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INTEGRATED ENVIRONMENT FOR INTERNET OF THINGS WITH SEMANTIC WEB

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Abstract

Semantic Web presently is very noticeable innovation that can be incorporated with the Internet of Things (IoT). In semantic web, the data on Objects (music, vehicles, autos, people, tickets and so on.) are put away in unique arrangement records and astute web applications which gather data from a wide range of sources, consolidate data, and present it to clients in an important manner. At whatever point the data about explicit help, item, organization or article is required, the clients explore diverse web crawlers with the goal that the related website can be gotten and specific data can be found. Presently, the significant issues with the conventional web indexes are that the data might be dispersed and insignificant. The Internet of Things (IoT) is one of the ongoing advancements in current time that emphasis on the interconnection of each article in reality. We can envision the genuine items with implanted registering gadgets and speaking with one another. By this innovation, we can follow everything from remote area utilizing Internet framework. Utilizing IoT, the entomb association in each framework, gadget, machine, person, home types of gear, office items can be built up utilizing existing system assets. For instance or instance of IoT, we can follow any train by utilizing the informing administration of Railways. Presently, numerous taxi administrators are associated with GPS and we can follow the area of that vehicle on cell phone, tablet or any system associated gadget. Shrewd Cities, Smart Home are executed utilizing IoT in which everything is associated and accessible.

Keywords: IoT, Internet of Things, IoT and Semantic Web, Semantic Web

Introduction

At the base level, IoT makes use of sensors and embedded chips which are inserted in the system that we want to monitor and track. RFID (Radio Frequency Identification) based devices are classically used for IoT implementation [1]. The Things, in IoT, refers to a wide variety of devices such as heart monitoring implants, biochip transponders deployed with patients for remote monitoring and prescription, animals, electric clams in coastal waters, automobiles with built-in sensors, or field operation devices that assist fire-fighters in search and rescue. Current market examples include smart thermostat systems and washer or dryers that utilize wifi for remote monitoring [2, 3].

Gartner, Inc. forecasts that 4.9 billion connected things will be in use in 2015, up 30 percent from 2014, and will reach 25 billion by 2020. The Internet of Things (IoT) has become a powerful force for business transformation, and its disruptive impact will be felt across all industries and all areas of society. [Source - Gartner Press Release, Barcelona, Spain November 11, 2014 http://www.gartner.com]

Gartner estimates that IoT will support total services spending of $69.5 billion in 2015 and $263 billion by 2020. Consumer applications will drive the number of connected things, while enterprise will account for most of the revenue. Gartner estimates that 2.9 billion connected things will be in use in the consumer sector in 2015 and will reach over 13 billion in 2020. The automotive sector will show the highest growth rate at 96 percent in 2015 [4, 5].

According to a new research by Gartner, The Internet of Things (IoT), which excludes PCs, tablets and smartphones, will generate incremental revenue exceeding $300 billion in services in 2020. The services include hardware, embedded software, communications services and information services associated with the things.
[Source - http://www.gartner.com]

Kevin Ashton, cofounder and executive director of the Auto-ID Center at MIT, first mentioned the Internet of Things in a presentation he made to Procter & Gamble. Here’s how Ashton explains the potential of the Internet of Things:

> *“Today computers -- and, therefore, the Internet -- are almost wholly dependent on human beings for information. Nearly all of the roughly 50 petabytes (a petabyte is 1,024 terabytes) of data available on the Internet were first captured and created by human beings by typing, pressing a record button, taking a digital picture or scanning*

a bar code. The problem is, people have limited time, attention and accuracy -- all of which means they are not very good at capturing data about things in the real world. If we had computers that knew everything there was to know about things -- using data they gathered without any help from us -- we would be able to track and count everything and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling and whether they were fresh or past their best."

Kevin Ashton is known for inventing the term "the Internet of Things" to describe a system where the Internet is connected to the physical world via ubiquitous sensors [6, 7, 8].

Usage of Sensor Data in Cloud Environment

The huge generation, processing and storage of sensor data is involved in the Internet of Things. To manage and control all these aspects, cloud is required. For this, the effective implementation of cloud infrastructure is required. In the upcoming years, the Internet of Things (IoT) will be transformed to the Cloud of Things (CoT) because it will be very difficult to manage huge data or BigData without cloud integration [9, 10, 11, 12].

Real Life Implementations and Applications of IoT

From building and home automation to wearables, the IoT touches every facet of our lives. Many corporate giants including Texas Instruments, Cisco, Ericsson, Freescale, GE are working in the development as well as deployment of IoT scenarios [13, 14]. The companies are making and developing the applications easier with hardware, software and support to get anything connected within the IoT. A set of key markets exists for the IoT with potential for exponential growth [15, 16].

- Medical and healthcare systems
- Building and home automation
- Transportation
- Wearables - Smart watch for Location and tracking
- Building & home automation
- Smart cities
- Smart manufacturing
- Employee safety
- Predictive maintenance
- Health care
- Remote monitoring
- Ambulance telemetry
- Drug tracking
- Hospital asset tracking
- Access control
- Automotive

Semantic Web

Since the appearance of web based distributing and computerized showcasing of items and administrations, there is enormous utilization of web indexes to get the exact data with the particular area. Presently days, a large portion of the administrations and items are looked by the clients from web search tools utilizing diverse looking through stunts and explicit catchphrases [17].

From the information investigation reports of InternetLiveStats.com, Google forms in excess of 40,000 inquiry questions for every second. Around 20% questions on Google are those which are new ordinary and never entered on the web crawler. The significant test with the web indexes is to get the precise outcomes without unessential results [18].

Semantic Web in expansive terms alludes to the Web with Meaning utilizing Interconnections. The web in semantic web can portray things such that PCs can comprehend the genuine importance which live in the inquiry question or perusing conduct [19].

The superb forces of semantic web can be seen on the noticeable website like Skyscanner.net and Trivago.com. These entryways look at the ongoing costs from various administrations giving gateways and give the best outcomes in type of correlation. The back-end libraries of these entries speak with various websites and afterward bring the outcomes so the clients can see the base cost of inns or flights [20, 21]. The conventions of semantic web work with these websites to bring the related data from different areas.

For example, if a user enters a search keyword "gold today" on the search engine, there are many haphazard results which may include the following aspects

- Gold Price
- Star Gold
- Gold Jewellers
- Gold Loan

If the user is fond of watching Movies on Star Gold, then the semantic web search engine should give all results of "Star Gold" on searching of "Gold".

In similar way, the search word "Python" will give results on "Python as Big Snake", "Python on Discovery Channel", "Python Programming" and many different domains which are directed to different topic.

With these types of scattered search results, it becomes difficult for the new user to understand the fetched results. If a user is willing to get information on Python Programming, the search engine does not understand the actual meaning and semantics of the words. That's where the concept and algorithms of semantic web are required.

Semantic Web is focused on the understanding of search queries on the basis of the syntax, semantics and actual meaning of the keywords entered by the user. The semantic web assist the user to get the results in categorized way so that the user can get the search engines in better and meaningful way with different classes of outputs [22].

For example, if user is getting results about "Python", the semantic web search engine gives the search results in different categories as:

Category 1: Python Programming:
Search Result-1, Search Result-2, Search Result-3, Search Result-4…..
Category 2: Python Reptile:
Search Result-1, Search Result-2, Search Result-3, Search Result-4…..
Category 3: Python Movie:
Search Result-1, Search Result-2, Search Result-3, Search Result-4…..

Now days, the Speech based Search on Google is implementing the semantic technology and speech recognition whereby the meaning and context of the sentences are understood and then responses are given by the Google Search Engine. But in some cases, the speech based searching also gives different results which may not be accurate.

Knowledge Representation and Ontologies

In the technology of semantic web, there is the base of knowledge representation and ontologies which extracts the actual meaning of the keywords entered by the user. The knowledge representation techniques are used in semantic web so that the database can be associated with their metadata and the knowledge to be stored in the databases. The creation of ontology is required so that the association the data objects can be possible.

Example of Knowledge Associations and Ontology:

A knows B
B knows C
C friend-of A → ***B may-be-knowing D***
D met C
D friend-of A

Without semantic web, the websites do not have the accurate and interrelated information. In general, the base programming language of web pages is HTML in which different markups are defined and then the websites are programmed but there are various limitations and disadvantages with the HTML. One of the major limitations of HTML is that it is simply a markup language to render and display the web pages on the web browser. The text or content written in HTML do not have any relationship. It means that anything can be displayed on the web browser using HTML whether that is having any association or not.

For example, the text like A is spouse of B and B is son of A can also be displayed on web browser using simple HTML tags. But these types of associations cannot be put using knowledge representation techniques in semantic web based web applications.

The main motive of semantic web application is to enable the machine in understanding the content and their relationship which are defined in the web pages. Using semantic web based knowledge representation, the direct queries can be asked from the search engines like “What is my date of birth ?”, “Which is my birth place ?” or any other. Using semantic web, the ontologies will scan the knowledge about the specific person from multiple sources and then will give the accurate results. By this way, a web based expert system can be developed using semantic web technology.

There are different types of standards associated with the knowledge representation and ontologies so that the data definition and interrelationships are created.

Following are the data formats and standards of semantic web for the knowledge representations

- XML: eXtensible Markup Language
- RDF: Resource Description Framework
- OWL: Web Ontology Language
- FOAF: Friend Of A Friend
- SPARQL: Recursively known as SPARQL Protocol and RDF Query Language

Friend Of A Friend (FOAF)

It is the standard and defines the ontology in machine readable format so that the description of different objects and their relationships can be specified.

For example, as in social media portals, the relationships are defined and extracted by the algorithms. In Facebook, Twitter, Instagram, these associations are grouped and then predicted. Generally in social media, the suggestions are given "THESE PERSONS MAY KNOW YOU", "YOU MAY BE INTERESTED IN FOLLOWING THESE PERSONS" and so on. These types of relationships are extracted using FOAF profiles.

Whenever, the new information is uploaded by the user on social media, the relationships are built using ontology and FOAF. After that, the persons matching their profile who met the person at a specific place are extracted and then given suggestions that "THESE PERSONS MAY KNOW YOU"

The FOAF profile about a person can be created using the URL http://www.ldodds.com/foaf/foaf-a-matic.html

The FOAF file will be created with RDF as follows

```
<rdf:RDF

xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"

xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:foaf="http://xmlns.com/foaf/0.1/"
    xmlns:admin="http://webns.net/mvcb/">
<foaf:PersonalProfileDocument
rdf:about="">
  <foaf:maker rdf:resource="#me"/>
  <foaf:primaryTopic rdf:resource="#me"/>
  <admin:generatorAgent
rdf:resource="http://www.ldodds.com/foaf/foaf-a-matic"/>
  <admin:errorReportsTo
rdf:resource="mailto:leigh@ldodds.com"/>
</foaf:PersonalProfileDocument>
<foaf:Person rdf:ID="me">
<foaf:name>Jamal G</foaf:name>
<foaf:title>Mr</foaf:title>
```

```
<foaf:givenname>Jamal</foaf:givenname>
<foaf:family_name>G</foaf:family_name>
<foaf:nick>GK</foaf:nick>
<foaf:mbox_sha1sum>eccb3d9dd0cba386706
462b4288acb0ff2678ab4</foaf:mbox_sha1su
m>
<foaf:homepage
rdf:resource="JamalGIraq.com"/>
<foaf:knows>
<foaf:Person>
<foaf:name>friend1</foaf:name>
<foaf:mbox_sha1sum>4d2e2bea6b04249b226
fe9b1761b32554f19e55d</foaf:mbox_sha1su
m></foaf:Person></foaf:knows>
<foaf:knows>
<foaf:Person>
<foaf:name>friend2</foaf:name>
<foaf:mbox_sha1sum>c666c29d65fcd3461f8f
81d3bc76e25802893e9f</foaf:mbox_sha1sum
></foaf:Person></foaf:knows></foaf:Person
>
</rdf:RDF>
```

The FOAF file can be used as the database and matching with the other profiles using semantic web protocols and algorithms.

FOAF Search Engine

Even, the FOAF search engine https://www.foaf-search.net/ is available which can be used to extract the information about any person

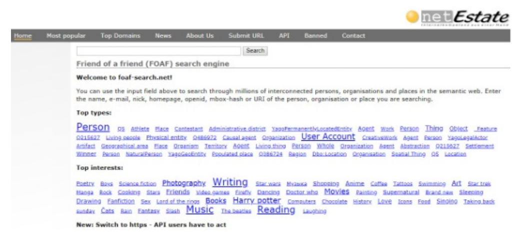

Figure 1: FOAF Search Engine

Open Source Tools and Libraries for Semantic Web

- Apache TinkerPop: https://tinkerpop.apache.org
- RDFLib: https://github.com/RDFLib/rdflib
- Apache Jena: http://jena.apache.org/
- Protégé: https://protege.stanford.edu
- Sesame: http://www.openrdf.org/
- Linked Media Framework: https://code.google.com/p/lmf/
- Open Semantic Framework: http://opensemanticframework.org/
- D2R: http://d2rq.org/d2r-server
- Paget: http://code.google.com/p/paget/
- Semantic Media: http://semantic-mediawiki.org/wiki/Semantic_Media Wiki
    - and many others

Installation and Working with Semantic Web based Apache Frameworks on Windows

Apache TinkerPop is one of the multi-featured and powerful frameworks for the development and programming on semantic web applications. Apache TinkerPop is available under free and open source distribution and is primarily used for graph computing and ontology based programming which is quite useful in Online Transaction Processing and Graph Analysis in the Social Media based applications.

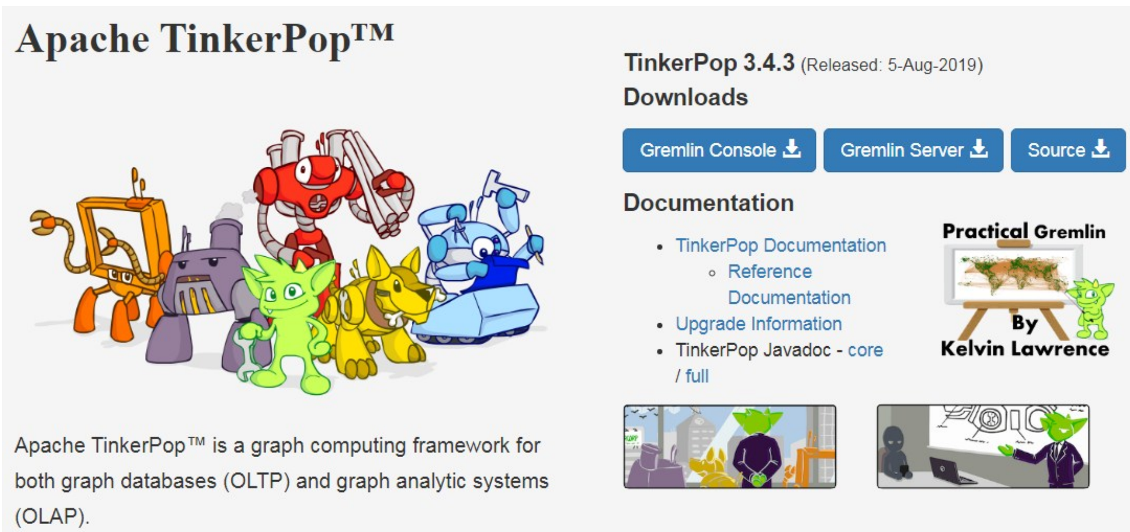

Figure 2: Official Portal of Apache TinkerPop

The dynamic graph of the persons with their relationship can be created. These graphs are used for the predictive mining of relationships in the social media as follows.

```
g.V().has("name","gremlin").
  out("knows").
  out("knows").
  values("name")
```

Figure 3: Extraction of Knowledge and Relationships of a person titled Gremlin

RDFLib is a powerful Python package for RDF Semantic Web Programming that contains standards required to work with RDF. It includes the parsers and serializers for RDF/XML, NTriples, N-Quads, N3, RDFa, Turtle, TriX, Microdata and many others. RDFLib is having the Graph interface so that the creation of connections and visualization is quite easy to implement.

Features of RDFLib

- Loading and saving RDF

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- Creating RDF triples and Relationships
- Navigation of Graphs
- Merging of Graphs
- Namespaces
- Bindings
- Interconnections
- Querying with SPARQL
- Utilities and Convenience functions

Installation of RDFLib with Python

On Anaconda Prompt, the following instruction can be executed for the installation of RDFLib.

Anaconda Prompt > pip install rdflib

After this, the RDFLib functions will be available for the programming with semantic web.

Python Programming with RDF

```
import rdflib
g=rdflib.Graph()
g.load('http://dbpedia.org/resource/Semantic_Web')
for s,p,o in g:
   print (s,p,o)
```

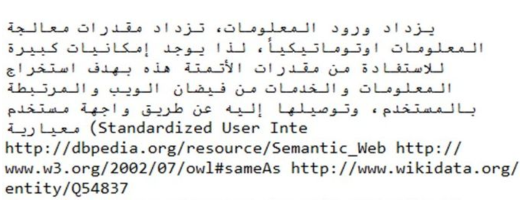
يزداد ورود المعلومات، تزداد مقدرات معالجة
المعلومات اوتوماتيكياً، لذا يوجد إمكانيات كبيرة
للاستفادة من مقدرات الأتمتة هذه بهدف استخراج
المعلومات والخدمات من فيضان الويب والمرتبطة
بالمستخدم، وتوصيلها إليه عن طريق واجهة مستخدم
معيارية (Standardized User Inte
http://dbpedia.org/resource/Semantic_Web http://
www.w3.org/2002/07/owl#sameAs http://www.wikidata.org/
entity/Q54837

Figure 5: Fetching Results using RDFLib about a Specific Subject

Querying with SPARQL

SPARQL query is used for the mapping of FOAF file with the Python code so that the dynamic extraction of data from FOAF RDF file can be done. Here, the FOAF RDF file myfoaf.rdf is used as the back-end database. To query this database, SPARQL query is fired rather than SQL.

```
import rdflib
mygraph = rdflib.Graph()
mygraph.parse("myfoaf.rdf")
mygraph qres = mygraph.query(
   """SELECT DISTINCT ?fname ?lname
     WHERE {
       ?a foaf:knows ?b .
       ?a foaf:name ?fname .
       ?b foaf:name ?lname .
     }""")
for myrow in qres:
   print("%s knows %s" % row)
```

In traditional RDBMS based databases, the SQL query is used for the query processing. In case of semantic web applications, the SPARQL query extracts the information associated from the ontology file and FOAF association dataset. This type of data extraction is used in case of extracting the hidden associations for the digital forensic applications.

Conclusion

The semantic web writing computer programs with the IoT is ordinarily subject to the affiliations and connections referenced in the RDF, FOAF and OWL. These learning portrayal gauges with the integration of IoT and conventions can be improved so the shrouded fingerprints in the information things and their connections can be related. Utilizing this methodology, the circuitous connections can be separated about a particular individual or article in the database.

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