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Performance Evaluation of Inference Engine in Static and Changeable Environment

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Abstract **—The semantic web has brought many challenges for knowledge representation and inference system [2].Inference Engine play important role to extract additional information implicitly by using fact and ontologies [3]. Standard benchmark practices are used to analyze the performance of different inference engine for different version of ontology. This paper aims to execute different parameters for variety of inference engines and generate statistics based on suitability of inference engine with respect to domain under consideration. The results may be useful in choosing the inference engine for different version of ontology and domain.**

Keywords—**Inference Engine, OWL-DL, Performance.**

I. INTRODUCTION

The Semantic Web is envisioned as a next generation of the Web in which information is machine processable, and automated agents can retrieve, extract, and combine information from the Web [4]. Ubiquitous computing services aim to provide information and services in more intelligent ways with more seamless interfaces that aid users to be conveniently served anytime, anywhere with any devices without awkward user intervention [1].It capture the users context and also extract hidden knowledge by applying reasoning with rules which are more useful and meaningful information within open web environment. Recently, inference engines such as Pellet, FacT++, Hermit have been proposed as a core component of intelligent ubiquitous computing systems. There had been many extensive evaluations of their reasoning capabilities in Data Size, Classified time, Description logic, Axioms, Classes, Data Property, Object Properties, Individual, Query Result [5, 6]. It is less widely known without fully analyzing how well the inference engines can be fare full-fledged ubiquitous computing services covering vast zones with various sets of requirements such as lots of fast moving users and other transient computing entities. The main purpose of this paper is to examine how well inference engines satisfy Query Result, Classified time, etc... For realistic ubiquitous open web environment. To do so, we have modelled scenarios based in a major university such as LUBM adapted from the original Lehigh benchmark, LUBM [7]. It is a university database where the number of universities, departments, and students can vary, so main aim is to study and adopt the most suitable reasoner for open web changeable environment. Specifically, three most prominent engines are considered based on their reasoning mechanisms.

II. INFERENCE ENGINES

A. PELLET

Pellet is an open-source Java OWL DL reasoner. It support expressivity of SROIQ(D). It supports SWRL rules. It can be used in conjunction with both Jena and OWL API libraries and also provides a DIG interface. It can be used in conjunction with both Jena and OWL API libraries. Pellet API provides functionalities to see the species validation, check consistency of ontologies, classify the taxonomy, check entailments and answer a subset of RDQL queries. It supports the full expressivity OWL DL including reasoning about nominal's.

B. HERMIT

HermiT is a new OWL reasoner based on a novel "hyper-tableau" calculus [2]. Hermit reasoner employs reasoning on SHIQ(D). It is available free for non-commercial usage. Takes OWL file as input and perform various reasoning tasks like consistency checking, identify subsumption relationships between classes and more. It also computes partial order of classes occurring in OWL. It is different from other reasoner like Pellet and FaCT such a way that it implements hyper-tableau reasoning algorithm that is much less deterministic than existing tableau algorithm.

C. FACT++

FaCT++ [8] an improved version of FaCT [9] employs tableaux algorithms for SHOIQ(D) description logic and implemented in C++ but has very limited user interface and services as compared to other reasoner. It not supports for rules. The strategies followed are absorption, model merging, told cycle elimination, synonym replacement, ordering heuristics and taxonomic classification.

III. PERFORMANCE EVALUATION

A. About University ontology

LUBM-derived tests include three rule sets (Query1, Query2, and Query3) that are adapted from the original Lehigh benchmark, LUBM [7]. It is a university database where the number of universities, departments, and students can vary. We tested four data sets. To analyze how the inference engines perform in realistic static and changeable environments.

B. Results: Performance Evaluation on Static and Changeable Context Information

This test were executed on a Intel(R) core(TM)2 duo cpuT6400@2GHz,with 3 GB RAM ,running on Windows Vista, Java SE 1.6, Protege_4.1.For the performance evaluation on static and changeable information, we placed our focus on scalability and subsequent performance issue. Specifically, in evaluating the performance of query processing, we considered 1 sets of University Ontology Benchmark [9] queries that were generated. In order to evaluate handling of context information, SPARQL is used as follows:

1) Query 1:

```
PREFIX rdf:  <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX ub:
<http://www.lehigh.edu/~zhp2/2004/0401/univ-bench.owl#>
PREFIX owl:  <http://www.w3.org/2002/07/owl#>

SELECT ?X ?C
WHERE {
      ?X rdf:type ub:Student .
      ?X rdf:type ?C .
      ?C rdfs:subClassOf ub:Employee .
}
```

2) Query 2:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs:     <http://www.w3.org/2000/01/rdf-schema#>
PREFIX ub:
<http://www.lehigh.edu/~zhp2/2004/0401/univ-bench.owl#>
PREFIX owl:      <http://www.w3.org/2002/07/owl#>
PREFIX sparqldl: <http://pellet.owldl.com/ns/sdle#>

SELECT ?X ?C
WHERE {
      ?X rdf:type ub:Student .
      ?X rdf:type ?C .
      ?C    sparqldl:directSubClassOf ub:Employee .
}
```

3) Query 3:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX ub:
<http://www.lehigh.edu/~zhp2/2004/0401/univ-bench.owl#>

SELECT ?X ?Y1 ?Y2 ?Y3
WHERE
{   ?X rdf:type ub:Professor .
    ?X ub:worksFor
<http://www.Department0.University0.edu> .
    ?X ub:name ?Y1 .
    ?X ub:emailAddress ?Y2 .
    ?X ub:telephone ?Y3}
```

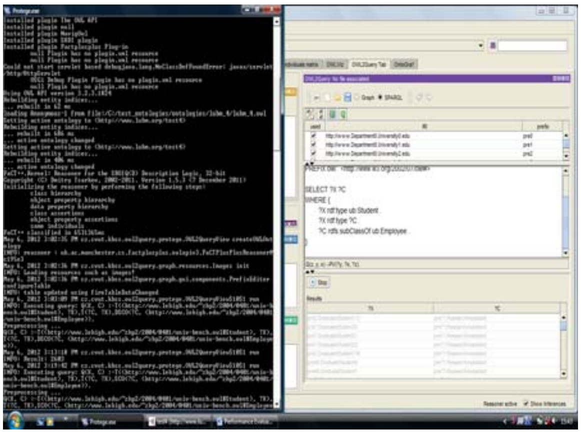

Fig. 1 Protégé GUI

By performing the different test cases, Summary of generate output for few parameters in static & changeable Environment for the LUBM benchmark is given below. We consider classification Time and Query answer for different version of ontology for different inference engine. Fig. 2 compares the results for classification time for all inference engines. Fig. 3 compares Query Result for different benchmark query for all inference engines.

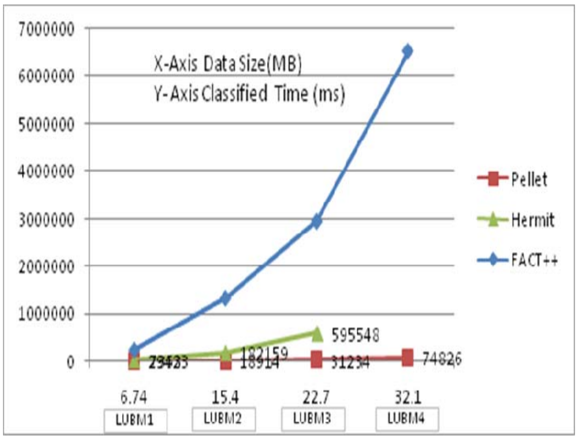

Fig. 2 Classified Times for Different Inference Engine

Fig. 3 Query Result for Different Benchmark Query for Different Version of Ontology for Different Inference Engine

TABLE I
GENERATE OUTPUT FOR FEW PARAMETERS IN STATIC AND CHANGEABLE ENVIRONMENT FOR THE LUBM BENCHMARK

INFERENCE ENGINE	VERSION OF LUBM	DATA SIZE (MB)	DOMAIN	DESCRIPTION LOGIC	CLASSIFIED TIME	A/C/OP/DP/I	BENCHMARK QUERY	QUERY RESULT
PELLET	LUBM1	6.74	University	SROIQ(D)	7363ms	100786/43/25/7/17174	Query 1	1094
							Query 2	547
							Query 3	34
	LUBM2	15.4	University		18914ms	230304/43/25/7/38334	Query 1	2454
							Query 2	1227
							Query 3	34
	LUBM3	22.7	University		31234ms	337370/43/25/7/55664	Query 1	3646
							Query 2	1823
							Query 3	34
	LUBM4	32.1	University		74826ms	478028/43/25/7/78679	Query 1	5206
							Query 2	2603
							Query 3	34
HERMIT	LUBM1	6.74	University	ALCQHIR+(D-)	29423ms	100786/43/25/7/17174	Query 1	1094
							Query 2	547
							Query 3	34
	LUBM2	15.4	University		182159ms	230304/43/25/7/38334	Query 1	2454
							Query 2	1227
							Query 3	34
	LUBM3	22.7	University		595548ms	337370/43/25/7/55664	Query 1	3646
							Query 2	1823
							Query 3	34
	LUBM4	32.1	University		Out of Memory Error	478028/43/25/7/78679	Query 1	-
							Query 2	-
							Query 3	-
FACT++	LUBM1	6.74	University	SROIQ(D)	256968ms	100786/43/25/7/17174	Query 1	1094
							Query 2	547
							Query 3	0
	LUBM2	15.4	University		1345942 ms	230304/43/25/7/38334	Query 1	2454
							Query 2	1227
							Query 3	0
	LUBM3	22.7	University		2958020ms	337370/43/25/7/55664	Query 1	3646
							Query 2	1823
							Query 3	Undefined Time
	LUBM4	32.1	University		6531365ms	478028/43/25/7/78679	Query 1	5206
							Query 2	2603
							Query 3	Undefined Time

IV. CONCLUSION

The Semantic Web creating an environment in which shares and reuse data across World Wide Web (WWW) for user in effective manner's This paper has evaluating performance the different inference engine for different parameters for static and changeable ontology. For domain of static information reasoning, inference engine performance evaluation is been limited, but for changeable environment, inference engine is been inconsistence. Here, for changeable ontology, data size is increase; pellet gives better performance compare to other inference engine. Given comparison table will help to select an appropriate inference engine based on their strengths and weaknesses for changeable environment.

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