Air Pollution Ontology to Monitor and Control Air Pollution Related Issues in Thailand

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Abstract. As years are passing-by air pollution is reaching its peak in major cities of the world. People are either unaware or helpless as to how to react to the rising air pollution levels. Addressing people's concern on air pollution monitoring, We have come up with a system that can monitor air pollution (PM 2.5) based on location of the user, province and region. The system also allows users to report the causes and enquire about popular solutions for some causes. Furthermore, giving simple yet valuable recommendations to protect themselves from facing potential hazards. The ontology is designed in Web Ontology Language(OWL) using Protege and perform SPARQL querying that simulates interesting user questions thus showing the reasoning power of the ontology..

Keywords: Ontology, air pollution, PM2.5, semantics, reasoning, class expression.

1 Introduction

Air pollution is reportedly the biggest and alarming issue that needs to be addressed in all the major cities of the world. They say, we don't realize the importance of something until we lose it. We humans did not realize the importance of clean and fresh air until we experience suffocation from polluted air. Now is the time get alert and respond to human negligence. So the first step towards better environment is to keep people aware and updated of the air quality around them so that they take some actions to protect their environment. However, the government authorities also have a role to keep check on levels of pollution and take necessary actions.

For the purpose of demonstration, we restrict our area scope to Thailand and its provinces for which we fetch data from Thai Pollution Control Department's website [4]. We have data pertaining to geographical locations, air quality indices issues by World Health Organization(WHO), various pollution causing activities and solutions, and recommended suggestions for the users to caution them towards safety.

In this paper we discuss in detail about our air pollution ontology, the usage of the domain knowledge mentioned above to construct a strong reasoning system. There is one existing ontology that is restricted to only providing hierarchy of pollutants and their sources. It does not deal with aspects like recommendation, location, cause and solutions that our ontology describes.

So the proposed ontology is discussed in detail in subsequent sections and some practical use-cases are considered in order to evaluate it. The remaining of this paper is divided into five sections. Section 2 gives some background about air pollution and domain knowledge. Section 3 describes our proposed system architecture. Section 3 is about ontology designing and Section 4 shows some interesting use-cases that the ontology can answer using SPARQL queries. section 6 is conclusion and future work.

2 Background

2.1 Domain Knowledge

Air pollution: Air pollution is the presence of contaminant or pollutant substances in the air that do not disperse properly and that interfere with human health or welfare, or produce other harmful environmental effects.
Causes: Most often, it is caused by human activities such as mining, construction, transportation, industrial work, agriculture, smelting, burning farms, burning garbage, automobile effluents etc. However, natural processes such as volcanic eruptions and wildfires may also pollute the air, but their occurrence is rare and they usually have a local effect, unlike human activities that are ubiquitous causes of air pollution and contribute to the global pollution of the air every single day. Thus we focus on more profound causes like burning of farms and garbage in the ontology.
Common types of air pollutants: A large number of contaminants may pollute the air in a large variety of forms. Almost any toxic chemical could make its way into the atmosphere to pollute the air that we breathe. Aerosol particles (clouds of liquid and solid particles in a gas) that are found in the air may also contain pollutants.

The chemical compounds that lower the air quality are usually referred to as air pollutants. These compounds may be found in the air in two major forms:

- in a gaseous form (as gases),
- in a solid form (as particulate matter suspended in the air).

As the PM 2.5 is the most dangerous form of solid state particulate matter that can get into the bloodstream and cause serious health hazards, there has been great panic among people regarding PM 2.5 levels. So we concentrate more on these levels in the paper.

AQI	Air Pollution Level	Air Pollution Category	Recommended Precautions
0–50	Level 1	Excellent	Everyone can continue their outdoor activities normally.
51–100	Level 2	Good	Only very few hypersensitive people should reduce outdoor activities.
101–150	Level 3	Lightly Polluted	Children, seniors and individuals with respiratory or heart diseases should reduce sustained and high-intensity outdoor exercises.
151–200	Level 4	Moderately Polluted	Children, seniors and individuals with respiratory or heart diseases should avoid sustained and high-intensity outdoor exercises. General population should moderately reduce outdoor activities.
201–300	Level 5	Heavily Polluted	Children, seniors and individuals with heart or lung diseases should stay indoors and avoid outdoor activities. General population should reduce outdoor activities.
>300	Level 6	Severely Polluted	Children, seniors and the sick should stay indoors and avoid physical exertion. General population should avoid outdoor activities.

Fig. 1. Air Quality Index of different levels of PM 2.5 published by World Health Organization(WHO)[2]

3 SYSTEM ARCHİTECTURE

This section describes in detail, the architecture and the proposed functionality of the system. The sources of our data come from air quality and temperature sensors obtained from Thailand PCD, air pollution category and recommendations are taken from WHO air quality index.

3.1 Layers of architecture

In this section we discuss about proposed system architecture. The architecture consists of three layers namely, Data layer, ontology layer and application layer.

And our target user groups being citizens of a place and government authorities.

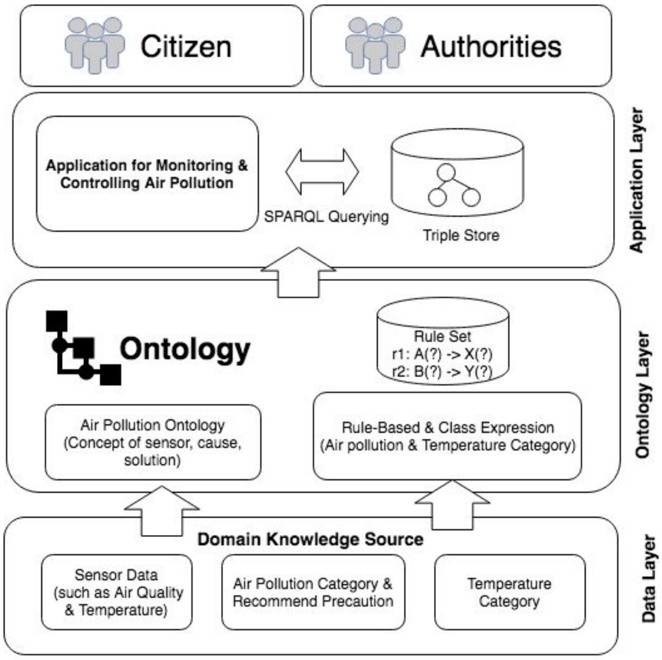

Fig. 2. System Architecture of Air Pollution Application

3.1.1 Application layer

This layer comprises of a mobile/web application which can be used to monitor air pollution by the users based on their current location. Other features include querying based on pollution levels, province, cause of pollution, etc. we discuss the features in detail in subsequent sections.

The querying of user request is done using SPARQL endpoint that queries the our OWL ontology loaded into the triple store.

3.1.2 Ontology layer

This layer includes design and construction of air pollution ontology with hierarchical concepts pertaining to locations, sensors, cause-solution and recommendations. Furthermore, the concepts are defined by various object and data properties that help in building rules, class expressions and define constraints on properties. Defining of functional properties helped to build reasoners to answer various competency questions that will be discussed in the next section.

4 Ontology Modeling

In this section, we describe the ontology scope and ontology design and development.

4.1 Ontology scope

The air pollution ontology consists of two main parts. First, sensor part is supposed to help the citizen to monitor air pollution, get weather condition at a given location from a particular sensor, and get recommendations about possible precautions to be taken. Another part is facilitates the citizens to report about any pollution causing activity, while authorities can monitor the causes of pollution.

The designed ontology is intended to answer the following competency questions(CQs) as shown in Table 1:

Table1: Competency Questions for air pollution ontology

CQ1	Show moderately polluted areas in PathumThani during 1st Jan 2019 to 14th Jan 2019	Normal Citizen
CQ2	recommend me a daily precaution that I should take in AIT area today (current date is 14th Jan 2019)	Normal Citizen
CQ3	Monitor weather at AIT (PM 2.5 and Temperature) today (current date is 1st Jan 2019)	Normal Citizen/ Authorities
CQ4	Get average PM2.5 at near_by area of my current location from 1st Jan 2019 to 14th Jan 2019	Normal Citizen
CQ5	Rank top 5 risk areas of air pollution in central region of Thailand during 1st Jan 2019 to 14th Jan 2019	Normal Citizen/ Authorities
CQ6	what are the sources of pollution in PathumThani during the month of January 2019 (1st to 31st Jan 2019)	Authorities

CQ7	what are some causes and solutions taken where source of pollution was CornFarms in pathum thani during the month of January 2019.	Authorities
CQ8	show the map of pathumThani pointing the major locations of air quality sensor stations.	Normal Citizen
CQ9	what are the sources of pollution caused by farmers in pathumThani durnig the month of January 2019	Authorities
CQ10	what are the most frequently reported source of pollution in pathumThani region during 1st Jan 2019 to 14th Jan 2019	Authorities

4.2 Ontology Design and Development

In this part of the section, we discuss Class hierarchy of our ontology, object and data properties, functional properties that are defined on some properties and class expressions used in the design of ontology.

4.2.1 Class hierarchy

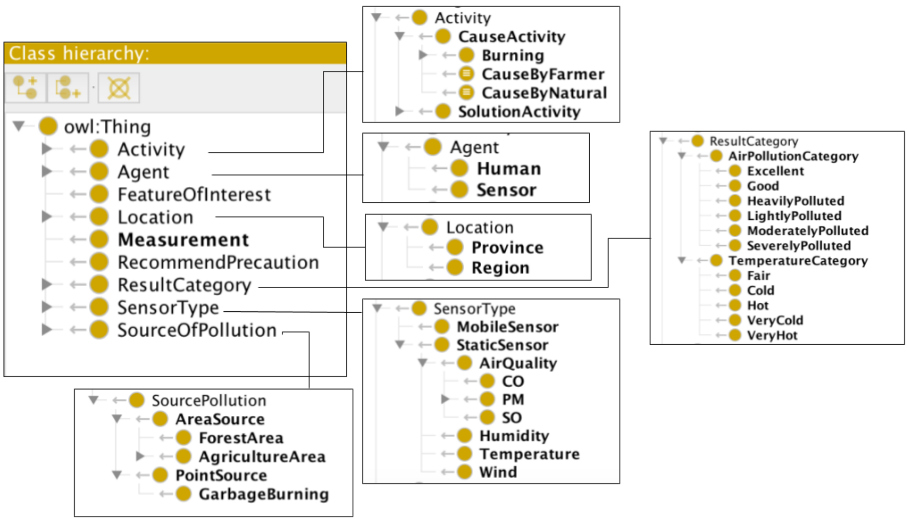

Fig. 3. Class hierarchy of Air Pollution Ontology

The ontology has got nine top-level concepts which are:

a) Location:

This concept defines the place where a sensor is located or an activity that took place in a particular location. It has Region and Province as subclasses. This is helpful to know pollution levels at current location of the user and also to locate the place of source of pollution.

b) SensorType:

It is a concept that defines various sensors that we consider for our system. AirQuality and Temperature are the subclasses we use in our scope.

c) Measurement :

This concept measures the readings and datetime generated by various sensors defined in concept Sensor of they type SensorType.

d) FeatureOfInterest:

It is the concept used to define a specific area of interest based on its region/province along with its latitude and longitude values.

e) Agent:

This concept defines the agent who carries out the task of measuring pollution, in our case the Sensor(subconcept). It consists of every agent sensor at particular FeatureOfInterest.

f) ResultCategory:

This concept categorizes air and temperature quality based on sensor readings. Air quality category consists of excellent, good, lightly polluted, moderately polluted, heavily polluted, severely polluted and temperature category very hot, hot, fair, cold, very cold . We use SWRL to define constraints on the categories. And thus the reasoner categorizes a particular area's conditions into specific categories.

g) RecommendationPrecaution:

This concept focuses on recommending precautions to users based on the air quality measurements value. These precautions are categorized for each air quality as Excellent Precaution, Good Precaution, Lightly

Polluted Precaution,Moderately Polluted Precaution, Highly Polluted Precaution, Severly Polluted Precaution.

h) SourceOfPollution:

This concept defines potential sources where pollution activities can take place. For example, we have CornFarm, PaddyFarm, ForestArea as subconcepts. we also define the province and location of these areas of interest so that any polluting activity can be easily reported.

i) Activity:

This is the concept is divided into pollution causing and solving activities. we considered burning as causeActivity and Extinguish, ArtificialRain and SplashWater as SolutionActivity. The user can report CauseActivity at a given time with its description.

4.2.2 Functional Properties

a) Hierarchy and Transitive Properties

Hierarchy is a concept of Class and Sub-classes. We can use this techniques for both class and properties. In this example, we created a Hierachy Object Property for the location based objects and we applied the link concept as a transitive property for directly refering across the location level as well.

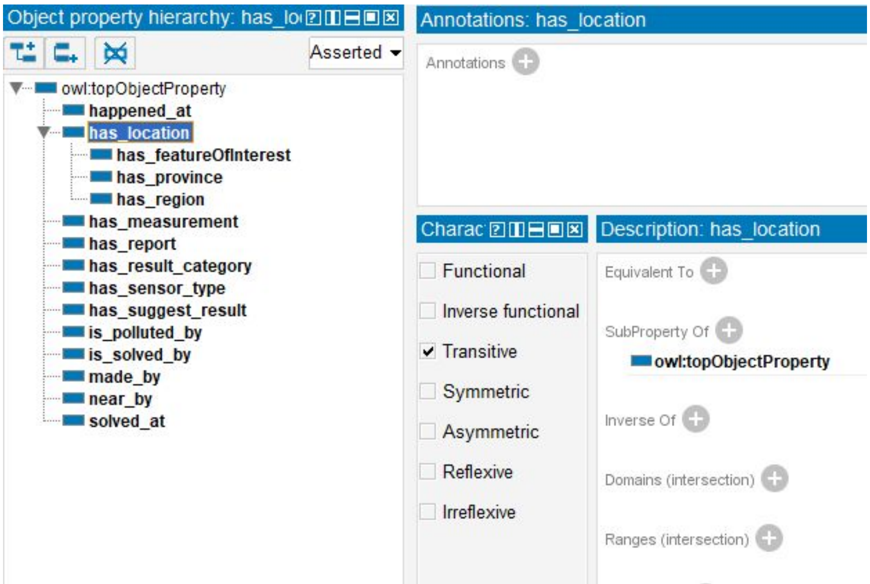

Fig 4. Example of object property that uses transitive property.

b) Inverse Of

Is_polluted_by is an object property we used to define by what cause is a sourceOfPollution polluted by and **happened_at** is another object property which defines a polluting activity that took place at a particular source of pollution. This is clearly **inverseOf** each other.

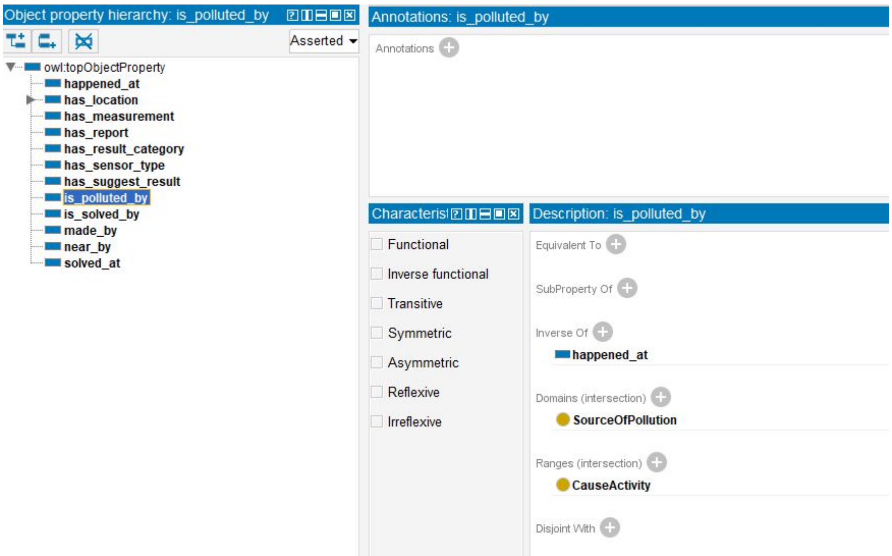

Fig 5. Example of object property that uses Inverse Of

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c) Symmetric Property

The property **near_by** is a symmetric property with province as domain.we can use the near_by property for provinces and locations in either way.

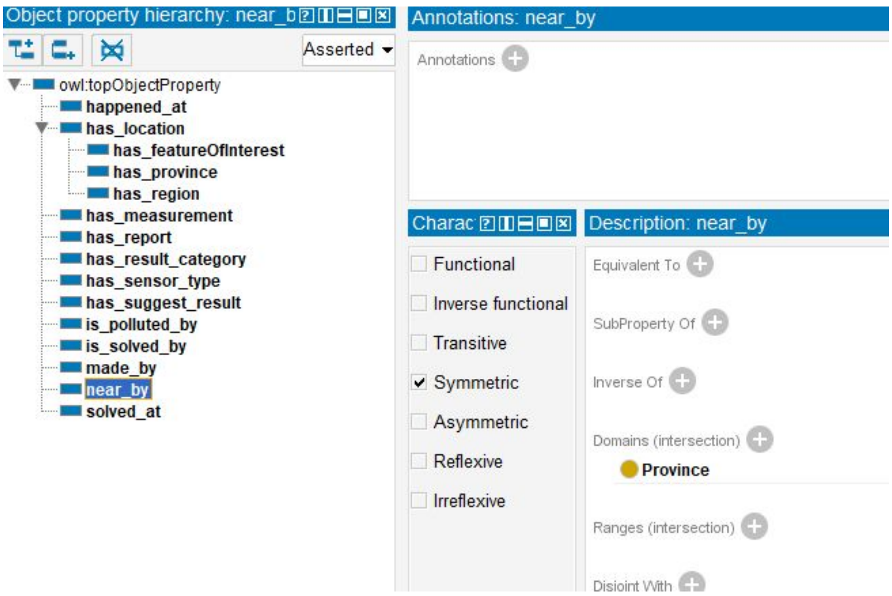

Fig 6. Example of object property that uses symmetric property.

4.2.3 Class Expression

We have provided some class expression to conveniently query the instances of well-defined classes. For example, we defined the causes by human activity as a class expression name **CauseByHuman** which is disjoint from the **CauseByNatural** as in the following pictures below.

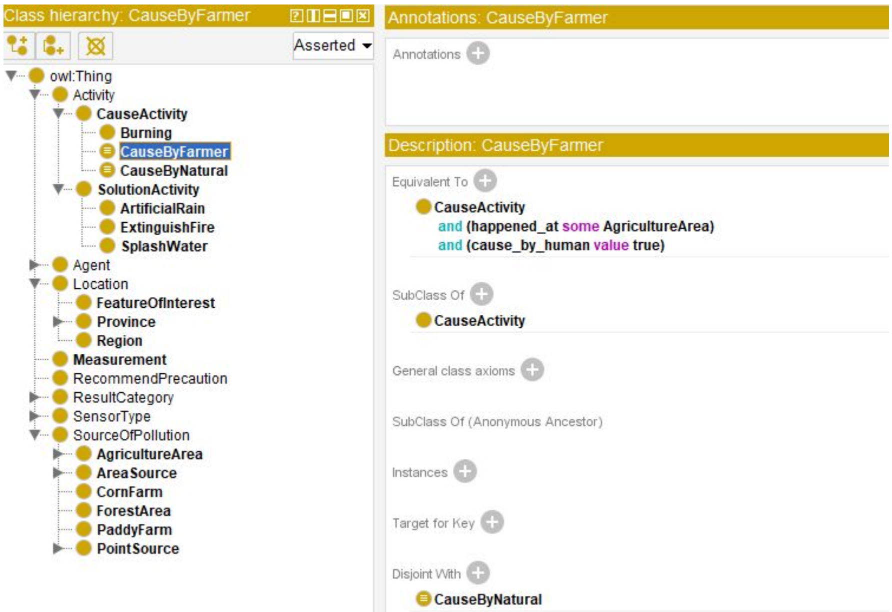

Fig 7. Class Expression to classify CauseActivity into CauseByFarmer and CauseByNature- No Reasoner

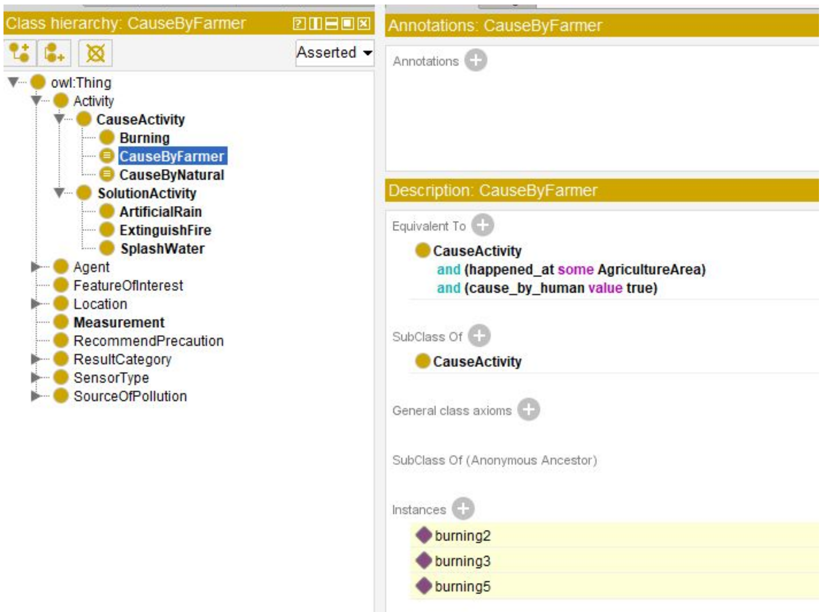

Fig 8. Class Expression to classify CauseActivity into CauseByFarmer and CauseByNature- with Reasoner

4.2.4 The Semantic Web Rule Language (SWRL)

SWRL is the standard language based on OWL-DL and on the Rule Markup Language (RuleML) [2]. In part of recommendation, we use SWRL in Protege to define constraints on the categories depended on the sensor type (PM2.5 and Temperature) and precaution recommendation for PM2.5. For example, if the measurement which is the sensor type PM2.5 and has measurement value less than 51, define this measurement has a result "Excellent" and the recommend precaution is "Everyone can continue their outdoor activities normally.". The rule used in this ontology includes 6 rule for PM2.5 category and 5 rules for temperature category as shown in Table 2.

The syntax of SWRL is of the following form "antecedent → consequent"

Table2: SWRL rules used for recommending precautions and result category.

Name	Rule	Description
S1-excellent_rec	Measurement(?m) ^ has_sensor_type(?m, SensorTypePM25) ^ has_measure_value(?m, ?m_val) ^ swrlb:lessThan(?m_val, 51) -> Excellent(?m) ^ has_suggest_result(?m, ExcellentPrecaution) ^ has_result_category(?m, Excellent)	If the measurement has sensor type PM2.5 and has measure value less than 51, define to class Excellent and suggest excellent precaution.
S2-good_rec	Measurement(?m) ^ has_sensor_type(?m, SensorTypePM25) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 50) ^ swrlb:lessThan(?m_val, 101) -> has_suggest_result(?m, GoodPrecaution) ^ Good(?m) ^ has_result_category(?m, Good)	If the measurement has sensor type PM2.5 and has measure value greater than 50 and less than 101, define to class Good and suggest good precaution.
S3-lightly_polluted_rec	Measurement(?m) ^ has_sensor_type(?m, SensorTypePM25) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 100) ^ swrlb:lessThan(?m_val, 151) -> has_suggest_result(?m, LightlyPollutedPrecaution) ^ LightlyPolluted(?m) ^ has_result_category(?m, LightlyPolluted)	If the measurement has sensor type PM2.5 and has measure value greater than 100 and less than 151, define to class LightlyPolluted and suggest lightly polluted precaution.
S4-moderately_polluted_rec	Measurement(?m) ^ has_sensor_type(?m, SensorTypePM25) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 150) ^ swrlb:lessThan(?m_val, 201) -> has_suggest_result(?m, ModeratelyPollutedPrecaution) ^ ModeratelyPolluted(?m) ^ has_result_category(?m, ModeratelyPolluted)	If the measurement has sensor type PM2.5 and has measure value greater than 150 and less than 201, define to class ModeratelyPolluted and suggest moderately polluted precaution.

S5-heavily_polluted_rec	Measurement(?m) ^ has_sensor_type(?m, SensorTypePM25) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 200) ^ swrlb:lessThan(?m_val, 301) -> has_suggest_result(?m, HeavilyPollutedPrecaution) ^ HeavilyPolluted(?m) ^ has_result_category(?m, HeavilyPolluted)	If the measurement has sensor type PM2.5 and has measure value greater than 200 and less than 301, define to class HeavilyPolluted and suggest heavily polluted precaution.
S6-severely_polluted_rec	Measurement(?m) ^ has_sensor_type(?m, SensorTypePM25) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 299) -> has_suggest_result(?m, SeverelyPollutedPrecaution) ^ SeverelyPolluted(?m) ^ has_result_category(?m, SeverelyPolluted)	If the measurement has sensor type PM2.5 and has measure value greater than 299, define to class SeverelyPolluted and suggest severely polluted precaution.
T1-very_hot_temp	Measurement(?m) ^ has_sensor_type(?m, SensorTypeTemp) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 35) -> VeryHot(?m) ^ has_result_category(?m, VeryHot)	If the measurement has sensor type Temperature and has measure value greater than 35, define to class VeryHot.
T2-hot_temp	Measurement(?m) ^ has_sensor_type(?m, SensorTypeTemp) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 27) ^ swrlb:lessThan(?m_val, 36) -> Hot(?m) ^ has_result_category(?m, Hot)	If the measurement has sensor type Temperature and has measure value greater than 27 and less than 36, define to class Hot.
T3-fair_temp	Measurement(?m) ^ has_sensor_type(?m, SensorTypeTemp) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 20) ^ swrlb:lessThan(?m_val, 28) -> Fair(?m) ^ has_result_category(?m, Fair)	If the measurement has sensor type Temperature and has measure value greater than 20 and less than 28, define to class Fair.
T4-cold_temp	Measurement(?m) ^	If the measurement has

	has_sensor_type(?m, SensorTypeTemp) ^ has_measure_value(?m, ?m_val) ^ swrlb:greaterThan(?m_val, 10) ^ swrlb:lessThan(?m_val, 21) -> Cold(?m) ^ has_result_category(?m, Cold)	sensor type Temperature and has measure value greater than 10 and less than 21, define to class Cold.
T5-very_cold_temp	Measurement(?m) ^ has_sensor_type(?m, SensorTypeTemp) ^ has_measure_value(?m, ?m_val) ^ swrlb:lessThan(?m_val, 11) -> VeryCold(?m) ^ has_result_category(?m, VeryCold)	If the measurement has sensor type Temperature and has measure value less than 11, define to class VeryCold.

4.3 Ontology usage

The application can provide information about air quality, weather and some suggestions to users. In addition, the application can help to notify users whenever they are in the area which have high value of air pollution.

4.3.1 Example instances

Here are sample instances for some concepts:

a) **Sensor instance**
This instance describes a sensor at a given station. We can notice its interaction with other top-level concepts such as Measurement and FeatureOfInterest.

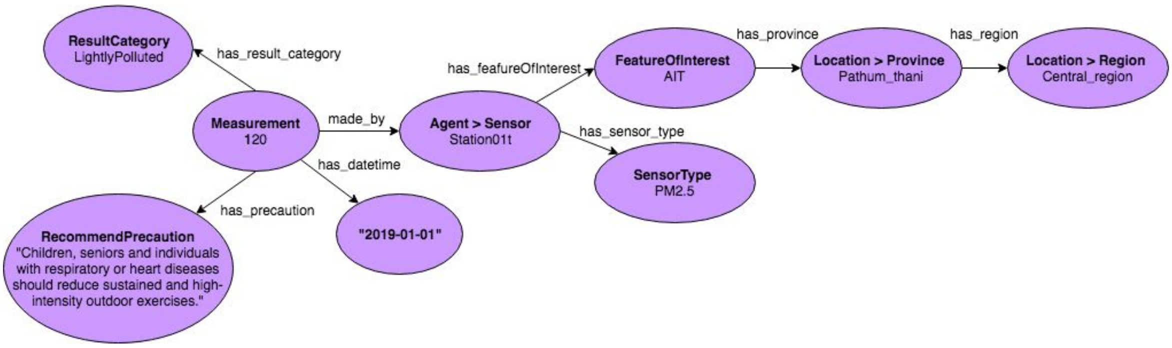

Fig 9. Example instance for Sensor concept

b) Cause instance

This is an instance of CauseActivity concept which consists of causes of pollution as subconcepts. The diagram shows how a user can report a cause.

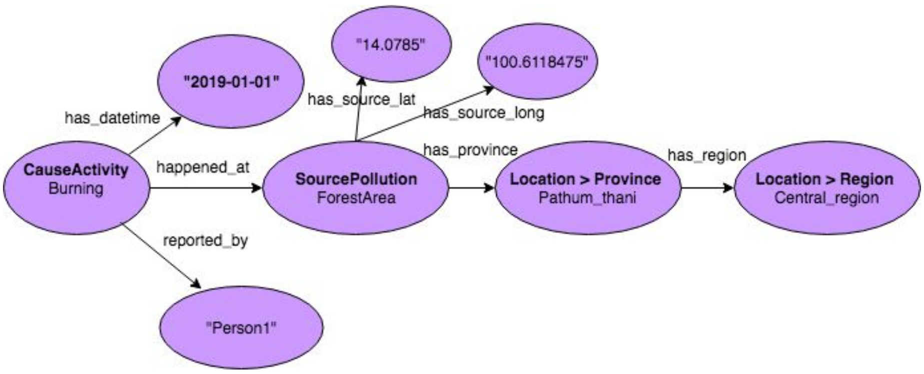

Fig 10. Example instance for CauseActivity concept

c) Solution instance

This is an instance of SolutionActivity concept which consists of solutions for a polluted area as subconcepts. The diagram shows where an when the solution has been applied and the organization that took the acion.

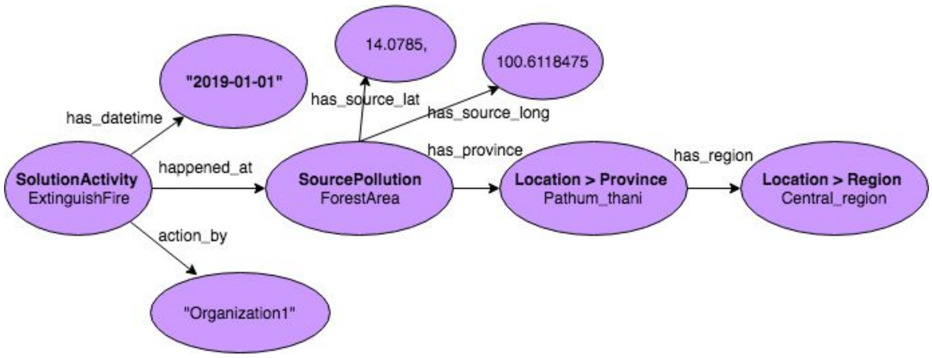

Fig 11. Example instance for SolutionActivity concept

4.3.2 Competency Questions answered

Table 3: SPARQL queries for competency questions(CQs) as shown in Table 1:

CQ1	Show moderately polluted areas in PathumThani during 1st Jan 2019 to 14th Jan 2019
	
	select * from
	<http://www.semanticweb.org/pattama/ontologies/2019/3/air_pollution>
	where {
	?measure **rdf:type air:ModeratelyPolluted** .
	?measure air:has_measure_value ?result .
	?measure air:made_by ?sensor .
	?measure air:has_datetime ?measure_date .
	?sensor air:has_featureOfInterest ?feature .
	?feature **air:has_province air:Pathum_thani**.
	FILTER (?measure_date > "2019-01-01"^^xsd:dateTime && ?measure_date < "2019-01-14"^^xsd:dateTime)
	}
		Normal Citizen

CQ2	recommend me a daily precaution that I should take in AIT area today (current date is 14th Jan 2019)	Normal Citizen

	select * from <http://www.semanticweb.org/pattama/ontologies/2019/3/air_pollution> where { ?measure rdf:type air:Measurement . ?measure air:has_measure_value ?result . ?measure air:made_by ?sensor . ?measure air:has_datetime "2019-01-14"^^xsd:dateTime . ?measure air:has_suggest_result ?suggest. ?suggest **air:has_precaution ?precaution .** ?sensor air:has_featureOfInterest air:**AIT** . }	
CQ3	Monitor weather at AIT (PM 2.5 and Temperature) today (current date is 1st Jan 2019) SELECT * WHERE { ?measure a air:Measurement . ?measure air:has_measure_value ?result . ?measure **air:has_sensor_type ?sensor_type .** ?measure air:has_result_category ?result_category. ?measure ?made_by ?sensor . ?sensor **air:has_featureOfInterest air:AIT** . ?measure air:has_datetime "2019-01-01"^^xsd:dateTime .}	Normal Citizen/ Authorities
CQ4	Get average PM2.5 at near_by area of my current location from 1st Jan 2019 to 14th Jan 2019 SELECT (AVG(?result) as ?air_quality_pathum) ?province_name from <http://www.semanticweb.org/pattama/ontologies/2019/3/air_pollution> where { ?measure rdf:type air:Measurement. ?measure air:has_measure_value ?result . ?measure air:has_datetime ?measure_date . ?measure **air:has_sensor_type air:SensorTypePM25 .** ?measure air:made_by ?sensor . ?sensor air:has_featureOfInterest ?feature. ?feature air:has_location ?nearby_prvince.	Normal Citizen

	?nearby_prvince **air:near_by air:Pathum_thani** . ?feature air:has_province ?province_name . FILTER (?measure_date > "2019-01-01"^^xsd:dateTime && ?measure_date < "2019-01-14"^^xsd:dateTime) }GROUP BY ?province_name	
CQ5	Rank top 5 risk areas of air pollution in central region of Thailand during 1st Jan 2019 to 14th Jan 2019 SELECT (**AVG(?result) as ?air_quality_pm25)** ?feature from <http://www.semanticweb.org/pattama/ontologies/2019/3/air_pollution> where { ?measure rdf:type air:Measurement. ?measure air:has_measure_value ?result . ?measure air:has_datetime ?measure_date . ?measure **air:has_sensor_type air:SensorTypePM25 .** ?measure air:made_by ?sensor . ?sensor air:has_featureOfInterest ?feature. ?feature **air:has_location air:central_region** . FILTER (?measure_date > "2019-01-01"^^xsd:dateTime && ?measure_date < "2019-01-14"^^xsd:dateTime) }GROUP BY ?feature ORDER BY **DESC(?air_quality_pm25) Limit 5**	Normal Citizen/ Authorities
CQ6	what are the sources of pollution in PathumThani that were caused by humans during the month of January 2019 (1st to 31st Jan 2019) SELECT * WHERE { #get Cause, Source in Pathum_thani ?cause rdf:type air:CauseActivity . ?cause air:has_datetime ?cause_date . ?cause air:happened_at ?source . ?cause air:cause_by_human ?human . ?source **air:has_location air:Pathum_thani .** OPTIONAL{?cause air:has_description ?cause_description}. FILTER (?cause_date > "2019-01-01"^^xsd:dateTime && ?cause_date	Authorities

	< "2019-01-31"^^xsd:dateTime)}	
CQ7	what are some causes and solutions taken where source of pollution was CornFarms in pathum thani during the month of January 2019. SELECT * where { #get cause, source in Pathum_thani ?cause rdf:type air:CauseActivity . ?cause air:happened_at ?source . ?cause air:has_datetime ?cause_date . ?source air:has_location air:Pathum_thani . ?source rdf:type air:CornFarm . OPTIONAL{?cause air:has_description ?cause_desc}. #get solution in Pathum_thani ?solution rdf:type air:SolutionActivity . ?solution air:solved_at ?source . ?solution air:has_datetime ?cause_date . OPTIONAL{?solution air:has_description ?solution_desc}. FILTER (?cause_date > "2019-01-01"^^xsd:dateTime && ?cause_date < "2019-01-31"^^xsd:dateTime)}	Authorities
CQ8	show the map of pathumThani pointing the major locations of air quality sensor stations. SELECT Distinct ?feature ?sensor ?sensor_type ?feature_lat ?feature_long WHERE { ?measure a air:Measurement . ?measure air:has_sensor_type ?sensor_type. ?sensor_type a **air:AirQuality** . ?measure air:made_by ?sensor. ?sensor rdf:type air:Sensor . ?sensor air:has_featureOfInterest ?feature. ?feature air:has_province air:Pathum_thani . ?feature air:has_feature_lat ?feature_lat . ?feature air:has_feature_lat ?feature_long .}	Normal Citizen
CQ9	what are the sources of pollution caused by farmers in pathumThani	

	during 1st Jan 2019 to 14th Jan 2019 SELECT ?cause_date ?source ?lat ?long ?cause ?cause_description WHERE { #get cause, source in Pathum_thani ?cause rdf:type air:CauseByFarmer . ?cause air:happened_at ?source . ?cause air:has_datetime ?cause_date . ?source air:has_location air:Pathum_thani . OPTIONAL{?source air:has_source_lat ?lat}. OPTIONAL{?source air:has_source_long ?long}. OPTIONAL{?cause air:has_description ?cause_description}. FILTER (?cause_date > "2019-01-01"^^xsd:dateTime && ?cause_date < "2019-01-14"^^xsd:dateTime) } ORDER BY DESC(?cause_date)	Authorities
CQ10	what are the most frequently reported causes of pollution in pathumThani region during 1st Jan 2019 to 14th Jan 2019 SELECT ?source (COUNT(?cause) as ?reported_count) WHERE { #get Cause, Source in Pathum_thani ?source rdf:type air:SourceOfPollution . ?source air:has_location air:Pathum_thani . ?source air:is_polluted_by ?cause . ?cause air:has_datetime ?cause_date . FILTER (?cause_date > "2019-01-01"^^xsd:dateTime && ?cause_date < "2019-01-31"^^xsd:dateTime) } GROUP BY (?source) ORDER BY DESC(?reported_count)	Authorities

4.4 Mockup for User Interface

We provide mockup user interface of our proposed system to demonstrate our competency questions working and to visualize user experience. Here are some screenshots of the mock-up UI.

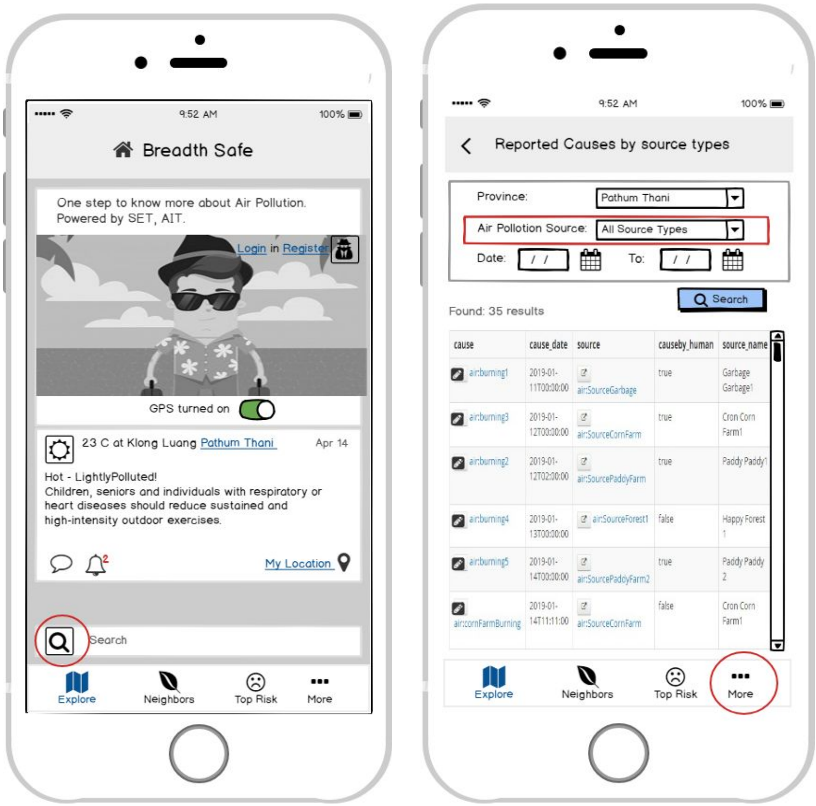

Fig 12. User interface mock-ups to visualize the proposed system.

The application can use current location of user via GPS and show weather and the result category of air quality in the user's location. According to our ontology design, user can also search for places of interest to see the result in other location. The application can plot sensors nearby into a map so that user can easily see how many sensors are present around them. Moreover, our ontology allows the user to report causes of pollution in their area as a social collaboration. Finally, the authorities or organizations who are responsible for taking action to cope with the causes can see the reported source of pollution and be able to add the solving measure that they have taken up into our ontology as well.

This ontology aims to give information about the air pollution status and raise the collaboration between common users and the authorities in order to decrease the critical status of the air pollution in Thailand and other countries as well.

5 Conclusion and Discussion

This paper proposes an onlogoto based on monitoring & controlling air quality in the city. Our Air Pollution Ontology can collect the measurement values of multiple types of sensor such as PM2.5, Temperature etc. The technique used for ontology development consists of class and properties hierarchy, class expression, property constraints and we use SWRL and class Expression for air pollution recommendation. However, this project has limitation about collecting the real-time data streaming, it supports historical data. Air Quality data stream such as, Air4thai update their data every hour, but we collect it on daily basis. Therefore, we need data preparation before transferring data into our ontology. As the future work, we plan to include standard ontology such as semantic sensor network ontology (SSN) and GeoNames as well as study about data management mechanism to support real time data.

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