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An Ontology to Support Semantic Management of FMEA Knowledge

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Abstract: Risk mitigation has always been a special concern for organization's strategic management. Various tools and techniques have been developed to manage risk in an effective way. Failure Mode and Effects Analysis (FMEA) is one of the tools used for effective assessment of risk. It analyzes all potential failure modes, their causes, and effects on a product or process. Moreover it recommends actions to mitigate failures in order to enhance product reliability. Organizations spend their resources and domain experts make their efforts to complete this analysis. It further helps organizations identify the expected risks and plan strategies in advance to tackle them. But unfortunately the analysis produced after spending a lot of organizational assets and experts' struggles, is not reusable due to its natural language text based description. Information and communication technology experts proposed some solutions but they are associated with some deficiencies. Authors in [13] proposed an ontology based solution to extract and reuse FMEA knowledge from the textual documents, and this article is the first step towards its implementation. In this article we proposed our ontology for Process Failure Mode and Effects Analysis (PFMEA) for automotive domain, along with its implementation, reasoning, and data retrieval through it.

Keywords: Ontology, FMEA, Knowledge Management, OWL, Protégé, SPARQL.

1 Introduction

Since ever we have been managing our knowledge as best as we could. In beginning the acquisition and storage of knowledge were the biggest issues but Information Technology turned the tables and now just one click on Google search button brings us pools of knowledge we desire. Ordinary gadgets can store Gigabyte to Terabytes of information and cloud storage offers access to logical storage of a physical storage spanning over multiple locations. On one hand these advances in technology are making storage and acquisition of knowledge easier and on the other hand it has become awfully essential for organizations to capture, store, apply and share their knowledge in a collective and systematic way, so they could survive and flourish in this knowledge based economy era. Thus the knowledge management has become a dire need of organizations and industry. They need to structure their knowledge and transform it into valuable competencies, products, and services for effective and well-timed utilization in order to make fruitful decisions. Risk management for an organization is a set of strategic level activities that maximizes the chances of objectives being achieved, by systematically understanding and

evaluating the project level risks. It has become a core part of organization's strategic management. Organizations spent the significant share of their investments in handling expected and unexpected risks on a project. Risk management is a process of risk identification, risk assessment, risk response and control development [6]. Risk assessment is a critical phase after risk identification as outcome of this phase leads to develop appropriate response and control for a risk. There are different tools available for risk assessment, e.g., scenario analysis for event probability and impact, risk assessment matrix, FMEA, probability analysis, and semi-quantitative scenario analysis. FMEA is a systematic tool to assess the risks associated to a product or process. It highlights all potential failure modes and their impacts on a product in advance so that they could be fixed timely in order to achieve desired goals. In 1960's for the very first time aerospace industry brought it into use during Apollo mission. In 1974, the US Navy developed MIL-STD-1629 about its use. Since late 1970's, it is in use in automotive industry for safety and reliability analysis. Nowadays this inductive reasoning tool is extensively being used in almost every engineering sector [14]. It finds all possibilities in which a product or process might go wrong (failure modes), determines the effect(s) of each failure mode along with severity, cause(s) of failure mode along with frequency(occurrence) and also the level of difficulty in order to detect a failure (detection). Further it calculates the Risk Priority Number (RPN) by multiplying magnitude values of severity, occurrence, and detection. Depending on the value of RPN, recommendations are determined and executed along with newly predicted values of severity, occurrence, detection, and RPN [15]. The knowledge produced during the process of

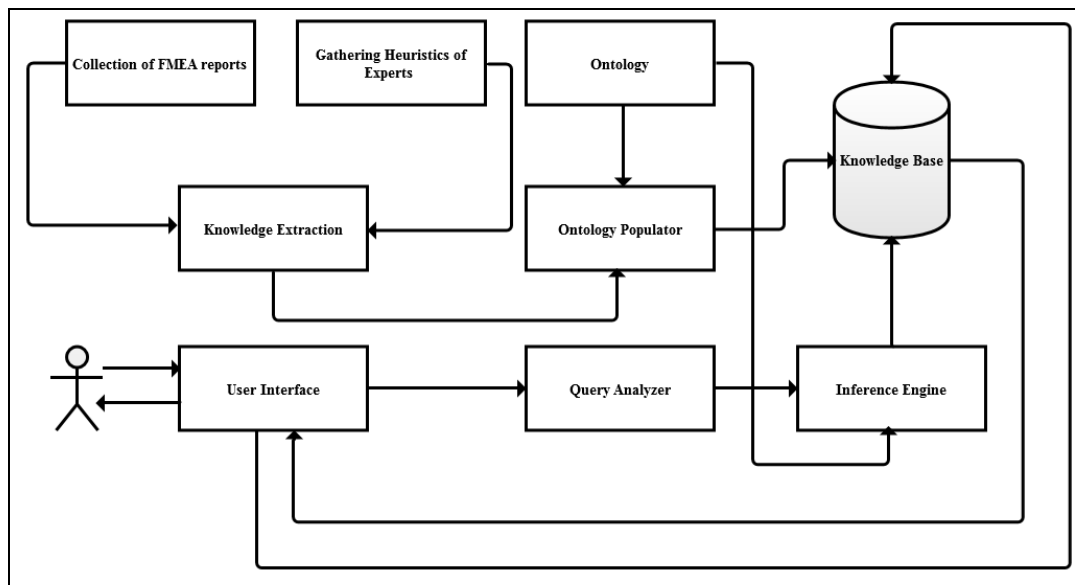


Figure 1: Conceptual architecture of ontology based knowledge management system for FMEA [13]

FMEA is really valuable. If it is adequately managed and re-utilized, it can reduce cost and effort. Although organizations spend huge cost and effort to apply FMEA method but knowledge acquired during this analysis is neither reused nor shared. Since it is not semantically organized, its interpretation varies from person to person and from situation to situation. It is usually found incomplete but larger in size due to its redundant production and that larger size makes it imprecise as well [9]. Artificial Intelligence proposed different solutions for this problem, e.g., rule based expert systems, case based reasoning, and knowledge based systems with ontological support. Among all these, knowledge based systems with ontological support are found most appropriate as rule based systems are not suitable if domain knowledge is larger enough, because

Table 1: FMEA Worksheet [16]

Process Failure Mode and Effects Analysis																
FMEA Number: _____			Team Leader: _____			Process Responsibility: _____										
Prepared By: _____			FMEA Date (Orig.): _____			FMEA Date (Rev.): _____										
Process Name	Potential Failure Mode	Effect(s) of Failure	SEV	Causes	OCC	Current Controls		DET	RPN	Recom. Action	Resp. & Comp. By	Action Result				
						Prevention	Detection					Action	SEV	OCC	DET	NRPN

its coding, verification, validation, maintenance, and inference through it becomes complex and time consuming [2]. In case based reasoning all probable cases are stored in case library with additional overhead of their attributes and references, moreover the information returned by such engines is not well formatted [8]. Available ontology based approaches to support FMEA also lack some significant aspects, e.g., in (Lee, 2001) authors presented FMEA only as a conceptual model without any inference and rules. Authors in [1] considered the discrepancies left by [7] and proposed a system, based on the combination of knowledge management and quality management concepts but it lacks functional taxonomy. In [10] authors discussed a better ontology based approach for FMEA procedure representation in lead free soldering but this proposal is still being worked on. Moreover no specific ontology is found to address the FMEA knowledge sharing and reuse for automotive domain. To address all these issues authors in [13] presented a conceptual architecture of their proposed system as given in figure 1 and this article in first step towards its implementation. This article is about the ontology we developed for representation and retrieval of PFMEA knowledge. Knowledge of interest used in this ontology is from automotive domain. Automotive engineering (vehicle engineering) deals with the design, manufacturing, and operation of vehicles (automobiles, buses, motorcycles etc.). It assimilates various components from different engineering sectors, e.g., mechanical, electrical, electronics, software, safety and quality engineering. From designing to production there are different kind of activities (belonging to different fields of engineering) are involved. Productivity of each activity heavily relies on past experiences, expertise of concerned people, and customer feedback. Better management of all this knowledge helps organizations improve time to market and customer satisfaction which not only helps earn better profit but brings sustainability for an organization in the market. In section 2 and 3, tools used to develop and query the ontology, are discussed. Section 4 describes the process of ontology development in detail, section 5 illustrates some query examples, and section 6 concludes the discussion with highlights of future work.

2 Protégé

Protégé is an open source software tool by Stanford University to develop domain models and knowledge based systems with ontology. It facilitates with both of the foremost means to model an ontology, e.g., frames and OWL (Web Ontology Language). It has built-in reasoning support for computing the inferred ontology class hierarchy and ontology consistency checking [13]. We used Protégé 5.0 beta version. Using it we developed our OWL ontology with RDF/XML format. RDF/XML format is a syntax defined by W3C to present RDF (Resource Description Format) graph by defining triples of subject, predicate, and object in XML (EXtensible Markup Language) format [12]. We developed ontology in OWL, the language beyond RDF schema that allows machines to perform more useful reasoning on its documents, and created its individuals (instances) in RDF. We got reasoning support from Protégé's built-in reasoner Hermit version 1.3.8.3. Hermit is an efficient reasoner based on "hypertableau" calculus that takes a few seconds to reason complex ontologies that are written in OWL. It reads an OWL file and determines the consistency of classes and their properties [4]

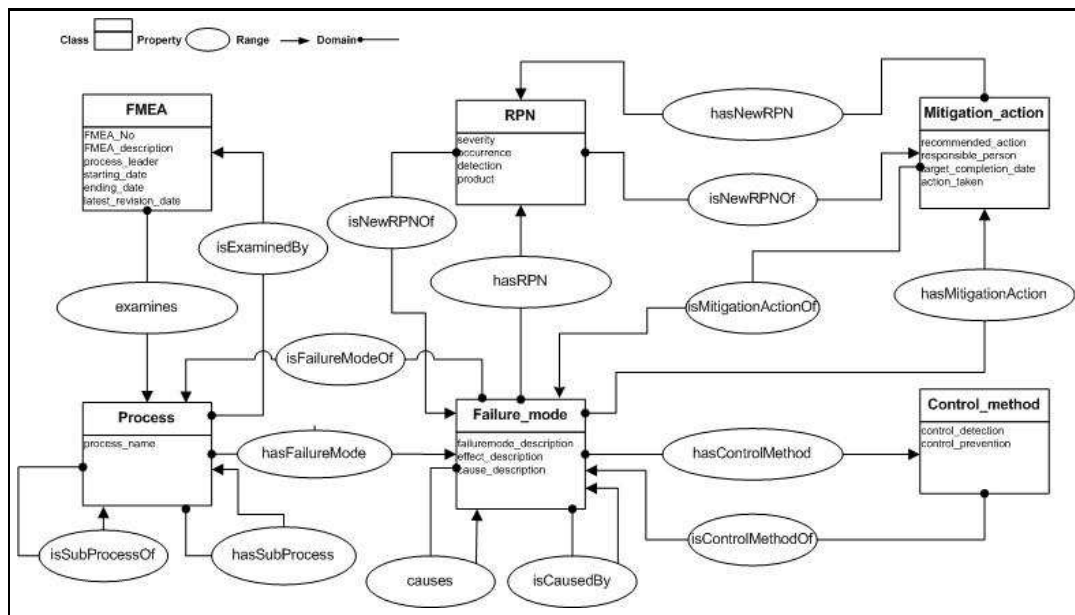


Figure 2: PFMEA ontology

3 SPARQL and Jena Fuseki Server

Jena is an open source Semantic Web framework for Java. It facilitates with an API (Application Program Interface) for extraction and writing data to/from RDF graphs. The graphs are represented as an abstract model, which can be sourced with data from files, databases, URLs or a combination of these. Fuseki is an http interface to RDF data that supports SPARQL (W3C recommended language to query directed labeled RDF graphs) for querying and updating RDF graphs. We used Apache Jena Fuseki server version 1.1.0. It provides REST-style SPARQL HTTP Update, SPARQL Query, and SPARQL Update by using the SPARQL protocol over HTTP [5]. It can be freely downloaded and runs on port 3030 in web browser.

4 Development of FMEA ontology

According to classic definition by [3] the ontology is an explicit specification of conceptualization. In information science perspective the ontology is a formal representation of the knowledge of a specific domain as a set of concepts within a domain, and the relationship between those concepts. It provides shared vocabulary and common (unambiguous) understanding of a domain and supports reasoning about the concepts. According to W3C definition, ontology is a vocabulary that defines concepts, relationship between concepts, and constraints on their usage in order to define and represent domain of discourse [11]. An ontology consists of different components, e.g., classes, properties (relationship of classes), and individuals (instances of the domain of discourse). In this section all these terms will be discussed in PFMEA perspective. In table 1 a PFMEA worksheet is shown. Using the PFMEA attributes given in that worksheet we designed an ontology given in figure 2.

This ontology is based on five different classes whereas all these classes are logically subsumed

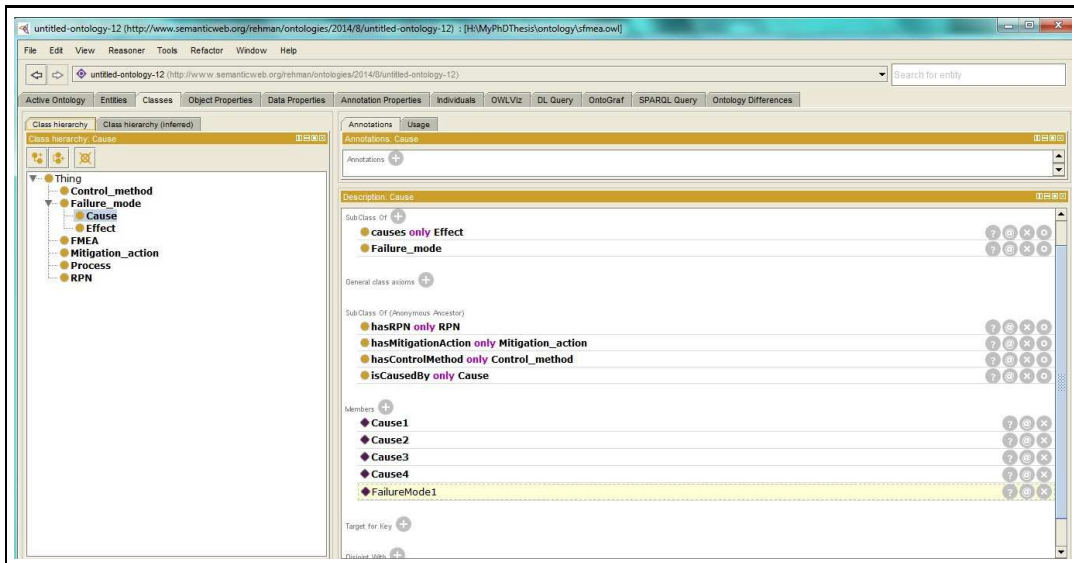


Figure 3: PFMEA classes and sub-classes in Protégé

sub-classes of the root concept “Thing”. According to ISO-15926 “Thing” is a top-level ontology (collection of general concepts same in all knowledge domains) that subsumes abstract object and possible individual classes. Any immaterial object (which exists only as a concept) can be said an abstract object, e.g., information; and any material object (which exists in time and space) is known as possible individual, e.g., a pen.

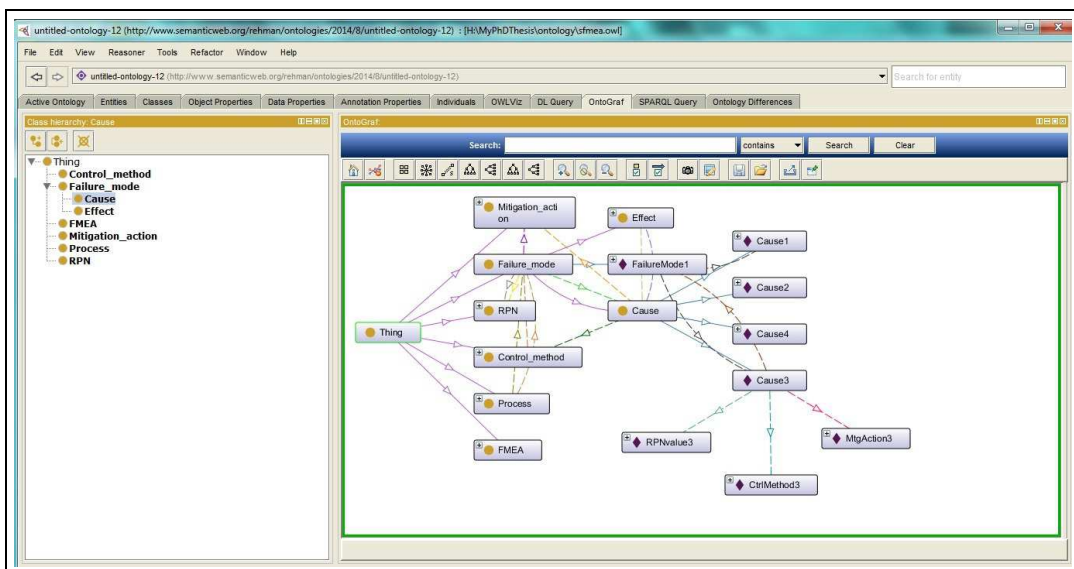


Figure 4: OntoGraph in Protégé

Rest of the classes, their attributes with data types, and relationships with one another are described following.

- FMEA class represents the header information of FMEA worksheet. Its attributes are FMEA_No (string), FMEA_description (string), process_leader (string), starting_date (dateTime), ending_date (dateTime), and latest_revision_date (dateTime). Object

property `examine` (inverse: `isExaminedBy`) connects FMEA class to Process class.

- Process class describes a process or a sub-process under analysis. It has a single attribute `process_name` (string). Object property `hasSubProcess` connects it to itself, whereas the property `hasFailureMode` (inverse: `isFailureModeOf`) connects it to class `Failure_mode`.
- `Failure_mode` class represents a failure mode, its cause(s) and effect(s). It has three attributes `failuremode_description` (string), `effect_description` (string) for sub-concept Effect, and `cause_description` (string) for sub-concept Cause. Different object properties are part of the concept `Failure_mode`. The `hasControlMethod` (inverse: `isControlMethodOf`) connects it to class `Control_method`, `hasMitigationAction` (inverse: `isMitigationActionOf`) connects it to concept `Mitigation_action`, it is related to class RPN through property `hasRPN` (inverse: `isRPNOF`). As a failure causes another failure and inversely a failure is the effect of another failure, therefore the concept `Failure_mode` is divided into two sub-concepts Cause and Effect. Object properties `causes` and `isCausedBy` (inverse of one another) make it distinguished if a failure is a cause or an effect. A failure that demonstrates root cause nature is only responsible to bear the relation with concepts `Control_method`, `Mitigation_action` and RPN.
- RPN class represents the magnitude impacts of a failure mode, its effect and analysis. Its attributes are `severity` (integer), `occurrence` (integer), `detection` (integer), and their product (integer).
- `Control_method` class describes the controls for detection and prevention of a failure. It has two attributes `control_detection` (string) and `control_prevention` (string).
- `Mitigation_action` class describes recommendations and actions taken in order to combat a failure. Its attributes are `recommended_action` (string), `responsible_person` (string), `target_completion_date` (dateTime), and `action_taken` (string). Object property `hasNewRPN` (inverse: `isNewRPNOF`) relates it to the concept RPN and on the basis of new RPN value effectiveness of a mitigation action is evaluated.

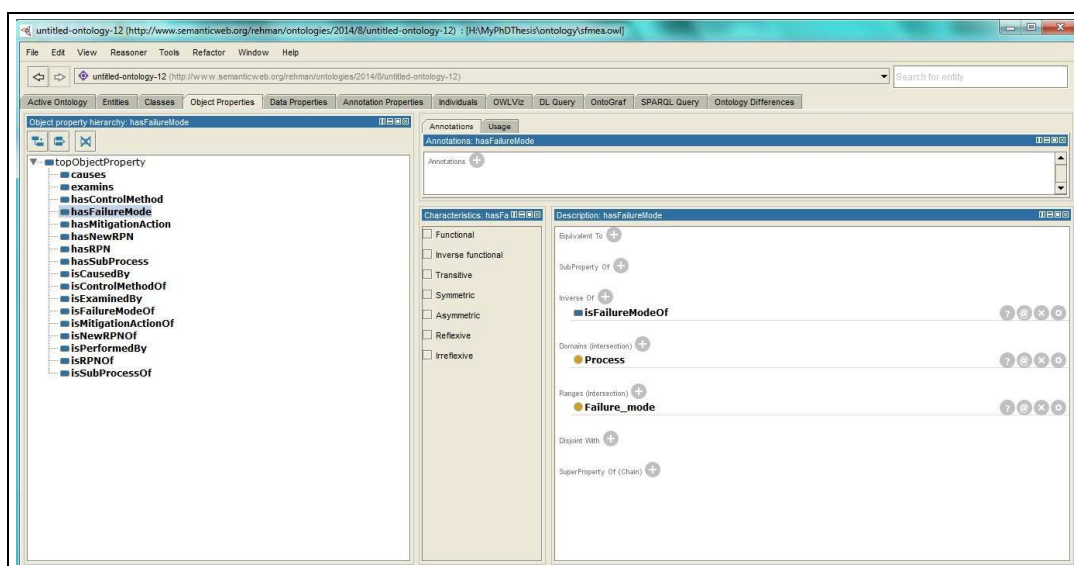


Figure 5: Object properties in Protégé

Figure 4 represents the ontology graph (OntoGraph) of proposed ontology as perceived in Protégé. In figure 5, Protégé is displaying the list of object properties. Each object property is a sub-property of topObjectProperty. Each property connects two classes, known as domain and range. For example the object property hasFailureMode connects two classes the Process and the Failure_mode. It is a relationship from Process to Failure_mode, thus the concept Process is domain of the property and concept Failure_mode is its range. Its inverse property isFailure_ModeOf would be a relation from concept Failure_mode to concept Process. Figure 6 shows the list of data properties, each data property is sub-property of topDataProperty. Data properties are attributes of class which are further used to create variables of instances in order to store some values. Each data property has a domain (the class name it belongs to) and a range (the data type, the type of data it allows to be stored). For example action_taken is an attribute of the concept Mitigation_action and its assertions can have only String data type.

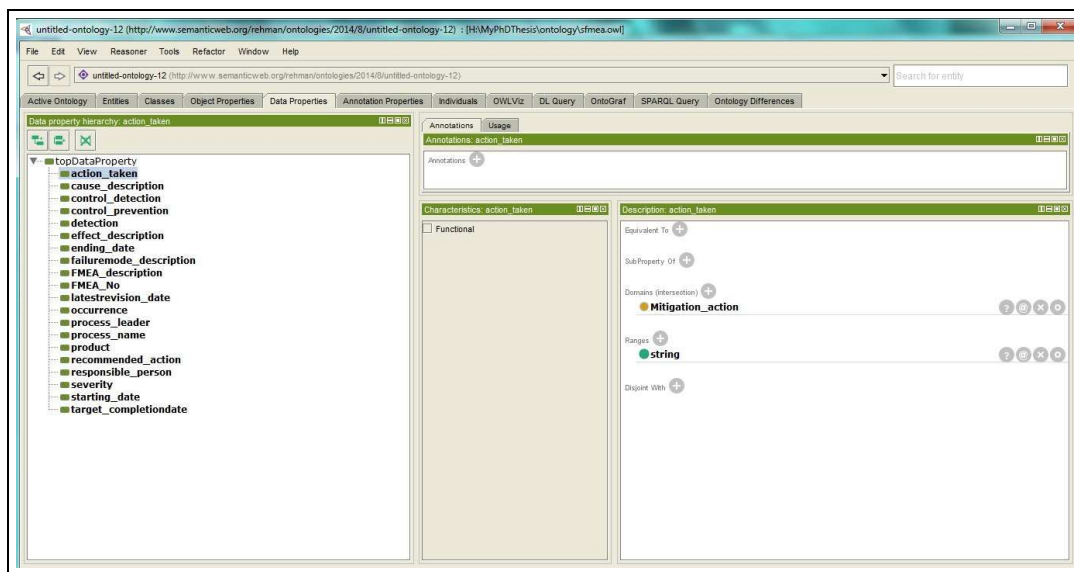


Figure 6: PFMEA data properties in Protégé

Figure 7 shows an inferred individual of concept Cause in Protégé. It clearly shows that a failure mode is caused by a cause and it further causes an effect, consequently any cause which causes a failure mode is actually responsible for its effect too. Figure 8 shows an instance of concept Effect. Figure 9 is also about an inferred individual of concept Mitigation_action. In figure 10 a complete FMEA ontology instance is shown. Whereas figure 11 shows a few instances of FMEA ontology in RDF form.

5 SPARQL queries to retrieve FMEA information from ontology

We used SPARQL with Apache Jena Fuseki server in order to access information from our ontology. Jena Fuseki server provides user friendly Graphical User Interface (GUI) to mount ontologies on server and allows retrieving query results in multiple formats. We chose CSV (Comma-Separated Values) format as original FMEA files are in the same format. Query results in CSV format can be downloaded and saved for further use and can be easily viewed in any CSV viewer. Here are some queries used to extract information from ontology.

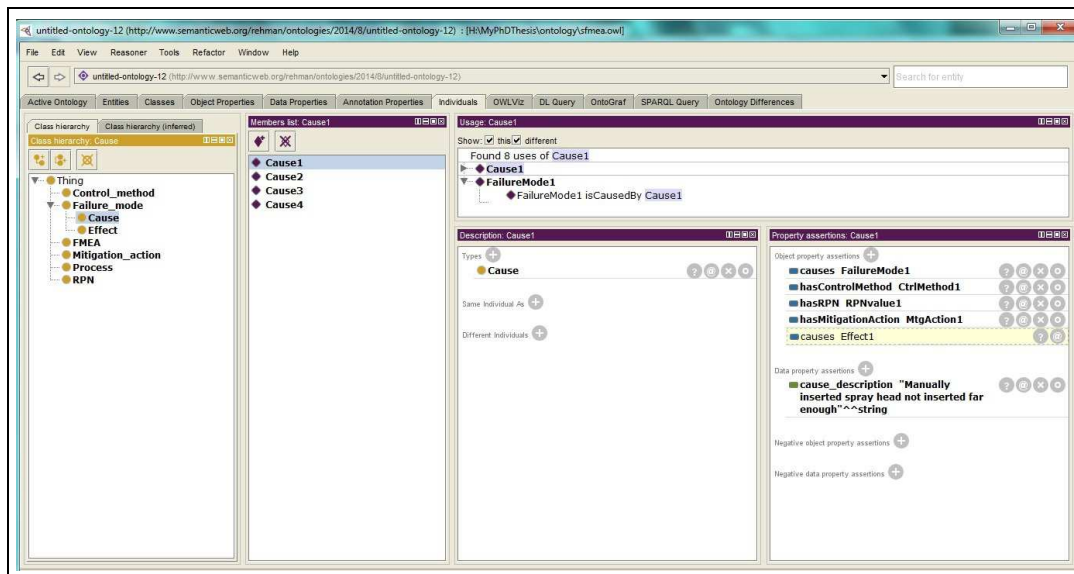


Figure 7: PFMEA instances of a sub-class cause in Protégé

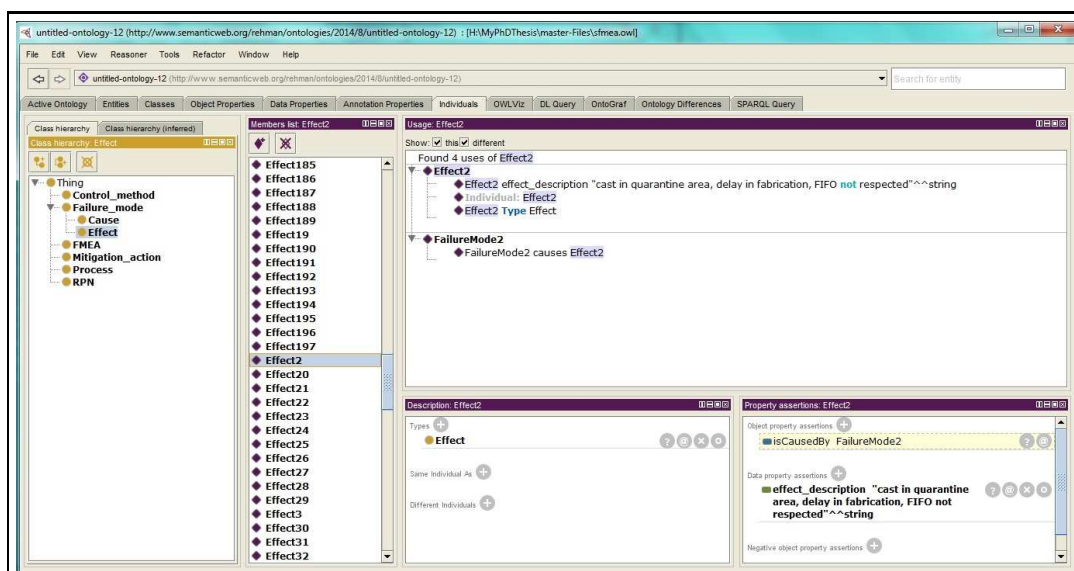


Figure 8: PFMEA instances of a sub-class effect in Protégé

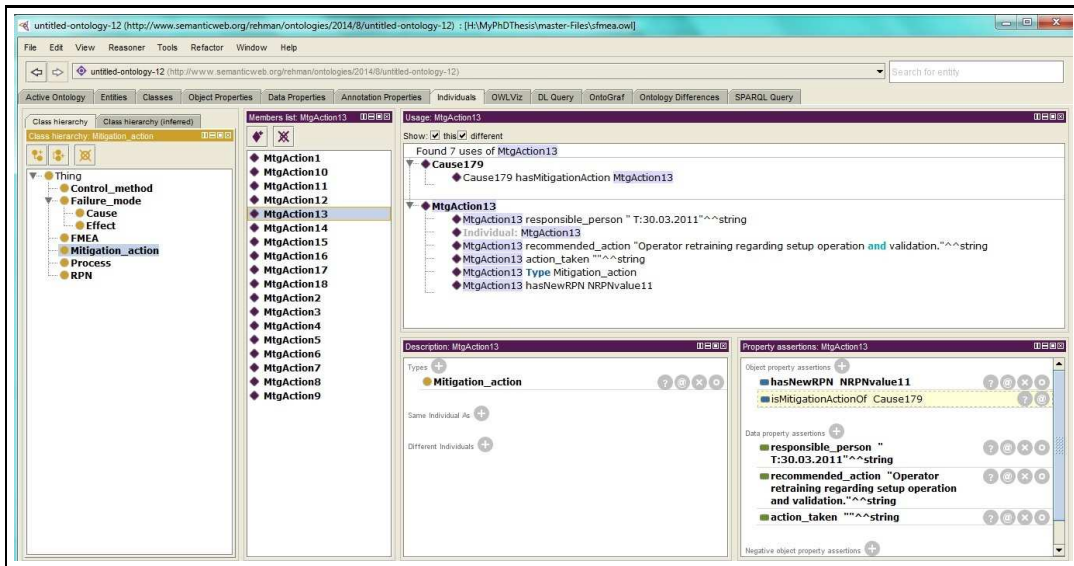


Figure 9: PFMEA instances of a sub-class mitigation_action in Protégé

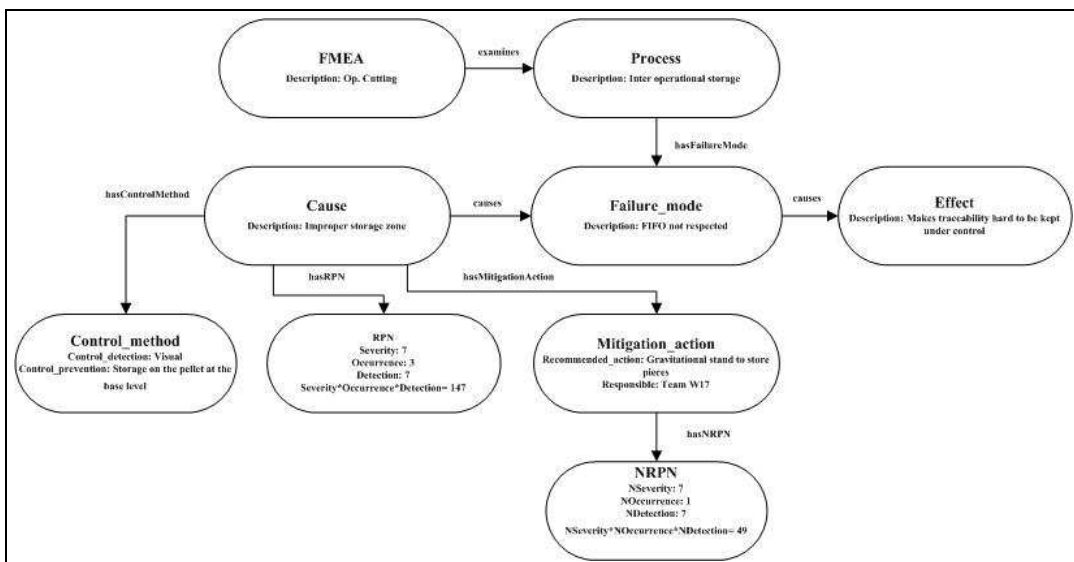


Figure 10: Example of ontology based FMEA instances

```

<!-- http://www.semanticweb.org/rehman/ontologies/2014/8/untitled-ontology-12#Cause1
-->
<owl:NamedIndividual rdf:about="http://www.semanticweb.org/rehman/ontologies/2014/
8/untitled-ontology-12#Cause1">
<rdf:type rdf:resource="http://www.semanticweb.org/rehman/ontologies/2014/8/untitled-
ontology-12#Cause"/>
<cause_description rdf:datatype="&xsd:string">Manually inserted spray head not inserted
far enough</cause_description>
<hasControlMethod rdf:resource="http://www.semanticweb.org/rehman/ontologies/2014/
8/untitled-ontology-12#CtrlMethod1"/>
<causes rdf:resource="http://www.semanticweb.org/rehman/ontologies/2014/8/untitled-
ontology-12#FailureModel"/>
<hasMitigationAction rdf:resource="http://www.semanticweb.org/rehman/ontologies/
2014/8/untitled-ontology-12#MtgAction1"/>
<hasRPN rdf:resource="http://www.semanticweb.org/rehman/ontologies/2014/8/untitled-
ontology-12#RPNvalue1"/>
</owl:NamedIndividual>

```

Figure 11: Example of an FMEA ontology instance in RDF

5.1 Prefixes

Following prefixes are a must for the queries to execute on Jena Fuseki sever, these are used to declare the ontology being used, the language it is developed in and its syntax and schema.

PREFIX owl: <http://www.w3.org/2002/07/owl#Ontology>

PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>

PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>

PREFIX fmea:<http://www.semanticweb.org/rehman/ontologies/2014/8/untitled-ontology-12#>

5.2 Query to display FMEA worksheet header information

```

SELECT (STR(?fno) as ?FMEA_No) (STR(?fd) as ?FMEA_Description) (STR(?pl) as ?Pro-
cessLeader)
(STR(?sd) as ?StartingDate) (STR(?ed) as ?EndingDate) (STR(?ld) as ?LatestRevisionDate)
WHERE
{
?x fmea:FMEA_No ?fno;
fmea:FMEA_description ?fd;
fmea:process_leader ?pl;
fmea:starting_date ?sd;
fmea:ending_date ?ed.
OPTIONAL
{
?x fmea:latestrevision_date ?ld.
}
}

```

Output of this query is shown in figure 12. This query helps know very basic information about an FMEA report. For example the description of the process the report is about, its leader, and all important dates about its initiation, completion, and revision.

	1	2	3	4	5	6
1	FMEA_No	FMEA_Description	ProcessLeader	StartingDate	EndingDate	LatestRevisionDate
2	PN079	Door Analysis	Bert	2014-07-01T09:30:20	2014-08-20T08:40:49	2014-09-15T10:20:15

Figure 12: FMEA worksheet header information in CSV viewer

5.3 Query to display complete details of FMEA process

```

SELECT (STR(?pn) as ?Process) (STR(?fmd) as ?FailureMode) (STR(?ed) as ?Effect) (STR(?sv1)
as ?SEV) (STR(?cd) as ?Cause) (STR(?oc1) as ?OCC) (STR(?cp) as ?CtrlPrevention) (STR(?cdt)
as ?CtrlDetection) (STR(?d1) as ?DET) (STR(?p1) as ?RPN) (STR(?ra) as ?RecommendedAc-
tion)(STR(?at) as ?ActionTaken) (STR(?rp) as ?Responsible) (STR(?tcd) as ?TargetComple-
tedBy) (STR(?sv2) as ?PSEV) (STR(?oc2) as ?POCC) (STR(?d2) as ?PDET) (STR(?p2) as
?PRPN)
WHERE
{
?x fmea:process_name ?pn;
fmea:hasFailureMode ?fm.
?fm fmea:failuremode_description ?fmd;
fmea:causes ?failureEffect;
fmea:isCausedBy ?failureCause.
?failureEffect fmea:effect_description ?ed.
?failureCause fmea:cause_description ?cd;
fmea:hasControlMethod ?ctrlMethod;
fmea:hasRPN ?RPN1;
fmea:hasMitigationAction ?mgt.
?ctrlMethod fmea:control_detection ?cdt;
fmea:control_prevention ?cp.
?RPN1 fmea:severity ?sv1;
fmea:occurrence ?oc1;
fmea:detection ?d1;
fmea:product ?p1.
?mgt fmea:recommended_action ?ra;
fmea:action_taken ?at.
OPTIONAL
{
?mgt fmea:responsible_person ?rp;
fmea:target_completiondate ?tcd;
fmea:hasNewRPN ?RPN2.
?RPN2 fmea:severity ?sv2;
fmea:occurrence ?oc2;

```

```
fmea:detection ?d2;
fmea:product ?p2.
}
}
```

Result was spanning over large window this is why we split it into three as shown in figure 13, 14, and 15. Purpose of this query is to extract all information related to a process. For example its probable failure modes, their causes and effects, magnitude impact of the failure, recommendations and actions taken to reduce impact of failure and the magnitude impact of mitigation made.

1	2	3	4
Process	FailureMode	Effect	SEV
op.70 Manual application of wax inside door panel	Insufficient wax coverage over specified surface	Allows integrity breach of inner door panel, Corroded interior lower door panels, Deteriorated life of door leading to rust through paint and impaired function of inner door hardware	7
op.70 Manual application of wax inside door panel	Insufficient wax coverage over specified surface	Allows integrity breach of inner door panel, Corroded interior lower door panels, Deteriorated life of door leading to rust through paint and impaired function of inner door hardware	7
op.70 Manual application of wax inside door panel	Insufficient wax coverage over specified surface	Allows integrity breach of inner door panel, Corroded interior lower door panels, Deteriorated life of door leading to rust through paint and impaired function of inner door hardware	7
op.70 Manual application of wax inside door panel	Insufficient wax coverage over specified surface	Allows integrity breach of inner door panel, Corroded interior lower door panels, Deteriorated life of door leading to rust through paint and impaired function of inner door hardware	7

Figure 13: FMEA Process details in CSV Viewer

5	6	7	8	9	10
Cause	OCC	Ctr/Prevention	Ctr/Detection	DET	RPN
Spray head deformed due to impact	2	Preventive maintenance programs to maintain heads	Variables check for film thickness, Visual check for coverage	5	70
Spray head clogged by too high viscosity, too low temperature, or too low pressure	5	Test spray at startup and after idle periods and preventive maintenance programs to clean heads	Variables check for film thickness, Visual check for coverage	5	175
Manually inserted spray head not inserted far enough	8	None	Variables check for film thickness, Visual check for coverage	5	285
Spray time insufficient	5	None	Operator instructions, lot sampling visual check coverage of critical areas	7	245

Figure 14: FMEA Process details in CSV Viewer

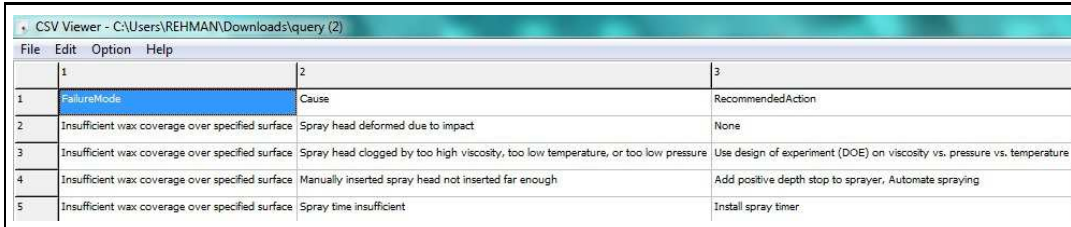
11	12	13	14	15	16	17	18
RecommendedAction	ActionTaken	Responsible	TargetCompletedBy	PSEV	POCC	POET	PRPH
None	None	None	None	None	None	None	None
Use design of experiment (DOE) on viscosity vs. pressure vs. temperature	Temp and pressure limits were determined and limit controls have been installed. Control chart shows that process is in control cpk=1.85	Mfg. Engineering	2014-09-01T10:30:30	7	1	5	35
Add positive depth stop to sprayer. Automate spraying	Stop added sprayer checked online. Rejected due to complexity of different doors on the same line.	Mfg. Engineering	2014-09-01T10:30:20	7	2	5	70
Install spray timer	Automatic spray timer installed operator starts spray, timer controls shut-off. Control chart shows process is in control cpk=2.05	Mfg. Engineering	2014-09-01T11:00:00	7	1	7	49

Figure 15: FMEA Process details in CSV Viewer

5.4 Query to display causes and recommendations for each failure mode

```
SELECT (STR(?fmd) as ?FailureMode) (STR(?cd) as ?Cause) (STR(?ra) as ?RecommendedAction)
WHERE
{
?fm fmea:failuremode_description ?fmd;
fmea:isCausedBy ?failureCause.
?failureCause fmea:cause_description ?cd;
fmea:hasMitigationAction ?mgt.
?mgt fmea:recommended_action ?ra;
fmea:action_taken ?at.
}
```

Output of this query is shown in figure 16. This query helps extract all causes and recommendation for each cause for a specific failure mode.



1	2	3
FailureMode	Cause	RecommendedAction
Insufficient wax coverage over specified surface	Spray head deformed due to impact	None
Insufficient wax coverage over specified surface	Spray head clogged by too high viscosity, too low temperature, or too low pressure	Use design of experiment (DOE) on viscosity vs. pressure vs. temperature
Insufficient wax coverage over specified surface	Manually inserted spray head not inserted far enough	Add positive depth stop to sprayer, Automate spraying
Insufficient wax coverage over specified surface	Spray time insufficient	Install spray timer

Figure 16: Causes and recommendations for each failure mode in CSV Viewer

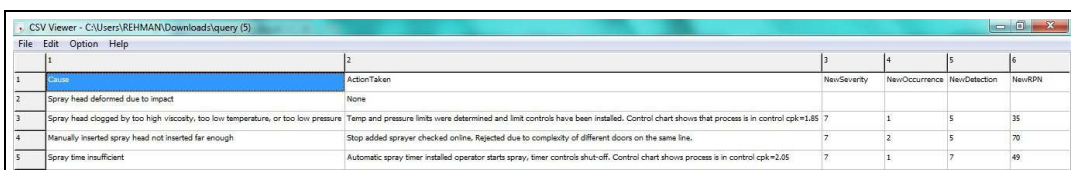
5.5 Query to display causes, effects and recommendations for a specific failure mode

```

SELECT (STR(?cd) as ?Cause) (STR(?at) as ?ActionTaken) (STR(?sv2) as ?NewSeverity)
(STR(?oc2) as ?NewOccurrence) (STR(?d2) as ?NewDetection) (STR(?p2) as ?NewRPN)
WHERE
{
?x fmea:hasFailureMode ?fmd.
?fmd fmea:failuremode_description ?fd.
FILTER regex(?fd,"Insufficient wax coverage over specified surface")
?fmd fmea:isCausedBy ?failureCause.
?failureCause fmea:cause_description ?cd;
fmea:hasMitigationAction ?mgt.
?mgt fmea:action_taken ?at.
OPTIONAL
{
?mgt fmea:responsible_person ?rp;
fmea:target_completiondate ?tcd;
fmea:hasNewRPN ?RPN2.
?RPN2 fmea:severity ?sv2;
fmea:occurrence ?oc2;
fmea:detection ?d2;
fmea:product ?p2.
}
}

```

Output of this query is shown in figure 17. This query extracts causes, mitigation actions, and their magnitude impacts for a given failure mode.



1	2	3	4	5	6
Cause	ActionTaken	NewSeverity	NewOccurrence	NewDetection	NewRPN
Spray head deformed due to impact	None				
Spray head clogged by too high viscosity, too low temperature, or too low pressure	Temp and pressure limits were determined and limit controls have been installed. Control chart shows that process is in control cpk=1.85	7	1	5	35
Manually inserted spray head not inserted far enough	Stop added sprayer checked online, Rejected due to complexity of different doors on the same line.	7	2	5	70
Spray time insufficient	Automatic spray timer installed operator starts spray, timer controls shut-off. Control chart shows process is in control cpk=2.05	7	1	7	49

Figure 17: Causes and mitigation action(s) for a specific failure mode in CSV viewer

6 Conclusion and future work

Nowadays risk management has become a vital part of an organization's strategic management. To achieve the organizational objectives it is mandatory to increase the probability of success and decrease the probability of failure for a product or process. It is only possible when an organization knows about all expected risks and has planned policies and actions for its timely avoidance and mitigation. FMEA is one of the tools available for risk assessment. Because of its effectiveness organizations spend a lot to complete its studies. Due to some reasons as mentioned in introduction section, the valuable information produced by FMEA is not reusable. To combat this problem authors in [13] proposed a system which would be capable enough to extract information from FMEA documents, store it in a knowledge repository, and help retrieving the required information. In this article we presented an important component of that proposed system, the ontology and retrieval of information through it. As we want to develop a system which should be capable of disseminating information in a domain of experts unambiguously, for this we need a common vocabulary, understanding and structure of the specified domain knowledge, machine interpret-able descriptions of concepts and their relations, and a barrier between domain knowledge and operational knowledge; therefore we developed and FMEA ontology that qualifies all these specifications. This article not only presents the ontology but also the semantic ways to retrieve information through it. Our next step is to use this ontology for auto-population of a knowledge base from CSV format FMEA worksheets and then we will measure its effectiveness (in terms of completeness and conciseness) by deploying it, so that domain experts could interact with it for required knowledge.

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