

An ontology for personalized environmental decision support

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The PESCaDO DSS

Personalized Environmental Decision Support

- A **multilingual** web-service platform providing **personalized environmental information** and **decision support**
- Examples of application scenarios:
 - A pollen allergic person, planning to do some outdoor activities, interested in being notified of potentially harmful environmental conditions
 - A city administrator, to be informed whether the current air quality situation requires some actions to be urgently taken
- Web-site: www.pescado-project.eu
 - demo, videos, code, downloads, publications, deliverables, ...

The PESCaDO DSS

Personalized Environmental Decision Support

- How it works:
 - A user submits a decision support **request** to the system (e.g., “I want to do some hiking on Corcovado tomorrow: is there any environmental-related health issues for me?”)
 - The system:
 1. Determines the **data relevant** for the request
 2. **Retrieves the data** from environmental web-sites and web-services providing them
 3. **Processes** these data providing **conclusions** (e.g., warnings, recommendations) according to the needs of the users
 4. Generates **reports** (e.g., text, tables, graphics) to be **communicated** to the user

The PESCaDO DSS

Personalized Environmental Decision Support

Situation in the selected area between 08h00 and 20h00 of 07/05/2012. The ozone warning threshold value ($240\text{g}/\text{m}^3$) was exceeded between 13h00 and 14h00 ($247\text{g}/\text{m}^3$), the ozone information threshold value ($180\text{g}/\text{m}^3$) between 12h00 and 13h00 ($208\text{g}/\text{m}^3$) and between 14h00 and 15h00 ($202\text{g}/\text{m}^3$). The minimum temperature was 2 C and the maximum temperature 17 C. The wind was weak (S). There is no data available for carbon monoxide, rain and humidity.

Ozone warning: ozone irritates eyes and the mucous membranes of nose and throat. It may also exacerbate allergy symptoms caused by pollen. Persons with respiratory diseases may experience increased coughing and shortness of breath and their functional capacity may weaken. Sensitive groups, like children, asthmatics of all ages and elderly persons suffering from coronary heart disease or chronic obstructive pulmonary disease, may experience symptoms. [...]

PESCaDO: an ontology-centric DSS

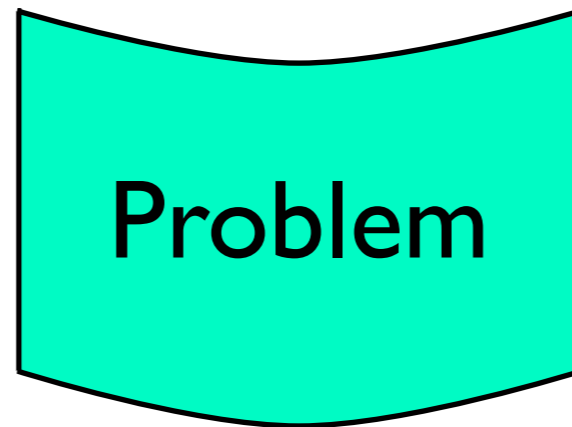
- Powered by the **PESCaDO Ontology**
 - an **OWL application** ontology
 - formalises **all the content** both processed and produced by the DSS in answering requests
 - the decision support **request** submitted by the user to the system
 - the **data** that the system processes for the given request
 - the **new content** and **conclusions** produced by the DSS from the available data and in view of the given request
 - each single request submitted to the DSS triggers the instantiation of a new **A-Box** in the language of the ontology
 - at the end of the processing of a request, we obtain a **semantic script of the request**

PESCaDO Ontology

- Three main components:
 - according to the main steps performed in DSSs

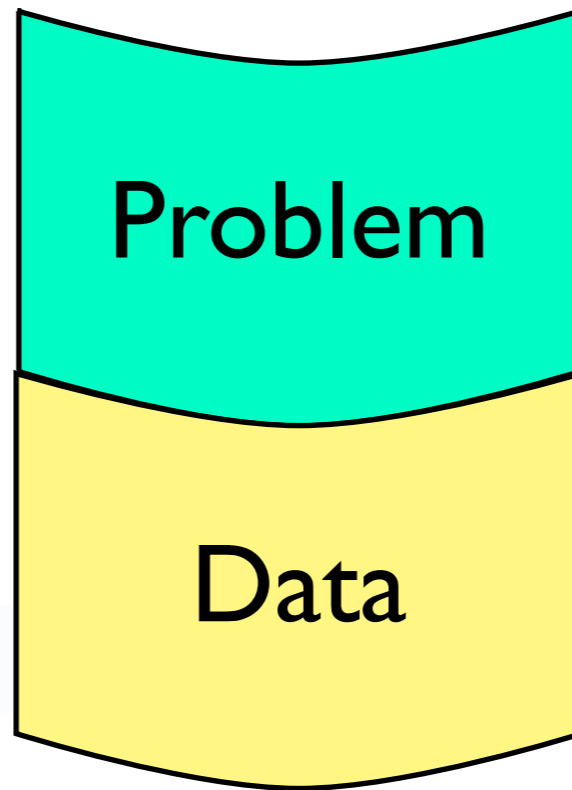
PESCaDO Ontology

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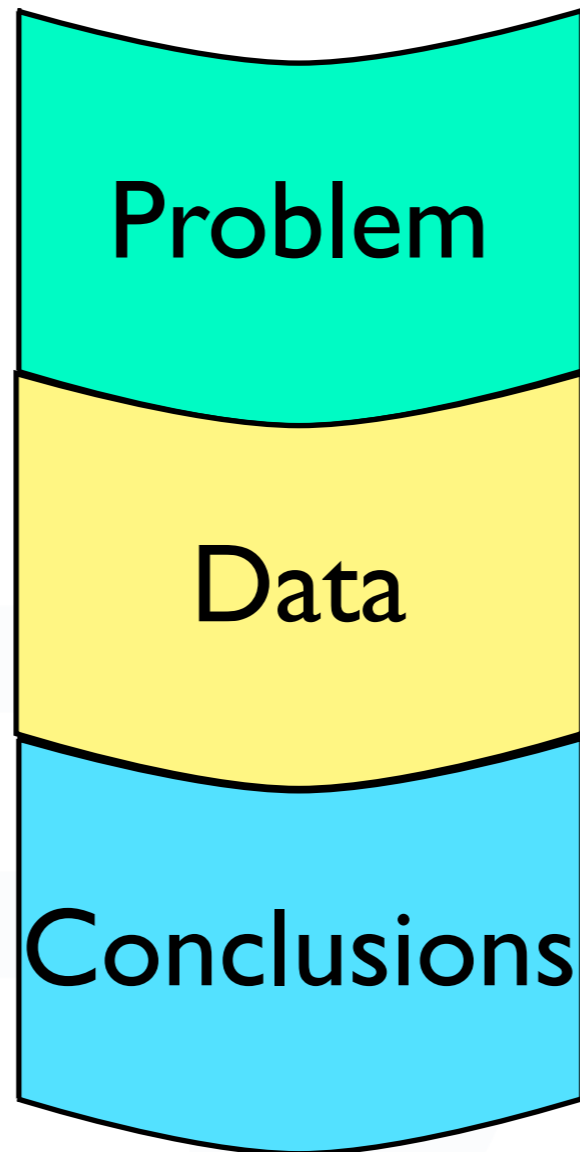
PESCaDO Ontology

- Three main components:
 - according to the main steps performed in DSSs



PESCaDO Ontology

- Three main components:
 - according to the main steps performed in DSSs



PESCaDO Ontology: Problem

- Formally describes **all aspects** of the decision support request that the user can submit to the DSS
- Organized in **sub-modules**:
 - **Request**: request types supported by the system (e.g., “Is there any health issue for me?”)
 - **Activity**: activities that the user may want to undertake (e.g., physical outdoor activity, travelling by car)
 - **User**: aspects of the users profile relevant for decision support
 - typology (e.g., end-user, administrative user), age, gender, diseases or allergies
- Sub-modules are **interrelated** by object properties and subclass axioms
 - Example of constrains:
 - `CheckAirQualityLimits` subClassOf `hasRequestUser` only `AdministrativeUser`

PESCaDO Ontology: Problem

- ▼ ● Request
 - ▼ ● InstructionRequest
 - SuggestAdministrativePlan
 - ▼ ● ReportRequest
 - CheckAirQualityLimits
 - CheckBlackIceCondition
 - CompareAirQualityInMultipleRegions
 - ReportAirQualityForecast
 - ▼ ● WarningRequest
 - AnyHealthIssue
 - AnyRestrictionForPrivateTransport
 - WarningDueToEnvironmentalConditions
- ▼ ● Activity
 - AttendingOpenAirEvent
 - ▼ ● LongTermStaying
 - GoingOnHolidayLongTermStaying
 - LivingLongTermStaying
 - PhysicalOutdoorActivity
 - ▼ ● Travelling
 - BikeOrFeetTravelling
 - FeetTravelling
 - BikeTravelling
 - CarTravelling
 - PublicTransportTravelling
- ▼ ● User
 - AdministrativeUser
 - ▼ ● EndUser
 - AdultUser
 - ChildUser
 - ▶ ● ElderlyUser
 - InfantUser
 - PregnantFemaleUser
 - ▶ ● UserSensitiveToAirPollutant
 - ▼ ● UserSensitiveToPollen
 - ▶ ● UserSensitiveToAlderPollen
 - ▶ ● UserSensitiveToBirchPollen
 - ▶ ● UserSensitiveToGrassesPollen
 - ▶ ● UserSensitiveToMugwortPollen
 - ▶ ● UserSensitiveToWeather
 - ▶ ● UserSufferingOfAllergicRhinitis
 - ▶ ● UserSufferingOfCirculatoryDisease
 - ▶ ● UserSufferingOfNasalOrEyeAllergy
 - ▶ ● UserSufferingOfRespiratoryDisease
 - YoungUser
 - Expert

PESCaDO Ontology: Data

- Describes the **environmental data** used by the system to provide decision support:
 - meteorological data (e.g., temperature, wind speed)
 - pollen data
 - air quality data (e.g., NO₂, PM₁₀, air quality index)
 - road conditions
- **Details** represented
 - observed, forecast, or historical data,
 - the time period covered
 - type of the data (e.g., instantaneous, average, minimum, maximum)
 - mapping between **qualitative** and **quantitative** values
 - moderate birch pollen count corresponds to 10 - 100 grains per meter cube of air
 - **data source** (e.g., measurement station, web-site, web-service) details,

PESCaDO Ontology: Data

- Describes the decision support
 - meteorological data (e.g., temperature, wind speed)
 - pollen data
 - air quality data (e.g., NO₂, PM₁₀, air quality index)

● EnvironmentalData

- EnvironmentalData **SubClassOf** hasFromDateTime **some** dateTime
- EnvironmentalData **SubClassOf** hasEnvironmentalDataNature **exactly** 1 EnvironmentalDataNature
- EnvironmentalData **SubClassOf** hasEnvironmentalDataEnvironmentalDataType **exactly** 1 EnvironmentalDataType
- EnvironmentalData **SubClassOf** hasToDateTime **some** dateTime

● EnvironmentalNode

- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeLocation **max** 1 Location
- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeEnvironmentalNodeAreaType **max** 1 EnvironmentalNodeAreaType
- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeName **exactly** 1 string
- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeForm **exactly** 1 EnvironmentalNodeForm
- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeEnvironmentalNodeType **max** 1 EnvironmentalNodeType
- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeConfidenceValue **max** 1 double
- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeEnvironmentalData **only** EnvironmentalData
- EnvironmentalNode **SubClassOf**
hasEnvironmentalNodeEnvironmentalNodeSourceOfEmissionType **max** 1 EnvironmentalNodeSourceOfEmissionType
- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeURL **max** 1 anyURI
- EnvironmentalNode **SubClassOf** hasEnvironmentalNodeEnvironmentalNodeLandUseType **max** 1 EnvironmentalNodeLandUseType

PESCaDO Ontology: Conclusions

- Formally describes
 - the **output** produced by the DSS by processing the problem description and the data available
 - **exceedances** of air pollutant limit values detected from data
 - **warnings** and **recommendations** that may be triggered by environmental conditions
 - **logico-semantic relations** (LSRs), i.e., domain-independent relations (e.g., implication, cause, violation of expectation) between domain entities:
 - e.g., an implication LSR may be instantiated between a high concentration pollen data and the warning it triggers
 - facilitates the deduction of **discourse relations** for the generation of explanatory textual information

PESCaDO Ontology: Conclusions

- ▼ ● ConclusionType
 - ▶ ● ExplanationType
 - ▶ ● RecommendationType
- ▼ ● WarningType
 - ▼ ● AirQualityRelatedWarningType
 - CORelatedWarningType
 - NO2RelatedWarningType
 - O3RelatedWarningType
 - SO2RelatedWarningType
 - PollenRelatedWarningType
 - ▼ ● WeatherRelatedWarningType
 - RainRelatedWarningType
 - TemperatureRelatedWarningType
 - UVRelatedWarningType
 - WindRelatedWarningType

PESCaDO Ontology: Conclusions

- ▼ ● ConclusionType
 - ▶ ● ExplanationType
 - ▶ ● RecommendationType
- ▼ ● WarningType
 - ▼ ● AirQualityRelatedWarningType
 - CORelatedWarningType
 - NO2RelatedWarningType
 - O3RelatedWarningType
 - SO2RelatedWarningType
 - PollenRelatedWarningType
 - ▼ ● WeatherRelatedWarningType
 - RainRelatedWarningType
 - TemperatureRelatedWarningType
 - UVRelatedWarningType
 - WindRelatedWarningType

◆ warningType_NO2limit

Type NO2RelatedWarningType

message [language: en]



Nitrogen dioxide causes respiratory symptoms especially in children and asthmatics, because high concentrations of this gas cause contraction of the bronchial airways. It may increase the sensitivity of the airways to other irritants such as cold air and pollen.

message [language: fi]



Typpidioksidi lisää hengityselinoireita erityisesti lapsilla ja astmaatikoilla, koska se korkeina pitoisuuksina supistaa keuhkoputkia. Typpidioksidi voi lisätä hengitysteiden herkkyyttä muille ärsykkeille, kuten kylmälle ilmalle ja siitepölyille.

message [language: sv]



Kvävedioxiden ökar andningsorganssymptomer speciellt bland barn och astmatiker, eftersom den höga kvävedioxidhalten sammandrar luftrörer. Kvävedioxiden kan öka känsligheten för andra irriterande, till exempel för kall luft eller pollen.

How is the PESCADO Ontology exploited by the PESCADO DSS?

- Format of the **internal data structure** used by the PESCADO DSS
- Support **data exchange** between the different modules of the system
- To **determine** (via DL reasoning) the type of **data** that are **relevant** for a given request/activity/user profile
 - based on mappings (formalized as OWL hasValue restrictions) between the classes describing requests, activities and user profiles in the Problem component and the types of environmental data defined in the Data component
- Generation of **warnings** and **recommendations**, the suggestion of possible **causes** of exceptional air quality episodes, and the instantiation of **logico-semantic relations**:
 - we combined DL-reasoning (Hermit) and rules (Jena RETE) on top of the ontology
- In the user interface (UI), to guide users in formulating their request:
 - to **dynamically** determine which type of requests, activities, and user profiles are **supported** by the system, as well as what combination of them form a **valid decision support problem**

Modelling Methodology

1. Ontology **requirements** specification
 - PESCaDO Ontology Requirements Specification Document (**ORSD**): purpose, scope, implementation language, intended users, intended uses, competency questions, ...
2. Identification of existing **reusable ontologies**
 - GeoSPARQL, PROV-O
3. Computer-assisted **terminology extraction**
 - automatic extraction of candidate terminology from a selected corpus of textual documents (e.g., pollens)
4. **Formalization** of the ontology
 - guided by the competency questions and input/feedback of domain experts and technical partners involved in the project
5. Ontology **revision**
 - triggered by checking the ontology against the competency questions
6. Ontology **documentation**
 - the ontology is extensively annotated in three languages (English, Finnish, Swedish)
 - PESCaDO Ontology Documentation (incl. ORSD)

PESCaDO Ontology: Metrics

DL Expressivity	ALCHOIQ(D)
Classes	255
Properties (Object / Data)	154 / 45
Individuals	694
Annotations	1302
Class Axioms	608
Properties Axioms (Object / Data)	294 / 105
Individual Axioms	1803
Modules	11 (+2)

Thank you! Questions?

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