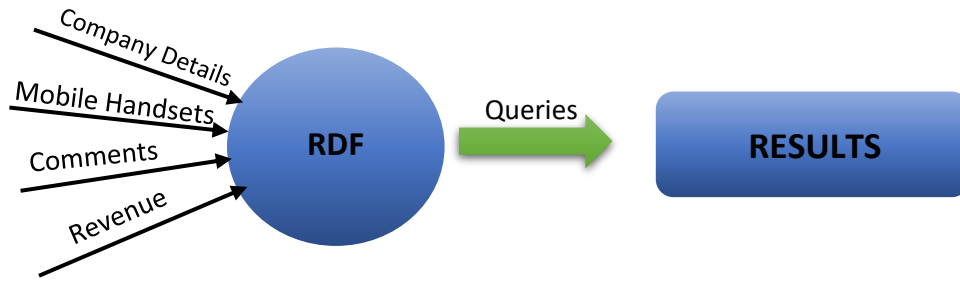


Figure 1. Workflow

3. Scope

In our project, we are focusing on data available from the following websites. The attributes crawled from each page are listed in Table 1:

1. [Kaggle](#)
2. [Device Specifications](#)
3. [Wikipedia](#)
4. [GSM Arena](#)

We have also extracted the yearly revenue of Brands starting from 2014 to 2016 by web scrapping Wikipedia and the scrapping individual Brand pages which were not present in Wikipedia's revenue data.

Website	Extracted Information
Kaggle	product name, brand name, price, rating, reviews, review votes
Device Specification, GSM Arena	dimensions, weight, SoC, CPU, Cores, RAM, Storage, Display, Battery, OS, Camera, SIM Card, Wi-Fi, USB, Bluetooth and positioning
Wikipedia	type, founded in, headquarters, area served, other products, number of employees and its website link
Revenue Dataset	Profit_Id, Profit_2014, Profit_2015, Profit_2016

Table 1. Information extracted from websites

4. Approach

In this section, we discuss different phases of the development and execution of our project. The project can be divided into four phases.

1. Data Acquisition
2. Data Cleaning
3. Data Modeling & Integration
4. Data Linking
5. Querying

4.1 Data Acquisition

We implemented Java-based crawlers to extract data from the above-mentioned data sources by

1. Using jsoup library that provides an API to extract and manipulate data from the web pages we used this to extract data from various websites like Device specifications, GSM Arena, Wikipedia to obtain Cell phone's technical specs, Detailed features, Brand info respectively.
2. For analysis of user reviews on individual models we got the users comments data set for cell phones on amazon from Kaggle which helped us to analyze each model based on user rating and comments in amazon.

Website	No. of records generated
Kaggle	4,13,000 records were generated for comments and review
Device Specification, GSM Arena	8,632 models were captured for various brands of mobile phones
Wikipedia	108 different brand information was captured
Revenue Data	25896 records pertaining to the profits through years 2014 to 2016

Table 2. Statistics about generated data

Data Acquisition Challenges: Web Scrapping may sound simple but is accompanied with its own challenges. We faced the following:

- 9,000 records are from various above-mentioned Data Sources.
- Non-uniform structure and hence it took long time for data refinement making it available for mapping.
- Navigation through elements and attributes in an XML document

4.2 Data Cleaning

- Organized scrapped data by removing the duplicates rows from the CSV file by writing generic Java code.
- Removed some special characters and supported some by using specific data structures.
- Used specific datatype for handling website links/image URLs.
- Enforced UTF-Encoding for proper conversion of data to RDF.

4.3 Data Modeling & Integration

We created an Ontology for our model as shown in Figure 2. There are total of 4 classes namely – Brand, Model, Comments, and Profits. A total of 4 Object Properties – has_brand, has_comment, has_model, profit_has_model. A total of 31 data properties. The object properties link different data sources.

has_brand links the model data source with the brand data source.

has_model links the comments data source with the model data source.

profit_has_model links the profit data source with the model data source.

There are 31 data properties from 4 data sources, each of these can be considered as the values associated with a particular data source. Figure 2 gives the complete details regarding both object and data properties.

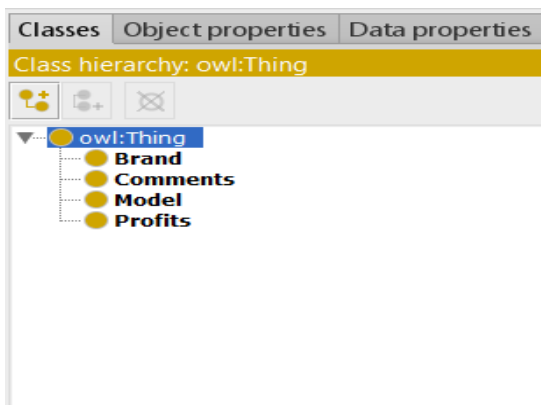


Figure 3. Classes

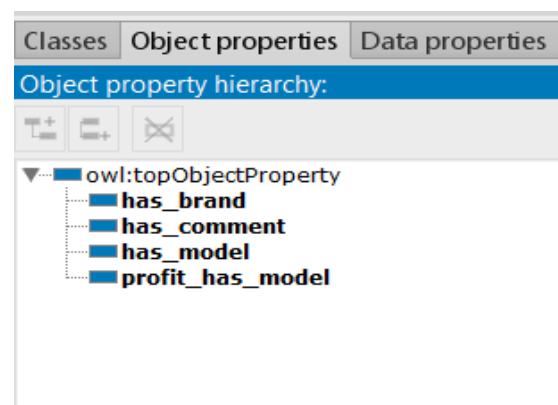


Figure 4. Object Properties

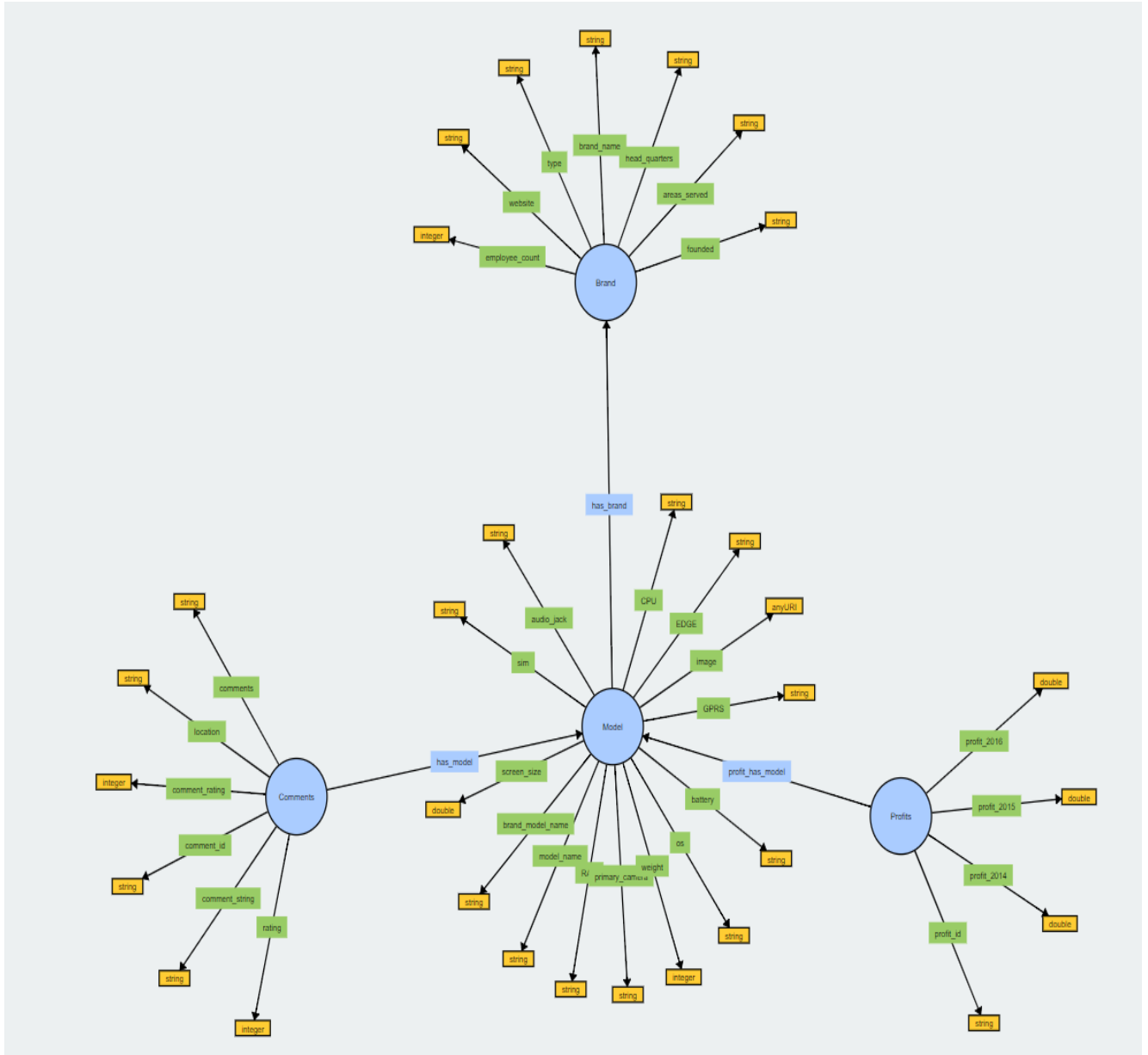


Figure 2. Ontology Graph

4.3 Data Linking

Data linking played a most prominent role in this application because the data was scrapped from various data resources and hence there was a requirement for linking or mapping of data in some way such that it makes sense. In order to do so we created a unique primary key in individual data set and then we linked them in owl using their URI so that we can obtain interlinked owl file containing mapped data. This was done by utilizing Protégé tool.

In below images we can notice that we have created unique id for individual data set and we have mapped them by utilizing their common attributes so that we can obtain N:1 and 1:N mapping between entities of mapped classes of different data sets.

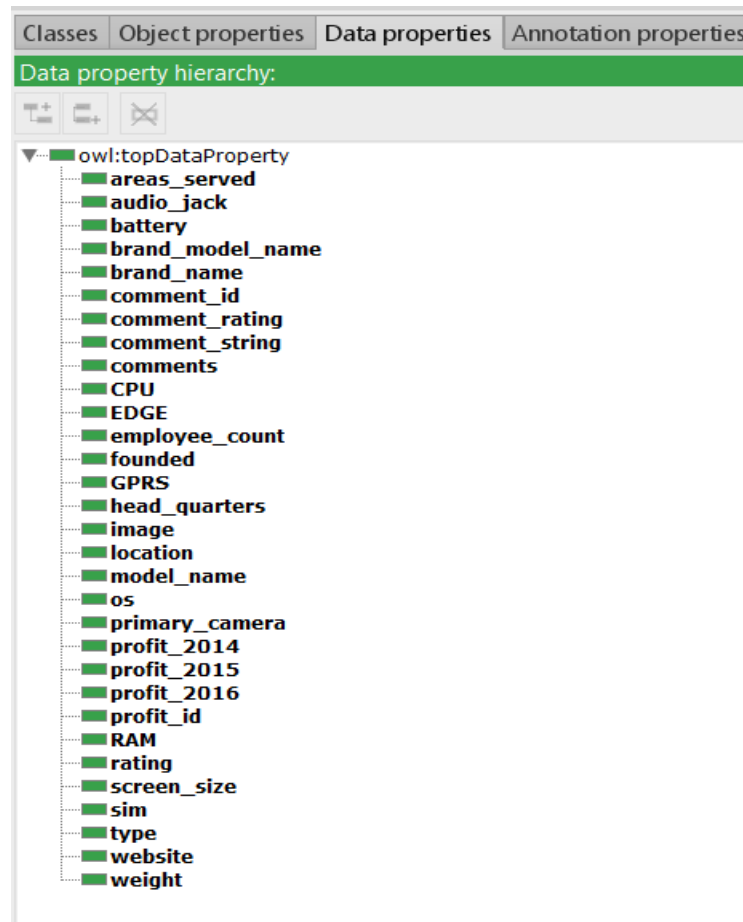


Figure 5. Data Properties

COMMENTS

	A	B	C	D	E	F	G
1	Brand Model comment 0	Brand Model	Brand	Model	Rating	Review	Location
2	Acer Liquid Jade Z comment 1	Acer Liquid Jade Z	Acer	Liquid Jade Z		1 The description says 16GB rom, it CALIFORNIA	
3	Acer Liquid Jade Z comment 2	Acer Liquid Jade Z	Acer	Liquid Jade Z		2 I had high hopes for this Acer phc CALIFORNIA	
4	Acer Liquid M220 comment 3	Acer Liquid M220	Acer	Liquid M220		1 First off, great service as usual. I ARIZONA	
5	Acer Liquid M220 comment 4	Acer Liquid M220	Acer	Liquid M220		1 I did not receive my order items. CALIFORNIA	
6	Acer Liquid M220 comment 5	Acer Liquid M220	Acer	Liquid M220		1 The phones were advertised as b TEXAS	
7	Acer Liquid M220 comment 6	Acer Liquid M220	Acer	Liquid M220		1 manure	FLORIDA
8	Acer Liquid M220 comment 7	Acer Liquid M220	Acer	Liquid M220		1 phone very poor quality. I recom TEXAS	
9	Acer Liquid M220 comment 8	Acer Liquid M220	Acer	Liquid M220		3 It'sn a powerfull phone.	FLORIDA
10	Acer Liquid M220 comment 9	Acer Liquid M220	Acer	Liquid M220		3 this phone was a replacement fo ARIZONA	
11	Acer Liquid M220 comment 10	Acer Liquid M220	Acer	Liquid M220		4 It's work well	CALIFORNIA
12	Acer Liquid M220 comment 11	Acer Liquid M220	Acer	Liquid M220		4 Item is good. The only thing is AT CALIFORNIA	

REVENUE

	A	B	C	D	E	F	G
1	profit id	model_id	Brand	model	Revenue 2016	Revenue 2015	Revenue 2014
2	Motorola E1000 1	Motorola E1000	Motorola	E1000	3.995884152	2.487442254	2.936621763
3	Motorola RAZR V XT889	Motorola RAZR V XT889	Motorola	RAZR V XT889	3.994552982	2.960712931	2.557519431
4	Motorola Moto 360 . 1	Motorola Moto 360 .	Motorola	Moto 360 .	3.991374214	3.304798991	2.779012273
5	HTC Desire 620 1	HTC Desire 620	HTC	Desire 620	3.990173801	3.169891124	3.363771433
6	Motorola V690 1	Motorola V690	Motorola	V690	3.986258922	3.462777975	3.392175545
7	HTC Dream 1	HTC Dream	HTC	Dream	3.985789737	3.613500601	3.554501269
8	Motorola Moto C Plus 1	Motorola Moto C Plus	Motorola	Moto C Plus	3.981485045	2.9331731	2.591083731
9	Motorola Moto 360 46m	Motorola Moto 360 46m	Motorola	Moto 360 46mm .	3.980722458	2.564511098	2.921502369
10	Motorola W360 1	Motorola W360	Motorola	W360	3.978904883	2.538550885	2.238986419
11	HTC Desire 820q dual sim	HTC Desire 820q dual sim	HTC	Desire 820q dual sim	3.978792933	3.143284196	3.869683061
12	Motorola E380 1	Motorola E380	Motorola	E380	3.978414749	2.198565592	3.275390667
13	HTC Touch 1	HTC Touch	HTC	Touch	3.977423143	2.411044322	2.689163358
14	Motorola RAZR V3 1	Motorola RAZR V3	Motorola	RAZR V3	3.973519073	2.682289476	3.111203281
15	Motorola MPx100 1	Motorola MPx100	Motorola	MPx100	3.973232893	2.955173778	2.907872705
16	Motorola M3688 1	Motorola M3688	Motorola	M3688	3.966866738	3.216377745	3.524824391
17	HTC DROID Incredible 4G	HTC DROID Incredible 4G	HTC	DROID Incredible 4G LTI	3.960629571	2.653048523	3.381693967
18	Motorola Droid Turbo 2 1	Motorola Droid Turbo 2	Motorola	Droid Turbo 2	3.959711795	2.288929778	3.094122462

SPECIFICATIONS

brand	Model	network_t	2G_bands	3G_bands	4G_bands	network_s	GPRS	EDGE	announce	status	dimentior	weight_g	weight_oz	SIM	display_t	display_r	display_s	OS	CPU	Chipset	GPU	memory_c	internal_r	RAM	
Acer	Iconia Tai GSM / HSF GSM 850, HSDPA 85	LTE band :	HSPA 42.2	Yes	Yes	2016 Aug Available	191.7 x 10	260	9.17	Dual SIM	IPS LCD ca 7.0 inches	720 x 128	Android 6	Quad-core	Mediatek	Mali-T720	microSD	16/32	GB	2	GB	RAM			
Acer	Liquid Z6 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2016 Aug Available	153.8 x 75	169	5.96	Single SIM	IPS LCD ca 5.5 inches	1080 x 19	Android 6	Octa-core	Mediatek	Mali-T720	microSD	32	GB	3	GB	RAM			
Acer	Liquid Z6 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2016 Aug Available	-	-	-	Single SIM	IPS LCD ca 5.0 inches	720 x 128	Android 6	Quad-core	Mediatek	Mali-T720	microSD	8	GB	1	GB	RAM			
Acer	Iconia Tai No cellula	N/A		No	No	2016 Apr Available	259 x 167 x 8.9 mm	10.20 x 6.1	No	IPS LCD ca 10.1 inch	1920 x 12	Android 6	Quad-core	Mediatek	Mali-T720	microSD	16/32/64	2	GB	RAM					
Acer	Liquid X2 GSM / HSF GSM 850, HSDPA 90	LTE 800 /	HSPA 42.2	Yes	Yes	2015 Apr Available	153.3 x 76	166	5.86	Triple SIM	IPS LCD ca 5.5 inches	720 x 128	Android 5	Octa-core	Mediatek	Mali-T720	microSD	32	GB	3	GB	RAM			
Acer	Liquid Jad GSM / HSF GSM 850, HSDPA 90	LTE	HSPA 42.2	Yes	Yes	2016 Feb Available	-	-	-	Dual SIM	Super AMOLED 5.5 inches	1080 x 19	Android 6	Hexa-core	Qualcomm	MSM899	microSD	32	GB	3	GB	RAM			
Acer	Liquid Zes GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2016 Apr Available	154 x 77 x 10 mm	6.06 x 3.03	Single SIM	IPS LCD ca 5.5 inches	720 x 128	Android 6	Quad-core	Mediatek	Mali-T720	microSD	16	GB	2	GB	RAM				
Acer	Liquid Zes GSM / HSF GSM 850, HSDPA 85	LTE	HSPA 42.2	Yes	Yes	2016 Feb Available	145.7 x 71	125	4.41	Single SIM	IPS LCD ca 5.0 inches	720 x 128	Android 6	Quad-core	Mediatek	Mali-400	microSD	8	GB	1	GB	RAM			
Acer	Predator i No cellula	N/A		No	No	2015 Sep Available	217.9 x 12	353.8	12.49	No	IPS LCD ca 8.0 inches	1920 x 12	Android 5	Quad-core	Intel Atom x7-28700	microSD	32/64	GB	2	GB	RAM				
Acer	Liquid Jad GSM / HSF GSM 850, HSDPA 85	LTE 800 /	HSPA 42.2	Yes	Yes	2015 Sep Available	156.5 x 75	150	5.29	Dual SIM	AMOLED c 5.5 inches	1080 x 19	Microsoft	Hexa-core	Qualcomm	Adreno 41	microSD	32	GB	3	GB	RAM			
Acer	Liquid Z3 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2015 Sep Available	136 x 66.5	142	5.01	Single SIM	IPS LCD ca 4.5 inches	480 x 854	Android 5	Quad-core	Qualcomm	Adreno 3C	microSD	8	GB	1	GB	RAM			
Acer	Liquid Z3 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2015 Sep Available	136 x 66.5	142	5.01	Single SIM	IPS LCD ca 4.5 inches	480 x 854	Android 5	Quad-core	Qualcomm	Adreno 3C	microSD	8	GB	1	GB	RAM			
Acer	Liquid Z6 GSM / HSF GSM 850, HSDPA 90	LTE	HSPA 42.2	Yes	Yes	2015 Sep Available	156.3 x 77	165	5.82	Single SIM	IPS LCD ca 5.5 inches	720 x 128	Android 5	Octa-core	Mediatek	Mali-T720	microSD	32	GB	3	GB	RAM			
Acer	Liquid Z6 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2015 Sep Available	156.3 x 77	165	5.82	Single SIM	IPS LCD ca 5.5 inches	720 x 128	Android 5	Quad-core	Mediatek	Mali-T720	microSD	8	GB	1	GB	RAM			
Acer	Liquid Z5 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2015 Sep Available	144 x 70.5	145	5.11	Single SIM	IPS LCD ca 5.0 inches	720 x 128	Android 5	Octa-core	Mediatek	Mali-T720	microSD	32	GB	3	GB	RAM			
Acer	Liquid Z5 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2015 Sep Available	144 x 70.5	145	5.11	Single SIM	IPS LCD ca 5.0 inches	720 x 128	Android 5	Quad-core	Mediatek	Mali-T720	microSD	8	GB	1	GB	RAM			
Acer	Liquid M3 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2015 Sep Available	136 x 66.5	142	5.01	Single SIM	IPS LCD ca 4.5 inches	480 x 854	Microsoft	Quad-core	Qualcomm	Adreno 3C	microSD	8	GB	1	GB	RAM			
Acer	Liquid M3 GSM / HSF GSM 850, HSDPA	LTE	HSPA 42.2	Yes	Yes	2015 Sep Available	136 x 66.5	142	5.01	Single SIM	IPS LCD ca 4.5 inches	480 x 854	Microsoft	Quad-core	Qualcomm	Adreno 3C	microSD	8	GB	1	GB	RAM			
Acer	Iconia Tai No cellula	N/A		No	No	2015 Apr Available	260 x 176	540	1.19	No	LED-backl	10.1 inch	1920 x 12	Android 5	Quad-core	Intel Atom Z3735F	microSD	16/32/64	2	GB	RAM				
Acer	Iconia On No cellula	N/A		No	No	2015 Apr Available	213.9 x 12	355	12.52	No	IPS LCD ca 8.0 inches	800 x 128	Android 5	Quad-core	Intel Atom Z3735G	microSD	16/32	GB	1	GB	RAM				
Acer	Iconia Tai No cellula	N/A		No	No	2014 Oct Available	256.5 x 17	508	1.12	No	LED-backl	10.1 inch	1280 x 80	Android 4	Quad-core	Mediatek	Mali-450	microSD	16	GB	1	GB	RAM		
Acer	Iconia Tai No cellula	N/A		No	No	2014 Oct Available	256.5 x 17	508	1.12	No	LED-backl	10.1 inch	1920 x 12	Android 4	Quad-core	Mediatek	Mali-450	microSD	32	GB	2	GB	RAM		
Acer	Liquid Jad GSM / HSF GSM 850, HSDPA 90	LTE band :	HSPA 21.1	Yes	Yes	2015 Mai Available	143.5 x 66	110	3.88	Dual SIM	IPS LCD ca 5.0 inches	720 x 128	Android 5	Quad-core	Mediatek	Mali-T760	microSD	8	GB	1	GB	RAM			
Acer	Liquid Z5 GSM / HSF GSM 850, HSDPA 900 / 2100	HSPA	Yes	Yes	Yes	2015 Mai Available	154 x 86 x	118	4.16	Single SIM	TFT capac 5.0 inches	480 x 854	Android 4	Quad-core	Mediatek	Mali-400	microSD	8	GB	1	GB	RAM			
Acer	Liquid Z2 GSM / HSF GSM 850, HSDPA 900 / 2100	HSPA	Yes	Yes	Yes	2015 Mai Available	125.3 x 64	120	4.23	Single SIM	Capacitiv 4.0 inches	480 x 800	Android 5	Dual-core	Qualcomm	Adreno 3C	microSD	8	GB	1	GB	RAM			
Acer	Liquid M2 GSM / HSF GSM 850, HSDPA 900 / 2100	HSPA 21.1	Yes	Yes	Yes	2015 Mai Available	124.9 x 64	119	4.2	Single SIM	TFT capac 4.0 inches	480 x 800	Microsoft	Dual-core	Qualcomm	Adreno 3C	microSD	4	GB	512	MB	RAM			
Acer	Liquid Z4 GSM / HSF GSM 850, HSDPA 90	LTE band :	HSPA 42.2	Yes	Yes	2015 Jani Available	136 x 66.7	145	5.11	Single SIM	IPS LCD ca 4.5 inches	540 x 960	Android 4	Quad-core	Mediatek	Mali-T760	microSD	8	GB	1	GB	RAM			
Acer	Liquid Jad GSM / HSF GSM 850, HSDPA 90	LTE band :	HSPA 21.1	Yes	Yes	2014 Dec Available	143 x 69 x	116	4.09	Dual SIM	IPS LCD ca 5.0 inches	720 x 128	Android 4	Octa-core	Mediatek	Mali-T760	microSD	16	GB	2	GB	RAM			
Acer	Liquid Z5 GSM / HSF GSM 850, HSDPA 900 / 2100	HSPA	Yes	Yes	Yes	2014 Sep Available	145 x 73 x	150	5.29	Single SIM	IPS LCD ca 5.0 inches	720 x 128	Android 4	Quad-core	Mediatek	Mali-400	microSD	4	GB	1	GB	RAM			
Acer	Liquid X1 GSM / HSF GSM 850, HSDPA 90	LTE band :	HSPA 42.2	Yes	Yes	2014 Jun Available	153.3 x 80	164	5.78	Micro-SIM	IPS LCD ca 5.7 inches	720 x 128	Android 4	Octa-core	Mediatek	Mali-450	microSD	16	GB	2	GB	RAM			
Acer	Liquid Jad GSM / HSF GSM 850, HSDPA 900 / 2100	HSPA	Yes	Yes	Yes	2014 Jun Available	140.5 x 66	110	3.88	Dual SIM	IPS LCD ca 5.0 inches	720 x 128	Android 4	Quad-core	Mediatek	Mali-400	microSD	8	GB	1	GB	RAM			

BRANDS

A	B	C	D	E	F	G	H	I
Brand	Type	Founded_In	Headquarters	Area_Served	Number	Website_URL	Other_Products	Country
Acer	Public	1976	Xizhi, New Taipei, Taiwan	Worldwide	7967	https://www.acer.com/content/US/content/home	Desktops, laptops, netbooks, servers	Taiwan
alcatel	Trademark	2004	Paris, France	Worldwide	52673	https://networks.nokia.com	Hardware, software and services to te	France
Allview	Public	1999	NULL	Worldwide	0	NULL	none	unknown
Amazon	Public	1994	Seattle, Washington, U.S	Worldwide	541900	https://www.amazon.com	Amazon Appstore, Amazon Echo, Ar	USA
Amoi	Public	1997	NULL	Worldwide	0	NULL	LCD Television	unknown
Apple	Public	1976	Cupertino, California, USA	Worldwide	123000	https://www.apple.com	Macintosh, iPod, iPhone, iPad, Appli	USA
Archos	Public	1989	Ignny, France	Worldwide	200	http://www.archos.com	Portable media players, tablet compu	France
Asus	Public	1989	Beitou District, Taipei, Taiwan	Worldwide	17000	https://www.asus.com/us/	Desktops, laptops, netbooks, mobile	Taiwan
AT&T	Public	1983	Dallas, Texas, United States	Worldwide	273000	https://www.att.com	Satellite television, Fixed line teleph	USA
Benetron	Public	2011	Salo, Finland	Worldwide	200	http://www.twigworld.com	Personal safety and GPS tracking pr	Finland
BenQ	Subsidiary	2001	Taipei, Taiwan	Worldwide	100000	http://www.benq.us	TFT LCD monitors, digital projectors	Taiwan
BenQ-Siemens	Subsidiary	2005	Taiyuan, Taiwan	Worldwide	3000	http://www.benqmobile.com	none	Taiwan
Bird	Public	1992	Fenghuo, China	Worldwide	0	http://www.chinabird.com/en/about/about.asp	none	China
BlackBerry	Public	1984	Waterloo, Canada	Worldwide	4044	https://us.blackberry.com	BlackBerry Messenger, BlackBerry, I	Canada
BLU	Public	2009	Miami, Florida, USA	Worldwide	500	http://bluproducts.com/android-phones/	none	USA
Bosch	Private	1886	Gerlingen, Germany	Worldwide	390000	https://www.bosch.com	Automotive parts, power tools, secur	Germany
BQ	Self-owned	2010	Madrid, Spain	Spain	1000	https://www.bq.com/en/	multimedia devices, 3D printers and	Spain
Casio	Public	1946	Shibuya, Tokyo, Japan	Worldwide	12287	https://world.casio.com	Watches (includes G-Shock and W'e	Japan
Cat	Public	1993	NULL	Worldwide	0	https://www.catphones.com/shop/cat-s60-smartpho	none	unknown
Cellkon	Private	2009	Hyderabad, India	Worldwide	200	http://www.cellkonmobiles.com	N/A	India
Chia	Public	1991	NULL	Worldwide	0	NULL	none	unknown
Coolpad	Public	1993	Shenzhen, China	Worldwide	5634	http://www.coolpad.com/hk/eng/global/home.php	Yulong Computers	China
Dell	Public	2016	One Dell Way, Round Rock, Tex	Worldwide	138000	https://www.delltechnologies.com/en-us/index.htm	Personal computers, Servers, SAN's	unknown
Emporia	Private	1992	Austria	Worldwide	50	http://www.emporia.eu	none	Austria
Energizer	Public	2002	NULL	Worldwide	0	NULL	none	unknown

Figure 6. Generating a consolidated dataset for Protégé

By integrating all the above data sets we got a consolidated data set with mapped key value pairs, now we can use single query to get the resquired results from the consolidated dataset.

Challenges in Data Linking – Due to the huge heterogeneity in data, we faced a few challenges while linking these datasets. The dataset acquired for Comments and reviews about mobile phones had redundant entries for comments, we resolved this ambiguity by deleting the duplicates. Then we had to assign a unique id for each of the rows of different datasets for linking. We carefully chose the brand name as the unique key for the brand xls sheet, the concatenation of brand name and the model name was the unique for the model sheet. For revenue and comments we assigned a unique id by hashing all the column values of each row. We also observed that a brand can have multiple models, for instance Samsung could produce hundreds of models under their brand. This problem of data linking with cardinality of n:1 was resolved by applying transformation rules(Figure 8). The below screenshot shows the process of data linking.

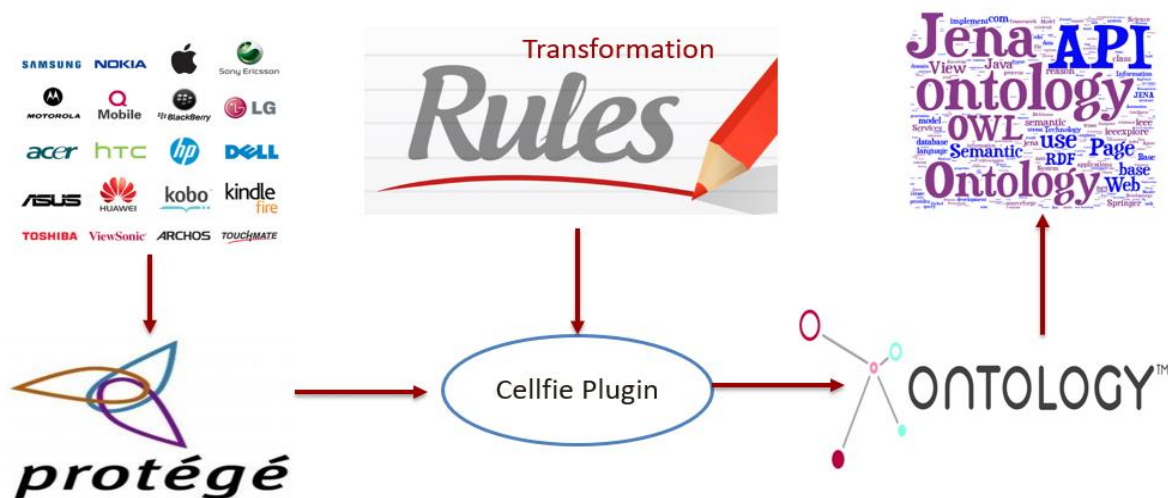


Figure 7. Data Linking Steps

In the figure 6, we can see that data was collected from heterogenous data sources and a consolidated dataset was generated to be fed to Protégé accompanied by Cellfie plugin to which we issued transformation rules to create a resulting OWL file. This OWL file was then given as an input to Apache Fuseki Jena that was our application's SPARQL endpoint.

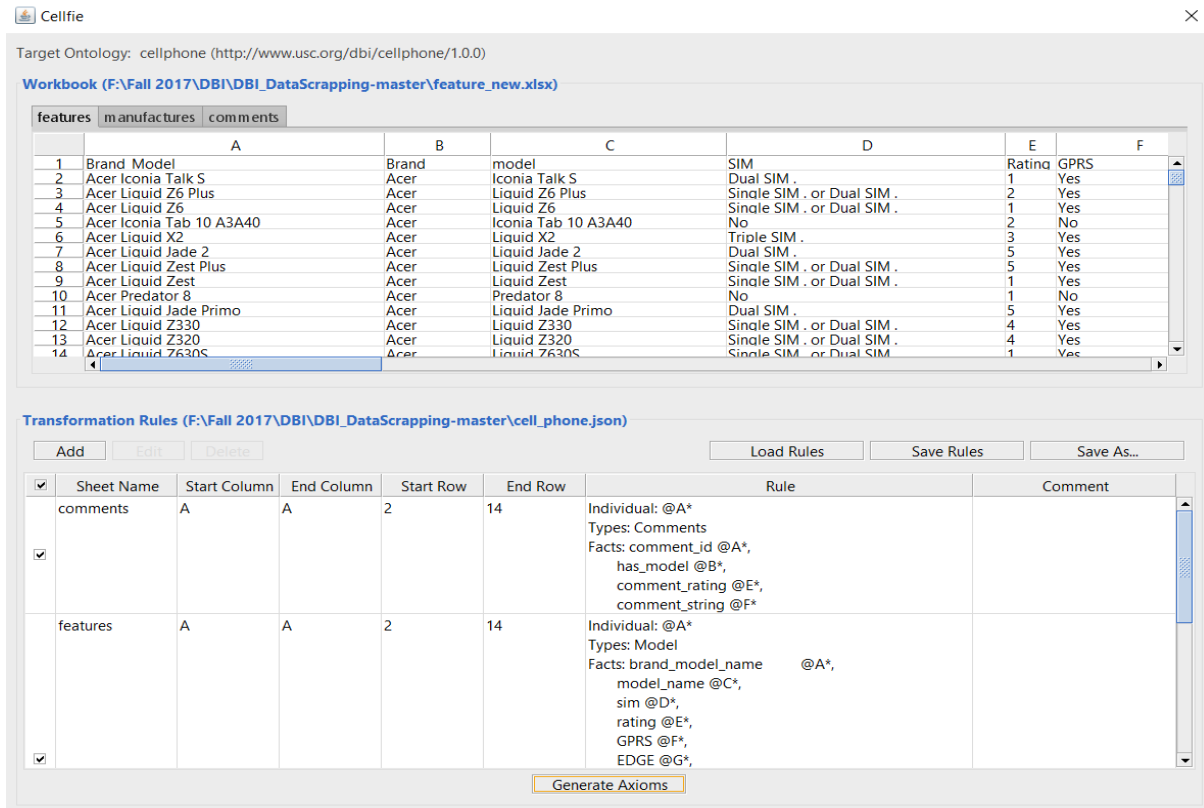


Figure 8. Adding data from CSV to RDF/OWL file by applying transformation rules

4.4 Querying

After data integration and linking, the RDF dataset had roughly 14,00,000 triples. We hosted the RDF dataset in Apache Jena Fuseki server. This server acted as a SPARQL end point. The repository was then queried using Apache Jena API. A user-interface was developed using HTML, jQuery and JavaScript to display the results of the query. We also used High charts, a JavaScript library to implement bar charts and histograms for the results of the queries. The user interface is shown in Figure 9. The queries are pre-defined and provisions for users to change the parameters of the query is provided in the UI, the functionality of the user issuing their own queries from the UI is in scope for future work. When user chooses to run a pre-configured query, the actual SPARQL query is also shown in the text area, which can be used as a template for custom queries. The list of pre-configured queries and their descriptions is given in Table 3.

Query	Query Description
Query #1	Get the revenue of top N models with highest user rating: In this query, we are finding the cell phone models which has the best reviews according to Amazon customers, then we get the profits obtained by the companies by selling each of these phone models. This helps in understanding the general trend of the revenue generated by the best rated cell phones. We have also given the bar chart representation for visualizing the trend.

Query #2	Get top N models based on their revenue: In this query we are retrieving top N models, which are having highest gross profit among all the available brands. This helps user in make better choice of a model while buying a cell phone.
Query #3	Get all the details of a cell phone based on brand and model: Helps user to get all the details of a cell phone by entering the brand name and model name. This query returns feature data, comments, ratings and profits.
Query #4	Get all the phones manufactured by reputed brands whose weight is less than a given weight: Here users are asked to enter the maximum weight of a cell phone which they wish to buy. The query returns all the cell phones whose weights is below the user entered weights.
Query #5	Get all the cell phones with screen size greater than X and has best user rating: In this query users enters the size of cell phone in inches, then we will retrieve all the top-rated cell phones greater than or equal to the user specified size.

Table 3. Query Description

1. Get the revenue of top N models with highest user rating:

The screenshot displays the 'CELL PHONE MART' application interface. On the left, a sidebar lists five queries. The main area is divided into three sections: 'AIM', 'SPARQL QUERY', and 'VISUAL RESPONSE'.

AIM: Get revenue of top N Models with highest user rating

SPARQL QUERY:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX cellphone: <http://www.usc.edu/dbi/cellphone#>
SELECT ?brand_name ?model_name ?average ?profit_2016
WHERE {{
  ?brand_uri cellphone:brand_name ?brand_name .
  ?model_uri cellphone:model_name ?model_name .
  ?model_uri cellphone:has_brand ?brand_uri .
  ?revenue_uri cellphone:profit_has_model ?model_uri .
  ?revenue_uri cellphone:profit_2016 ?profit_2016 .
  { SELECT ?model_uri (AVG(?rating) as ?average) (COUNT(?rating) as ?count)
    WHERE {
      ?comment_uri cellphone:has_model ?model_uri .
      ?comment_uri cellphone:comment_rating ?rating .
    } GROUP BY ?model_uri
    HAVING (?count > 700)
    ORDER BY DESC (?average)
    LIMIT 15
  }}
}}
```

SUBMIT QUERY: A text input field contains the number '5', and a 'Search' button is located below it.

VISUAL RESPONSE: A bar chart titled 'Top Smartphones' showing 'Revenue In Million' on the y-axis (0 to 15) for five models on the x-axis. The bars are colored blue, red, green, teal, and purple.

Smartphone Model	Revenue (Million)
Galaxy Note II N7100	~6.5
Samsung Galaxy Alpha	~6.5
Sony Xperia Z1	~1.0
Samsung Galaxy J7	~12.5
Samsung J700	~6.5

2. Get top N models based on their revenue:

localhost:8080/DBIApp/

CELL PHONE MART

SEARCH

QUERY #1
QUERY #2
QUERY #3
QUERY #4
QUERY #5

AIM

Get top N Brand names based on Revenue

SPARQL QUERY

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX cellphone: <http://www.usc.org/dbi/cellphone#>
SELECT ?brand_name (SUM(?profits) as ?revenue) ?area_served ?
employee_count ?founded
?head_quarters ?type ?website ?brand_uri
WHERE {
?brand_uri cellphone:area_served ?area_served .
?brand_uri cellphone:employee_count ?employee_count .
?brand_uri cellphone:founded ?founded .
?brand_uri cellphone:head_quarters ?head_quarters .
?brand_uri cellphone:type ?type .
?brand_uri cellphone:website ?website .
?model_uri cellphone:has_brand ?brand_uri .
?brand_uri cellphone:brand_name ?brand_name .
?model_uri cellphone:model_name ?model_name .
{ SELECT ?model_uri ?profits
WHERE { ?profit_uri cellphone:profit_has_model ?model_uri .
?profit_uri cellphone:profit_2014 ?profits .
}}
} GROUP BY ?brand_uri ?area_served ?employee_count ?founded ?
head_quarters ?type ?website
?brand_name ORDER BY DESC (?revenue) LIMIT 5
```

SUBMIT QUERY

5

Search

VISUAL RESPONSE

Top Companies

Company	Revenue
Samsung	~12,000
Motorola	~2,000
HTC	~1,000
Apple	~1,000
LG	~1,000

3. Get all the details of a cell phone based given brand and model:

localhost:8080/DBIApp/

CELL PHONE MART

QUERY #1
QUERY #2
QUERY #3
QUERY #4
QUERY #5

AIM

Get all details of the cell phone using Brand and Model name

SPARQL QUERY

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX cellphone: <http://www.usc.org/dbi/cellphone#>
SELECT DISTINCT ?employee_count ?founded ?type ?website ?brand_uri ?
model_name ?CPU ?EDGE ?GPRS
?RAM ?audio_jack ?battery
?image ?primary_camera ?rating ?screen_size ?sim ?os ?weight ?model_uri ?
profit_2014
?profit_2015 ?profit_2016 ?comment_string
WHERE {
{ ?brand_uri cellphone:brand_name "" + BrandName + "" .
?brand_uri cellphone:area_served ?area_served .
?brand_uri cellphone:employee_count ?employee_count .
?brand_uri cellphone:founded ?founded .
?brand_uri cellphone:head_quarters ?head_quarters .
?brand_uri cellphone:type ?type .
?brand_uri cellphone:website ?website .
?model_uri cellphone:has_brand ?brand_uri .
?model_uri cellphone:model_name "" + modelName + "" .
?model_uri cellphone:CPU ?CPU .
?model_uri cellphone:EDGE ?EDGE .
?model_uri cellphone:GPRS ?GPRS .
?model_uri cellphone:RAM ?RAM .
?model_uri cellphone:audio_jack ?audio_jack .
?model_uri cellphone:battery ?battery .
?model_uri cellphone:image ?image .
?model_uri cellphone:primary_camera ?primary_camera .
?model_uri cellphone:rating ?rating .
?model_uri cellphone:screen_size ?screen_size .
?model_uri cellphone:sim ?sim .
?model_uri cellphone:os ?os .
?model_uri cellphone:weight ?weight .
?profit_id cellphone:profit_has_model ?model_uri .
?profit_id cellphone:profit_2014 ?profit_2014 .
?profit_id cellphone:profit_2015 ?profit_2015 .
?profit_id cellphone:profit_2016 ?profit_2016 .
} UNION
{ ?brand_uri_1 cellphone:brand_name "" + BrandName + "" .
?model_uri_1 cellphone:has_brand ?brand_uri_1 .
?model_uri_1 cellphone:model_name "" + modelName + "" .
?comment_id cellphone:has_model ?model_uri_1 .
?comment_id cellphone:comment_string ?comment_string .
}}
}
```

SUBMIT QUERY

Samsung

Galaxy S7


Search

VISUAL RESPONSE

Device Specs as part of result:

localhost:8080/DBIApp/

Samsung Galaxy S7



Features

EDGE : Yes
GPS : Yes
RAM : 4 GB RAM
Audio Jack : Yes
Battery : Nonremovable Lilon 3000 mAh battery
OS : Android 6
Primary Camera : 12 MP, 1.7, 26mm, phase detection autofocus, OIS, LED flash,
Rating : 1
Screen Size : 5.1
SIM : Single SIM . G930F
Weight : 152
Model URI : <http://www.usc.org/dbi/cellphone#SamsungGalaxyS7>

```
WHERE {  
  { ?brand_uri cellphone:brand_name "" + BrandName + "" .  
    ?brand_uri cellphone:areas_served ?area_served .  
    ?brand_uri cellphone:employee_count ?employee_count .  
    ?brand_uri cellphone:founded ?founded .  
    ?brand_uri cellphone:head_quarters ?head_quarters .  
    ?brand_uri cellphone:type ?type .
```

Brand, revenue, rating as part of results:

localhost:8080/DBIApp/

Samsung Galaxy S7

Brand Details

Brand URI : <http://www.usc.org/dbi/cellphone#Samsung>
Number of Employees : 489000
Founded : 1938
Type of Company : Public
WebSite URL : <http://www.samsung.com/us/>

Revenue Details

Profits in 2014 : 15.62540201586363
Profits in 2015 : 14.9591247360014
Profits in 2016 : 5.307176420023779

Comments

1. Great phone some boatware installed but simple to uninstall or disable. Came with cheap US adapter, but not frequently in US enough to matter. Camera outperforms.
2. The charger seems to work just fine, but I was disappointed that manufacturer included no USB cable or wall charger. I must order a new cable or swap with travel charger.
3. Love it
4. Some items can only be displayed in chinese. These include sim card number in notificationsHave issues with data. It starts as 4g but then drops data connection despite displaying 3g.Have tested many times and its not a coverage problem.When restarted data sometimes works again.Switching back to my s6 duos
5. After two months of use, my phone completely blacked out. It would not turn off or on or do anything. I knew that this was an international phone, but I did not know that SAMSUNG US was not able to help me. This phone apparently has a different OS than those in the US. Even though I have a 24 month warranty on the phone, I could not simply return it to the retailer for a replacement who was very pleasant and tried to be helpful over the phone but when you pay this much for a product you expect better, because it was beyond 30 days. I was first told to contact SAMSUNG Vietnam, but they responded that the phone was distributed in Africa and that I needed to contact SAMSUNG Nigeria. They said that I would need to send the phone in and pay for shipping, which is not cheap. I did end up sending it, and now I have still not received my phone back after 3 weeks. DO NOT BUY THIS PHONE IF YOU LIVE IN THE US. I really wanted a dual SIM phone, but it's not worth the risk. Get a single SIM unlocked phone from Best Buy with insurance and save yourself money and hassle.

```
WHERE {  
  { ?brand_uri cellphone:brand_name "" + BrandName + "" .  
    ?brand_uri cellphone:areas_served ?area_served .  
    ?brand_uri cellphone:employee_count ?employee_count .  
    ?brand_uri cellphone:founded ?founded .  
    ?brand_uri cellphone:head_quarters ?head_quarters .  
    ?brand_uri cellphone:type ?type .
```

4. Get all the phones manufactured by reputed brands whose weight is less than a given weight:

The screenshot shows a web application titled "CELL PHONE MART" with a navigation bar containing "SEARCH" and "TEAM". On the left, a sidebar lists "QUERY #1" through "QUERY #5", with "QUERY #4" highlighted. The main content area has a green background and contains three panels:

- AIM**: A text box containing the query description: "Get all the phones manufactured by Reputed companies with android OS that weigh less than a given weight".
- SUBMIT QUERY**: A form with a text input field containing "100" and a "Search" button.
- SPARQL QUERY**: A text box containing the following SPARQL query:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX cellphone: <http://www.usc.org/db/cellphone#>
SELECT DISTINCT ?brand_name ?model_name ?employee_count ?weight ?
image_uri
WHERE {
  ?brand_uri cellphone:areas_served "Worldwide" .
  ?brand_uri cellphone:brand_name ?brand_name .
  ?brand_uri cellphone:employee_count ?employee_count .
  ?model_uri cellphone:has_brand ?brand_uri .
  ?model_uri cellphone:model_name ?model_name .
  ?model_uri cellphone:image ?image_uri .
  ?model_uri cellphone:os ?os .
  ?model_uri cellphone:weight ?weight .
  FILTER (regex(?os, "Android", "i") && ?employee_count >= 100000 && ?
weight <= ?weight + ?)
} ORDER BY ASC(?weight)
```

Result with all models along with weight:

The screenshot shows the same application with a modal window titled "Phones with weights less than 100" displaying the results of the query. The results are shown in a table with three columns: Brand, Model, and Weight. Each row also includes a small image of the phone.

Brand	Model	Weight
Samsung	Guru E1081T	64
LG	A270	65
LG	GB110	65

Below the table, the same SPARQL query is displayed in a text box.

5. Get all the cell phones with screen size greater than X and has best user rating:



The screenshot shows the 'CELL PHONE MART' application interface. On the left, there is a sidebar with a list of queries: QUERY #1, QUERY #2, QUERY #3, QUERY #4, and QUERY #5 (highlighted in orange). The main area is divided into four panels: 'AIM' (containing the text 'Get all cellphones which have screen bigger than value X and a good rating'), 'SPARQL QUERY' (containing a SPARQL query), 'SUBMIT QUERY' (with a text input field containing '5.5' and a 'Search' button), and 'VISUAL RESPONSE' (which is currently empty).

SPARQL QUERY

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX cellphone: <http://www.usc.org/db/cellphone#>
SELECT ?brand_uri ?model_name ?brand_name ?average ?screen_size ?
image_uri
WHERE {
?model_uri cellphone:has_brand ?brand_uri .
?model_uri cellphone:image ?image_uri .
?model_uri cellphone:model_name ?model_name .
?brand_uri cellphone:brand_name ?brand_name .
?model_uri cellphone:screen_size ?screen_size .
FILTER (?average >= 4 && ?screen_size >"+ screen_size +")
{
SELECT ?model_uri (AVG(?rating) as ?average)
WHERE {
?comment_uri cellphone:has_model ?model_uri .
?comment_uri cellphone:comment_rating ?rating
} GROUP BY ?model_uri
}}
}
```

Result has all the phones whose screen size is above X (5.5 inches) and with their average rating:

The screenshot shows the 'CELL PHONE MART' application interface with a modal window displaying the results of the SPARQL query. The modal window contains a table with the following data:

Brand Name	Model Name	Screen Size	Average Rating	Image
Motorola	Moto X Play	5.5	4.625	
Samsung	Galaxy S5 Active	5.1	4.167655786350146367952522	

The background of the application shows the 'SUBMIT QUERY' and 'VISUAL RESPONSE' panels, which are partially obscured by the modal window.

5. Conclusion & Future Work

Use of Ontology is progressively gaining popularity to unify data in various domains. In Cell Phone Mart, we showed one of its many uses in mobile phone industry by answering queries which would have required exploring multiple web pages to answer.

For future work, we could have an endpoint for more generalized queries for the user to key in. More datasets could be added to extend the current schema and the ontology for a better data management and more complicated queries. For instance, data related to stocks of a company. The current scope of Cell Phone Mart included a set of predefined queries covering a few key performance indices a user would be interested in; however, this could be extended with various analytical tools, and statistical concepts. We used high charts, a JavaScript charting library, in future high stocks could be used to show trends of various company stocks.

6. References

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