



21

March
2024

Introductory webinar on MLDCAT-AP

interoperable
europe
innovation ∞ govtech ∞ community

Agenda



Introduction



MLDCAT-AP & the DCAT-AP ecosystem



Guest speaker: OpenML



MLDCAT-AP: a closer look



Next steps

Workshop practicalities

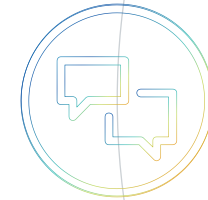
Audio

Click on 'connect audio' but please mute your microphones



Chat

You can also share your questions for the Q&A session via the chat



Recording

The workshop will be recorded

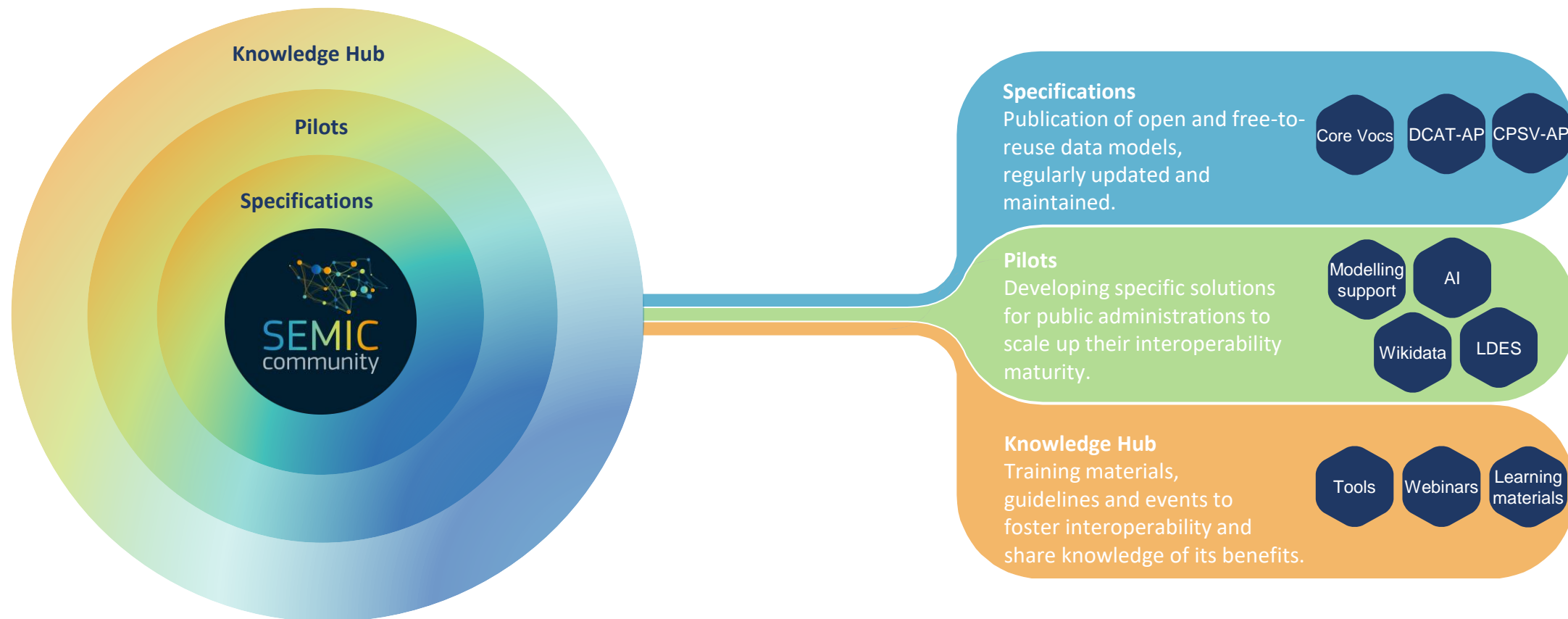




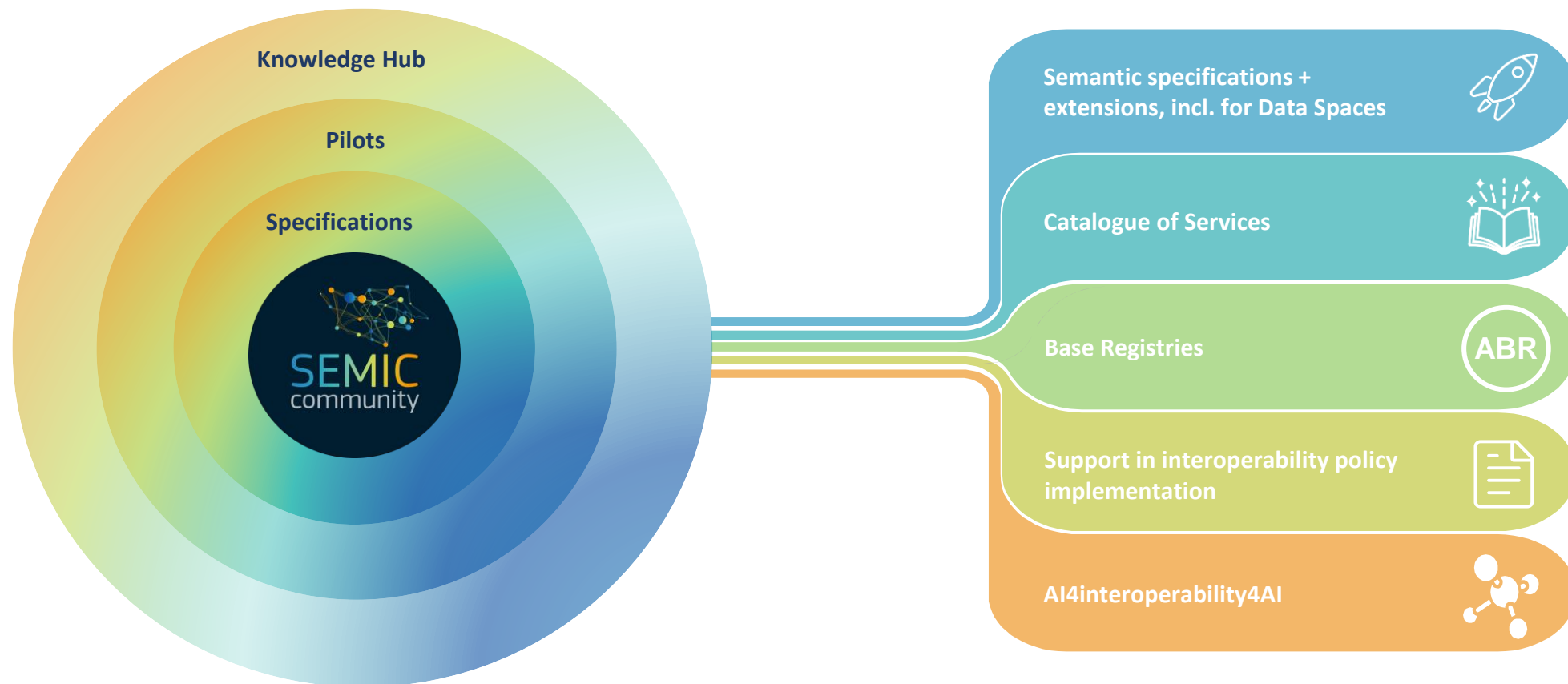
Context of the SEMIC assets

SEMIC

SEMIC's mission is to promote Semantic Interoperability amongst the EU Member States and deliver pragmatic support to help build an Interoperable Europe.



SEMIC Focus Areas





Specifications

SEMIC specifications enable interoperability:

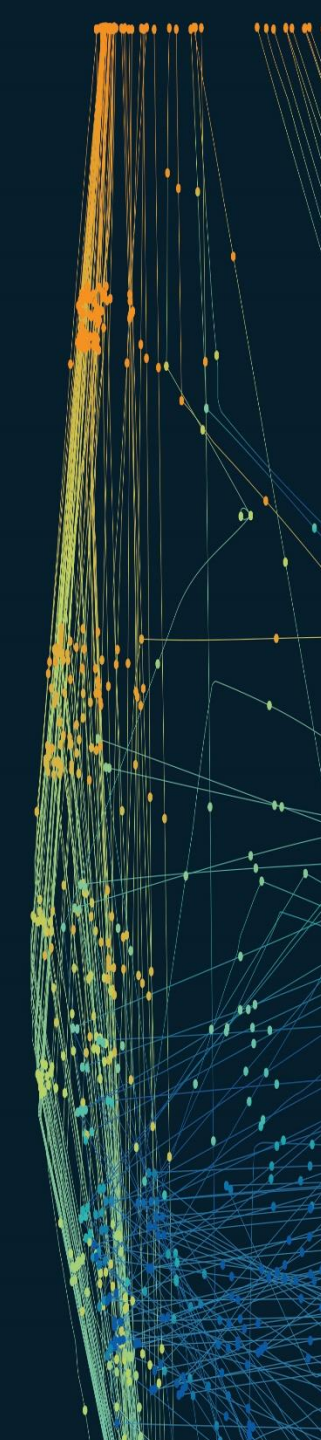
- They make data **transparent** and **available**
- They support the **coherent** implementation of laws and policies
- They help implement **cost efficiencies**
- They help **digitalisation** and **harmonising** processes

Core Vocabularies

Core Vocabularies are a cornerstone element of semantic interoperability. They provide a standardised approach for describing key concepts such as locations, businesses, organisations and natural persons.

Application Profiles

Application Profiles make use of vocabularies for a detailed set of use cases to define mandatory relations, constraints and relationships.



A large, dark blue circular graphic on the left side of the slide contains a complex network diagram. The diagram consists of numerous thin, curved lines in shades of blue, green, and yellow, connecting small dots of the same colors. The lines are dense and create a sense of interconnectedness and data flow. The text 'MLDCAT-AP and the DCAT-AP ecosystem' is overlaid on this graphic in white, sans-serif font. A small horizontal line with a color gradient (blue to yellow) is positioned below the text.

MLDCAT-AP and the DCAT-AP ecosystem

Objectives of DCAT-AP



Supporting the discovery of/access to (open) data in a cross-border and cross-domain environment, by describing metadata to be harvested across a distributed network of portals.



In the form of an application profile of W3C DCAT, by

- expressing constraints and usages on DCAT properties and classes, and
- including additional properties and usages of controlled vocabularies

Domains of applications



Open data portals with an extension for statistics and geospatial data.



Base registries metadata descriptions



Data spaces

- NAPCORE-Mobility
- GeoDCAT-AP
- HealthDCAT-AP
- ...



Machine Learning with MLDCAT-AP

DCAT-AP ecosystem



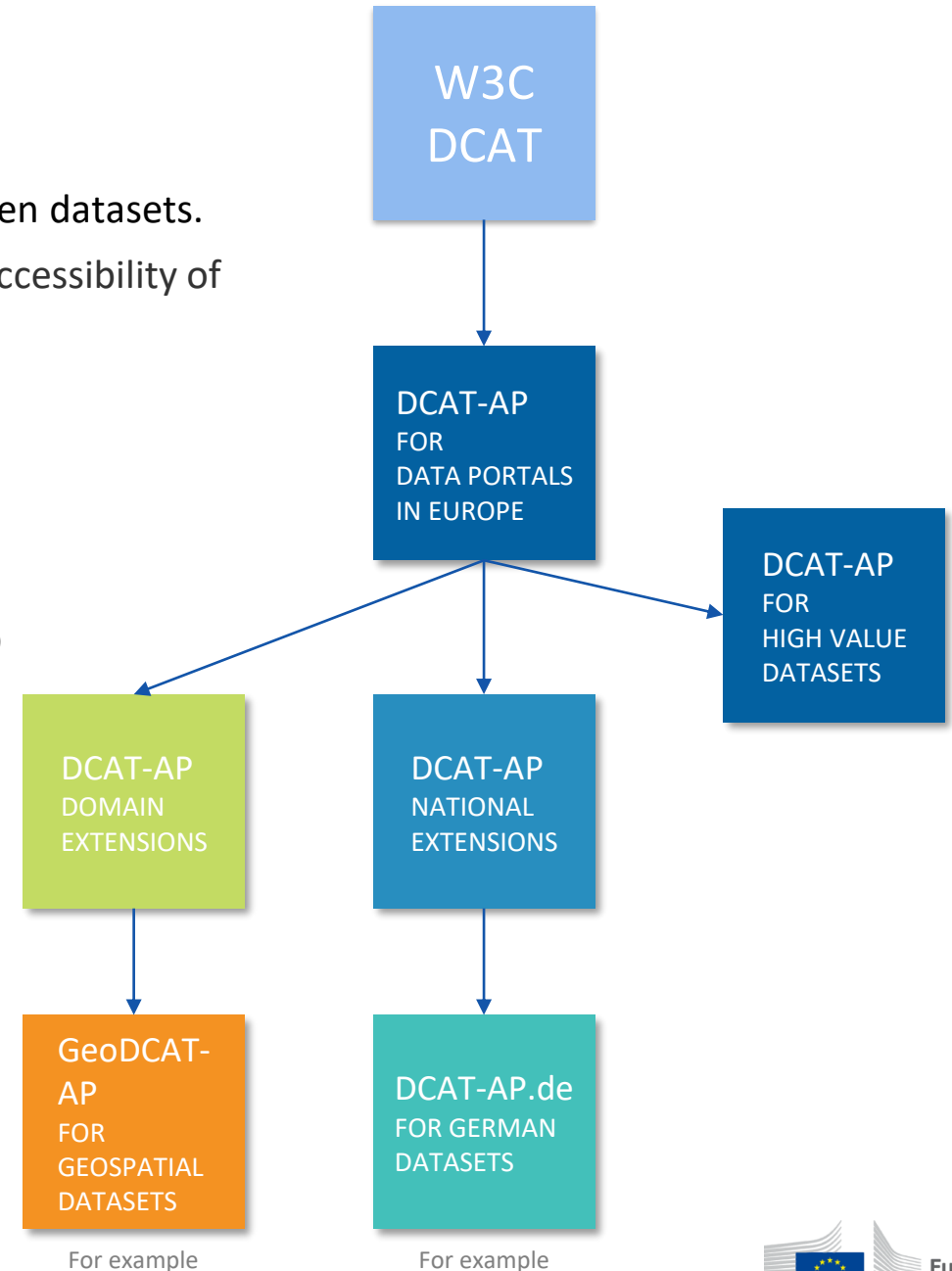
W3C Data Catalogue Vocabulary for facilitating interoperability between datasets.

- **DCAT 3:** extends DCAT 2 and introduces classes to support offline accessibility of datasets and datasets that are part of a series.



DCAT Application Profile for describing datasets based on W3C DCAT.

- **DCAT-AP 3.0.0:** fully compatible and aligned with DCAT 3.
- **DCAT-AP for High-Value Datasets:** facilitates adherence to the HVD Implementing Regulation with little additional effort.



DCAT-AP ecosystem



DCAT-AP National Extension for describing national datasets.

- DCAT-AP.de (Germany)
- DCAT-AP.it (Italy)
- ...



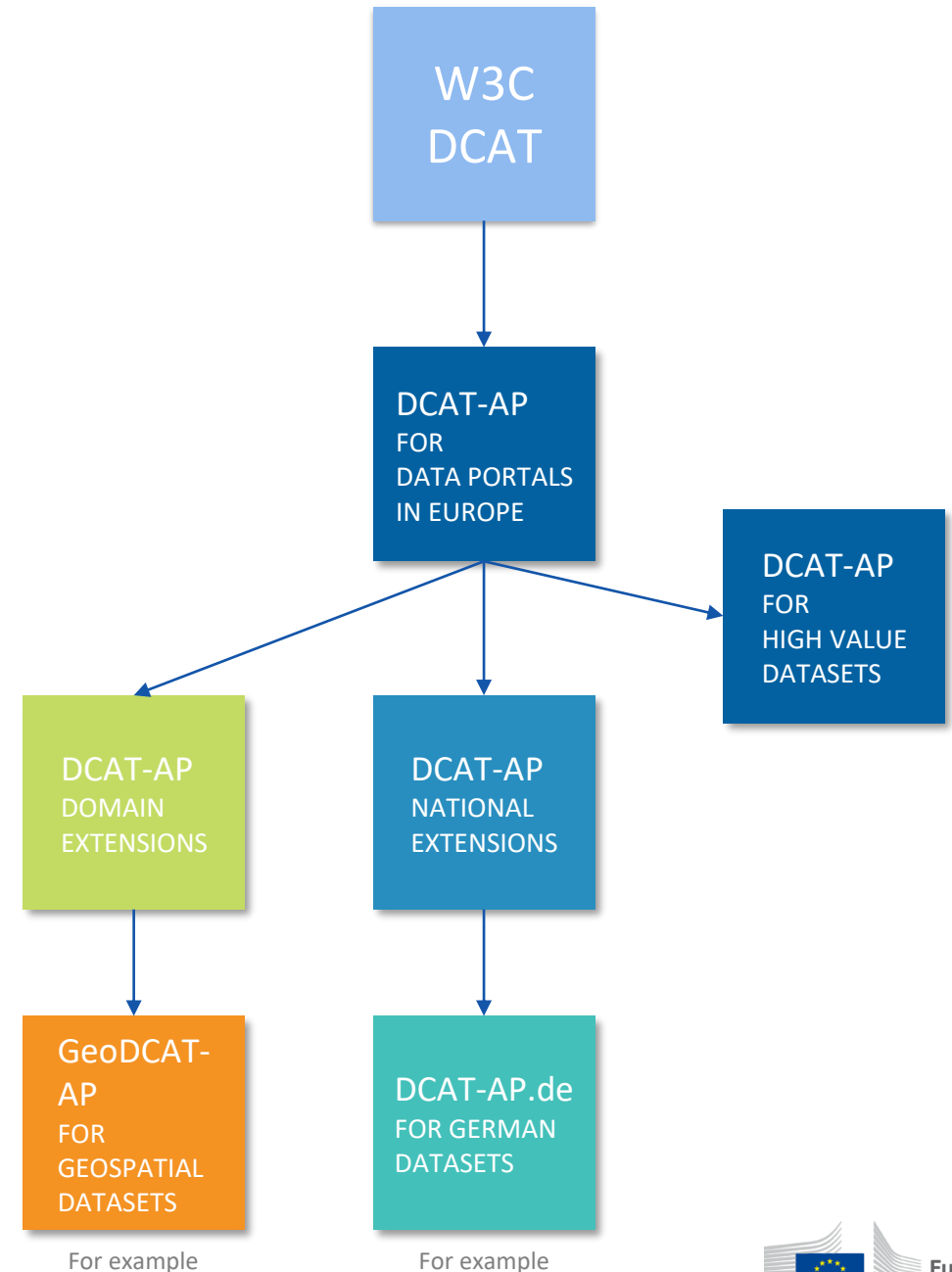
DCAT-AP Domain Extension for describing domain specific datasets.

- GeoDCAT-AP for geospatial datasets
- StatDCAT-AP for statistical datasets
- HealthDCAT-AP for datasets in the health industry
- ...



The official European Data Portal – data.europa.eu

- Provides access to data from all EU institutions, agencies, and bodies.
- Uses DCAT-AP for own datasets.
- Aggregates datasets from DCAT-AP compliant portals across Europe.



Benefits of the DCAT-AP ecosystem



DCAT-AP ecosystem & MLDCAT-AP

Problem statement

Lack of semantic interoperability forbids assets (including machine learning models) to be easily exchanged with other platforms.

Strategy

Define a common data model and enrich existing API with semantics.

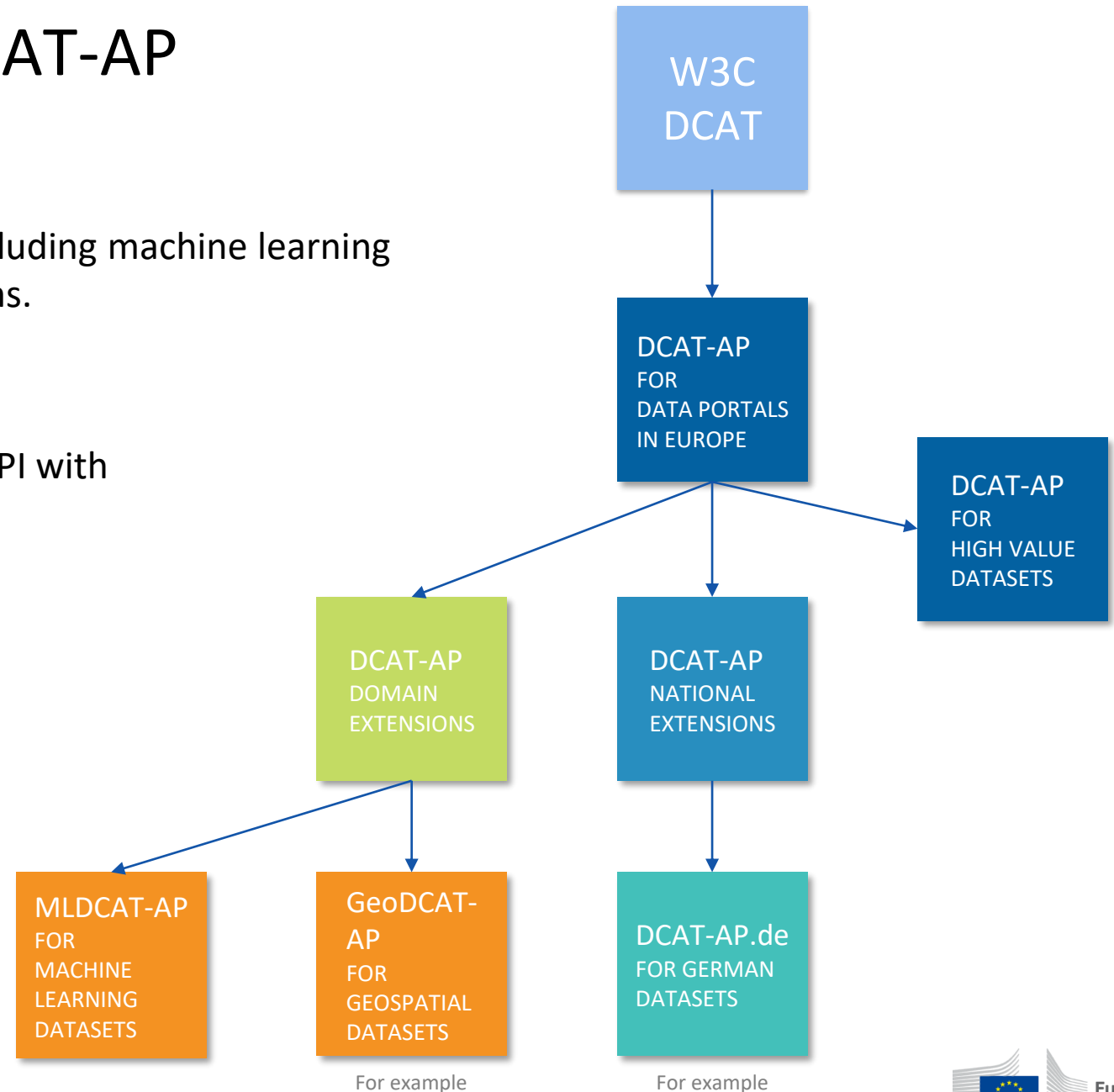
- Compatible with DCAT-AP 3.0.0

Benefits

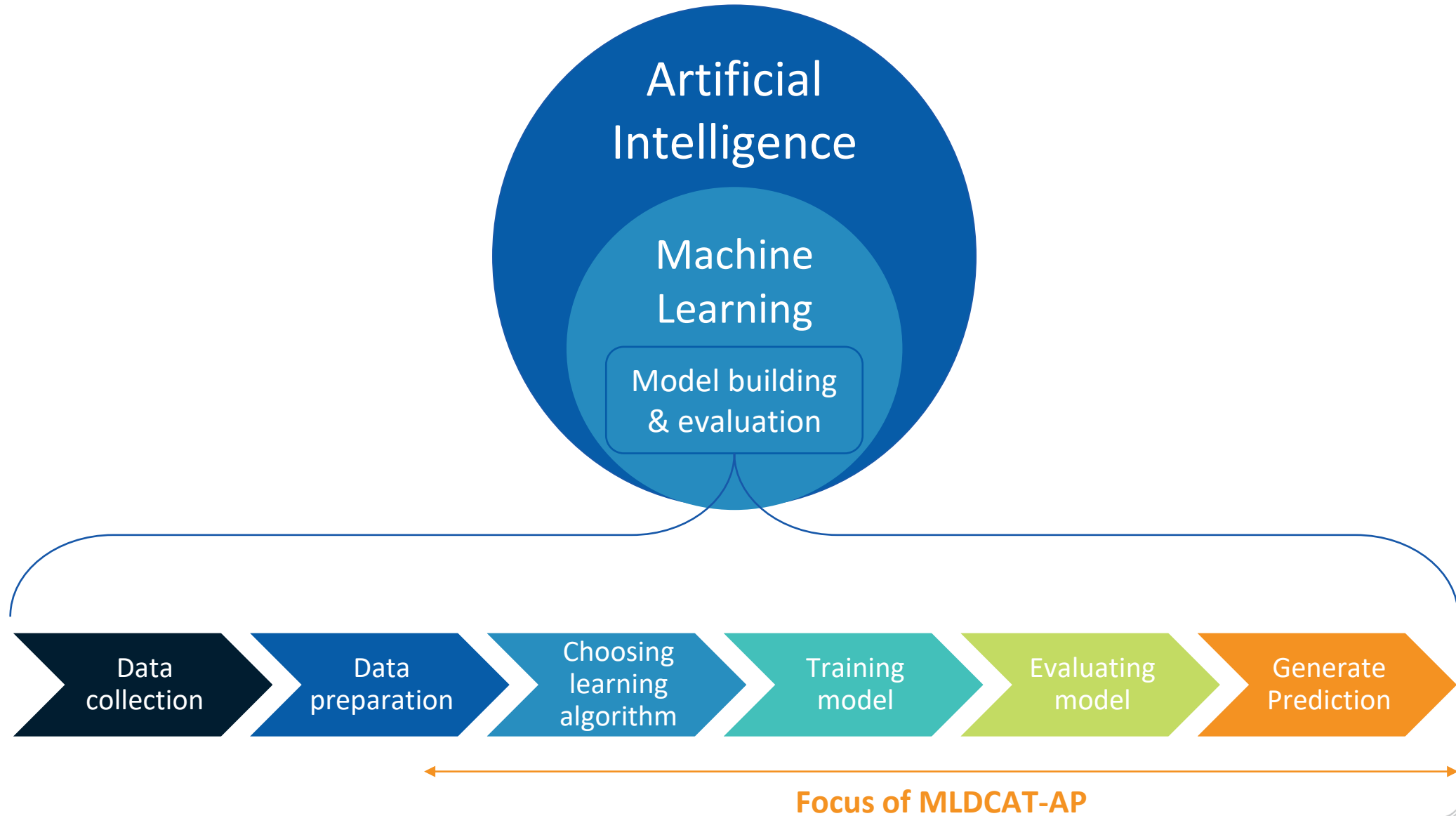
Describing ML Datasets with MLDCAT-AP yields all the advantages of using DCAT-AP.

Additional domain specific benefits are:

- Improved reproducibility
- Integration of RAI principles such as transparency and accountability
- Facilitates adherence to AI Act

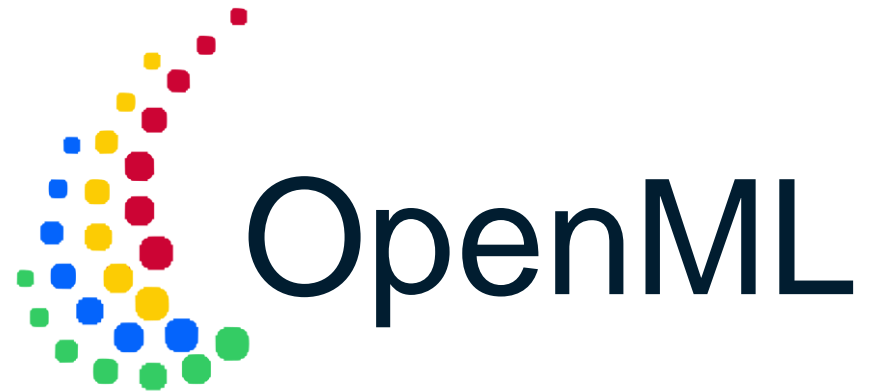


Domain of MLDCAT-AP





Guest speaker: OpenML



MLDCAT-AP pilot



Democratize Machine Learning



Democratize Machine Learning

Make ML research easily accessible and reusable...



Democratize Machine Learning

Make ML research easily accessible and reusable...

... by giving frictionless access to all ML experiment data



Democratize Machine Learning

Make ML research easily accessible and reusable...

... by giving frictionless access to all ML experiment data



Data



Democratize Machine Learning

Make ML research easily accessible and reusable...

... by giving frictionless access to all ML experiment data



Data



Models



Democratize Machine Learning

Make ML research easily accessible and reusable...

... by giving frictionless access to all ML experiment data



Data



Models



Results



Main Concepts:




Datasets

- Tabular
- Small-ish (~Gb scale)

credit-g

This dataset classifies people described by a set of attributes as good or bad credit risks.

 506k  28  312  1000 x 21  31  10 years ago

v.1 ✓

blood-transfusion-service-center




Data taken from the Blood Transfusion Service Center in Hsin-Chu City in Taiwan -- this is a classification problem.

 469k  6  101  748 x 5  1464  9 years ago

v.1 ✓

monks-problems-2

Once upon a time, in July 1991, the monks of Corsendonk Priory were faced with a school held in their priory, namely the 2nd European Summer School on Machine Learning. After listening

 395k  3  34  601 x 7  334  10 years ago

v.1 ✓

tic-tac-toe

This database encodes the complete set of possible board configurations at the end of tic-tac-toe games, where "x" is assumed to have played first. The target concept is "win for x" (i.e., true when

 387k  958 x 10  50  10 years ago





Main Concepts:

Datasets

- Tabular
- Small-ish (~Gb scale)
- Working on DL data

credit-g

This dataset classifies people described by a set of attributes as good or bad credit risks.

 506k  28  312  1000 x 21  31  10 years ago

v.1 

blood-transfusion-service-center






Data taken from the Blood Transfusion Service Center in Hsin-Chu City in Taiwan -- this is a classification problem.

 469k  6  101  748 x 5  1464  9 years ago

v.1 

monks-problems-2

Once upon a time, in July 1991, the monks of Corsendonk Priory were faced with a school held in their priory, namely the 2nd European Summer School on Machine Learning. After listening

 395k  3  34  601 x 7  334  10 years ago

v.1 

tic-tac-toe

This database encodes the complete set of possible board configurations at the end of tic-tac-toe games, where "x" is assumed to have played first. The target concept is "win for x" (i.e., true when

 387k  958 x 10  50  10 years ago



Main Concepts:

 Datasets

 Tasks

- Evaluation Procedure
- Splits
- Target
- Metric

credit-g classification

Predict feature 'checking_status'. Possible values are '<0,0<=X<200,>=200,no checking'.
Evaluate models using 5 times 2-fold Crossvalidation. The evaluation measure is binominal_test.

 233150  4 years ago

credit-g classification

Predict feature 'checking_status'. Possible values are '<0,0<=X<200,>=200,no checking'.
Evaluate models using 10-fold Crossvalidation. The evaluation measure is binominal_test.

 233151  4 years ago



Main Concepts:



Datasets



Tasks



Flows

- Algorithm descriptions
- Hyperparameters

automlbenchmark_autosklearn

Auto-sklearn as set up by the AutoML BenchmarkSource: source:
<https://github.com/openml/automlbenchmark/releases/tag/v0.9>

 26  15509  5 years ago

dabl.preprocessing.EasyPreprocessor

A simple preprocessor.

 19112  2 years ago




sklearn.svm.classes.SVC

Automatically created sub-component.

 58  5499  7 years ago

sklearn.neighbors.classification.KNeighborsClassifier

Automatically created sub-component.

 6  5501  7 years ago



Main Concepts:



Datasets



Tasks



Flows



Runs

- evaluation of a Flow on a Task
- predictions
- computed metrics

weka.AttributeSelection-R... on Titanic

weka.kf.AttributeSelection-Ranker-Relief... on Titanic by William Raynaut

 8869531 ACC 0.776 AUC 0.6996 RMSE 0.4733  6 years ago



weka.AttributeSelection-R... on Titanic

weka.kf.AttributeSelection-Ranker-Relief... on Titanic by William Raynaut

 8869401 ACC 0.7519 AUC 0.7064 RMSE 0.4202  6 years ago

weka.AdaBoostM1-SMO(1) on Titanic

weka.kf.AdaBoostM1-SMO(1) on Titanic by William Raynaut

 8869747 ACC 0.776 AUC 0.7208 RMSE 0.4118  6 years ago

OpenML: Accessing Data

openml.org

OpenML

Search

Sign In Sign Up

OpenML
A worldwide machine learning lab

Machine learning research should be easily accessible and reusable. OpenML is an open platform for sharing datasets, algorithms, and experiments - to learn how to learn better, together.

I shared a new data set
I found a better model!

Search OpenML Datasets

Sign Up to start tracking and sharing your own work. OpenML is open and free to use.

AI-ready data
All datasets are uniformly formatted, have rich, consistent metadata, and can be loaded directly into your favourite environments.

ML library integrations
Pipelines and models can be shared directly from your favourite machine learning libraries. No manual steps required.

A treasure trove of ML results
Learn from millions of reproducible machine learning experiments on thousands of datasets to make informed decisions.

MINIFY DARK



OpenML: Accessing Data

data



task



GET

/task/{id} Get task description. Tasks describe machine learning tasks (e.g. classification), defining inputs (e.g. target features), outputs (e.g. predictions), and evaluation criteria (e.g. cross-validation splits).



DELETE

/task/{id} Delete task



GET

/task/list/{filters} List and filter tasks



POST

/task Upload task



Uploads a task. Upon success, it returns the task id.

Parameters

Try it out

Name

Description

description * required

An XML file describing the task. Only name, description, and task format are required. Also see the [XSD schema](#) and an [XML example](#).

file

(query)

Choose File no file selected

api_key * required

Api key to authenticate the user

string

(query)

api_key





OpenML: Accessing Data



```
import openml  
iris = openml.datasets.get_dataset("iris")
```



OpenML - Why MLDCAT-AP?

- Custom Format = Learning Curve
- Interoperable Format =
 - No/Smaller Learning Curve



OpenML - Why MLDCAT-AP?

- Custom Format = Learning Curve
- Interoperable Format =
 - No/Smaller Learning Curve
 - Interface with OpenML



OpenML - Why MLDCAT-AP?

- Custom Format = Learning Curve
- Interoperable Format =
 - No/Smaller Learning Curve
 - Interface with OpenML
 - Complement other platforms



OpenML - MLDCAT-AP Process





OpenML - MLDCAT-AP Process





OpenML - MLDCAT-AP Process



{“foo”:“bar”}

MLDCAT-AP

OpenML Dataset	DCAT-AP Class	Property
id	Dataset	identifier
name	Dataset	title
tag	Dataset	keyword
status	Dataset	?
quality	?	?

MLDCAT-AP

OpenML Dataset	DCAT-AP Class	Property
id	Dataset	identifier
name	Dataset	title
tag	Dataset	keyword
status	Dataset	✦ status
qualities	✦ Quality	

MLDCAT-AP

Qualities describe the *data values*:

- simple: number of rows, number of classes, number of nominal features

MLDCAT-AP

Qualities describe the *data values*:

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- statistical: mean of means, skewness

MLDCAT-AP

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- information theoretic: information gain

MLDCAT-AP

Qualities describe the *data values*:

- simple: number of rows, number of classes, number of nominal features
- statistical: mean of means, skewness
- information theoretic: information gain
- landmarking: based on small ML models

MLDCAT-AP







§ 7.9 Quality Measurement

Definition

Represents the evaluation of a given dataset (or dataset distribution) against a specific quality metric.

Properties

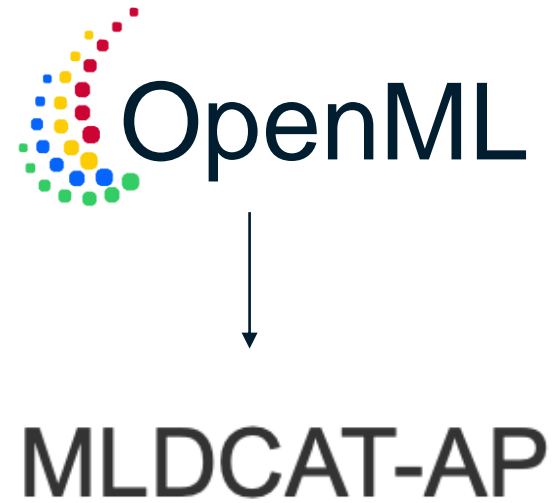
For this entity the following properties are defined: [dataset](#) , [feature index](#) , [interval end](#) , [interval start](#) , [type](#) , [value](#) .

Property	Range	Card	Definition	Usage
 dataset	Quality Measurement Dataset	0..*	Indicates the data set of which this observation is a part.	
 feature index	Feature	0..1	The feature on which the quality is measure on.	
 interval end	Literal	0..1		
 interval start	Literal	0..1		
 type	Data quality	1	A classification for a quality.	
 value	Literal	1	Refers to values computed by metric.	

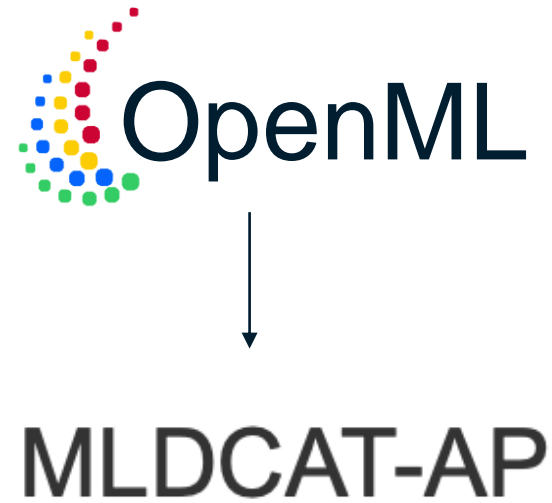
Integration



Integration



Integration



Implementation

<https://test.openml.org/mlcatap/docs>

MLDCAT-AP ^

GET	/mlcat_ap/distribution/{distribution_id}	Get Mldcat Ap Distribution	∨
GET	/mlcat_ap/dataservice/{service_id}	Get Dataservice	∨
GET	/mlcat_ap/quality/{quality_name}/{distribution_id}	Get Distribution Quality	∨
GET	/mlcat_ap/feature/{distribution_id}/{feature_no}	Get Distribution Feature	∨

Roll out together with new API later this year

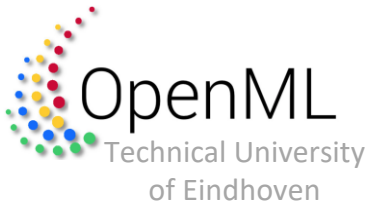
OpenML pilot

Stakeholders

Input

Mapping

Output



OpenML API

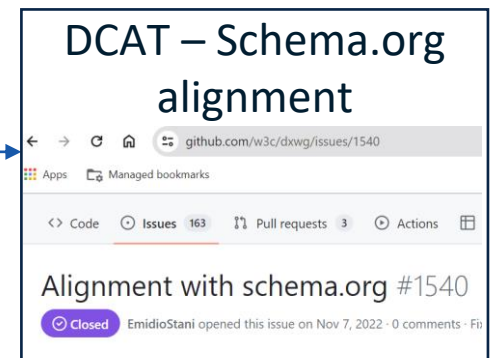
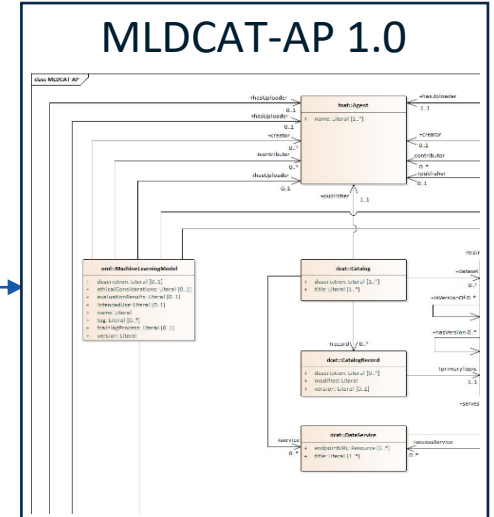
DCAT-AP FOR DATA PORTALS IN EUROPE

Schema.org



OpenML		DCAT-AP	
Class	Property	Class	Property
Dataset			
Dataset	id	Dataset	dct:identifier
Dataset	name	Dataset	dct:title
Dataset	version	Dataset	owl:versionInfo
Dataset	description	Dataset	dct:description
		Dataset	dct:creator
Dataset	description version	Dataset	
Dataset	format	Distribution	dct:format
Dataset	publisher	Dataset	dct:publisher

URI	owl:equivalentClass	rdfs:subClassOf
sdo:DataCatalog		dcat:Catalog
sdo:dataset		
sdo:measurementTechnique		
sdo:CreativeWork		
sdo:about		
sdo:abstract		



Nov 2022

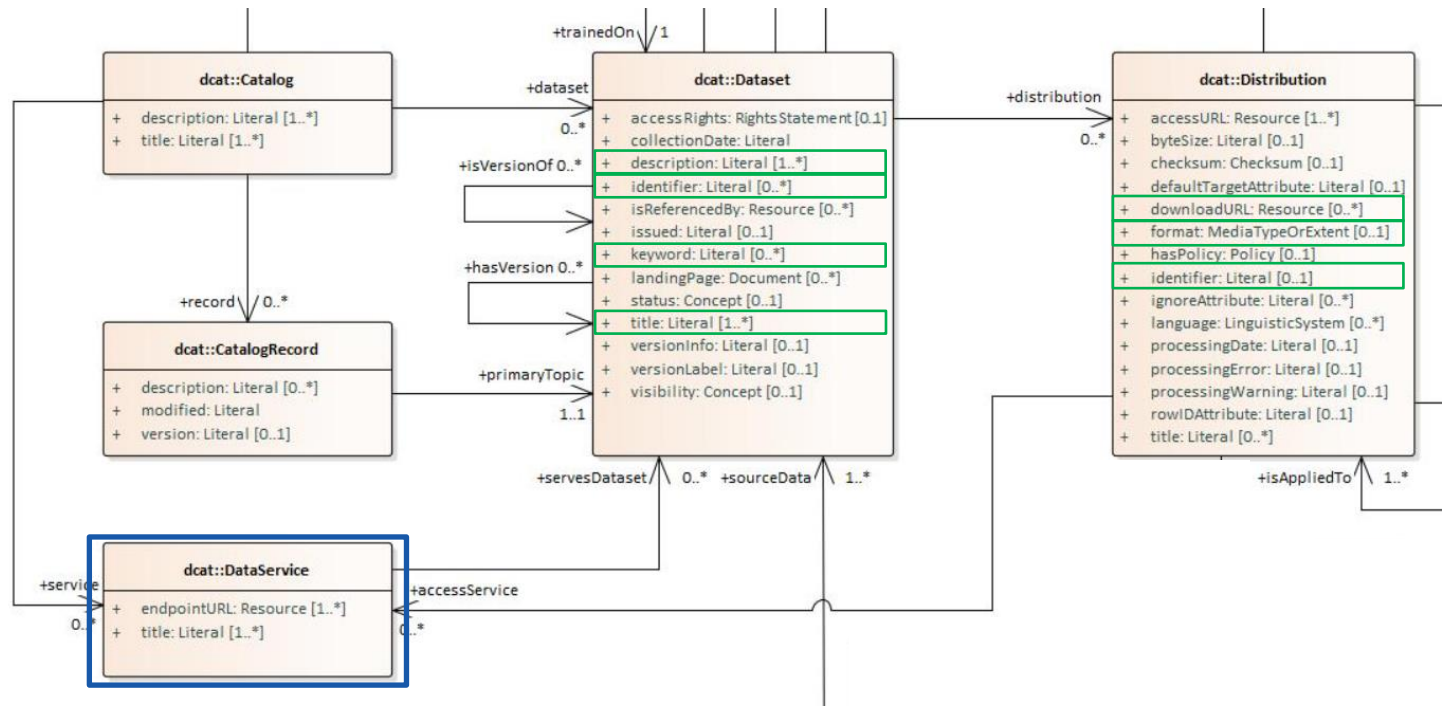
Today





MLDCAT-AP: a closer look

MLDCAT-AP 1.0.0 – Reusing DCAT-AP concepts



credit-g

ID: 31 | verified | ARFF | Public | 2014-04-06 | v.1

Jan van Rijn | 28 likes | 0 issues | 312 downloads

credit_scoring | Economics | finance_problem | Human Activities | myhdbusting_1 | OpenML-CC18 | OpenML100 | uci

Description

Author: Dr. Hans Hofmann
Source: UCI - 1994
Please cite: UCI

German Credit dataset
This dataset classifies people described by a set of attributes as good or bad credit risks.

This dataset comes with a cost matrix:

	Good	Bad (predicted)
Good	0	1 (actual)
Bad	5	0

It is worse to class a customer as good when they are bad (5), than it is to class a customer as bad when they are good (1).

Attribute description

- Status of existing checking account, in Deutsche Mark.
- Duration in months

OpenML dataset

OpenML API 1.0.0 OAS3

openml-api.json

REST API for sharing, organizing and reusing machine learning datasets, code, and experiments.

- Follows a predictive URL scheme from endpoint <https://www.openml.org/api/v1/json> (or /xml). E.g. get info about dataset 40996 from <https://www.openml.org/api/v1/json/data/40996>.
- You need to add your API key (i.e., add `?api_key=abcde12345`) for POST and DELETE calls. The API key can be found in your profile on openml.org.
- Hint: use a browser plugin to pretty-print JSON responses (e.g. for Chrome, Firefox).

Servers: <https://www.openml.org/api/v1/json>

Actions

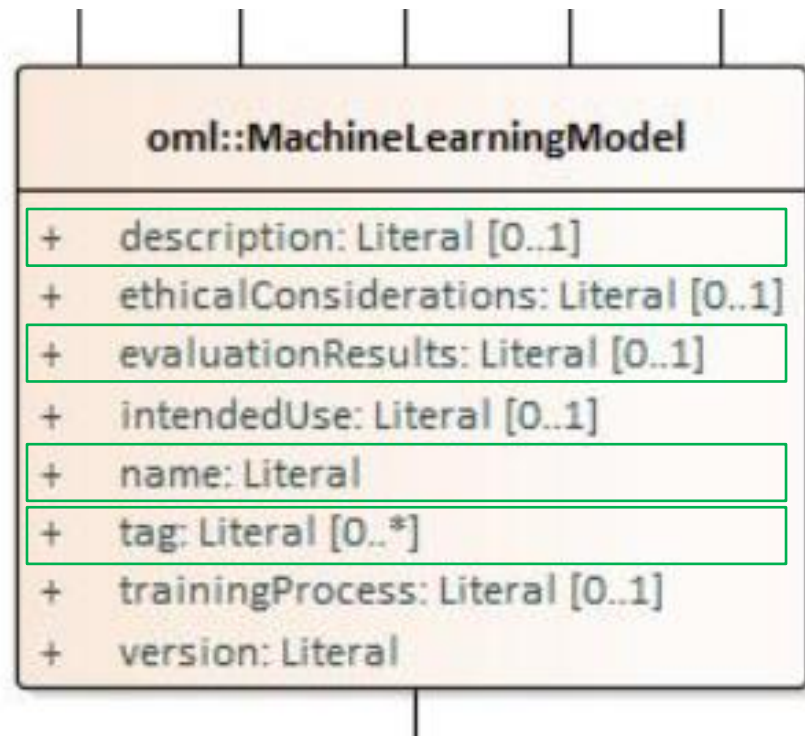
data

GET /data/{id} Get dataset description. Contains all the meta-data about the dataset, as well as links to download the formatted data.

OpenML API

MLDCAT-AP 1.0.0 - MachineLearningModel

- Based on Hugging Face and ONNX



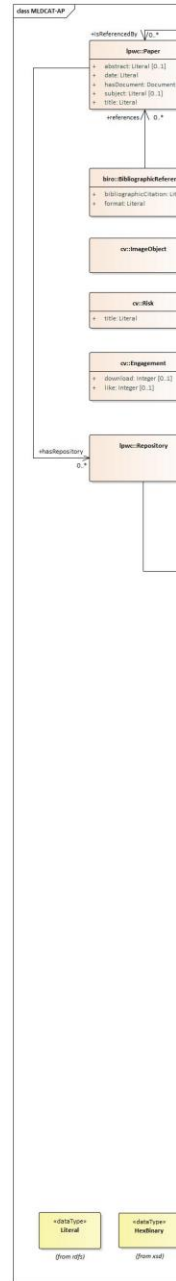
The screenshot shows the Hugging Face model card for `wav2vec2-large-xlsr-53-english` by `jonatasgrosman`. The model is a fine-tuned XLSR-53 large model for speech recognition in English. It is based on the `facebook/wav2vec2-large-xlsr-53` model and trained on the `Common Voice 6.1` dataset. The model card includes a description, a license (Apache-2.0), and evaluation results.

Evaluation results

Task	Score
Test WER on Common Voice en	19.060
Test CER on Common Voice en	7.690
Test WER (+LM) on Common Voice en	14.810
Test CER (+LM) on Common Voice en	6.840
Dev WER on Robust Speech Event - Dev Data	27.720
Dev CER on Robust Speech Event - Dev Data	11.650
Dev WER (+LM) on Robust Speech Event - Dev Data	20.850
Dev CER (+LM) on Robust Speech Event - Dev Data	11.010

MLDCAT-AP 2.0.0

- Comparative analysis between repositories of machine learning models
- Inclusion of Papers related to machine learning models
- Inclusion of Algorithm executed during the model building
- Focus on data quality and risk in view of the AI Office and AI Act
- Published in ReSpec HTML format



MLDCAT-AP

14 February 2024

▼ More details about this document

Latest published version:

<https://semiceu.github.io/MLDCAT-AP/releases/1.0.0/>

Latest editor's draft:

<https://semiceu.github.io/MLDCAT-AP/releases/2.0.0>

History:

[Commit history](#)

Editor:

Emidio Stani (PwC EU Services)

Feedback:

[GitHub SEMICeu/MLDCAT-AP](#) (pull requests, [new issue](#), [open issues](#))

Copyright © 2024

Abstract

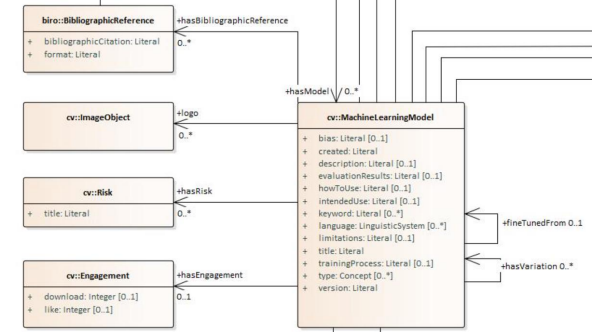
MLDCAT-AP aims to describe machine learning models, together with their datasets, quality measured on the datasets and citing papers. It has been originally developed in collaboration with [OpenML](#).

§ 1. Introduction

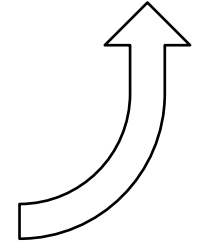
MLDCAT-AP (Machine Learning DCAT-AP) is an application profile that extends DCAT-AP in the field of machine learning.



MLDCAT-AP 2.0.0 – MachineLearningModel

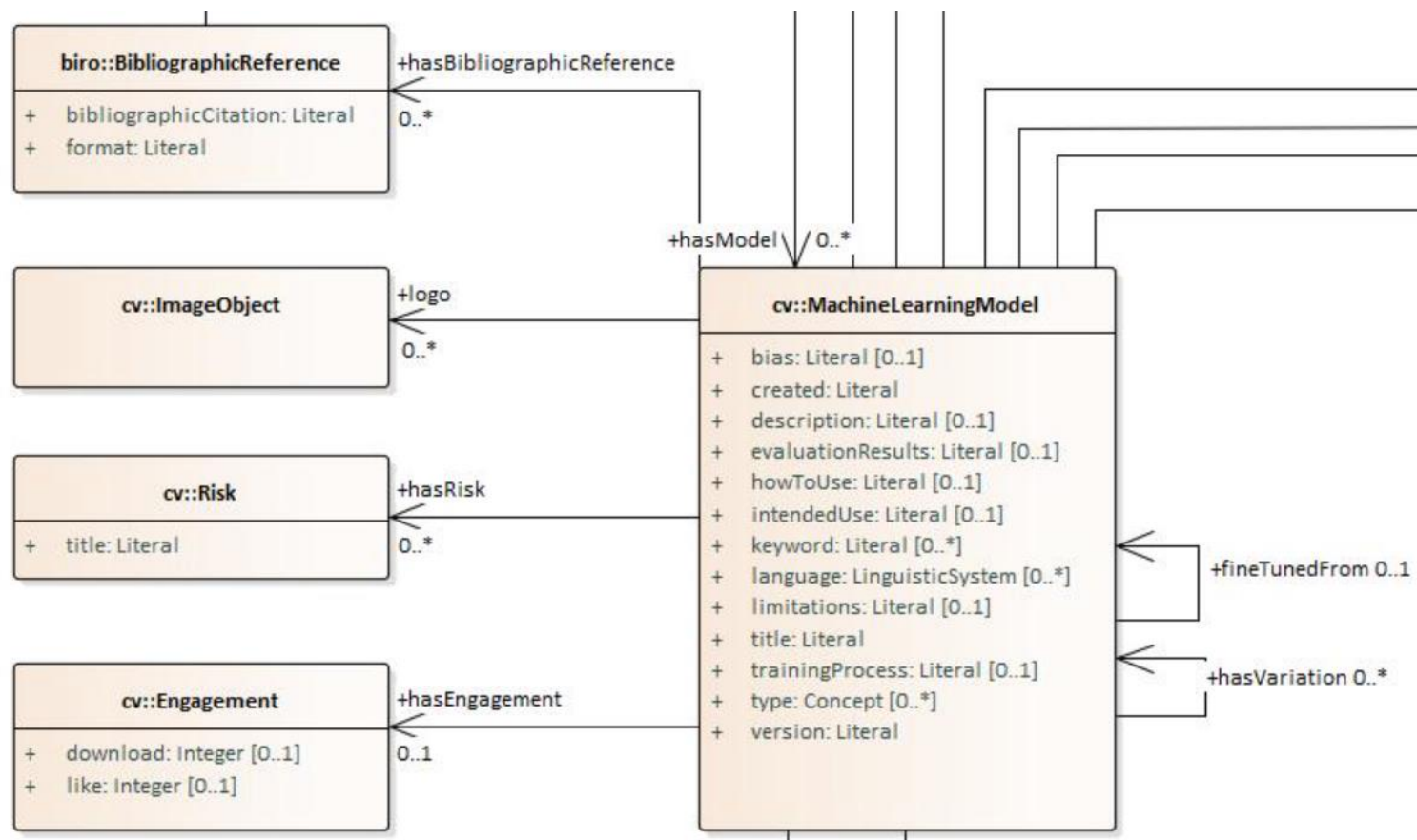
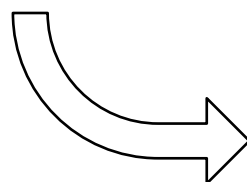


Common Properties	Hugging Face 423K models	Kaggle -TensorFlow 278-2K	Pytorch 55	AzureAI 100+ (in org)
Language	X	X	X	X
References to Paper/Code	X	X	X	
How to use	X	X	X	
Logo	X	X	X	
Files	X	X		X
Likes	X	X	X (GitHub stars)	
Downloads	X	X		
Relation	X (fine tuned from)	X (variation)		
Created date	X			X
Checksum	X			X



MLDCAT-AP 2.0.0 – MachineLearningModel

Common Properties	Hugging Face 423K models	Kaggle -TensorFlow 278-2K	Pytorch 55	AzureAI 100+ (in org)
Language	X	X	X	X
References to Paper/Code	X	X	X	
How to use	X	X	X	
Logo	X	X	X	
Files	X	X		X
Likes	X	X	X (GitHub stars)	
Downloads	X	X		
Relation	X (fine tuned from)	X (variation)		
Created date	X			X
Checksum	X			X



MLDCAT-AP 2.0.0 – Algorithm



Commission Decision Establishing the European AI Office

Download

In particular, the Office shall

- (a) work with other relevant Directorate-Generals and services of the Commission in the performance of its tasks pursuant to Article 2, notably with the European Centre for Algorithmic Transparency as regards the evaluation and testing of general-purpose AI models and systems;

Document 52021PC0206

? Share

Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL LAYING DOWN HARMONISED RULES ON ARTIFICIAL INTELLIGENCE (ARTIFICIAL INTELLIGENCE ACT) AND AMENDING CERTAIN UNION LEGISLATIVE ACTS

COM/2021/206 final

Expand all Collapse all

Languages and formats available

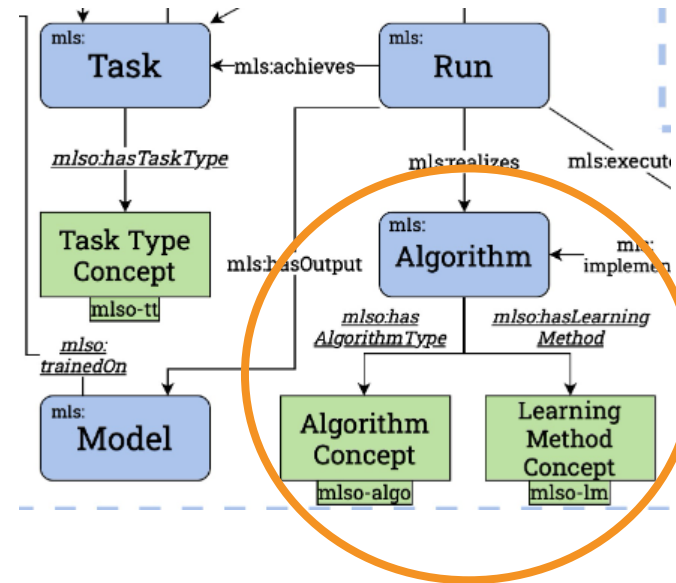
	BG	ES	CS	DA	DE	ET	EL	EN	FR	GA	HR	IT	LV	LT	HU	MT	NL	PL	PT	RO	SK	SL	FI	SV
HTML																								
DOC																								
PDF																								

ANNEX I ARTIFICIAL INTELLIGENCE TECHNIQUES AND APPROACHES referred to in Article 3, point 1

- (a) Machine learning approaches, including supervised, unsupervised and reinforcement learning, using a wide variety of methods including deep learning;
- (b) Logic- and knowledge-based approaches, including knowledge representation, inductive (logic) programming, knowledge bases, inference and deductive engines, (symbolic) reasoning and expert systems;
- (c) Statistical approaches, Bayesian estimation, search and optimization methods.

MLDCAT-AP 2.0.0 – Algorithm

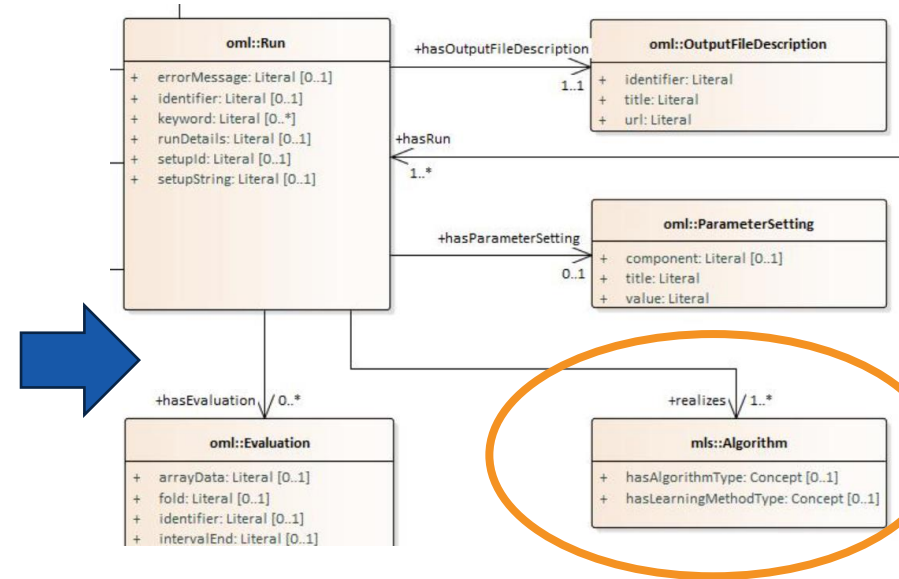
MLSO



Machine Learning Algorithm Learning method

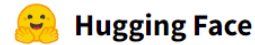
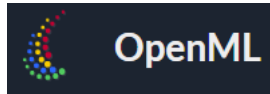
- :ArtificialNeuralNetwork
- :AssociationRuleLearningAlgorithm
- :Bayesian**
- :ClusteringAlgorithm
- :DecisionTree
- :DeepLearningAlgorithm**
- :DimensionalityReductionAlgorithm
- :EnsembleAlgorithm
- :InstanceBasedAlgorithm
- :RegressionAlgorithm
- :RegularizationAlgorithm
- :ReinforcementLearningAlgorithm**
- :RuleBased

- :ActiveLearning
- :AdversarialLearning
- :AnalyticalLearning
- :BayesianLearning**
- :ConceptLearning
- :CurriculumLearning
- :EnsembleLearning
- :FederatedLearning
- :FewShotLearning
- :IncrementalLearning
- :InductiveLearning
- :MetaLearning
- :MetricLearning
- :MultiModalLearning
- :MultiTaskLearning
- :OnlineLearning
- :Reinforcement_Learning_Algorithm**
- :SelfSupervisedLearning
- :SelfTaughtLearning
- :Semi-supervised_Learning_Algorithm
- :SequentialLearning
- :Supervised_Learning_Algorithm**
- :TargetedLearning
- :TransferLearning
- :Unsupervised_Learning_Algorithm**



*In **bold** those mentioned by the AI ACT

MLDCAT-AP 2.0.0 – Quality



credit-g
This dataset classifies people described by a set of attributes as good or bad credit risks.
506k ♥ 28 📄 311 📄 1000x21 📄 31
🕒 10 years ago v.1 ✓

blood-transfusion-service-center
Data taken from the Blood Transfusion Service Center in Hsin-Chu City in Taiwan -- this is a
469k ♥ 6 📄 101 📄 748x5 📄 1464
🕒 9 years ago v.1 ✓

monks-problems-2
Occurrence-time in July 1991, the monks of

107 Qualities Expand

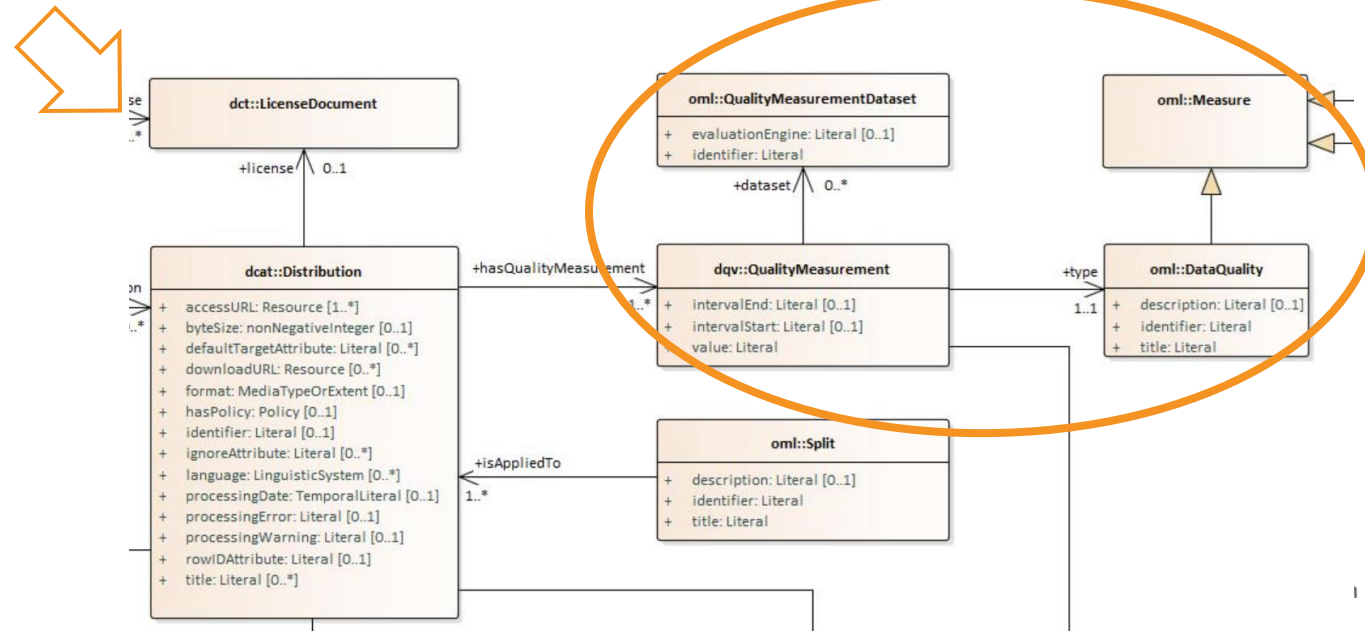
Quality Name	Value
number of instances	1000
number of features	21
number of classes	2
number of missing values	0

id	category	original-instruction
string · lengths 4=5 59.9%	string · classes 8 values	string · lengths 4 11.7k
0	closed_qa	When did Virgin Australia start...
1	classification	Which is a species of fish? Tope or...
2	open_qa	Why can camels survive for long...









# TotalDistance_km	# Calories	# VeryActiveHours	# FairlyActiveHours
TotalDistance_km: This column represents the total distance covered by an individual in kilometers.	Calories: This column represents the total number of calories burned by an individual.	VeryActiveHours: This column represents the number of hours an individual was very active.	FairlyActiveHours: This column represents the number of hours an individual was fairly active.
8.5	1985	0.42	0.22
6.97	1797	0.35	0.32
6.74	1776	0.5	0.18

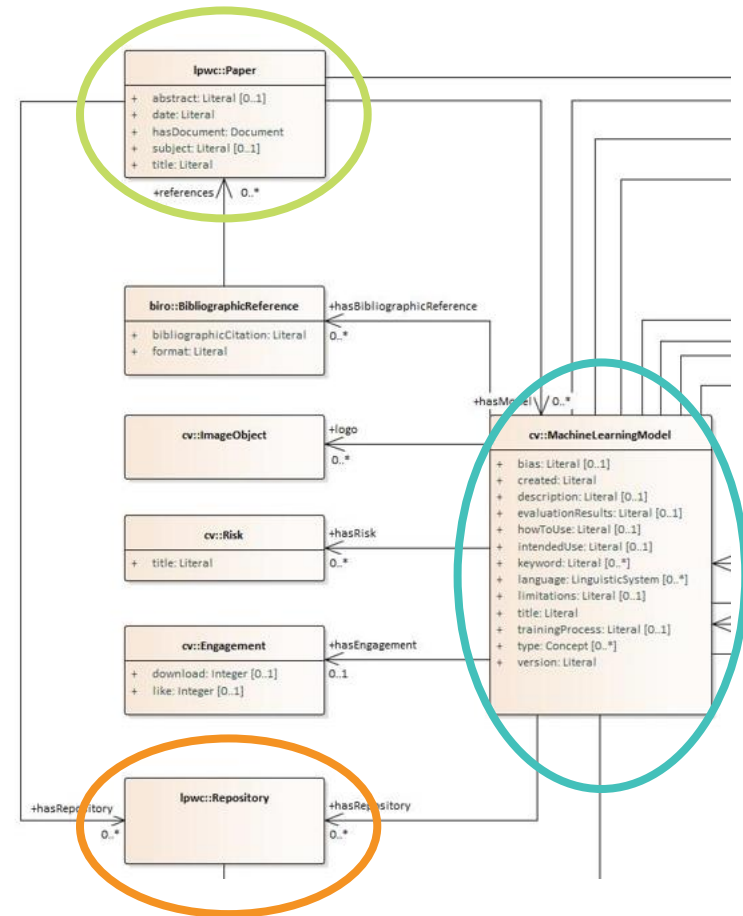
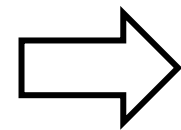
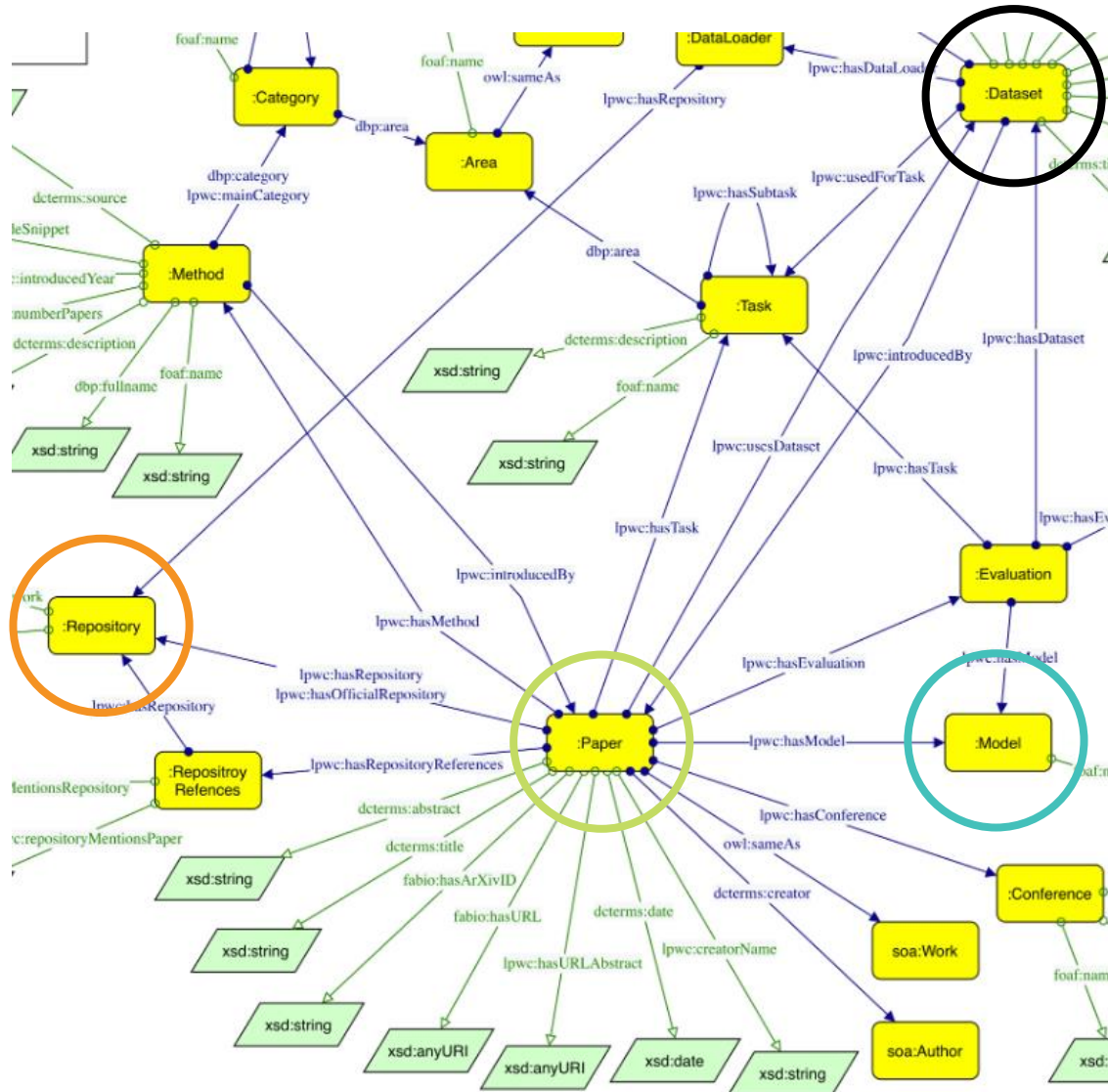
AI Act

For high-risk AI systems, the requirements of **high quality data**, documentation and traceability, transparency, human oversight, accuracy and robustness, are strictly necessary to mitigate the risks to fundamental rights and safety posed by AI and that are not covered by other existing legal frameworks.



MLDCAT-AP 2.0.0 – Paper

-  376,557 Papers
-  153,476 Repositories
-  52,519 Evaluations
-  24,598 Models
-  8,322 Datasets
-  4,267 Tasks
-  2,101 Methods
-  1,407 Conferences



MLDCAT-AP 2.0.0 – Controlled Vocabularies

MLDCAT-AP 1.0.0

Uses 3 Controlled Vocabularies published by OP. For example:

- Dataset.accessRights: [Access Rights Named Authority List](#)
- Distribution.format: [EU Vocabularies File Type Named Authority List](#)
- Distribution.language: [EU Vocabularies Languages Named Authority List](#)

Introduces 9 newly created Controlled Vocabularies. For example:

- Dataset.status: *Active, Deactivated, In Preparation*
- Dataset.visibility: *Public, Private*



MLDCAT-AP 2.0.0

Controlled Vocabularies published by OP can be reused.

Controlled Vocabularies that were newly introduced will have to be recreated and published by OP.

New Controlled Vocabularies necessary for:

- MachineLearningModel.type
- Algorithm.hasAlgorithmType
- Algorithm.hasLearningMethodType

Questions



Next steps

Next steps

- Monitor AI Act
- Process feedback received
- Continue building the ML community

A network visualization on a dark blue background. A central node is highlighted in bright orange. From this central node, numerous lines radiate outwards, connecting to other nodes. The lines are color-coded, transitioning from orange near the center to green and then to light blue as they extend further. The overall structure is symmetrical and resembles a starburst or a complex network graph.

Thank you



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innovation ∞ govtech ∞ community

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