Commercially Empowered
Linked Open Data Ecosystems in Research

D 7.3 – Standardization Proposal

Summary: This deliverable describes standardization activities carried out within the project. Our contribution in this respect is twofold: i) RDF Data Cube Vocabulary & PROV Ontology and ii) the Visual Analytics Vocabulary. The former effort was driven by UNI PASSAU where official implementation reports have been provided within the standardization process of the RDF Data Cube Vocabulary and extensions are proposed. Visual Analytics Vocabulary was developed by the Know-Center to semantically describe visualisation components. Given statistical data sets described with the Data Cube Vocabulary, automatic visualisation of such data sets becomes possible by mapping of the data onto suitable visualisation and visual properties.

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SEVENTH FRAMEWORK PROGRAMME

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1st Draft	2014-04-07	V. Sabol	Know-Center	Document structure, summary
2nd Draft	2014-04-11	B. Mutlu	Know-Center	Visual Analytics Vocabulary
3rd Draft	2014-04-20	V. Sabol	Know-Center	Review Visual Analytics Vocabulary
4th Draft	2014-04-29	F. Stegmaier	UNI PASSAU	Added standardization efforts from UNI PASSAU
5th Draft	2014-04-29	F. Stegmaier	UNI PASSAU	Finalized deliverable.
Final Version	2014-04-30			

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1 Introduction

The dissemination and exploitation plan of the CODE projects WP7 foresees the engagement of participating peers in standardization efforts and community projects towards the end of the project. In this sense, we identified two major bodies for this task: W3C to support international standardization as well as the Open Knowledge Foundation serving as well-grounded community platform in terms of Open Data. With respect to the developed prototypes, the following standardization tasks have been identified, initiated and partly finished:

- Implementation report for the RDF Data Cube Vocabulary
- Extensions to the RDF Data Cube Vocabulary and the PROV Ontology
- Specification of the Data Extraction Microformat
- Specification of the Visual Analytics Vocabulary

The reminder of this deliverable is as follows: Section 2 focuses on the standardization efforts in terms of the RDF Data Cube Vocabulary as well as extensions for the PROV Ontology. The specification of the Visual Analytics Vocabulary is part of Section 3. The planned standardization inputs will be discussed as future work in Section 4 whereas both appendices contain the serializations of the proposed vocabularies.

2 Data Cubes & Provenance information

As outlined in Deliverables D3.1, D3.3 and D3.4 of the CODE project, all services heavily utilize the two recent W3C specifications RDF Data Cube Vocabulary[1] and the PROV Ontology[2]. In this regard, two main standardization efforts are recognizable:

- Implementation report, which is added to the official W3C space
- Proposed changes / extensions to both vocabularies

The RDF Data Cube Vocabulary is utilized within the whole CODE project to reach a homogeneous data integration of primary research data as well as to generate an OLAP-aware storage. Besides, this standardized data model also fosters the interaction with consuming peers, such as the envisioned visual analytics component.

The details of the evaluation can be found in Table 1. If an integrity constraint has failed, an explanation has been added.

Table 1: Details on the integrity constraints test

Test case	Result	Description
IC-1. Unique DataSet	Pass	
IC-2. Unique DSD	Pass	
IC-3. DSD includes measure	Fail	:Water_level a rdf:Property , qb:MeasureProperty ;
IC-4. Dimensions have range	Fail	Range not yet defined in the prototype.
IC-5. Concept dimensions have code lists	Pass	Code lists are not used.
IC-6. Only attributes may be optional	Pass	qb:AttributeProperty are not yet used.
IC-7. Slice Keys must be declared	Pass	Slices are not used.
IC-8. Slice Keys consistent with DSD	Pass	See IC-7
IC-9. Unique slice structure	Pass	See IC-7
IC-10. Slice dimensions complete	Pass	See IC-7
IC-11. All dimensions required	Pass	
IC-12. No duplicate observation	Pass	
IC-13. Required attributes	Pass	
IC-14. All measures present	Pass	
IC-15. Measure dimension consistent	Pass	
IC-16. Single measure on measure dimension observation	Pass	
IC-17. All measures present in measures dimension cube	Pass	

[1] http://www.w3.org/TR/2014/REC-vocab-data-cube-20140116/

[2] http://www.w3.org/TR/prov-o/

IC-18. Consistent data set links	Pass	See IC-7
IC-19. Codes from code list	Pass	See IC-5
IC-20. Codes from hierarchy	Pass	See IC-5
IC-21. Codes from hierarchy (inverse)	Pass	See IC-5

An overview of the integrity constraints and the overall implementation reports can be found in the official W3C space[3].

While implementing the prototypes, we recognized the need for extensions within both specifications to better fit to further processing:

- ***RDF Data Cube Vocabulary:*** Originally, the *rdfs:range* definition of a dimension property can point to an arbitrary concept or literal type. To normalize this behaviour, the generic concept *entity* was introduced. An entity then always provides a *rdfs:label* and additionally the disambiguated concept for this resource. Therefore, there is always a human readable label available and the concept is used for identification purposes.
- ***PROV-O:*** The elements of PROV-O were reused with the prefix *prov*. The *prov:wasDerivedFrom* property is used to denote the relevant source cubes, if the current cube is produced by integrating multiple cubes. Activity and agent for the cube construction are denoted by *prov:wasGeneratedBy* and *prov:wasStartetBy*. An identifier then identifies the agent.

Within the prototypes of WP3, a major focus was the lifting of un- or semi-structured primary research data into *5 Star Open Data*[4]. Within this workflow, we recognized the need for a vocabulary to save the annotations during the semi-automatic lifting process. Here, a microformat has been specified that allows enrichment and annotation of tabular data (HTML5 tables) using HTML5 custom data-attributes and is specifically designed for the data extraction and triplification chain of the CODE research project in the filed of linked open data. The annotations include provenance information for trust and traceability and qualify semantic concepts of the content for interlinking purpose. To ensure interoperable services, such a microformat is highly beneficial, esp. in the Web domain. The current specification can be found in Chapter 6 and a constantly updated version is hosted in the CODE space:

http://code-research.eu/dataextraction/microformat

[3] http://www.w3.org/2011/gld/wiki/Data_Cube_Implementations

[4] http://5stardata.info/

3 Visual Analytics Vocabulary

Describing visualizations semantically has been recognized as a very effective way for querying and analysing data visually [2]. Because of tight coupling between visualizations and statistical data achieved in this way, the querying is considerably simplified and the data can be directly mapped onto visualizations.

The RDF-based description of the visualizations has following advantages:

1. it provides a common persistence model for representing visualizations that can be used by various visualization technologies
2. it allows to query existing visualizations enriched with data — therefore, visualizations are created only once
3. it is possible to interlink visualizations with each other and to combine them within a single user interface

Semantic description of visualizations using RDF is a new research topic and the related work, up to now, remains scarce. The most significant research contribution, the Statistical Graph Ontology (SGO) [3], comes from the biomedical domain, and presents a new approach to manage statistical graph knowledge by semantic annotation of graphs. The aim of this work is to make statistical graphs available as highly structured representation that can be queried and exchanged using Semantic Web technologies.

While SGO provides a sophisticated ground for describing statistical graphs, some attribute are missing to enable automated visualization like the attribute *datatype, instantiation occurrence* etc. This is why we extended the SGO Vocabulary and defined our own Visual Analytics Vocabulary [6]. The extensions help us to build a model that defines the mapping between research data and visualizations. The goal of the Visual Analytics Vocabulary is to integrate visualizations into CODE platform and to relate them to the research data.

3.1 Semantic Descriptions for Visual Analytics Components

Based on our analysis of related work and existing standards, and on the choice of using the RDF Data Cube Vocabulary for representing the underlying data sets, the Visual Analytics Vocabulary consists of the following parts:

1. Description of visualizations and their visual elements
2. Description of data points and data sources taken from the RDF Data Cube Vocabulary (http://purl.org/linked-data/cube#)
3. A mapping between RDF Data Cubes and Visual Analytics Vocabulary

The following abbreviations and namespaces are used:

- qb (RDF Data Cube Vocabulary, http://purl.org/linked-data/cube#)
- sio (SemanticScience Integrated Ontology, http://semanticscience.org/ontology/sio.owl)
- va (Visual Analytics Vocabulary, http://code-research.eu/ontology/visual-analytics#)
- rdf, rdfs (Core RDF namespaces)
- dc (Dublin Core Metadata Initiative, http://purl.org/dc/terms/)

The VA Vocabulary has been defined in the form of an OWL (Web Ontology Language) ontology.

In our context, the semantic description offers the way of knowing simple facts about visualizations. The semantic description strictly focuses on describing the visual encoding process; hence we represent visualisations in terms of their visual channels (visual properties). Hereby, we undertake a semantic description of well-established semiotic principles, e.g. visual channels [4]. However,

instead of pursuing a thorough specification encompassing all known facts about visual perception, we concentrate on pragmatic, simple facts that will aid the sensible mapping [5], extending the description to many different types of visualisations.
Thus, we have separated our VA Vocabulary into two parts:

1. the model of an abstract visualisation (i.e. an abstract visualisation type) that captures only the commonalities, which are shared between all concrete visualisations and
2. concrete visualisation models, which capture just specific information. These concrete visualisation models refine the abstract model depending on the visualisation type.

The abstract visualisation specifies most important structural components that any concrete visualisation may have. These are:

- Name: Identification for a visualisation.
- Visual Channel: A container for data, which have to be visualised. It contains structural rules required to correctly map statistical data to a visualisation. For example, a visual channel for a bar chart is defined to represent its *x-axis* and *y-axis*.
- Description: A collection of non-mandatory components (e.g. textual description or image such as SVG figure for a concrete visualisation).

The difference between concrete visualisations lies in its reification of visual channels. For example, the bar chart has only two visual channels, *x-axis* and *y-axis*. According to their type definition, *y-axis* always represents a numeric (e.g. decimal, float, integer, etc.), whereby *x-axis* has more supported types (string for example). Further, this visualisation will be suggested only if suitable data is provided for both visual channels (we say here, they are instantiated). In the case of bar chart, both visual channels are mandatory. In contrast, the parallel coordinates, requires at least one *x-axis* , while the additional instances of that visual channel are optional, a characteristic shared by Jquery Table visualisation and the Scatterplot matrix.
To capture such differences in our VA Vocabulary, we characterize visual channels with the following attributes:

- Data type: Defines a set of primitive data types that a visual channel can support.
- Occurrence: Defines the cardinality of a visual channel (i.e. how many instances are allowed for the concrete visual channel).
- Persistence: Defines whether a visual channel is mandatory part of the concrete visualisation or not.

The occurrence attribute identifies whether a visual channel can be instantiated only once (e.g. bar chart *x-axis* and *y-axis*, see Figure 1) or multiple times (e.g. parallel coordinates *x-axis,* see Figure 2). There are two different values for this attribute: *one* and *many*. The occurrence *many* is used for visualising high-dimensional RDF Data Cubes. In contrast, the occurrence *one* defines a fixed cardinality. Another important role of the occurrence is that it reveals the structure of the concrete visualisation.

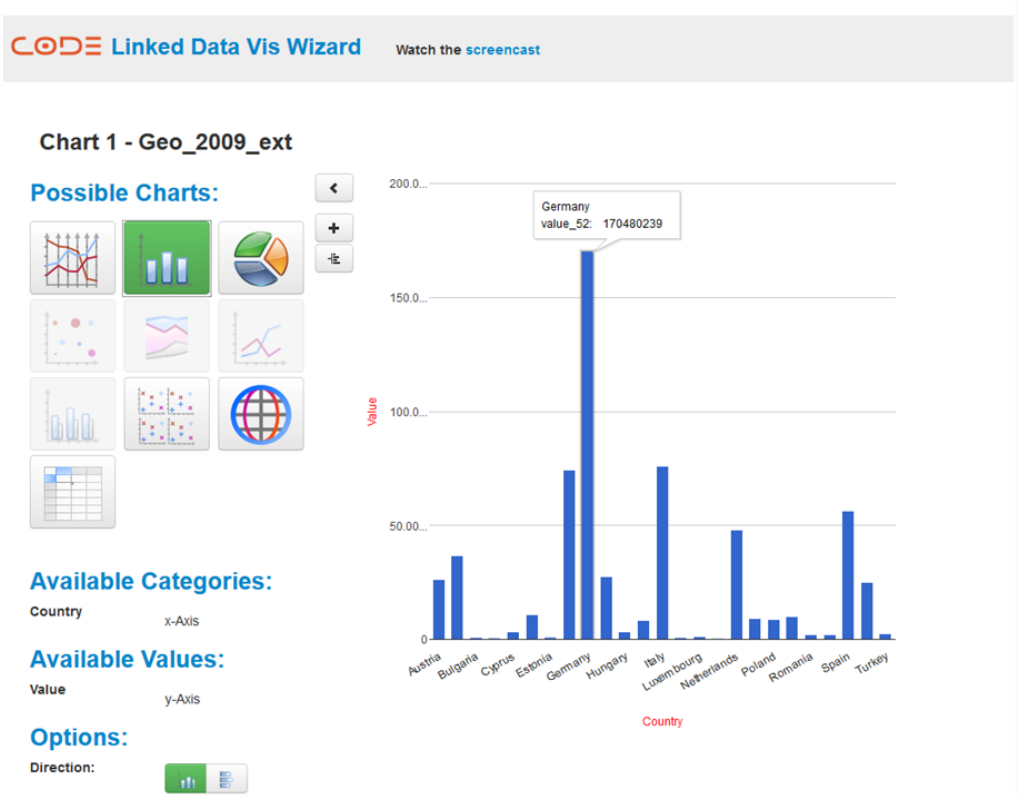

Figure 1: Bar chart has visual attributes x-axis and y-axis both with occurrence one

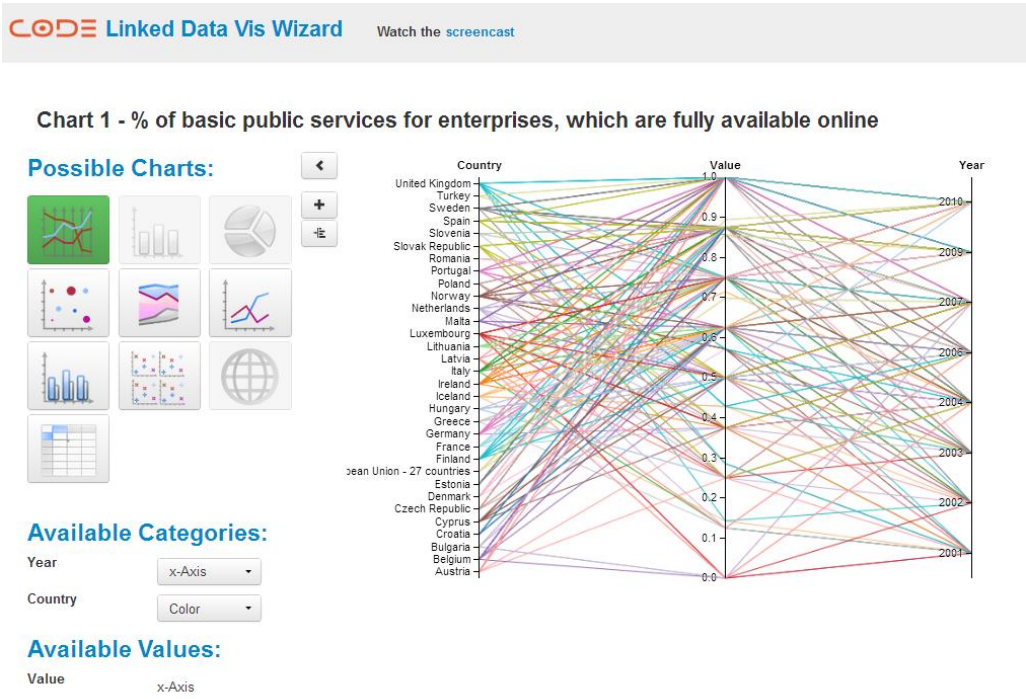

Figure 2: Parallel coordinates has only one visual attribute x-axis with the occurrence many.

The persistence attribute helps define more complex cases, e.g. a visualisation with three mandatory and two optional visual channels. Hereby, the case with the parallel coordinates can be alternatively defined as follows: one mandatory visual channel with the occurrence *one*, and another one, which has an occurrence *many* and *no* persistence.
Based on this information described in these attributes, we are able to define the integration of the visualisation with the data (i.e. whether an appropriate visualisation exists for a given RDF Data Cube).

4 Future Work

As shown, the outlined vocabularies are able to heavily support Web-enabled data extraction as well as visualization processes. Currently, the dissemination of those vocabularies is mostly limited to the scientific domain, but will be recently communicated to standardization bodies and the Semantic Web community. In detail, the following is planned:

- Since the standardization process on the RDF Data Cube Vocabulary has been recently finished, we will initiate activities to release our proposed extensions as errata to the original specification within summer 2014.
- The microformat will be communicated to the mailing lists in order to discuss its value with the community.
- The Visual Analytics Vocabulary is currently included in Linked Open Data Vocabulary[5] of the Open Knowledge Foundation and is also being considered with Parrot[6] (a RIF and OWL documentation service).

[5] http://lov.okfn.org/dataset/lov/details/vocabulary_va.html

[6] http://ontorule-project.eu/parrot/parrot?documentUri=http%3A%2F%2Fcode.know-center.tugraz.at%2Fstatic%2Fontology%2Fvisual-analytics.owl&mimetype=text%2Fn3&profile=business&language=en&customizeCssUrl=

5 References

[1] CODE Description of Work (2012), Version Date 20012-01-23.

[2] Martin Voigt, Stefan Pietschmann, Lars Grammel, Klaus Meißner (2012) **Context-aware recommendation of Visualization Components**. *In the Fourth International Conference, Process, and Knowledge Management*. 2012, Valencia, Spain.

[3] Dumontier, M., L. Ferres, and N. Villanueva-Rosales (2010) **Modelling and querying graphical representations of semantic web**. *Web Semantics: Science, Services and Agents on the World Wide Web* 8(2-3):241-254, 2010.

[4] Bertin J. (1986) **Semiology of graphics**. *University of Wisconsin Press*, 1983.

[5] J. Mackinlay (1986) **Automating the design of graphical presentations of relational information**. *ACM Trans. Graph.*, 5(2):110-141, Apr. 1986.

[6] Belgin Mutlu, Patrick Hoefler, Gerwald Tschinkel, Eduardo Veas, Vedran Sabol, Florian Stegmaier, Michael Granitzer (2014) **Suggesting Visualisations for Published Data**, *in Proceedings of the 5th International Conference on Information Visualization Theory and Applications (IVAPP 2014)*, January 2014, Lisbon, Portugal.

6 Appendix A: Data Extraction Microformat

```
Attributes:
1. data-code-title
2. data-code-agent
3. data-code-url
4. data-code-component
5. data-code-range
6. data-code-type
7. data-code-source
8. data-code-activity

1. data-code-title
Defines a human readable label for the extracted dataset.
     Restricted on: <table>
     Value: <String>

2. data-code-agent
Defines the person that bears responsibility for the data extraction.
     Restricted on: <table>
     Value: <URL> (currently we support Mendeley profile url)

3. data-code-url
Defines the linked data con- cept for the value of the cell or table semantic.
     Restricted on: <table> or <td>
     Value: <URL>

4. data-code-component
Defines the structure type of this cell. It can be a dimen- sion or a observation
values.
     Restricted on: <td>
     Value: <URL> (http://code-research. eu/ontology/dataextraction/cubeDimension or
         http://code-research.eu/ontology/dataextraction/cubeObservation)

5. data-code-range
Defines the super or gen- eral concept of this cell value e.g. 0.3 could be
code:typePercentage.
     Restricted on: <td>
     Value: <URL>

6. data-code-type
Qualifies and interpret the cell value. Enables specifi- cation of a data type like
String or Integer.
     Restricted on: <td>
     Value: <URL>

7. data-code-source
Defines the source of ex- tracted data. E.g. link to a research paper.
     Restricted on: <td>
     Value: <URL> (currently we supports Mendeley library links)

8. data-code-activity
Specifies whether and how the source data was modified.
     Restricted on: <td>
     Value: <URL>
```

7 Appendix B – Visual Analytics Ontology

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.
@prefix xs: <http://www.w3.org/2001/XMLSchema#>.
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix owl: <http://www.w3.org/2002/07/owl#>.
@prefix dc: <http://purl.org/dc/elements/1.1/>.
@prefix dcterms: <http://purl.org/dc/terms/>.
@prefix code: <http://code-research.eu/ontology/visual-analytics>.
@prefix sio: <http://semanticscience.org/ontology/sio.owl>.
@prefix va: <http://code-research.eu/ontology/visual-analytics#>.
@prefix qb: <http://purl.org/linked-data/cube#>.


<http://code-research.eu/ontology/visual-analytics>
    a owl:Ontology;
    owl:versionInfo "0.1.20121122";
    rdfs:label "The Visual Analytics Vocabulary";
    rdfs:comment "This vocabulary allows the semantic description of visual
analytics applications. It is based on the RDF Data Cube Vocabulary and the
Semanticscience Integrated Ontology.";
    dcterms:created "2012-10-31"^^xs:date;
    dcterms:modified "2013-06-01"^^xs:date;
    .


# === Classes ==============================

# --- General Classes --------------------------

va:Chart a rdfs:Class, owl:Class;
        rdfs:label "Chart"@en;
        rdfs:comment "Is the graphical representation of numerical or qualitative
data."@en;
        owl:equivalentClass sio:SIO_000904;
        va:hasChartName va:ChartName;
        va:supportedDimension va:SupportedDimension;
        va:hasVisualChannel va:VisualChannel;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
    .

va:VisualChannel a rdfs:Class, owl:Class;
        rdfs:label "Visual channel"@en;
        rdfs:comment "Represents a visual dimension of a chart."@en;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        va:hasDataType va:DataType;
        va:hasOccurrence va:Occurence;
        va:hasPersistence va:Persistence;
        .

va:ChartName a rdfs:Class, owl:Class;
        rdfs:label "Chart Name"@en;
        rdfs:comment "Represents the name of a chart."@en;
        rdfs:subClassOf va:Chart;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

va:Axis a rdfs:Class, owl:Class;
        rdfs:label "Axis"@en;
        rdfs:comment "Is a line segment that is part of a chart in which the
position along the line corresponds to a numeric or categorical value. "@en;
        rdfs:subClassOf va:VisualChannel;
        owl:equivalentClass sio:SIO_000450;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
```

```
        .

va:Color a rdfs:Class, owl:Class;
        rdfs:label "Color"@en;
        rdfs:comment "Represents a visual dimension of a chart."@en;
        rdfs:subClassOf va:VisualChannel;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

va:Size a rdfs:Class, owl:Class;
        rdfs:label "Size"@en;
        rdfs:comment "Represents a visual dimension of a chart."@en;
        rdfs:subClassOf va:VisualChannel;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

va:Symbol a rdfs:Class, owl:Class;
        rdfs:label "Symbol"@en;
        rdfs:comment "Represents a visual dimension of a chart."@en;
        rdfs:subClassOf va:VisualChannel;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

va:DataType a rdfs:Class, owl:Class;
        rdfs:label "Data type"@en;
        rdfs:comment "Data type identifies a type of data represented in chartâ€™s
visual channel."@en;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

va:Persistence a rdfs:Class, owl:Class;
        rdfs:label "Persistence"@en;
        rdfs:comment "Persistence denotes whether a visual channel is permanently
present in the chart and must be specified or it might be defined if needed."@en;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

va:Occurrence a rdfs:Class, owl:Class;
        rdfs:label "Occurrence"@en;
        rdfs:comment "Occurrence denotes whether a visual channel can be set only
one times or multiple times."@en;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .


va:Mandatory a rdfs:Class, owl:Class;
        rdfs:label "Mandatory Persistence "@en;
        rdfs:comment "Denotes that a visual channel must be specified."@en;
        rdfs:subClassOf va:Persistence;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

va:Optional a rdfs:Class, owl:Class;
        rdfs:label "Optional Persistence"@en;
        rdfs:comment "Denotes that a visual channel must be specified."@en;
        rdfs:subClassOf va:Persistence;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .


va:One a rdfs:Class, owl:Class;
        rdfs:label "Occurence one"@en;
        rdfs:comment "Denotes that a visual channel can only set at one times."@en;
        rdfs:subClassOf va:Occurrence;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
```

```
        .


va:Multiplicity a rdfs:Class, owl:Class;
        rdfs:label "Occurence multiplicity"@en;
        rdfs:comment "Denotes that a visual channel can set at multiple times."@en;
        rdfs:subClassOf va:Occurrence;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

va:SupportedDimension a rdfs:Class, owl:Class;
        rdfs:label "Supported dimension"@en;
        rdfs:comment "Denotes how many dimensions can be visualize by a chart."@en;
        rdfs:subClassOf va:Chart;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

# --- Mapping-Specific Classes ---------------------------

va:Mapping a rdfs:Class, owl:Class;
        rdfs:label "Mapping"@en;
        rdfs:comment "This class contains all mappings created for an RDF Data
Cube."@en;
        va:hasComponentMapping va:ComponentMapping;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .


va:ComponentMapping a rdfs:Class, owl:Class;
        rdfs:label "Component mapping"@en;
        rdfs:comment "Represents a mapping for a particular chart."@en;
        va:representsChart va:MappedChartName;
        va:hasComponentMapping va:ComponentMapping;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .


# --- Dashboard-Specific Classes ---------------------------

va:Dashboard a rdfs:Class, owl:Class;
        rdfs:label "Dashboard"@en;
        rdfs:comment "Represents a collection of one or more charts that visualize
the same Data Cube."@en;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .


# === Properties ==============================

# --- General Properties ---------------------------

va:unit a rdf:Property, owl:ObjectProperty;
        rdfs:label "Unit"@en;
        rdfs:comment "Defines the unit measure of a visual channel."@en;
        rdfs:domain va:VisualChannel;
        rdfs:range  rdfs:Resource;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

owl:Restriction owl:onProperty va:unit;
        owl:minCardinality 1;
        owl:maxCardinality 1;
        .

va:hasDataType a rdf:Property, owl:ObjectProperty;
```

```
        rdfs:label "Has data type"@en;
        rdfs:comment "Defines which data type a visual channel has."@en;
        rdfs:domain va:VisualChannel;
        rdfs:range  va:DataType;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .
owl:Restriction owl:onProperty va:hasDataType ;
        owl:minCardinality 1;
        .

va:hasPersistence a rdf:Property, owl:ObjectProperty;
        rdfs:label "Has persistence"@en;
        rdfs:comment "Denotes which visual channel of a chart must be specified or
might be defined if needed."@en;
        rdfs:domain va:VisualChannel;
        rdfs:range  va:Persistence;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .
owl:Restriction owl:onProperty va:hasPersistence;
        owl:minCardinality 1;
        owl:maxCardinality 1;
        .

va:hasOccurrence a rdf:Property, owl:ObjectProperty;
        rdfs:label "Has occurrrence"@en;
        rdfs:comment "Denotes whether a visual channel can be set only at one times
or multiple times."@en;
        rdfs:domain va:VisualChannel;
        rdfs:range  va:Occurence;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .
owl:Restriction owl:onProperty va:hasOccurrence;
        owl:minCardinality 1;
        owl:maxCardinality 1;
        .


va:hasVisualChannel a rdf:Property, owl:ObjectProperty;
        rdfs:label "Has visual channel"@en;
        rdfs:comment "Represents which visual channel a chart has."@en;
        rdfs:domain va:Chart;
        rdfs:range  va:VisualChannel;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

owl:Restriction owl:onProperty va:hasVisualChannel;
        owl:minCardinality 1;
        .


va:hasChartName a rdf:Property, owl:ObjectProperty;
        rdfs:label "Has chart label"@en;
        rdfs:comment "Represents which name a chart has."@en;
        rdfs:domain va:Chart;
        rdfs:range  va:ChartName;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

owl:Restriction owl:onProperty va:hasChartName ;
        owl:minCardinality 1;
        owl:maxCardinality 1;
        .

va:cubeDimensionNominal a qb:DimensionProperty, rdf:Property, owl:ObjectProperty;
        rdfs:label "Nominal cube dimension";
```

```
        rdfs:comment "This class can be used as a fallback for nominal dimensions.
It should be avoided in favor of more specific dimension properties.";
        rdfs:domain qb:Observation;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .


# --- Mapping-Specific Properties ---------------------------

va:getMapping a rdf:Property, owl:ObjectProperty;
        rdfs:label "Get Mapping"@en;
        rdfs:comment "Displays the mappings for a RDF Data Cube."@en;
        rdfs:domain va:RDFDataCube;
        rdfs:range  va:Mappig;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

owl:Restriction owl:onProperty va:getMapping;
        owl:minCardinality 1;
        .


va:hasComponentMapping a rdf:Property, owl:ObjectProperty;
        rdfs:label "Has components mapping"@en;
        rdfs:comment "Displays a particular mapping of a RDF Data Cube."@en;
        rdfs:domain va:Mapping;
        rdfs:range  va:ComponentMapping;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

owl:Restriction owl:onProperty va:hasComponentsMapping;
        owl:minCardinality 1;
        .


va:representsCubeProperty a rdf:Property, owl:ObjectProperty;
        rdfs:label "Represents chart"@en;
        rdfs:comment "Represents the component (dimension,measure) of a RDF Data
Cube, which has been mapped."@en;
        rdfs:domain va:Mapping;
        rdfs:range  qb:DimensionProperty;
        rdfs:range  qb:MeasureProperty;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

owl:Restriction owl:onProperty va:representsCubeProperty;
        owl:minCardinality 1;
        owl:maxCardinality 1;
        .

# --- Dashboard-Specific Properties ---------------------------

va:visualizes a rdf:Property, owl:ObjectProperty;
        rdfs:label "visualizes"@en;
        rdfs:comment "Links a Visual Analytics Dashboard with a Data Cube or Data
Slice"@en;
        rdfs:domain  va:Dashboard;
        rdfs:range qb:DataSet, qb:Slice;
        rdfs:isDefinedBy <http://code-research.eu/ontology/visual-analytics>;
        .

owl:Restriction owl:onProperty va:visualizes;
        owl:minCardinality 1;
        owl:maxCardinality 1;
        .
```