The Profiles Vocabulary

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Abstract. The Profiles Vocabulary (PROF) is a small RDF vocabulary to describe profiles of (one or more) specifications, i.e. a named set of constraints over those specifications. It provides a general pattern for describing the narrowing the scope of a specification with additional, but consistent, constraints and may be used to describe relationships between profiles and standards. PROF enables profile descriptions to specify the role of component resources such as schemas, ontologies, controlled vocabularies, validation tools, and guidelines. PROF may also describe the role of resources in any situation where constraints are made on the usage of more general specifications and this is particularly relevant to data exchange situations where conformance to profiles is expected and carries additional context.

This vocabulary is currently under active development by the W3C Dataset eXchange Working Group (DXWG), and we welcome feedback.

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1 Introduction

The Profiles Vocabulary (PROF) [2] describes an RDF vocabulary to describe profiles of specifications. Its development, by the World Wide Web Consortium

⋆ The views expressed are purely those of the author and may not in any circumstances be regarded as stating an official position of the European Commission.

(W3C)'s Dataset eXchange Working Group (DXWG)[6], was triggered by the appearance of multiple *application profiles* of the Dataset Catalog Vocabulary (DCAT) [15]. Other examples of profiles include vocabularies developed in the Dublin Core community following the Dublin Core Application Profiles guidelines [4] and various profiles of Open Geospatial Consortium (OGC)[7] specifications.

Profiles aim to increase interoperability within a community of users by introducing constraints such as restrictions on the cardinality of certain properties, or a requirement to select values of a property from a specified controlled vocabulary. The profile then aligns resources within that community in ways it can specify and with more detail than a general specification can.

The DXWG defines a profile as "a named set of constraints on one or more base *specifications* (standards or other profiles), including the identification of any implementing subclasses of datatypes, semantic interpretations, vocabularies, options and parameters of those base specifications necessary to accomplish a particular function".

PROF also provides for the description of relationships between profiles and specifications they conform to, as well as among profiles themselves. A *base specification* then – the thing a profile profiles – can be a standard, a vocabulary or it can be another profile. PROF provides a standardized, machine-readable formalism for describing these relationships: the basis of PROF is a specialization of `dct:Standard`[8] with the general notion of "specification", as per the Dublin Core Terms definition `dct:Standard` [5] used. We also use `dct:conformsTo` to specify conformance to a profile.

The sets of constraints defining a profile (referred to as "resource descriptors" in PROF) may be expressed in the form of human-readable documents, machine-process-able definitions, as schemas, vocabularies or ontologies (XSD [10], OWL [26]), resources specific to validation tools (SHACL [13], ShEx [22], Schematron [12]), or any other resource that supports constraint expressions. Each *resource descriptor* has a role that defines its function within a profile and it may have multiple roles. PROF provides an vocabulary of resource descriptors' roles which denote the purposes (e.g., validation) and it is expected, and intended, for users of PROF to extend this roles vocabulary.

This paper describes a W3C Second Public Working Draft release of PROF and focuses on its its motivation, scope and possible use. Our aim is also to raise awareness about this profile work and thereby trigger community feedback, which will be taken into account for PROF's final release.

The remainder of this paper is organized as follows. Section 2 outlines the rationale behind work on PROF and Section 3 contains descriptions of related work. Section 4 provides an overview of the PROF model and Section 5 describes some aspects of the PROF specification. Section 6 presents examples of resources

[6] https://www.w3.org/2017/dxwg/charter
[7] http://www.opengeospatial.org
[8] `dct` is a prefix for the DCMI Terms vocabulary . Some other well known prefixes are used in this document such as `xsd` (for [20])

characterised using PROF and examples of its expected use. Section 7 describes a test suite & implementations and this paper's main points are summarized in Section 8.

2 Motivation

Observing that "Maximizing interoperability between services [...] requires not just the use of standard vocabularies but of application profiles", the W3C DXWG has set about to promote and support the use of (application) profiles, by which it means a profile of a specification for use in a particular application.

2.1 Differentiation from previous systems

Many ways to describe components needed to define a profile and support the creation and validation of data that is to be conformant with have been developed previously (e.g. [16], see the next Section also). However, typically these only describe a few types of components seen within existing profiles, such as guidance documents or constraint language validators. Other important things about profiles could be known, such as:

- their dependence on specifications (standards or other profiles);
- the inheritance of profile information from the things being profiled, or
- descriptions of profile parts in a standardised and extensible way.

PROF aims to provide extensible ways to describe these.

2.2 Objectives of new profile mechanics

With a standard mechanism to relate profiles to the things they profile, the parts they inherit and the multiple roles their parts play, new collections of information may be generated, such as profile hierarchies which may assist with the reuse of profile and profile part resources. For instance, one can profile another profile, adding a small set of additional constraints to it and declaring compatibility to it and the things it profiles rather than re-profiling the original specification. Having a well-known, yet extensible, set of profile part roles and mechanisms to describe profile part inheritance means profile parts may be reused in their entirety. These possibilities will reduce the total effort and information necessary to specify a new profile.

Moreover, profile hierarchies would allow for machine-interpretations of profiles and automated profile negotiation with fallback options: if a client requests a resource representation according to profile that a server cannot deliver, a server may be able to deliver a more generic version of the requested resource representation instead. This is done by exploiting the link between a profile and the specification(s) it profiles, which would be characterized in the PROF description of the requested profile. Also, a client may be able to generate, by itself, a request indicating fallback options for resources when the primary requested profile is unavailable.

2.3 DXWG Profile Requirements

The W3C DXWG's work relating to profiles was started based on a general perception that profiling needs were n-met but is based on an extensive gathering of specific use cases and requirements collated in the *Dataset Exchange Use Cases and Requirements* document [9] that has been published. Requirements related to profiles are given there in five themed subsections:

1. abstract requirements applying to the general definition of profiles
2. Profile functionality
3. Profile distributions
4. Profile metadata
5. Profile and content negotiation

This vocabulary addresses many of the requirements in the first four subsections with a concrete realisation – an RDF vocabulary – of how to describe profile parts, the functions that profile parts may play and a profile's relationship to the things it profiles. Guidance is given in the this vocabulary's specification on how to present general metadata for profiles (title, creator etc.), how to publish profiles and how to indicate data's adherence to a profile.

Other documents in the W3C DXWG's family of profile-related documents address how machine clients may *negotiate* for the profile(s) that best fit their needs over the Internet [24] and provide general guidance on how to create profiles [3] (see Section 3.4).

3 Related Work

Here we describe other profiling systems that have influenced this work.

3.1 Constraint languages

Formal languages exist that define ways to express constraints on whole information objects or individual properties of them. Systems such as Schematron [12] for XML documents, SHACL [13] & ShEx [22] for RDF graphs and provide machine-actionable ways to validate data's claimed conformance to a set of conditions which could be published as a profile. Some of these systems, such as the system-independent Description Set Profile [16] provide for both human- and machine-readable forms for expressing conditions.

All of the above named constraint languages provide mechanisms to reuse objects produced using them, making the inheritance of collections of conditions from one specification to another (a profile of it) possible.

3.2 Frameworks for profiling

PROF's approach to profiles is based on existing profile frameworks, and in particular, the Dublin Core Metadata Initiative's Singapore Framework and the Open Geospatial Consortium's Standard for modular specification [18]. PROF also draws from the general mechanisms within OWL-based ontologies [26] to *import* from other ontologies.

DCMI's Singapore Framework: The Dublin Core Metadata Initiative's Singapore Framework (DCMISF) [17] is (quoting):

> [...] a framework for designing metadata applications for maximum interoperability and for documenting such applications for maximum reusability. The framework defines a set of descriptive components that are necessary or useful for documenting an Application Profile and describes how these documentary standards relate to standard domain models and Semantic Web foundation standards.

DCMISF uses a wide interpretation of the term *profile* which it gives as "a document that describes how standards or specifications are deployed to support the requirements of a particular application, function, community, or context". Moreover, DCMISF describes how application profiles of the Dublin Core Abstract Model [21] may, for some class of metadata descriptions, define which properties are referenced in statements and how the use of those properties may be constrained. DCMISF's key requirement is that properties are RDF properties.

OGC's Specification Model: The Open Geospatial Consortium's "Standard for modular specification" [18] provides "requirements for writing standards to be used for any document whose eventual purpose is the specification of requirements for software, services or data structures". The standard "specifies the structures of other standards" and is "a set of testable constraints against a finished document".

OWL's import mechanism: The Web Ontology Language (OWL)'s primer document [27] states that "It is ... common in OWL to reuse general information that is stored in one ontology in other ontologies. Instead of requiring the copying of this information, OWL allows the import of the contents of entire ontologies in other ontologies, using import statements...".

One ontology that imports another will necessarily profile it as it sets constraints on ontology classes or properties in the form of restrictions or extensions.

3.3 Complementary vocabularies

RDF vocabularies exist that are designed to provide a description of (some types of) specifications, and therefore can potentially be used also to describe profiles. However, to the best of our knowledge, none of them was designed to provide for contextual descriptions of profiles and profiles hierarchies. As such, PROF and these vocabularies are complementary, and may be used together. Particularly complementary vocabularies are, we suggest, ADMS and VOAF.

Asset Description Metadata Schema: The Asset Description Metadata Schema (ADMS) [1] is a profile of DCAT used to describe 'semantic assets', which it defines as "as highly reusable metadata (e.g. xml schemata, generic data models) and reference data (e.g. code lists, taxonomies, dictionaries, vocabularies) that are used for eGovernment system development".

ADMS is focused on describing catalogs (`adms:AssetRepository`s) of semantic `adms:Asset`s as well as their `adms:AssetDistribution`s. As such it provides the key elements to document these entities, make them discoverable and assess their fitness for purposes. It re-uses DCAT [11] property suggestions to describe the provenance of resources (creator) and their coverage (keywords). ADMS also provides an indication of the maturity of an `adms:Asset` or an `adms:AssetDistribution` thereof, with an `adms:status` property with values such as *Completed*, *Deprecated* and *Withdrawn*, links to other independent versions of `adms:Asset` resources, and some additional properties for assets' support objects, such as names and types for agents. ADMS also provides an `adms:identifier` property to indicate non-URI identifiers for `adms:Asset`s. PROF emulates this property with `prof:token` and may directly re-use it in future versions. Overall, while ADMS' notion of a "semantic asset" encompasses "profile", it is not meant to describe profile-specific features such as the relationships between a profile and the specification(s) it profiles, or the precise roles of parts they are comprised of.

Vocabulary of a Friend: Designed to be used in the Linked Open Vocabulary service (https://lov.linkeddata.es/), the Vocabulary of a Friend (VOAF) [25] is specifically targeted at RDF vocabularies and OWL ontologies to describe their relationships. It also provides classes and properties for giving quantitative information about the content of a vocabulary (e.g. the number of classes and properties they define). Some of the predicates defined in VOAF (as `voaf:reliesOn` / `voaf:usedBy`, `voaf:extends`, `voaf:generalizes`, `voaf:specializes`) could be used to express relationships between profiles. However, they can be used only with profiles which are RDF vocabularies or OWL ontologies, and their semantics are not meant to specifically express that a vocabulary is a "profile of" another one. Instead, they reflect relationships between the individual classes and properties that these vocabularies contain, such as `rdfs:subClassOf` relationships between classes. VOAF, being focused on RDF/OWL vocabularies, chiefly assumes that there is one machine-readable "definition" and one human-readable "homepage" for the vocabulary, missing the various nuances (i.e. roles) that the DXWG has identified for the components of profiles in its requirement analysis [9].

PROV-O: The PROV Ontology: PROV-O is the W3C-recommended ontology for representing provenance [14]. While PROV-O doesn't directly deal with profiling, it does deal with derivations of works from other works, as well as

some modelling patterns, such as the qualified relations pattern[9], and this has influenced how PROF indicates derivation and qualified relations.

After inspecting PROV-O's most general and more specific predicates for indicating derivation, `prov:wasInfluencedBy` & `prov:wasDerivedFrom` respectively, the DXWG does not feel that either of these properties adequately convey what it means to profile something and thus PROF does not directly specialize PROV-O properties for this task.

3.4 W3C DXWG profile documents

PROF is to be published alongside two other profiles-related documents also authored by the DXWG: *Profile Guidance* [3], which aims to provide guidance on how to create, describe and publish profiles, and *Content Negotiation by Profile* [24], which explains how Internet clients may negotiate for content provided by servers according to profiles.

The latter document parallels an IETF Internet Draft [23] aimed at formalizing HTTP headers needed for content negotiation by profile within the HTTP standard.

This family of documents is designed to be complementary and yet independently usable. Both independent and joint implementations are being sought by DXWG.

4 Conceptual Model

Figure 1 depicts the conceptual model of PROF. The model takes `dct:Standard` as a starting point, which is used to denote the general notion of "specification", and defines the specialization `prof:Profile`: a `dct:Standard` which profiles another `dct:Standard`. A `prof:Profile` can be associated with one or more `prof:ResourceDescriptor`s that define rules for implementation, provide guidance for profile use, or some other role.

Each `prof:ResourceDescriptor` must indicate the `prof:ResourceRole` it plays (to guide implementers, to validate data, etc.), the formalisms it adheres to (`dct:format`, used for example with `https://w3id.org/mediatype/application/pdf`) and any `dct:Standard` that it conforms to (`dct:conformsTo`, used for example with `http://www.w3.org/ns/shacl`).

PROF defines eight `prof:ResourceRole` individuals for likely common roles, however this list is expected to be extended by users and this is encouraged.

Several elements of PROF are still being finalised, in particular the properties `prof:isProfileOf` and `prof:isInheritedFrom`. For the first, discussion is about different forms of profiling and whether or not more than one property, perhaps multiple, specialized, sub-properties would be useful. For the second, whether or not a more general property can be used to allow a ResourceDescriptor to directly indicate the Profile that defines it and its role.

[9] For a more general explanation of this pattern, see http://patterns.dataincubator.org/book/qualified-relation.html

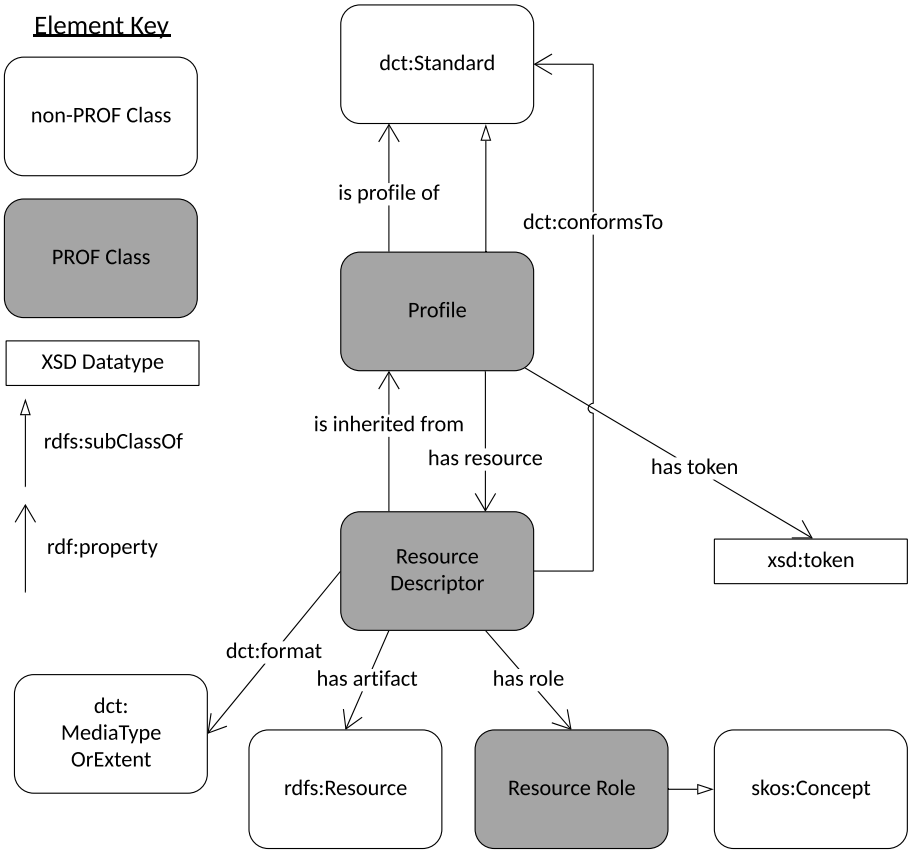

Fig. 1. Overview diagram of PROF

5 Vocabulary Specification

PROF is aimed at being a W3C Recommendation in HTML for human reading [2]. The namespace URI of PROF's RDF is http://www.w3.org/ns/dx/prof/ which links to multiple formats.

PROF defines three classes and seven properties and suggests two further properties from the DCMI Metadata Terms properties for use. It's HTML document also links throughout to additional RDF files, such as examples of PROF in use, constraint language (SHACL [13]) graphs for validating data conforming to PROF and alignments to other vocabularies.

6 Demonstrations

6.1 PROF described using PROF

Here the Profiles Vocabulary is used to describe itself: as a profile of two specifications and consisting of four parts. This example uses RDF's turtle serialization.

```
@prefix prof: <http://www.w3.org/ns/dx/prof/> .
@prefix roles: <http://www.w3.org/ns/dx/prof/roles/> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .

<http://www.w3.org/ns/dx/prof>
a owl:Ontology , prof:Profile ;
dct:title "The Profiles Vocabulary" ;
prof:isProfileOf owl: , dct: ;
    prof:hasResource _:1 , _:2 , _:3 , _:4 .

_:1
    a prof:ResourceDescriptor ;
    dct:title "Profiles Ontology Recommendation (Standard) document"@en ;
    prof:hasRole roles:guidance ;
    dct:format <https://w3id.org/mediatypes/text/html> ;
    prof:hasArtifact <https://www.w3.org/TR/dx-prof/> .

_:2
    a prof:ResourceDescriptor ;
    dct:title "Ontology specification document in RDF (Turtle)"@en ;
    prof:hasRole roles:specification ;
    dct:conformsTo owl: ;
    dct:format <https://w3id.org/mediatypes/text/turtle> ;
    prof:hasArtifact prof: .

_:3
    a prof:ResourceDescriptor ;
    dct:title "Constraints in SHACL"@en ;
    prof:hasRole roles:constraints ;
    dct:conformsTo <http://www.w3.org/ns/shacl#> ;
    dct:format <https://w3id.org/mediatypes/text/turtle> ;
    prof:hasArtifact prof:constraints.ttl .

_:4
    a prof:ResourceDescriptor ;
    dct:title "Examples of the Profiles Ontology profile in use"@en ;
    prof:hasRole roles:example ;
    dct:format
         <https://w3id.org/mediatypes/text/turtle> ,
         <https://w3id.org/mediatypes/text/turtle> ;  # both RDF & images
    prof:hasArtifact <http://www.w3.org/ns/dx/prof/examples/> .
```

In the example above, PROF is described as profiling (`prof:isProfileOf`) Dublin Core Terms and OWL and being comprised of (`prof:hasResource`) four parts: one to guide use, a second to provide its formal specification, a third to provide a complete set of constraints for conformance testing and a fourth which is a collection of examples.

Not shown in this example are standard metadata elements for the profile and its parts other than a basic title (`dct:title`). DCAT [11] should be followed as a guide for how to use basic metadata properties.

6.2 DCAT Application Profile

PROF can be used to describe the "DCAT application profile for data portals in Europe" (DCAT-AP) [8], a profile of DCAT aiming to enhance search over 67 data portals in 34 countries to "make public sector data better search-able across borders and sectors [...] achieved by the exchange of descriptions of data sets among data portals".

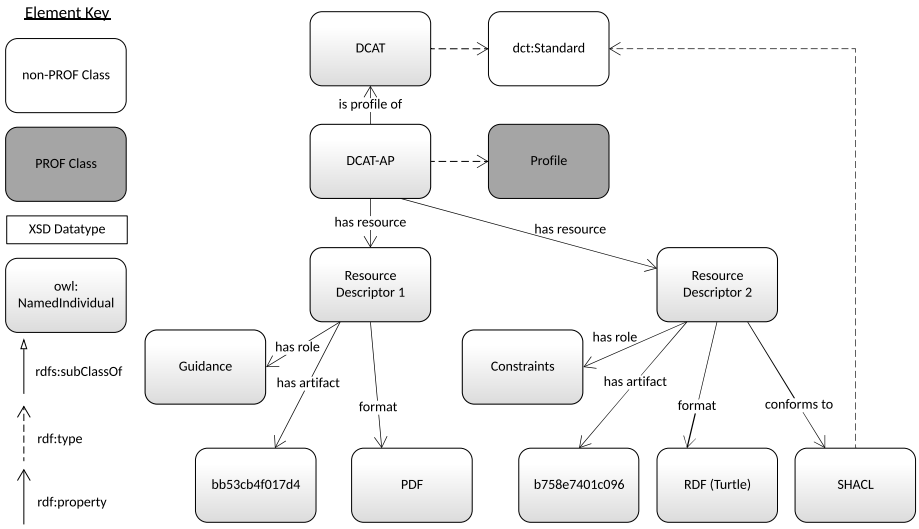

Fig. 2. DCAT-AP described using PROF

DCAT-AP defined an *application profile* to be "a specification that reuses terms from one or more base standards, adding more specificity by identifying mandatory, recommended and optional elements to be used for a particular application, as well as recommendations for controlled vocabularies to be used" and declared itself to be one that defines additional constraints over DCAT. DCAT-AP's publication includes a series of resources aimed at assisting users of the profile, such as UML [19] class diagrams, descriptive textual documents

in several formats and validation resources in SHACL [13]. In addition, there are supporting services supplied such as schema plugins for catalog tools and editors.

Figure 2 shows DCAT-AP as a `prof:Profile` and some elements of it, not all[10], interpreted as `prof:ResourceDescriptor`s with `prof:ResourceRole`s. This modeling, as opposed to the `dcat:Dataset` + `dcat:Distribution` modelling of DCAT-AP (a pattern inherited from DCAT), is able to indicate the role that individual elements within the DCAT-AP profile play, thus a user is able to distinguish between guidance documents and constraints, regardless of their format. Note that `Resource Descriptor 2` with role "Constraints" indicates conformance to SHACL [13] which lets a user determine what standard (here a constraint language) the `prof:ResourceDescriptor` uses, not just the file format which is RDF turtle (`dct:format`).

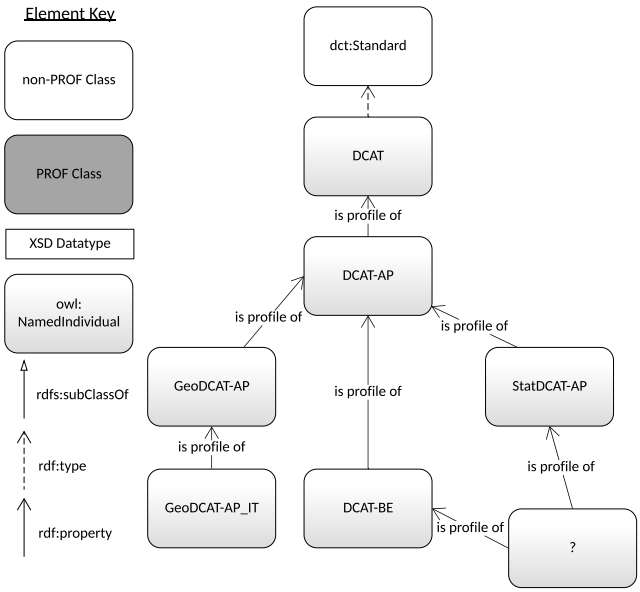

Fig. 3. DCAT-AP and related profiles in a hierarchy

DCAT-AP has itself been profiled for various European countries, such as Belgium who has issued DCAT-BE[11]. Additionally, there are several *domain* profiles of DCAT-AP, such as GeoDCAT-AP [6] – for describing geospatial datasets, dataset series and services – and StatDCAT-AP [7] – for enhancing interoperability between descriptions of statistical datasets. Further to this, there is even

[10] See PROF's more detailed example of DCAT-AP for all elements: https://www.w3.org/TR/dx-prof/#eg-dcat-ap

[11] http://dcat.be/

an Italian profile of GeoDCAT-AP, GeoDCAT-AP_IT[12] and it would be possible to create a profile of both DCAT-BE and StatDCAT-AP since profiles may profile multiple base specifications. Figure 3 shows this hierarchy using PROF with the hypothesized profile shown as "?".

6.3 Using PROF data

Here we anticipate some uses of PROF.

Use 1, collating constraints: With a collated set of constraints for a profile and the things it profiles, data may be checked for conformance against it and the things it depends on. A profile hierarchy, if characterized using PROF, as per Figure 3, may be navigated to do collation by:

- traversing the hierarchy up from the target profile to all things it profiled
- inspecting each found profile/standard
  - if it contains a `ResourceDescriptor` with role "Constraints", or a narrower term of it
  - and if the `dct:conformsTo` property of the `ResourceDescriptor` indicates an acceptable constraints language
  - add it to the collated constraints

Note that PROF contains the property `prof:isTransitiveProfileOf` which can be used to "declare all specifications (including profiles) that the subject profile requires an information resource to conform to" (from [2]). Use of this property by a profile would simplify hierarchy traversal.

Use 2, cataloguing and presenting profiles: Since PROF provides for the characterization of profile elements with roles, a system wishing to list profiles in the style of a catalogue may do so with more detail than generic cataloguing standards such as DCAT [11]. A system could present statistics on catalogued profiles' assumed capacities, such as ability for machine interpretability, by looking for specific role and conformance combinations of profile parts (`ResourceDescriptor` instances). Statistics of standards/profiles profiled and dependency graphs between them may be revealed indicating dependency to users. Additional, specialised functions may be performed based on specific role types too, such as `role:vocabulary`: `ResourceDescriptor` instances with this role could have their terms harvested and presented in a systematic way by the system.

Note that a profile of PROF for a catalogue system to mandate to ensure certain metadata about the profile, such as who created it and when and perhaps certain resource descriptors with certain roles are present would be reasonable.

[12] https://joinup.ec.europa.eu/news/geodcat-apit

Use 3: Content negotiation by profile:

Interactions between Internet clients and servers to negotiate for resources by profile conformance are the subject of the DXWG's "Content Negotiation by Profile" document [24] published alongside PROF. However, profiles characterised using PROF could be used to inform both clients and servers about negotiation possibilities.

A client requesting a resource's representation conforming to *Profile X* may receive a representation according to *Profile Y*, if the server can be sure that *Profile X* is a profile, perhaps transitively, of *Profile Y*. Both clients and servers may validate profile conformance claims by resolving a profile and navigating from it to the things it profiles – the profile hierarchy it is in.

7 Test Suite & Required Implementations

A SHACL [13] Shapes Graph (RDF file) is supplied with PROF to allow for the testing of any claims of implementations' conformance to it. This validator is described in PROF's description of PROF (see Section 6). It is not inconceivable, though not currently planned, that a ShEx [22] validator will also be implemented and for that a new `ResourceDescriptor` would be created.

As per W3C requirements for Recommendations Track documents, two full, independent, implementations of this vocabulary are sought within the lifetime of the DXWG. The first implementation tendered published is"The LocI Ontology"[13] which is an OWL ontology that profiles several other ontologies. It is published by CSIRO - Australia's national science agency. Several candidates are currently under consideration for a second implementation.

Test implementations of PROF, not considered to satisfy W3C requirements but useful to demonstrate aspects of PROF are also available:

- **CSIRO ePublish Dublin Core Application Profile**[14]
  - showcases PROF characterizing a dummy profile of Dublin Core Terms [5] constrained using the Dublin Core Application Profile [4]
  - also contains dummy instance data that can be validated
- **RightsML Profile**[15]
  - The RightsML 2.0 standard[16] which is delared to be a profile of ODRL2[17]
  - The ODRL2 Information Model contains notes on profiling[18] and work on this RightML profile is being done to ensure PROF caters for all of ODRL2's profiling requirements

[13] http://linked.data.gov.au/def/loci
[14] https://github.com/CSIRO-enviro-informatics/csiro-epub-dcap
[15] https://github.com/CSIRO-enviro-informatics/rightsml-profile
[16] https://iptc.org/standards/rightsml/
[17] https://www.w3.org/ns/odrl/2/
[18] https://www.w3.org/TR/odrl-model/#profile

8 Discussion & Future Work

PROF is a vocabulary for the description of profile components and relations between profiles and specifications. The vocabulary is deliberately lightweight (3 classes, 7 properties) and general to allow for the representation of a wide range of profiles, both formal Semantic Web profiles and others. PROF uses profile-specific classes and properties (viz. the property `prof:isProfileOf`) rather than general properties such as DCMI Terms [5]'s `dct:relation` or PROV-O [14]'s `prov:wasDerivedFrom` to indicate specific profile concerns. Hopefully this will precipitate more considered handling of profiles without which, as it grows, the Semantic Web will become more unwieldy.

Specific future work for PROF is listed in an Issues tracker for the document[19] with the medium-term focus being on the semantics and entailements of profiling and profile component inheritance (see Section 4).

PROF and its related DXWG profile documents are still under development by the W3C Dataset eXchange Working Group and we are keen on receiving feedback from the community, which will be incorporated in final versions.

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