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SEMANTIC PREVENTIVE CONSERVATION
OF CULTURAL HERITAGE COLLECTIONS

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Extended Semantic Web Conference
Semantic Web for Cultural Heritage

University of the Aegean
Department of Cultural Technology & Communication

Intelligent Interaction
Research Group

INTELLIGENT INTERACTION RESEARCH GROUP

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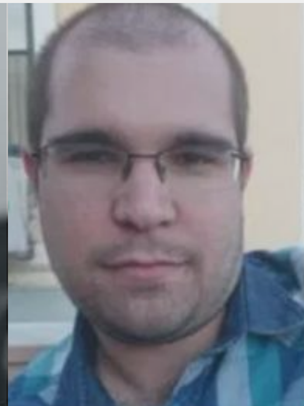

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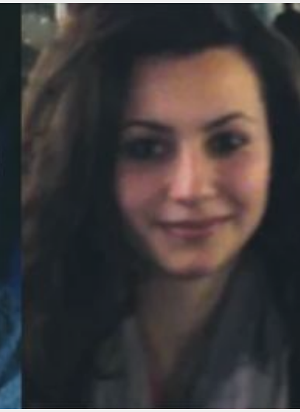

Irene Kalatha

II Group was established in June 2016. George Caridakis is the founder and coordinator of the group’s educational, research and development activities. The core of group consists of young researchers of the Department.

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RESEARCH INTERESTS

Cultural Content & Management

- ✓ Digital Representation of Cultural Objects and Collections
- ✓ Technologies of Semantic Web
- ✓ Linked Open Data (LOD)

Context & User Experience

- ✓ User Experience and Cultural User Experience
- ✓ Internet of Things and Ubiquitous Computing focusing on the Context Awareness.

Promotion & Communication of Cultural Content

- ✓ Affective Computing
- ✓ Artificial Intelligence and Machine Learning
- ✓ Mixed/Augmented Reality
- ✓ Digital Serious Games on the domain of Education and Cultural Heritage.

STRUCTURE

Preventive Conservation

Definition, documentation procedures and environmental monitoring

Knowledge Management

Conservation information and sensor data management using semantic web approach and technologies

Proposed Approach

Ontologies merging and rules development

Discussion & Future Work

Interesting points, advantages and ideas for further development and applications

1 Preventive Conservation

ARTWORKS CONSERVATION

What is it ?

Artworks conservation is an important process of museum collection management cycle, aiming to preserve it in the best possible condition for present and future generations.

Procedures

Conservation procedures include examination, analysis, diagnosis, preventive or active conservation, as well as research on internal or external information sources.

Preventive Conservation

It includes indirect actions taken to avoid and minimize future deterioration of artworks and collections and therefore is related to the management of environmental conditions.

CONSERVATION DOCUMENTATION

Scientists of the conservation domain must accurately **document original features** and **changes** of artworks and collections, as well as related **observations, conclusions** and **applied procedures**.

Different procedures require different **level of detail** and focus on different **fields of interest**.

Condition state, **pathology**, production **materials and techniques**, conservation **materials** and **methods**, **analysis** methods, **administrative information**.

Textual records, including checklists or narratives and **multimedia records,** including photo, audio, video, diagrams, 2D or 3D models.

ENVIRONMENTAL MONITORING
aka Context-Awareness

Scientists of the domain of Cultural Heritage conservation often use **sensors** to **monitor and control** some critical physical parameters related to the degradation of the artworks.

Sensors

Small sensing devices which change their status according to physical stimulus

Types

Data loggers and sensors in wired or wireless sensor networks, have been used.

Measurements

Can be downloaded to a computer, flow from low-powered devices to high-powered systems or transferred to a cloud.

Factors

Most commonly temperature and relative humidity, but also light and other forms of radiation, air pollutants, pests and vibration.

RECORDED SENSOR DATA

SHORT - TERM

Sustained supervision aims to the **immediate detection** of environmental changes and the **estimation** of a potentially harmful condition.

DATA

LONG - TERM

Sensed data and related documented information may lead to useful **inferences** about the **relation** between the **material decay** and its **environment.**

2 | Knowledge Management

EFFICIENT DATA MANAGEMENT

- ✓ Considering the amount and diversity of information related to conservation procedures, high organization in a concept level is often required for its integration and management.

- ✓ Sensor data may be difficult to be shared, integrated and processed, in order to support knowledge extracting and reasoning capabilities.

- ✓ An approach of **ontology-based knowledge representation** could define domain concepts and their relations and make them usable in the semantic web.

CULTURAL HERITAGE ONTOLOGIES

CIDOC CRM

Conceptual Reference Model developed by the ICOM/CIDOC Documentation Standards Group

Domain ontology for cultural heritage information, facilitates the **integration and exchange of heterogeneous** cultural heritage information, providing semantic definitions and clarifications

There are some family models which extend CIDOC CRM: CRMsci, CRMinf, CRMdig, CRMba, CRMachaeo…

CULTURAL HERITAGE ONTOLOGIES

OPPRA

Specialized **“Ontology of Paintings and Preservation of Art”**, uses the CIDOC CRM, OreChem and OAI ORE

Focuses mainly on **experimental procedures and materials analysis** about 20th c. paintings

PARCOURS

It is a domain ontology dedicated to **conservation-restoration domain**.

Uses **CIDOC CRM** as a top-level ontology. Also includes **CRMsci** and **thesauri** about cultural objects, alteration, material and analysis.

THE CORE APPROACH

Pathology

Conservation Procedures

Date

Dimension

Condition State

Equipment

Actor

CORE ENTITY

Event

TimeSpan

Information Object

Place

Physical Feature

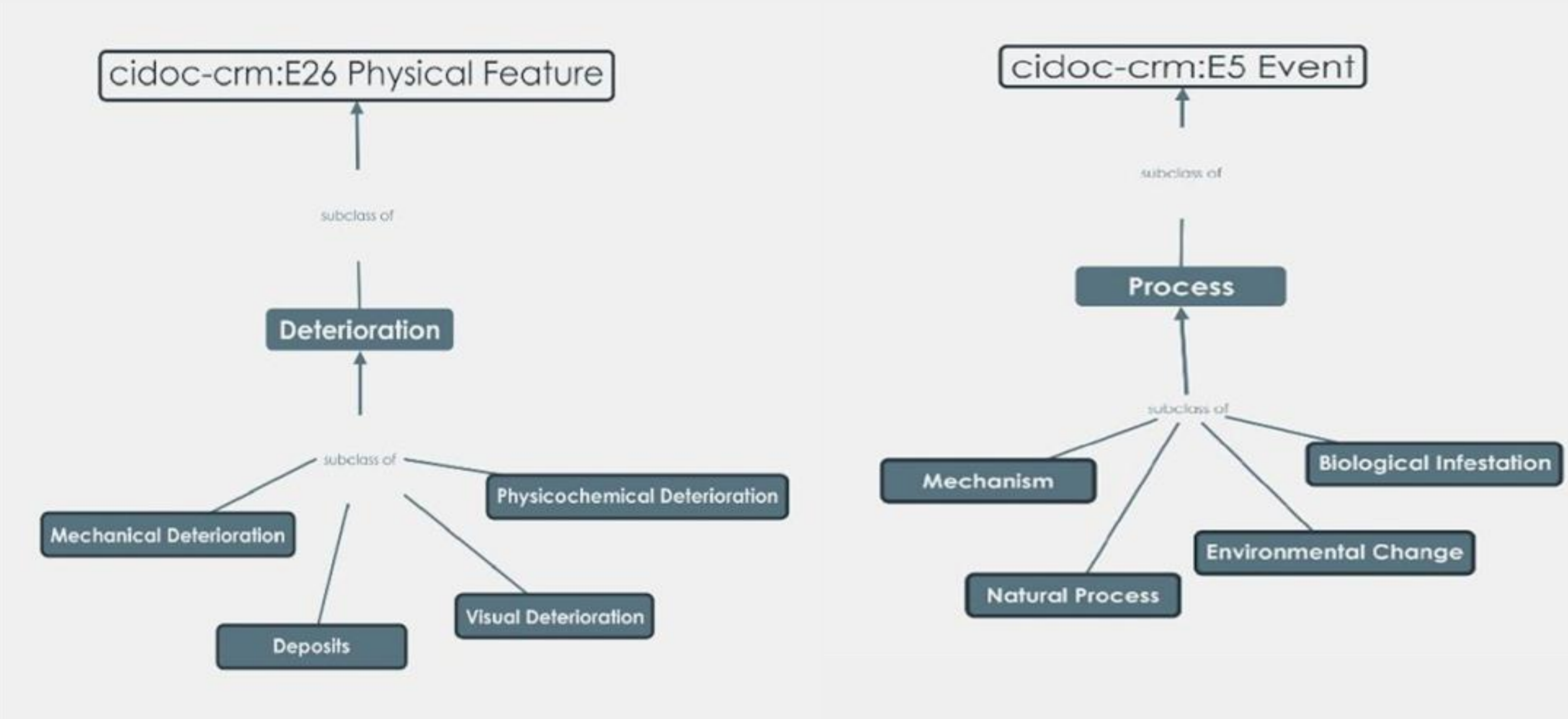
ManMade Object

Physical & Material Structure

Information Resources

THE CORE APPROACH

TRIPTYCH | Cause-Mechanism-Result



THE CORE APPROACH

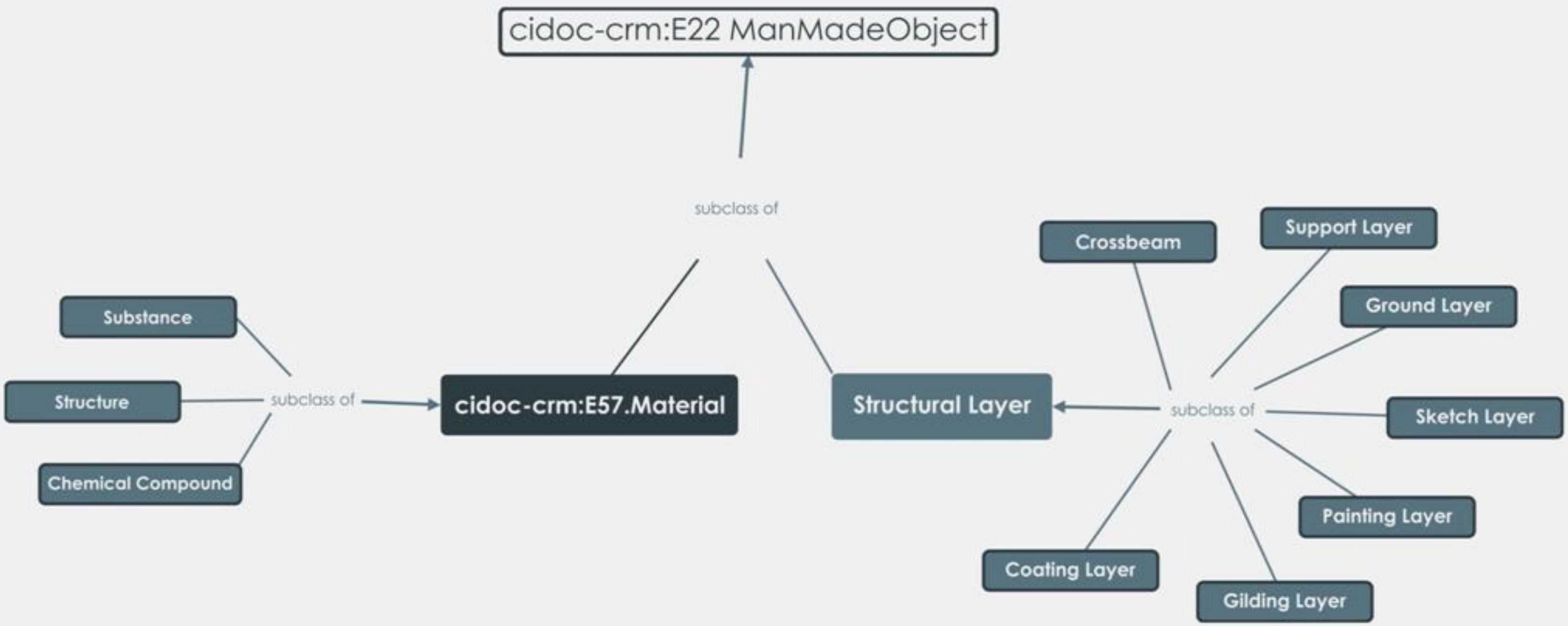
TRIPTYCH | Cause-Mechanism-Result

Environmental Change → Mechanism → Mechanical Deterioration

“ Some **radiation exposure** triggers **oxidative reaction**,
in particular **photoxidation**,
which effects **peeling** of the painting layer ”

THE CORE APPROACH

ASSOCIATION | Features & Activities – Material & Structural Layer



SENSORS ONTOLOGIES

CSIRO

The CSIRO sensor ontology is a generic ontology for describing **sensors and deployments**. It is intended to be used in data integration, search, classification and workflows. It has been used as the **initial version of the Semantic Sensor Network** ontology.

An ontology of sensor types and a DL and logic **programming rules reasoner** for making inferences about data and anomalies in measurements.

CESN

The CESN (Coastal Environmental Sensing Networks) ontology has ten concept definitions for sensor instances and six individuals.

SENSORS ONTOLOGIES

SSN

The ontology can describe sensors, the accuracy and capabilities of such sensors, observations and methods used for sensing.

The SSN ontology is built around a central **Ontology Design Pattern** describing the relationships between sensors, stimulus, and observations, the **Stimulus–Sensor–Observation (SSO) pattern**.

3 | Proposed Approach

METHOD & TOOLS

Tools

The free open source software Protégé (Protégé Desktop version 5.2.0) of Stanford University and the reasoners "Pellet" and "HermiT" were used. The rules were expressed through SWRL tab of Protégé.

Ontologies

In order to model conservation information and sensor data of environmental conditions, CIDOC CRM, CORE domain ontology and SSN sensors ontology were combined.

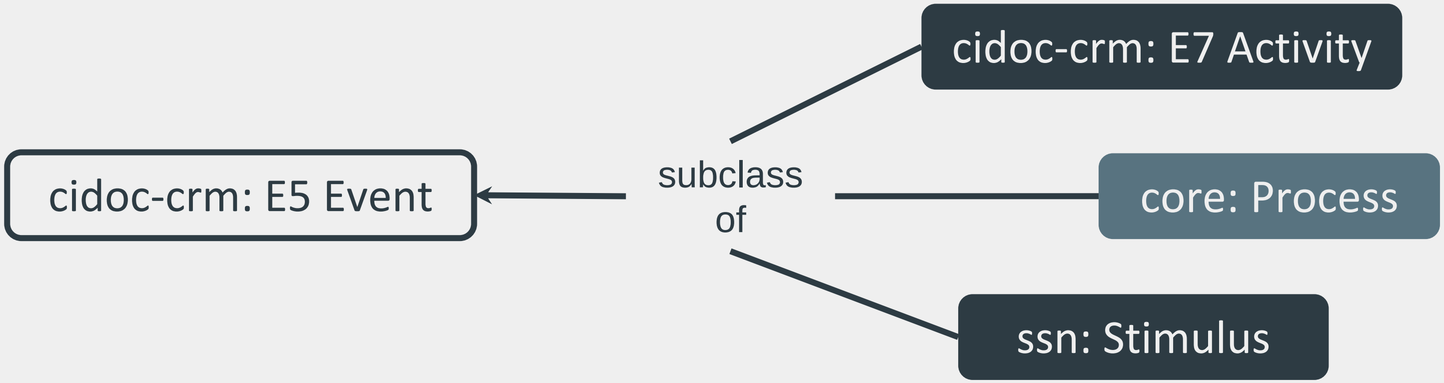
Merging

CIDOC CRM is the top-ontology which CORE entity extends, while the SSN entities are manually mapped and integrated with the rest of the other two ontologies.

CORE-SSN ENTITIES & RELATIONS

Subclasses

SSN Classes as Subclasses of CIDOC CRM-CORE's

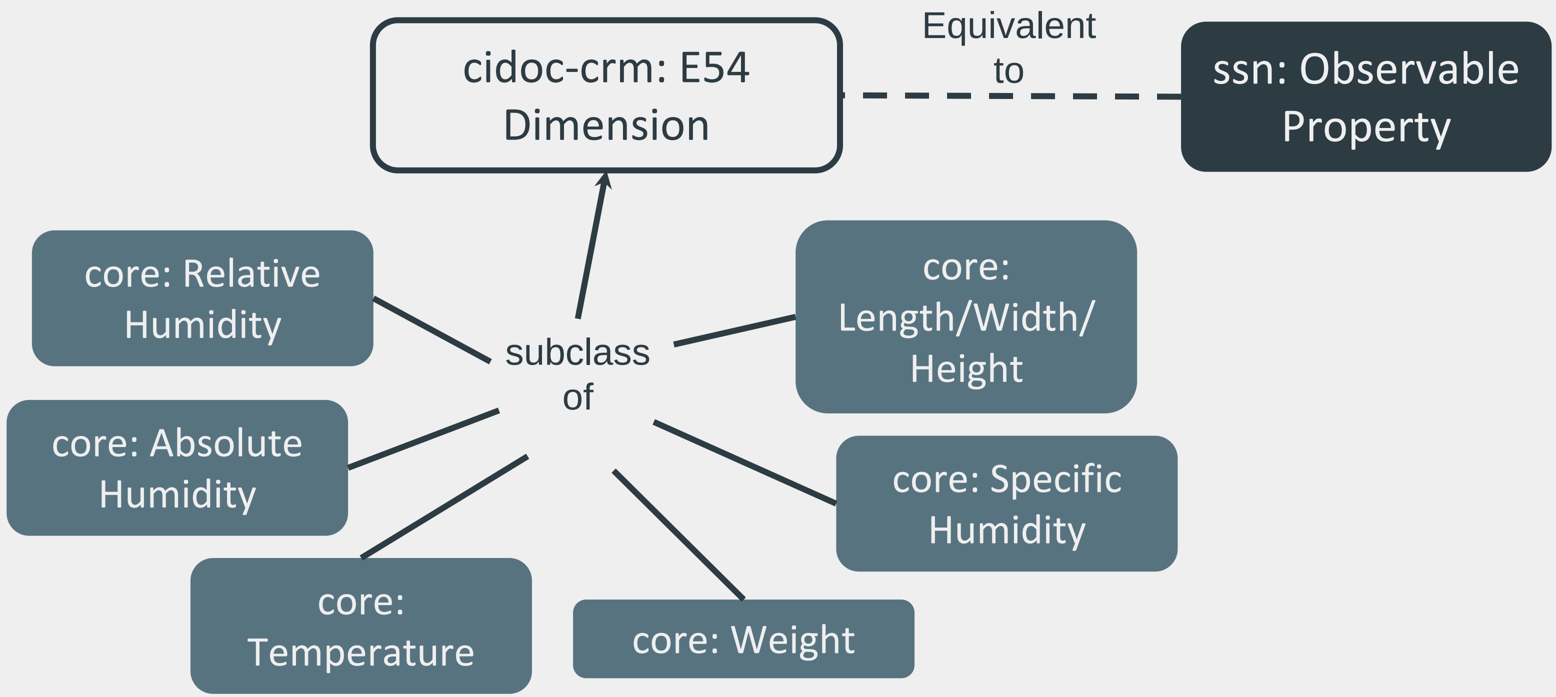


Some CORE classes are semantically related to these of SSN ontology. As a result it was possible to integrate SSN classes in CORE structure as subclasses, based on their definitions.

CORE-SSN ENTITIES & RELATIONS

Equivalence

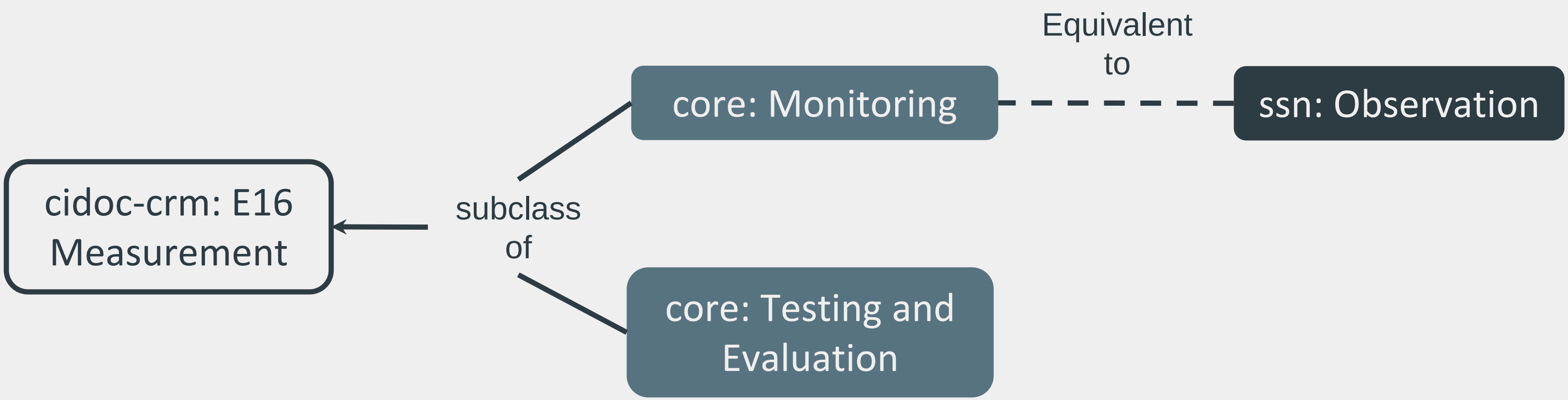
SSN Classes as Equivalent of CIDOC CRM or CORE's



Some SSN classes were defined as equivalent to some CIDOC CRM or CORE classes.

CORE-SSN ENTITIES & RELATIONS

Equivalence | SSN Classes as Equivalent to CIDOC CRM or CORE's



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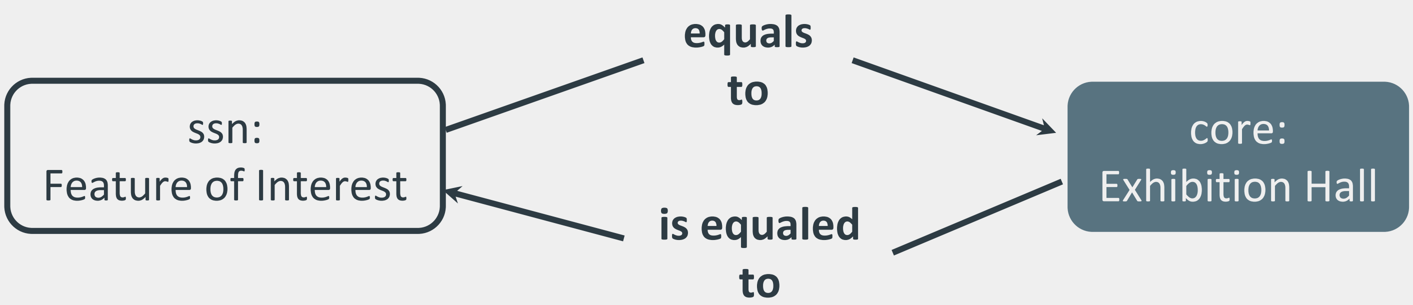
CORE-SSN ENTITIES & RELATIONS

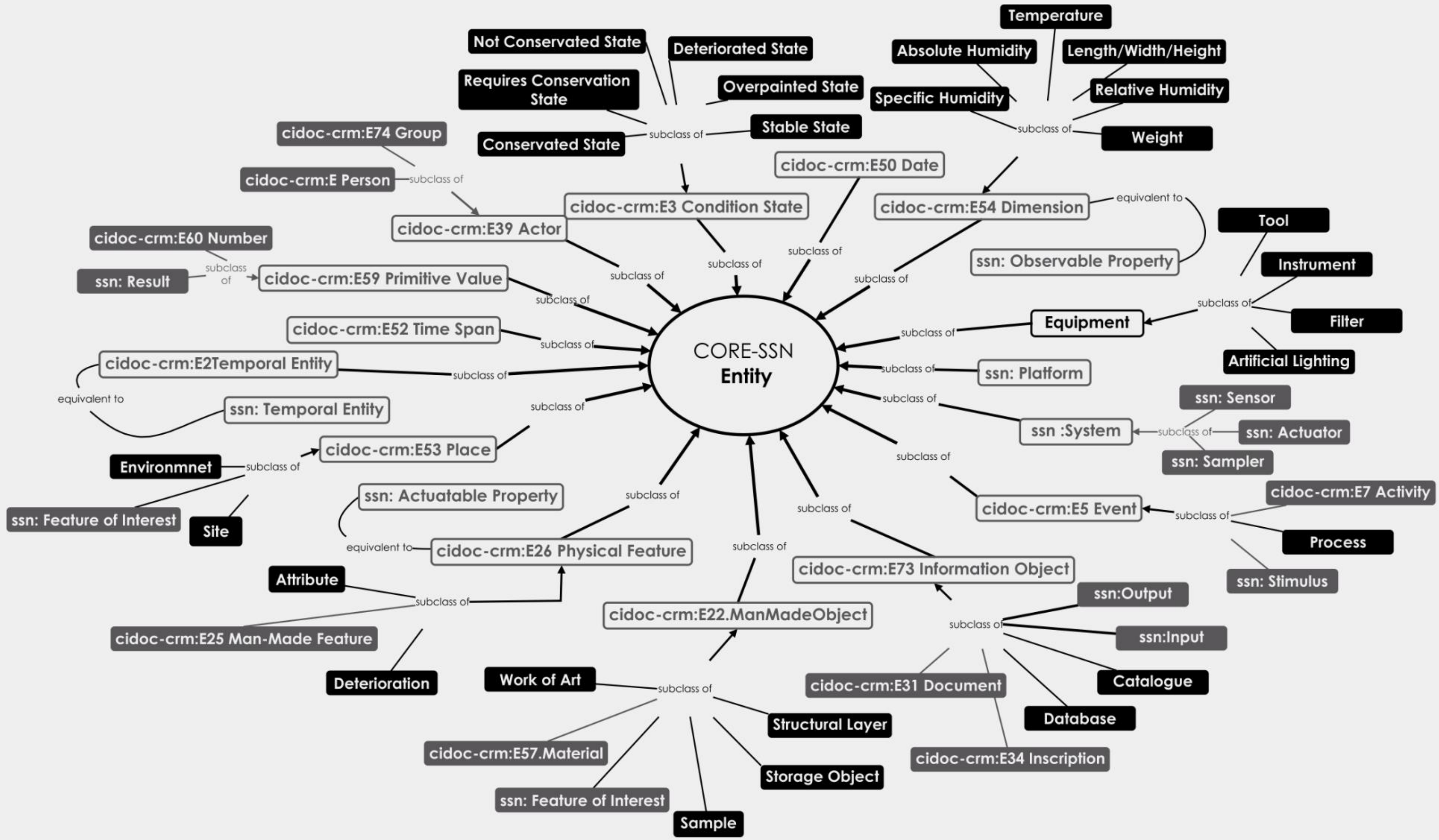
Relations

Adding new properties



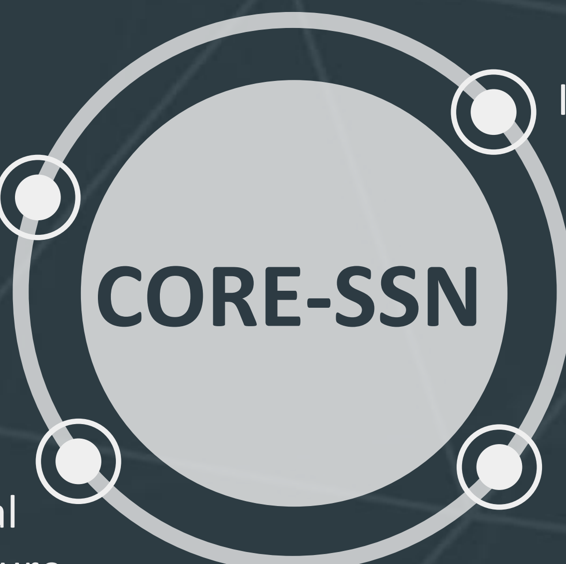
The logical association between the CORE and SSN classes was further achieved by using the existing relations of the ontologies, as well as by adding some new.

CIDOC CRM-CORE-SSN



CORE-SSN ENTITIES & RELATIONS

In order to test the scope and integrity of CORE-SSN ontology a number of individuals of entities and object property assertions between them was created.



Temperature

It was the property under observation

Exhibition Hall

It was observed

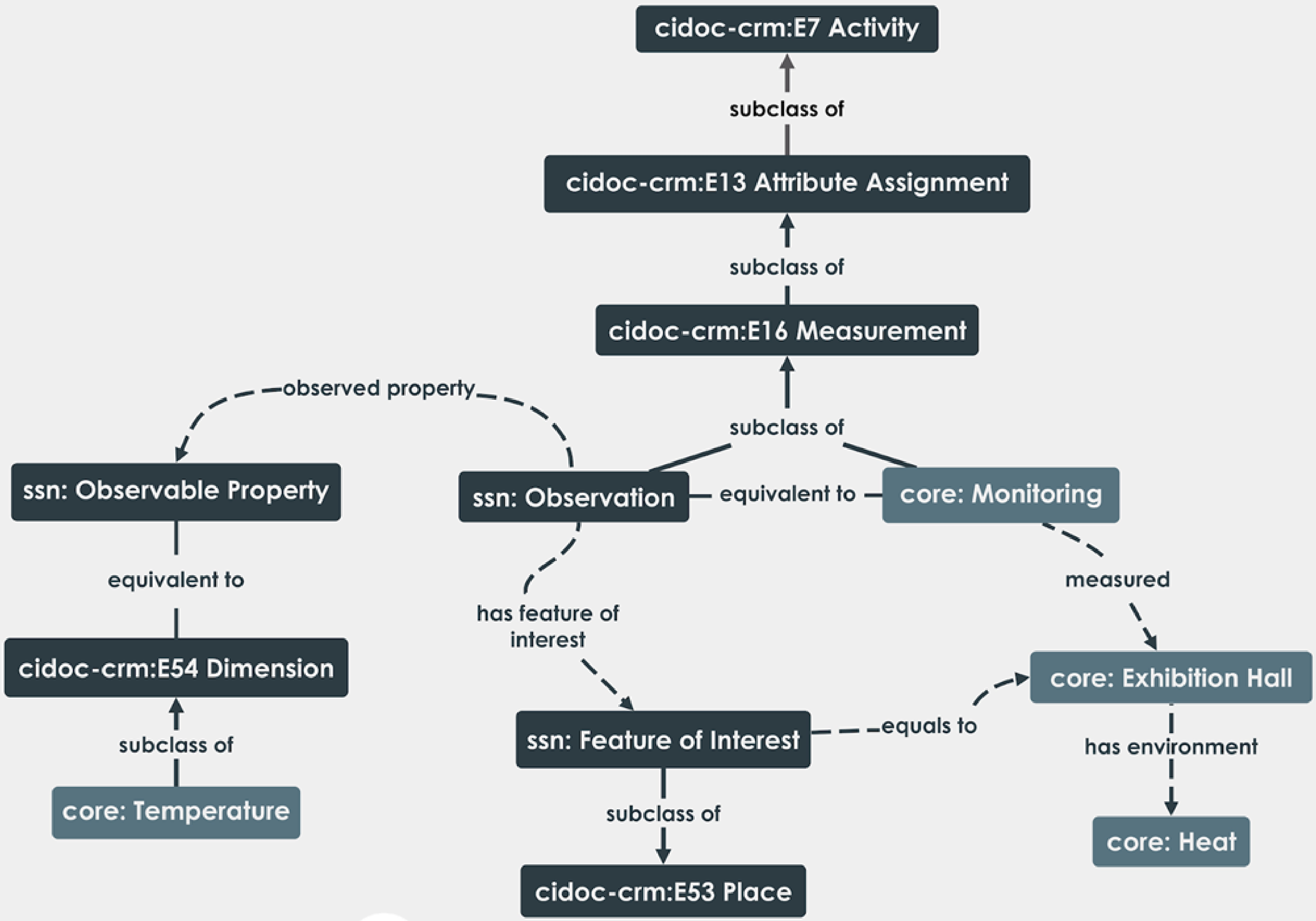
Heat

It was the environmental factor related to temperature

Heat Change

It was the stimulus by which the observation was originated was triggered

CORE-SSN ENTITIES & RELATIONS



RULES

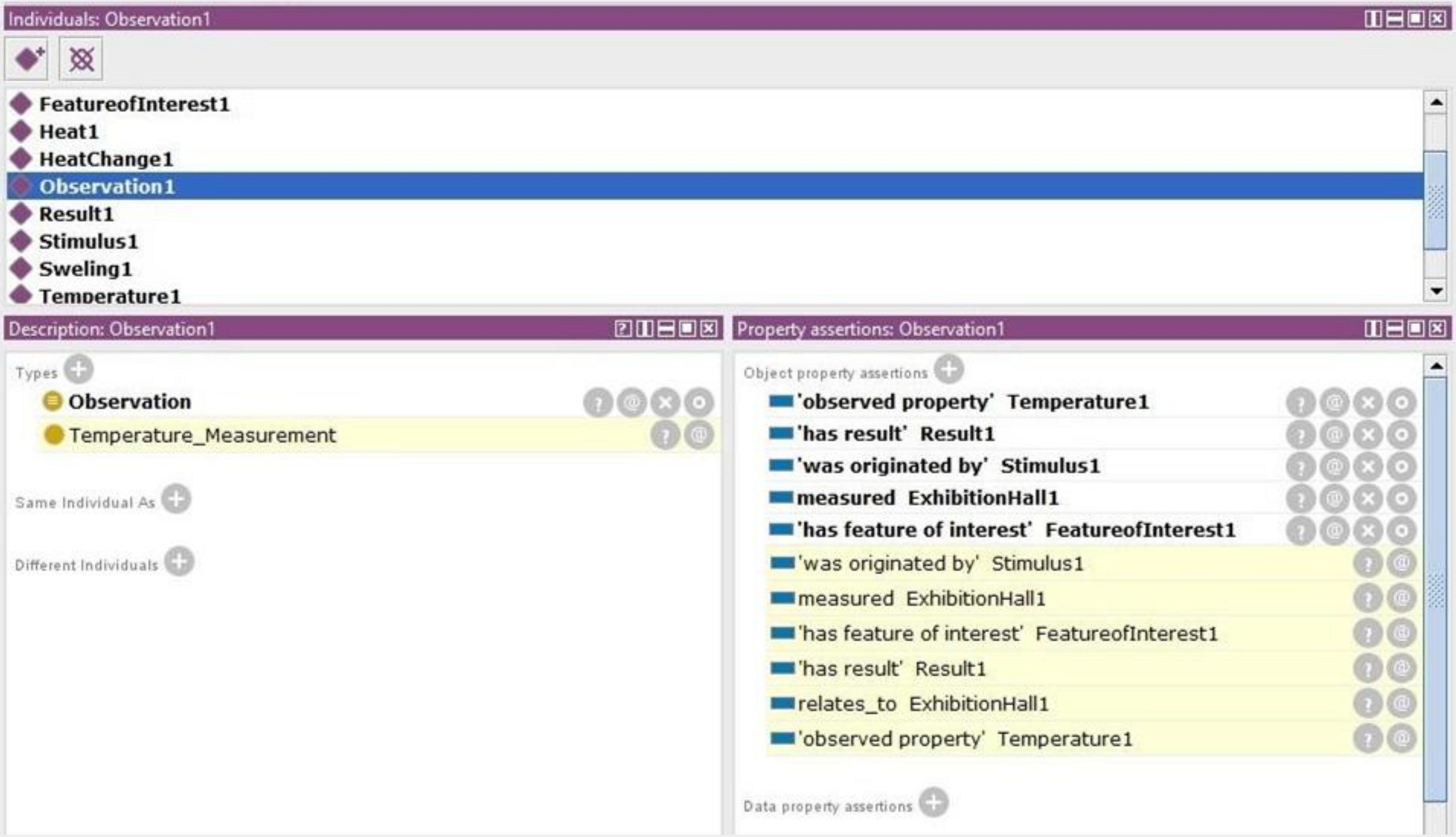
Case 1

In cases of temperature monitoring of a site, in particular an exhibition hall, it is possible to use both the concepts of **heat and temperature**. However the first is referred to the environmental factor while the second to its measured dimension.

Rule 1

An Exhibition Hall has heat (refers to the environment factor) and temperature (refers to the dimension). The temperature refers to the heat of the place and it was observed (observation) particularly by a temperature measurement activity (temperature measurement).

INFERRED INFORMATION



RULES

Case 2

The ontology-based rules could express preventive conservation guidelines and rules, such as the definition of a temperature “set point” for a sensor of the system.

Rule 2

Using the built-in atom “swrlb:greaterThan” we can compare the temperature measurement of an observation with a threshold *(ex. 35 °C)* and infer that there is a change in heat factor.

RULES

Case 3

In the context of CORE ontology some axioms about the mechanisms and the results of environmental changes had been formulated. Furthermore, the expressivity of the ontology allows the definition of artworks structure and production materials.

Rule 3

We used the CORE relation *"has the tendency to"* in order to express a rule about the potential presentation of swelling on an artwork with textile support when is exhibited to heat.

4 | Discussion & Future Work

DISCUSSION & FUTURE WORK

Extending ontologies of cultural heritage domain and the use of CIDOC CRM family models (such as the CORE extension) to the current computing framework.

Further work is necessary for the validation of the integration and the testing of the rules efficiency.

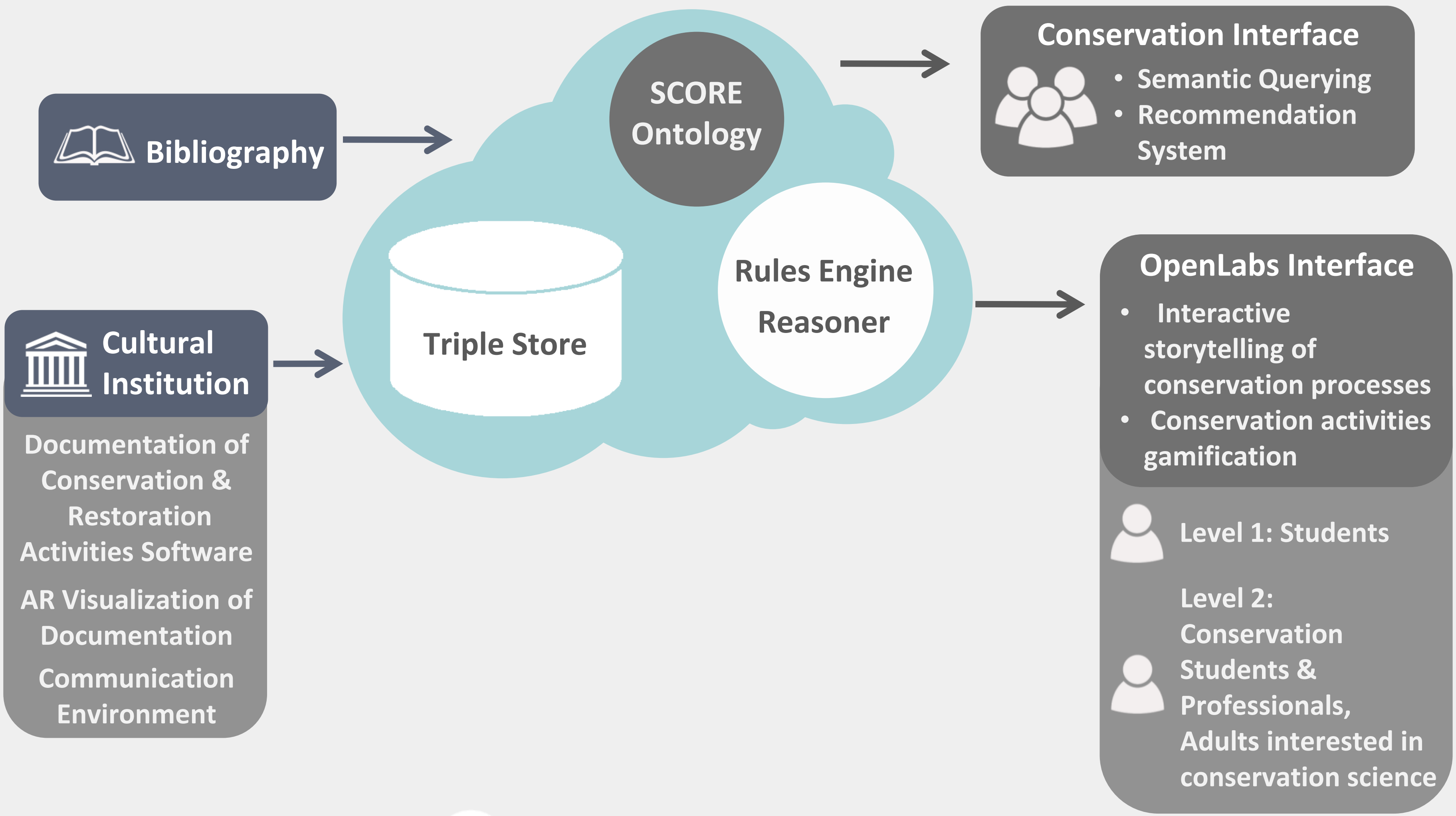
It is probable that the requirements of real-time processing, ontology's complexity and the amount of the processed semantic data could potentially lead to the use of a different rule language.

DISCUSSION & FUTURE WORK

- ✓ Taking into consideration sensor measurements, observations and samples, we can create a system which provides predictions about the risks and deterioration of the objects regarding environmental conditions such as heat and humidity.

- ✓ Future research mainly focus on the design and development of a recommendation system which supports decision-making in compliance with art conservation rules and semantic knowledge.

DISCUSSION & FUTURE WORK



Cheers ☺

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