Relicensing Combined Datasets

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***Abstract*—Metadata portals offer access to Open Data, which is increasingly published on the basis of RDF vocabularies and ontologies. Individual datasets include URIs and descriptions of licenses under which the datasets are published. Licenses can be defined by attributes of the types permission, requirement and prohibition. This paper focuses on the problem of relicensing datasets that include multiple other open datasets published under different licenses. If combined datasets are republished, a chosen license must comply with the original licenses of each dataset. The approach is based on mapping licenses to deontic interpretations and combining them using an OR-composite operator. The result of the operator is used to determine matching licenses from a Knowledge Base containing license information. The approach is evaluated based on the Creative Commons License Compatibility Chart.**

I. Introduction

Metadata portals offer access to Open Data published on the web. The European Data Portal (EDP)[1] [1] as well as national variants like GovData (Germany)[2] or data.gov.uk (United Kingdom)[3] are popular examples for such portals. They provide centralized catalogs for datasets and therewith facilitate finding of datasets. The reference standard for metadata used in such portals is the DCAT application profile for European data portals (DCAT-AP)[4], which is a specification based on the Data Catalog Vocabulary (DCAT)[5] developed by W3C for describing metadata of public sector datasets.

Metadata information available at metadata portals includes descriptions of licenses under which datasets are published. Licenses specify what is permitted, required and prohibited when using or republishing datasets. Creative Commons licenses[6] are commonly used for Open Data. For machine-processable licenses, there are several Rights Expression Languages (REL) such as the Creative Commons Rights Expression Language (ccREL)[7] [2], the Open Digital Rights Language (ODRL)[8] [3] and the Open Data Rights Statement Vocabulary (ODRS)[9] that provide RDF expressions of licenses, i.e. storing license information in knowledge graphs.

Regarding the Semantic Web and RDF vocabularies, Open Data portals use DCAT to describe datasets and distributions (specific representations of datasets, e.g. multiple serializations) including related rights and licensing resources. These concepts are also part of ODRL and ccREL. The two vocabularies additionally provide concepts to describe the semantics of licenses by different types of license attributes. Figure 1 illustrates related concepts in the three vocabularies, which are relevant for this work. The license vocabularies ccREL and ODRL are used to access Knowledge Graphs in the evaluation (Sect. IV). Concepts such as permission, prohibition and requirement are expressed formally using deontic logic [4]. Several related works [5], [6] present extensions to deontic logic and create rules to reason over licenses. The approach of this paper is focused on the deontic interpretation of licenses and their attributes.

The existence of licenses for datasets is particularly useful for users of Open Data portals who want to reuse datasets or combine multiple datasets. In these cases, users have to be able to identify the terms under which they are allowed to use and republish combined datasets. Combined datasets must be published under a license that complies with the original licenses of each dataset. Therefore, a composite license has to be equal to or more restrictive than each of the original licenses. In other words, the composite license must not violate any of the original licenses and has to be compatible with the terms of republishing all datasets. In this paper, we present an approach for relicensing combined datasets dubbed ReCoDa. Our approach offers an automated efficient computation of composite licenses for a list of datasets and their licenses, which avoids the need for users to manually compare licenses pairwise. ReCoDa was implemented as part of the development of the OPAL metadata portal at national scale. The aim of the OPAL[10] project is to enable easier access to Open Data, which requires a range of functionalities for crawling, extracting, analyzing, converting, integrating and

[1] https://www.europeandataportal.eu/
[2] https://www.govdata.de/
[3] https://data.gov.uk/
[4] https://joinup.ec.europa.eu/solution/dcat-application-profile-data-portals-europe
[5] https://www.w3.org/TR/vocab-dcat/
[6] https://creativecommons.org/licenses/
[7] https://www.w3.org/Submission/ccREL/
[8] https://www.w3.org/TR/odrl-model/
[9] https://schema.theodi.org/odrs/
[10] https://dice-research.org/OPAL

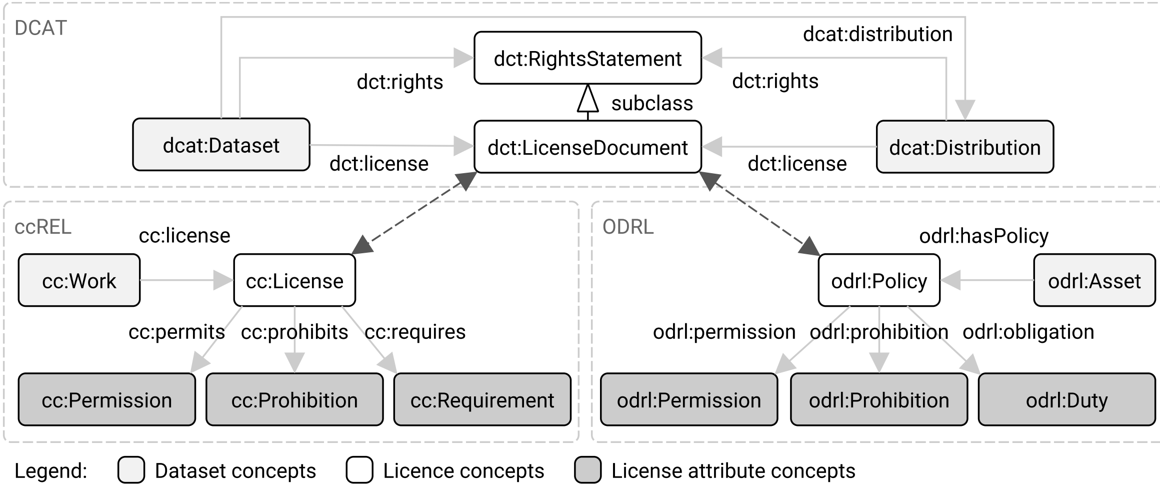

Fig. 1. Related licensing concepts in DCAT, ccREL and ODRL

using the respective metadata. The Java implementation is published under the GNU AGPL license and available with additional resources at the ReCoDa repository[11].

ReCoDa uses RDF Knowledge Graphs that include a list of licenses and their attributes. We define an operator for combining attributes of two or more licenses. The output of this operator is a list of composite attributes. Afterwards, we determine those licenses from the Knowledge Bases whose attributes match the composite attributes. If no license is found, the datasets cannot be combined and reused together.

The rest of this paper is organized as follows: Section II discusses related works. Sect. III introduces the approach consisting of the attribute mapping (Sect. III-A), the types of attributes (Sect. III-B), the computation of composite attributes (Sect. III-C) and the back-mapping to a list of licenses (Sect. III-D). Sect. IV presents the evaluation of ReCoDa, and Sect. V concludes the paper with a discussion and ideas for future work.

II. Related work

To address the issues of license compatibility and composition, [7] propose a framework to examine the compatibility of Creative Commons licenses. Their approach provides compatibility rules between elements of licenses. In cases where licenses are compatible, a composite license is generated that aggregates the clauses of the different licenses. The limitation of this work is that compatibility rules are defined for selected attributes of licenses. [5] is closely connected to [7] but is not limited to Creative Commons licenses. This paper proposes the l4lod[12] vocabulary (Licenses for Linked Open Data) for expressing license terms in a machine-readable format. To evaluate license compatibility, a formal framework is defined using deontic logic semantics. An extension of their work is presented in [8] which deals with the computation of composite licenses using defined heuristics and the deontic logic semantics presented in [9], [5]. In the same line of works, [10] offers Licentia,[13] a web service for supporting users in data licensing. It applies reasoning over licenses using the deontic logic described in [9]. The main difference between the listed works above and the approach of this paper is that these works generate new licenses, while in our approach we select existing licenses that match the composite attributes. Disadvantages of newly generated licenses are the lack of reusing well-known existing licenses as well as potential inconsistencies regarding legal texts. Therefore, generated licenses are probably unusable in practice.

[11] proposes CaLi, a lattice-based model that partially orders licenses. Their approach defines license compatibility and compliance using restrictiveness relations among licenses. The feasibility of the approach is studied using Creative Commons vocabulary and ODRL. The usability of CaLi is demonstrated in [12] as a license-based search engine to find resources licensed under license compliance or compatibility with a particular license. Therefore, that work solves a subproblem of the approach presented in this paper.

Since ODRL [3] is well suited as a library to model licenses, [13] offer an extension to ODRL to model several well-known license families. The extension is used by the DALICC system presented in [14]. DALICC is a Data License Clearance Center System that allows reasoning over license texts. It enables users to compose new customized licenses and check compatibility between them. The authors argue that collaboration with legal experts has been performed in order to ensure the validity of the composed license. However, similar to other works mentioned above, this work involves the generation of new licenses instead of using existing licenses as implemented in our approach.

Regarding the issue of license selection, [15] propose an ontology based on Formal Concept Analysis (FCA) to facilitate the process of license selection. In their approach, the authors

[11]https://github.com/dice-group/ReCoDa
[12]http://ns.inria.fr/l4lod/
[13]http://licentia.inria.fr

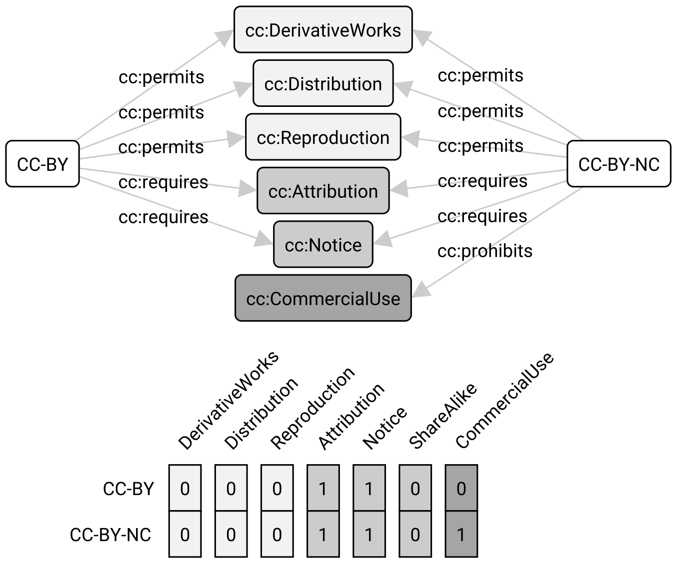

Fig. 2. Example: Mapping of attributes to binary values (φ-operator)

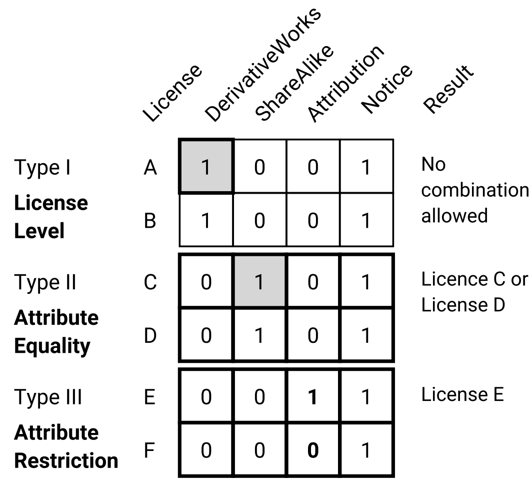

Fig. 3. License comparison types

developed the Contento tool,[14] which implements FCA for classifying licenses depending on their features. However, this work does not handle the issue of license compatibility.

The European Data Portal (EDP) has been assessed with a focus on data formats [16].

In this paper, we propose a different approach that combines attributes from multiple licenses and determines licenses from a Knowledge Graph that match the resulting configuration of the combined attributes.

III. The ReCoDa approach: Composition of licenses

Our approach consists of four parts: First, we use a Knowledge Base that contains licenses and their attributes to generate the mapping of license attributes to binary values. Second, the semantics of attributes and therefore their effects on the compatibility are introduced. Building on this, we employ an operator to generate composite attributes. In the final step, we perform the mapping of resulting attributes back to a list of licenses. Each of these steps is described in the following.

A. Definition and mapping of attributes

ReCoDa utilizes an RDF Knowledge Graph that includes a list of license URIs and their attributes. For each dataset to be combined, the related license and its attributes have to be extracted from the data available in the Knowledge Base.

Let $\mathcal{L}$ be an m-set of input licenses $\{\mathcal{L}_1, \ldots, \mathcal{L}_m\}$. For each license $\mathcal{L}$, there is an ordered list of n attributes $\mathcal{A} = (b_1, \ldots, b_n)$, where the value of each attribute is mapped to binary $b \in \{0, 1\}$. The attributes are ordered such that, for a license $\mathcal{L}$ and another license $\mathcal{L}'$, b_i and b'_i correspond to the same attribute. We denote the mapping operator as $\varphi : \mathcal{L} \to \{0, 1\}^n$, where the mapping depends on the type of attributes. Restricting rights implies an attribute is either not permitted, prohibited or required. Thus, attributes of type permission must be mapped as the negation of attributes of type prohibition or requirement, as follows:

- Permissions: $b = \begin{cases} 1 & \text{if } \underline{\text{not}} \text{ permitted} \\ 0 & \text{if permitted} \end{cases}$
- Prohibitions: $b = \begin{cases} 1 & \text{if prohibited} \\ 0 & \text{if not prohibited} \end{cases}$
- Requirements: $b = \begin{cases} 1 & \text{if required} \\ 0 & \text{if not required} \end{cases}$

Figure 2 illustrates a mapping example for three permissions, three requirements and one prohibition of a Knowledge Base for the licenses CC-BY and CC-BY-NC. As there are no RDF triples for the attribute ShareAlike (top), the related values are mapped to 0 (bottom).

B. Types of attributes

We differentiate between three types of attributes. Examples are shown in Fig. 3. Type I is the license level. If such an attribute is set, the compatibility with other licenses is also determined and does not require further comparisons. For example, in case the attribute *DerivativeWorks* of type permission is not permitted (i.e. set to one in license A) for at least one input license, no derivatives are allowed and the licenses can not be combined. Type II is the attribute equality. An enabled attribute of this type requires pairwise equality of all attributes. For instance, this is the case for the requirement *ShareAlike* of licenses C and D. As all attributes of both licenses are equal, they are compatible. Type III is the attribute restriction. In this case, the most restrictive attribute value is chosen for further comparison. In the example, the requirement *Attribution* is set for license E. If two datasets with licenses E and F have to be relicensed, only license E can be used. If license F would be used, no attribution of the author would be required, which violates license E. The computation of this type is explained in detail in the following.

[14] https://data.open.ac.uk/contento/

	DerivativeWorks	Distribution	Reproduction	Attribution	Notice	ShareAlike	CommercialUse
CC-BY	0	0	0	1	1	0	0
CC-BY-NC	0	0	0	1	1	0	1
ρ (CC-BY, CC-BY-NC)	0	0	0	1	1	0	1

Fig. 4. Example: Computation of composite attributes (ρ-operator)

	DerivativeWorks	Distribution	Reproduction	Attribution	Notice	ShareAlike	CommercialUse	
ρ (CC-BY, CC-BY-NC) = b	0	0	0	1	1	0	1	
CC-BY = b¹	0	0	0	1	1	0	0	✗
CC-BY-NC = b²	0	0	0	1	1	0	1	✓

Fig. 5. Example: Exclusion of a less restrictive license from composite attributes

C. Computation of composite attributes

We use the theory of boolean algebra to formalize deontic notations, which was introduced in [17]. Boolean operators provide a well-known mathematical framework to study the properties of deontic logic [18]. Here, an operator is required to generate composite attributes from attributes of two or more input licenses. The mappings introduced in Sect. III-A permit the construction of one operator to be used in the combination of all attributes regardless of the type of the attribute. The most important characteristics of such composite operator are the commutativity and associativity, since the order of input licenses should not alter the resulting combined attributes. By choosing the above mappings, the OR-composition operator fits to be utilized in the construction of composite attributes. We use the maximum function to apply OR-operations.

OR-composition operator: $\rho : \mathcal{A} \times \mathcal{A} \rightarrow \mathcal{A}$,
$\rho(b, b') = b'' : b''_i = \max(b_i, b'_i),\ \forall i \in \{1, \ldots, n\}$
The OR-composition operator ρ has several properties that allow its application to attributes of multiple licenses. The properties, which will be used afterwards in the application of the operator, are associativity, commutativity and idempotency.

Let b, b' and b'' be binary attributes for licenses $\mathcal{L}$, $\mathcal{L}'$ and $\mathcal{L}''$ respectively, then the following properties hold $\forall i \in \{1, \ldots, n\}$:

- $\max(b_i, \max(b'_i, b''_i)) = \max(\max(b_i, b'_i), b''_i)$
- $\max(b_i, b'_i) = \max(b'_i, b_i)$
- $\max(0, 0) = 0$ and $\max(1, 1) = 1$

Figure 4 shows an example of computing composite attributes of three permissions, three requirements and one prohibition for the input licenses CC-BY and CC-BY-NC.

D. Determining compatible licenses based on attributes

The ordered list of computed composite attributes in $\mathcal{A}$ with n binary values $\mathcal{A} = (b_1, \ldots, b_n), b \in \{0, 1\}$ has to be compared to the attributes b^c of each candidate license $\mathcal{L} \in \mathcal{L}_c$. Candidate licenses are defined as all licenses available in the knowledge base. If an attribute b^c_i is less restrictive (more open) than the equivalent computed attribute b_i, the related candidate license is excluded from the list of compatible licenses $\mathcal{L}_{out}$:

Exclusion of less restrictive licenses: $\mathcal{L} \notin \mathcal{L}_{out}$ if $b_i = 1 \neq b^c_i$

An example is demonstrated in Figure 5. The licenses CC-BY (with binary attributes b^1) and CC-BY-NC (with binary attributes b^2) are compared to the previously computed composite attributes b. b^1 is less restrictive compared to b, as *Commercial Use* is not prohibited in b^1. Therefore, b^1 is incompatible and consequently excluded. The computed list of compatible licenses is $\mathcal{L}_{out} = \{\text{CC-BY-NC}\}$.

IV. Evaluation

To evaluate the automatic computation of compatible licenses, two datasets are required. First, a Knowledge Graph describing licenses and their respective attributes is needed to apply the approach. Additionally, a database describing the compatibility of licenses is required to evaluate the correctness.

Creative Commons licenses and their attributes are available in the cc.licenserdf repository.[15] The RDF data in the repository is structured by *ccREL: The Creative Commons Rights Expression Language*[16] and the respective namespace [19]. It contains 614 RDF files describing 612 licenses.[17] Some files share the same license basis and therefore contain equal attribute values but differ in the respective license version and natural language translation. In order to provide the required licenses of the *License Compatibility Chart* (LCC), described in the next paragraph, we had to select one of each license from different versions and choose six CC licenses in the newest version 4.0 and two public domain licenses in version 1.0. We traversed the properties `cc:permits`, `cc:requires` and `cc:prohibits` of all licenses and extracted all related attributes. The attributes are listed in Table I.

Compatibility information about licenses is given in the Creative Commons wiki.[18] The LCC lists the pairwise compatibility of eight licenses which are denoted by $\mathcal{L}_{LCC}$ hereinafter and shown in the header of Table II. The compatibility information consists of a simple value, either positive or negative, and a description of how to interpret a positive value: "Use at

[15] https://github.com/creativecommons/cc.licenserdf
[16] https://www.w3.org/Submission/ccREL/
[17] Two license files have been erroneous, see https://github.com/creativecommons/cc.licenserdf/issues/9
[18] https://wiki.creativecommons.org/index.php?title=Wiki/cc_license_compatibility&oldid=70058

TABLE I
ATTRIBUTES IN CREATIVE COMMONS *cc.licenserdf*

Permissions	Requirements	Prohibitions
cc:DerivativeWorks cc:Distribution cc:Reproduction	cc:Attribution cc:Notice cc:ShareAlike	cc:CommercialUse

least the most restrictive licensing of the two [licenses] (use the license most to right or down state) for the new work."

For the evaluation we formed 64 pairs of the eight licenses in the LCC and used them as input for the operators $\rho(\varphi(\mathcal{L}_r), \varphi(\mathcal{L}_c)) = \mathcal{A}_{r,c}$; $\forall r, c \in \{1, ..., 8\}; \mathcal{L}_r, \mathcal{L}_c \in \mathcal{L}_{LCC}$ and computed the list of compatible licenses. The application of the approach produced a perfect result, which is presented in Table II. Using the automated extraction, the values of the LCC were reproduced. Furthermore, a maximum of two compatible licenses are included instead of one in the LCC.

An extended result is presented in Table III. It shows up to eight compatible licenses, without limitation to the respective two input licenses. Instead, we allowed an extended back-mapping by including all licenses in $\mathcal{L}_{LCC}$ as license candidates. The columns for the two licenses with the *ND* attribute are removed, as no permission for derivatives is given and therefore no compatible licenses for relicensing in $\mathcal{L}_{LCC}$ exist. In cases where all eight licenses are compatible, the value *all* is used instead of listing all licenses.

In addition to the evaluation using the LCC, we computed the compatible licenses for all 612 licenses in the cc.licenserdf repository. First, we used license pairs as input licenses. Based on the 612 licenses and the symmetric characteristic of ρ, we created $187,578 = \frac{(k+n-1)!}{k!(n-1)!}$, $n = 612, k = 2$ license pairs used as input data. The number of resulting compatible licenses are shown in the left plot of Figure 6. The x-axis represents the number of compatible licences, while the y-axis shows the number of pairs used as input.

Through the structure of the input data, which consists of the same licenses localized to different languages and different versions of the same licenses as well as the small set of 7 license attributes, the results are clustered into 15 data points. Approximately 69 % of the pairs are incompatible and resulted in an empty output set (data point at upper left). The six most compatible license pairs (data point at bottom right) consist of combinations of the licenses CC0 1.0 Universal, Public Domain and Public Domain Mark 1.0. The data point nearby with almost as many compatible licenses consists of nine license pairs, which are extended by the software licenses BSD and MIT.

To investigate the distribution for cases where more than 2 licenses are used as input, we used groups of 3 input licenses and created 38,390,964 ($n = 612, k = 3$) license triples. The number of resulting compatible licenses is shown in the right plot of Figure 6. As every triple in this experiment contains at least one tuple of the previous experiment, similar 15 cluster points were generated. Even the number of results in this experiment is higher by a factor of $204.\bar{6}$, the distribution on

TABLE II
COMPUTED CREATIVE COMMONS LICENSE COMPATIBILITY

	PD	CC0	BY	BY-SA	BY-NC	BY-ND	BY-NC-SA	BY-NC-ND
PD	PD	CC0, PD	BY	BY-SA	BY-NC	-	BY-NC-SA	-
CC0	CC0, PD	CC0	BY	BY-SA	BY-NC	-	BY-NC-SA	-
BY	BY	BY	BY	BY-SA	BY-NC	-	BY-NC-SA	-
BY-SA	BY-SA	BY-SA	BY-SA	BY-SA	-	-	-	-
BY-NC	BY-NC	BY-NC	BY-NC	-	BY-NC	-	BY-NC-SA	-
BY-ND	-	-	-	-	-	-	-	-
BY-NC-SA	BY-NC-SA	BY-NC-SA	BY-NC-SA	-	BY-NC-SA	-	BY-NC-SA	-
BY-NC-ND	-	-	-	-	-	-	-	-

a logarithmic scale is very similar to the previous experiment as a result of combinatorics. This shows that combinations of more open licenses allow a wider choice for further relicensing.

V. CONCLUSION

In summary, the ReCoDa approach compares licenses of multiple datasets to compute a list of compatible licenses for a republication. We use four major steps to compute a list of compatible licenses for multiple input licenses: first, we distinguished three types of license comparison types based on attribute semantics. Second, license attributes are mapped to binary values. Third, the binary values are used to compute composite attributes. Fourth, the computed composite attributes are compared to known licenses and compatible licenses are extracted. The implementation was evaluated by the Creative Commons License Compatibility Chart.

We utilized deontic logic based on license attributes. The algorithm based on plain attributes was extended by additional rules for license characteristics that go beyond the comparison of attributes.

The approach described in this paper can be extended by introducing additional attribute types (Sect. III-B), if required. Additionally, the implementation allows to add further licenses and related attributes to ensure compatibility with other datasets.

Regarding the design of future ontologies and vocabularies for license attributes, we recommend that atomic attributes be designed. A negative example, where attributes are not atomic, is the permission *Sharing*, which is part of the ccREL namespace [19]. The attribute *Sharing* "permits commercial derivatives, but only non-commercial distribution". This is related to the prohibition *Commercial Use* ("exercising rights for commercial purposes") and the permission *Derivative Works* ("distribution of derivative works"). Therefore, it is a mixture of (non-) commercial usage as well as the creation

TABLE III
EXTENDED COMPUTED CREATIVE COMMONS LICENSE COMPATIBILITY

	PD	CC0	BY	BY-SA	BY-NC	BY-NC-SA
PD	all	all	BY, BY-NC, BY-NC-ND, BY-NC-SA, BY-ND, BY-SA	BY-SA	BY-NC, BY-NC-ND, BY-NC-SA	BY-NC-SA
CC0	all	all	BY, BY-NC, BY-NC-ND, BY-NC-SA, BY-ND, BY-SA	BY-SA	BY-NC, BY-NC-ND, BY-NC-SA	BY-NC-SA
BY	BY, BY-NC, BY-NC-ND, BY-NC-SA, BY-ND, BY-SA	BY, BY-NC, BY-NC-ND, BY-NC-SA, BY-ND, BY-SA	BY, BY-NC, BY-NC-ND, BY-NC-SA, BY-ND, BY-SA	BY-SA	BY-NC, BY-NC-ND, BY-NC-SA	BY-NC-SA
BY-SA	BY-SA	BY-SA	BY-SA	BY-SA	-	-
BY-NC	BY-NC, BY-NC-ND, BY-NC-SA	BY-NC, BY-NC-ND, BY-NC-SA	BY-NC, BY-NC-ND, BY-NC-SA	-	BY-NC, BY-NC-ND, BY-NC-SA	BY-NC-SA
BY-NC-SA	BY-NC-SA	BY-NC-SA	BY-NC-SA	-	BY-NC-SA	BY-NC-SA

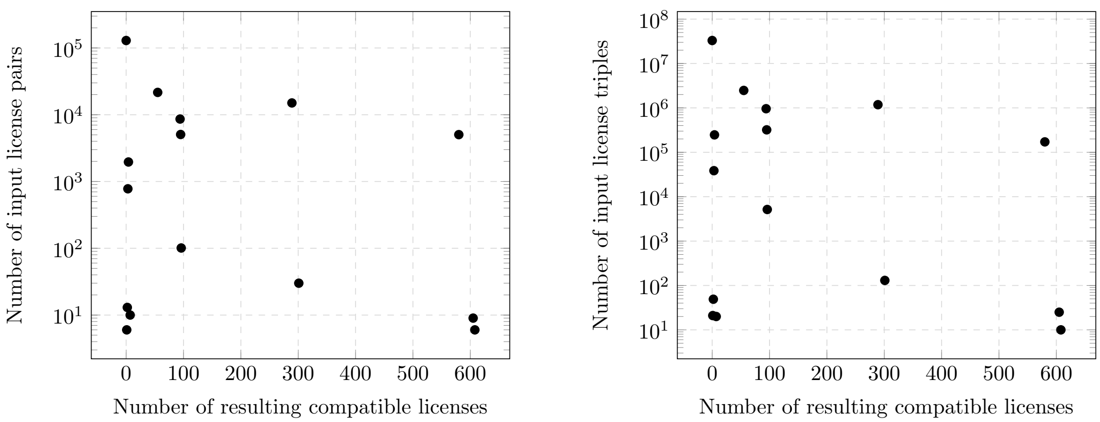

Fig. 6. Number of compatible licenses for Creative Commons license pairs and triples

of derivatives and distributions. To enable the composition of expressive licenses to build on the combination of attributes, future ontologies should focus on atomic attributes.

The question of which license to choose for publishing a dataset is obvious: use the most possible open license to support the potential of reusing your dataset. With the evaluation of this paper, another argument becomes clear: the use of open licenses also increases the possibility for datasets to be combined with other datasets without breaking legal restrictions. This is also relevant for multiple iterations of reusing previously reused datasets.

Regarding future works, the The European Data Portal provides a *License Compatibility Matrix* in the form of an Excel file.[19] It contains two tables, named *License Descriptions* and *Simple Derivative*. *License Descriptions* describes 32 licenses, consisting of a license name, a URI and the 13 attributes. Based on the available compatibility information and restrictions, we selected those input licenses with complete attribute information and applied the operators to pairs of the same license. The computed lists of compatible licenses were compared with the data from the *Simple Derivative* table. The evaluation of 961 results achieved a precision of 0.93 and a recall of 0.67, resulting in an $f_1$score of 0.78. It has to be noted that the underlying database is not complete and therefore not completely correct. The evaluation provides 19 false positives out of 961 test runs (1.98 %). The experiment is provided in the ReCoDa repository and can be used for future works.

The ReCoDa approach is designed to enable end users of Open Data portals to pick multiple datasets and easily choose a compatible license for republishing combined data.

[19]http://www.europeandataportal.eu/sites/default/files/edp-licence-compatibility-published_v1_0.xlsx

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