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Using JSON and SPARQL to map Insurance Domain Data from Spreadsheets to OWL

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Abstract - Semantic Web tools are beneficial for the smooth transfer, access and interpretation of information in the traditionally complex insurance industry, which is all-inclusive of local standards, metadata elements and isolated data models. Auto ontology introduces a new data model for digital insurance. Standardised products and relationships with well-defined properties ensure a common understanding of information and make explicit domain assumptions, thus allowing organizations to make better sense of their data and establish interoperability of data between insurers, partners and customers.

The ontology itself is realized using Protégé (Protégé OWL Web Ontology Editor) and is implemented in OWL and queried using SPARQL query language.

Keywords: Semantic Web, knowledge representation, Protégé, OWL (Web Ontology Language), RDF, Cellfie, SPARQL (SPARQL and RDF Query Language).

1. INTRODUCTION:

Auto ontology introduces a new data model for digital automobile insurance. Standardised products and relationships with well-defined properties ensure a common understanding of information and make explicit domain assumptions, thus allowing organisations to make better sense of their data and establish interoperability between insurers, partners and customers. Even though the automobile industry has to standardize data related to the insurance sector, there is still no unified accepted ontology for this. Due to the presence of different companies, there are different policy terms, which can lead to ambiguities and different interpretations of the terms in the industry. Due to this, we feel there is a need of universal ontology that can lead to a unified platform for all the companies together. Auto ontology is a unified ontology that describes a set of concepts within the automobile insurance domain and the relationships among them, providing a uniform way to enable communication among the associated stakeholders. Knowledge differs from data and information as data is present in raw and unprocessed form, information is the processed form of data, whereas knowledge is the self-learning through experiences and skills [1]. The transition of concepts from data to knowledge is taking place around the world, as is the transition of the web from a document model to a data model. The Semantic Web, which is an extension of the current web [2], aims to enrich the Web with a layer of machine-interpretable metadata so that computer programs can predictably derive new information and knowledge, furnishing better data integration, interoperation and more intelligent support for the end users.

Since the ontology development in the insurance domain is underexplored, we created the ontology from scratch. Auto ontology is a unique ontology that systematically maps spreadsheet-based insurance data into the ontology with the help of JSON transformation rules. The ontology is evaluated using SPARQL. It helps to improve interoperability, reusability, and intelligent querying in the insurance sector.

Ontology creation in any domain requires a syntax for representing metadata and Vocabularies for expressing the metadata. The W3C (World Wide Web Consortium) has defined such open standards for metadata syntax as RDF (Resource Description Framework), OWL (Web Ontology Language), SPARQL, SQWRL, etc.

In this paper, a Knowledge Representation (KR) of the automobile insurance sector domain is presented using Semantic Web tools. Ontology development is an evolving process; there is surely a scope for further enhancement. Section 2 presents a discussion on related work in multiple domains, followed by a brief overview of the tools and techniques used for knowledge representation,

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which is outlined in Section 3. Section 4 contains the evaluation of the ontology using SPARQL queries, which ends with the conclusion and future scope of our research in Section 5.

2. RELATED WORK

An extensive amount of work has been done in the field of knowledge representation in various domains using SW technologies. A thorough literature review was done with the motive to study the different Knowledge Representation (KR) methodologies using SW technologies.

Research in the Semantic Web has created a robust framework for knowledge representation and interoperability that allows various concepts, relations and constraints to be machine-interpreted across numerous domains [2, 12]. An ontology-based framework has become a part of various knowledge-based industrial business applications. The oil and Gas industry has used semantic web technology to detect the cause of external corrosion. The data of the state of corroding assets was collected in CSV files and transformed into RDF, and to address the heterogeneity, an ontology model was developed, and knowledge was inferred from the ontological data [3]. The technology supported the design of a system that could detect corrosion efficiently and precisely. The data of a city in an urban space domain was also represented using OWL 2. A knowledge base was created to include the public, private buildings and open spaces in the street. The street knowledge was represented using Urban Morphology Ontology (UMO) and UrbanGen tool, and the alternatives for street designers were also generated to design street patterns [4]. A complete overview of SW and KR was given in [5]. The researchers, through their experimentations, extended the capability of ontologies to represent the temporal knowledge, that is, quantitative and qualitative. The extension of quantitative temporal knowledge was implemented using Semantic Web Rule Language (SWRL) and OWL axioms [6]. To reason the temporal knowledge, an interval-based ontology, TL-OWL, was created [7]. Ontology-based knowledge representation and reasoning techniques were also used to provide knowledge about the environment to the robots [8]. The multiple geometric knowledge representations were performed through turtle, RDF API JENA, and ontology in the geo-visualisation domain [9]. A KB is created using SPIN (SPARQL Inferencing Notation) rule engine, and knowledge from multiple rescue missions was stored in different formats, like OWL, RDF triples, etc. using JSON rules [10].

Before the creation of Auto ontologies, a search was performed for ontologies about Automobile Insurance Data. However, no available ontologies were found, with the adhering characteristics to the required ontology to be extended and reused. So, the next step was to create an Automobile Insurance ontology from a starting point using rules and data from the domain of the automobile insurance sector. The aim is to provide frameworks for representing shareable and reusable knowledge across the insurance domain, providing interconnectedness and suitable relationship representation leading to interoperable, linked and coherent data.

3. TOOLS AND TECHNIQUES USED FOR REPRESENTATION

An ontology is a formal description of knowledge as a collection of concepts within a domain and the connections between them. It guarantees a shared interpretation of the data and explicitly states the domain assumptions, enabling companies to better understand their data.

Ontologies make it easier for the domain to connect individuals, groups, and application systems. A number of formal languages have evolved for ontology development. These languages make it easier to encode knowledge in specified domains, and they usually provide reasoning features that allow for the processing of the stored knowledge. Typically, these languages are declarative in nature, based on description logic or first-order logic [11]. Auto is created using the W3C Web Ontology Language (OWL) [12] and Protégé 5.5.0 which is an ontology development environment. OWL is a Semantic Web language designed to render complicated knowledge about objects, their groupings, and the relationships among them.

Data was entered in Protégé tool (version 5.5.0), with the purpose of creating an ontology called Auto containing the automobile domain insurance classes and their associated object properties. The hierarchical representation is as implemented in Figure 1. The plugin works with the Java Script Object Notation (JSON) rules. These rules were created while maintaining the integrity of the data. The rules then generate instances on the basis of the dataset, as shown in Figure 2.

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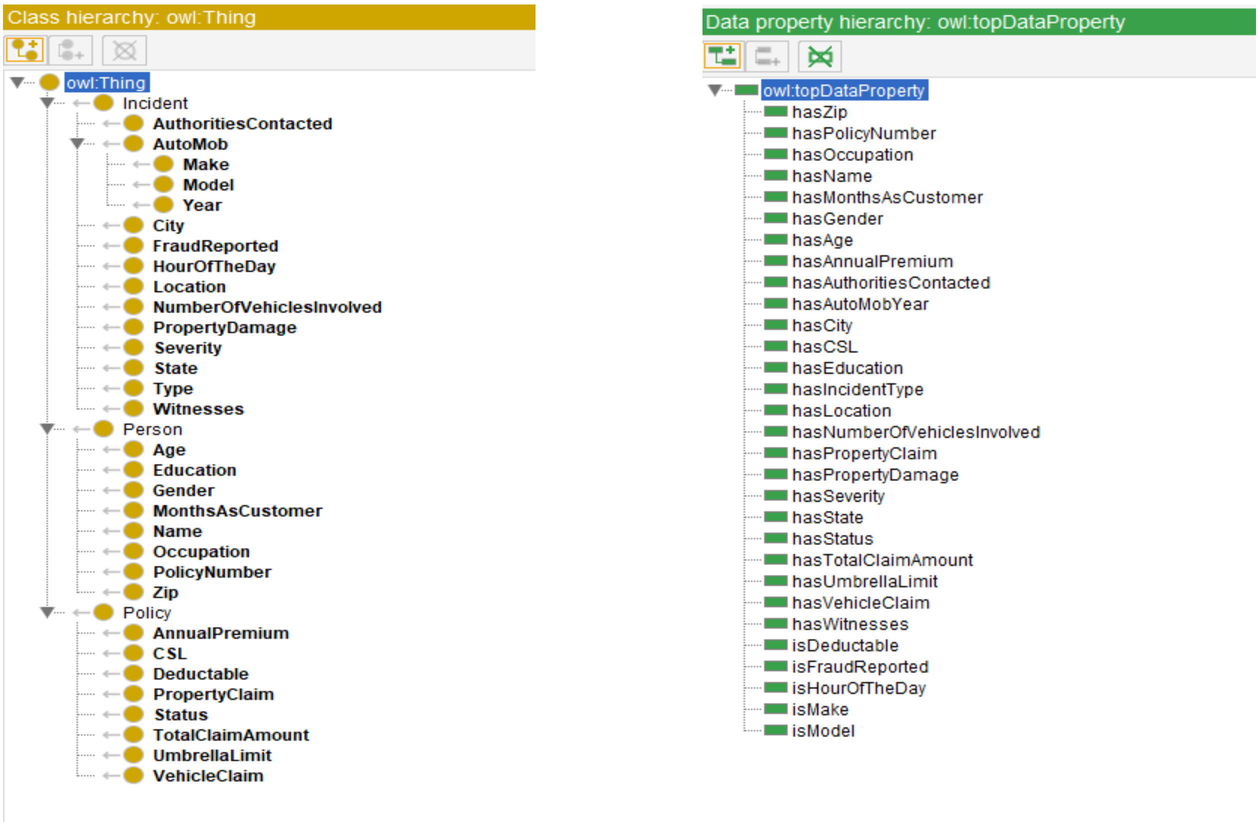

Figure 1: Hierarchical representation of the automobile domain

The instances are created using Cellfie plugin, such that it includes data into the ontology. The editor included with the Cellfie plugin is used to construct the transformation rules. The rules are kept as JSON files. According to the transformation rules, axioms are generated.

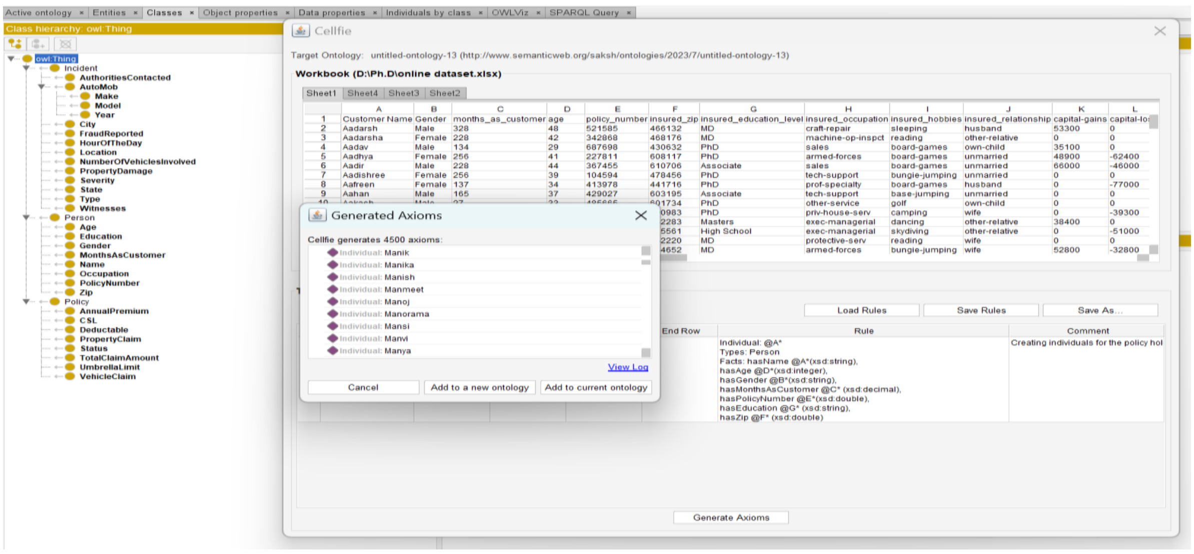

Figure 2: Instances created using JSON rules

These instances are further represented using RDF triples. The representation of the dataset in the form of triples is depicted in the table given below.

Subject	Predicate →	Object
Aadhya	hasAge →	41
Aadhya	hasPolicyNumber →	227811

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A customer dataset pertaining to insurance sector been taken from an online platform, Kaggle.com, and then mapped to the ontology using Cellfie protégé plugin [13]. The dataset has been cleaned by removing the unnecessary outliers, values and duplicate values. It includes 500 values which are represented using Cellfie plugin of the Protégé application. Each entity of the dataset has the values such as customer name, gender, age, policy number, etc. The knowledge of these entities is represented using JSON transformation rules. A snapshot of the dataset is shown in Figure 3.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Customer Name	Gender	months_a	age	policy_nu	insured_zi	insured_e	insured_o	insured_h	insured_re	capital-gai	capital-los	incident_t	collision_t	incident_s	authoritie
2	Aadarsh	Male	328	48	521585	466132	MD	craft-repa	sleeping	husband	53300	0	Single Veh	Side Collis	Major Dar	Police
3	Aadarsha	Female	228	42	342868	468176	MD	machine-c	reading	other-rela	0	0	Vehicle Th	?	Minor Dar	Police
4	Aadav	Male	134	29	687698	430632	PhD	sales	board-gan	own-child	35100	0	Multi-vehi	Rear Collis	Minor Dar	Police
5	Aadhya	Female	256	41	227811	608117	PhD	armed-for	board-gan	unmarriec	48900	-62400	Single Veh	Front Colli	Major Dar	Police
6	Aadir	Male	228	44	367455	610706	Associate	sales	board-gan	unmarriec	66000	-46000	Vehicle Th	?	Minor Dar	None
7	Aadishree	Female	256	39	104594	478456	PhD	tech-supp	bungie-jur	unmarriec	0	0	Multi-vehi	Rear Collis	Major Dar	Fire
8	Aafreen	Female	137	34	413978	441716	PhD	prof-speci	board-gan	husband	0	-77000	Multi-vehi	Front Colli	Minor Dar	Police
9	Aahan	Male	165	37	429027	603195	Associate	tech-supp	base-jump	unmarriec	0	0	Multi-vehi	Front Colli	Total Loss	Police
10	Aakash	Male	27	33	485665	601734	PhD	other-serv	golf	own-child	0	0	Single Veh	Front Colli	Total Loss	Police
11	Aalok	Male	212	42	636550	600983	PhD	priv-house	camping	wife	0	-39300	Single Veh	Rear Collis	Total Loss	Other
12	Aanchal	Female	235	42	543610	462283	Masters	exec-man	dancing	other-rela	38400	0	Single Veh	Front Colli	Total Loss	Police
13	Aaradhya	Female	447	61	214618	615561	High Scho	exec-man	skydiving	other-rela	0	-51000	Multi-vehi	Front Colli	Major Dar	Fire
14	Aarav	Male	60	23	842643	432220	MD	protective	reading	wife	0	0	Single Veh	Rear Collis	Total Loss	Ambulanc
15	Aashi	Female	121	34	626808	464652	MD	armed-for	bungie-jur	wife	52800	-32800	Parked Ca	?	Minor Dar	None
16	Aashna	Female	180	38	644081	476685	College	machine-c	board-gan	not-in-fam	41300	-55500	Single Veh	Rear Collis	Total Loss	Police
17	Abha	Female	473	58	892874	458733	MD	transport-	movies	other-rela	55700	0	Multi-vehi	Side Collis	Major Dar	Other
18	Abhay	Male	70	26	558938	619884	College	machine-c	hiking	own-child	63600	0	Multi-vehi	Rear Collis	Major Dar	Other
19	Abhi	Male	140	31	275265	470610	High Scho	machine-c	reading	unmarriec	53500	0	Single Veh	Side Collis	Total Loss	Police
20	Abhijeet	Male	160	37	921202	472135	MD	craft-repa	yachting	other-rela	45500	-37800	Single Veh	Side Collis	Total Loss	Other
21	Abhik	Male	196	39	143972	477670	High Scho	handlers-c	camping	own-child	57000	-27300	Multi-vehi	Side Collis	Major Dar	Police
22	Abhilash	Male	460	62	183430	618845	JD	other-serv	bungie-jur	own-child	0	0	Multi-vehi	Rear Collis	Minor Dar	Police
23	Abhimanyu	Male	217	41	431876	442479	Associate	machine-c	skydiving	own-child	46700	0	Multi-vehi	Side Collis	Total Loss	Police
24	Abhinav	Male	370	55	285496	443920	High Scho	prof-speci	paintball	other-rela	72700	-68200	Multi-vehi	Rear Collis	Major Dar	Ambulanc

Figure 3: Glimpse of the dataset

The resulting mapping of the dataset in the protégé application is the form of knowledge representation of the domain. An example of the JSON transformation rule has been shown in Table 1. The mapping through the Cellfie 2.1.1 plugin represented the knowledge in the form of rdf, rdf/s, and ontology. These rules were created for the knowledge representation of 500 individuals.

Using the dataset and knowledge gathered from the domain experts and other sources,4595 axioms and 500 instances were generated pertaining to 34 classes and 30 data properties.

{"Collections": [{"sheetName":"Sheet1",
"startColumn":"A",
"endColumn":"A",
"startRow":"2",
"endRow":"+",
"comment": "Creating individuals for the policy holders",
"rule": "Individual: @A*\n
Types: Person\n
Facts: hasName @A*(xsd: string), \n
hasAge @D*(xsd: integer), \n
hasGender @B*(xsd: string), \n
hasMonthsAsCustomer @C* (xsd:decimal),\n
hasPolicyNumber @E*(xsd: double), \n
hasEducation @G* (xsd:string),\n
hasZip @F* (xsd:double)",
"active":true}]}

Table 1: Transformation rule example

4. EVALUATION USING SPARQL QUERY

RDF is a data model for defining resources on the World Wide Web and how they relate to each other, as it stores data in the form of triples. RDF presents data as a data graph, and there is no hierarchy in a data graph. No root node exists. Resources are interrelated with one another in a graph, with no particular resource taking priority over another. This data model's structure is flexible, and relationships are not clearly defined. Therefore, a more adaptable query language is required to efficiently query such a data model. The Semantic Web's SPARQL (SPARQL and RDF Query Language) [14] query language is capable of accessing and modifying data that has been saved in the RDF format.

The Auto ontology has been evaluated using SPARQL language. To run SPARQL query, Apache Jena Fuseki version 4.5.0 has been installed and queries executed using command prompt. The snapshot of the Fuseki server is attached via Figure 4.

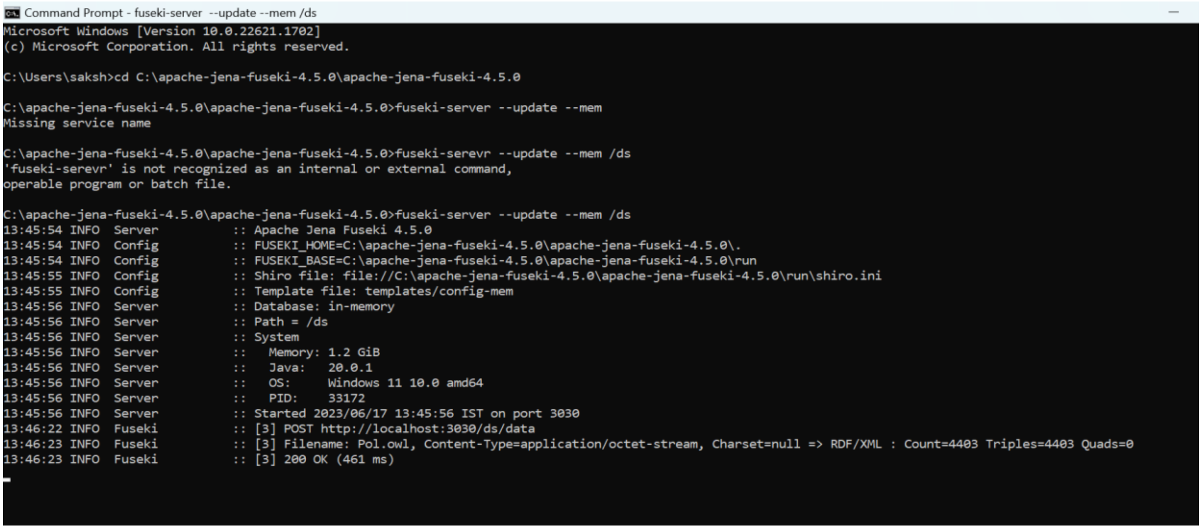

Figure 4: Snapshot of the Fuseki server

The SPARQL query has been executed for the Auto ontology. The auto ontology containing 4596 triples have been uploaded on the server. We have developed different scenarios to validate our ontology and presented results. The SPARQL query to extract the names, policy number and age of the policy holders, and another query to find out the persons having age above 40 years, is shown in the table below:

```
PREFIX owl: http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology 13#
PREFIX rdf: http://www.w3.org/1999/02/22-rdf-syntax-ns#
PREFIX rdfs: http://www.w3.org/2000/01/rdf-schema#
SELECT ?Name ?PolicyNumber ?Age
{
        ?Person owl:hasName ?Name.
        ?Person owl:hasPolicynumber ?PolicyNumber.
        ?Person owl:hasAge ?Age.
}

SELECT ?Person
WHERE
{
        ?Person owl:hasAge ?Age.
        FILTER (?Age >= 40)
}
```

Table 2: SPARQL Query

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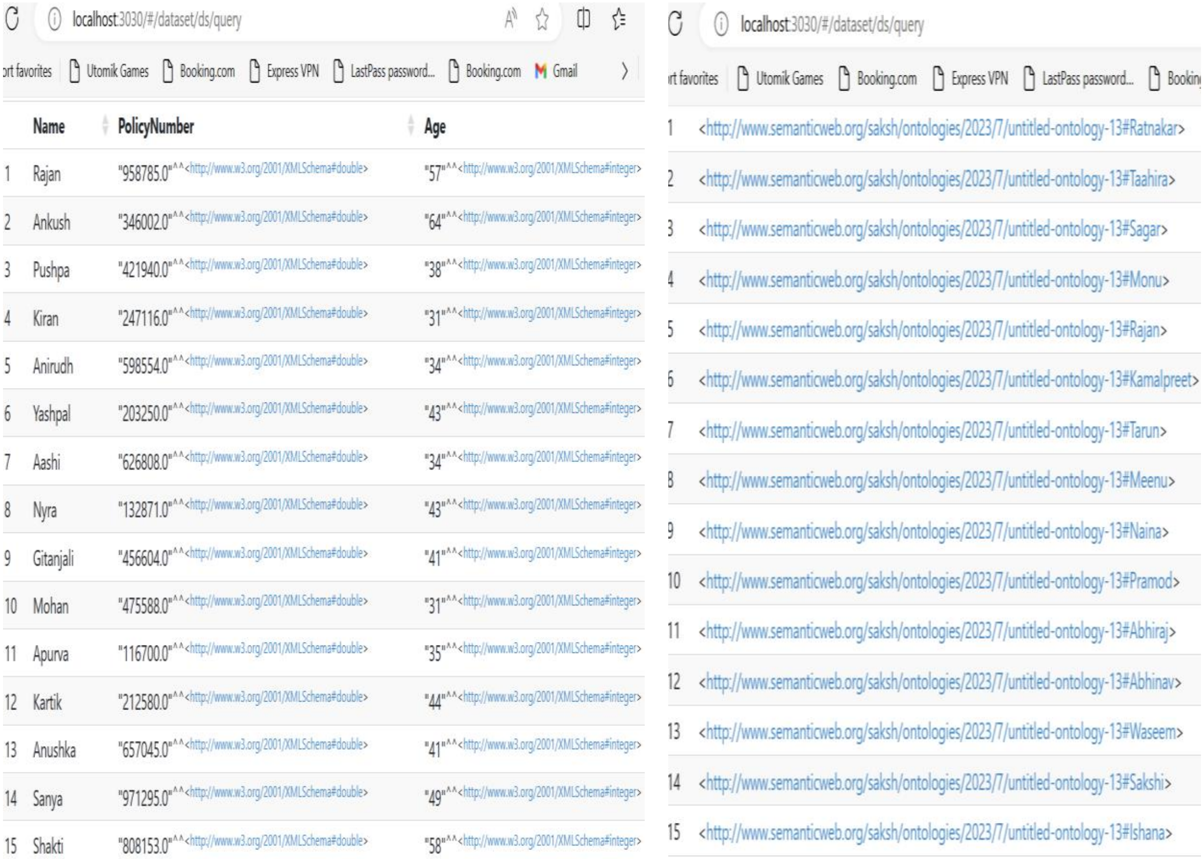
The result of the above query to extract the fields of the dataset, and by applying a Filter condition, is shown in the snapshots below:



	Name	PolicyNumber	Age
1	Rajan	"958785.0"^^<http://www.w3.org/2001/XMLSchema#double>	"57"^^<http://www.w3.org/2001/XMLSchema#integer>
2	Ankush	"346002.0"^^<http://www.w3.org/2001/XMLSchema#double>	"64"^^<http://www.w3.org/2001/XMLSchema#integer>
3	Pushpa	"421940.0"^^<http://www.w3.org/2001/XMLSchema#double>	"38"^^<http://www.w3.org/2001/XMLSchema#integer>
4	Kiran	"247116.0"^^<http://www.w3.org/2001/XMLSchema#double>	"31"^^<http://www.w3.org/2001/XMLSchema#integer>
5	Anirudh	"598554.0"^^<http://www.w3.org/2001/XMLSchema#double>	"34"^^<http://www.w3.org/2001/XMLSchema#integer>
6	Yashpal	"203250.0"^^<http://www.w3.org/2001/XMLSchema#double>	"43"^^<http://www.w3.org/2001/XMLSchema#integer>
7	Aashi	"626808.0"^^<http://www.w3.org/2001/XMLSchema#double>	"34"^^<http://www.w3.org/2001/XMLSchema#integer>
8	Nyra	"132871.0"^^<http://www.w3.org/2001/XMLSchema#double>	"43"^^<http://www.w3.org/2001/XMLSchema#integer>
9	Gitanjali	"456604.0"^^<http://www.w3.org/2001/XMLSchema#double>	"41"^^<http://www.w3.org/2001/XMLSchema#integer>
10	Mohan	"475588.0"^^<http://www.w3.org/2001/XMLSchema#double>	"31"^^<http://www.w3.org/2001/XMLSchema#integer>
11	Apurva	"116700.0"^^<http://www.w3.org/2001/XMLSchema#double>	"35"^^<http://www.w3.org/2001/XMLSchema#integer>
12	Kartik	"212580.0"^^<http://www.w3.org/2001/XMLSchema#double>	"44"^^<http://www.w3.org/2001/XMLSchema#integer>
13	Anushka	"657045.0"^^<http://www.w3.org/2001/XMLSchema#double>	"41"^^<http://www.w3.org/2001/XMLSchema#integer>
14	Sanya	"971295.0"^^<http://www.w3.org/2001/XMLSchema#double>	"49"^^<http://www.w3.org/2001/XMLSchema#integer>
15	Shakti	"808153.0"^^<http://www.w3.org/2001/XMLSchema#double>	"58"^^<http://www.w3.org/2001/XMLSchema#integer>

1	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Ratnakar>
2	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Taahira>
3	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Sagar>
4	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Monu>
5	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Rajan>
6	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Kamalpreet>
7	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Tarun>
8	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Meenu>
9	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Naina>
10	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Pramod>
11	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Abhiraj>
12	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Abhinav>
13	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Waseem>
14	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Sakshi>
15	<http://www.semanticweb.org/saksh/ontologies/2023/7/untitled-ontology-13#Ishana>

Figure 5: Snapshots of the result of SPARQL query

The query is executed for the dataset of 500 values. So, it has generated 500 results for the first query and 225 results for the second query.

5. CONCLUSION AND FUTURE SCOPE

The vastness of data generated and ever-enduring data requirements have been propulsive in Semantic Technology research to progress and to meet the industrial expectations by improving query access, performance, and inferencing competence. An insurance ontology can play the role of a common, standardized vocabulary that helps communication and knowledge exchange between insurance partners, in the form of Linked Data. By taking advantage of the Auto ontology, we have shown that it is possible to make query formulation and execution more comprehensible and to enable reasoning-based queries facilitating industries facing ever-increasing datasets in making meaningful use out of them, and use semantic analytics as an advantage.

Protégé 5.5.0 served as a reliable tool for the representation the undertaken work for its aptness towards creating interoperable, reusable and unambiguous ontologies.

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Declarations:

Ethical Approval: This study did not require formal ethical approval as it involved the use of publicly available data and did not involve human participants or animals. All procedures adhered to ethical research standards, including respect for privacy and confidentiality. The research was conducted in accordance with applicable institutional guidelines and regulations. No sensitive or personal data were collected, and the study did not pose any risks to individuals or groups. Ethical considerations were carefully observed throughout the research process to ensure the integrity and reliability of the findings.

Consent to publish: I, Sakshi Gupta, hereby give my consent for the publication of the research paper titled 'Using JSON and SPARQL to map Insurance Domain Data from Spreadsheets to OWL' in Multimedia Tools and Applications. I confirm that the work is original, and all necessary approvals, including ethical and institutional, have been obtained. I have contributed significantly to the research and the writing process, and all co-authors, if any, have given their consent as well. I understand that the paper will be publicly available and may be subject to peer review. I agree to abide by the publication's terms and conditions, including copyright policies.

Consent to participate: I, Sakshi Gupta, give my consent to participate in the research work titled "Using JSON and SPARQL to map Insurance Domain Data from Spreadsheets to OWL' conducted by me. I understand the objectives of the study, the procedures involved, and any possible risks or benefits. I am aware that my participation is entirely voluntary, and I can withdraw at any time without any consequence. I also understand that my data will be kept confidential and used only for the purposes of this research.

Author Contributions: The present study done by Sakshi Gupta, Lalit Sen Sharma and Neha Jain, introduces the ontological framework for the representation of insurance domain data. The current insurance sector is quite messy and unreliable as it is driven by agents of the companies. Our work incorporates the semantic view to the knowledge of the insurance domain. The ontology is the explicit representation of the concepts used. An ontology is a reliable way to incorporate the conceptual knowledge of concepts used in this domain.

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Competing Interests Statement: The authors declare that they have no competing interests.

There are no financial, professional, or personal conflicts that could have influenced the

research, analysis, or conclusions presented in this manuscript.