Towards a Domain-Agnostic Computable Policy Tool*

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Abstract. Policies are often crucial for decision-making in a wide range of domains. Typically they are written in natural language, which leaves room for different individual interpretations. In contrast, computable policies offer standardization for the structures that encode information, which can help decrease ambiguity and variability of interpretations. Sadly, the majority of computable policy frameworks are domain-specific or require tailored customization, limiting potential applications of this technology. For this reason, we propose ADAPT, a domain-agnostic policy tool that leverages domain knowledge, expressed in knowledge graphs, and employs W3C standards in semantics and provenance to enable the construction, visualization, and management of computable policies that include domain knowledge to reduce terminology inconsistencies, and augment the policy evaluation process.

1 Introduction

Policies (often referred to as *guidelines*) are sets of rules that describe the preferred responses to a given set of conditions, and typically are used to support practitioners with making decisions. Policies are often expressed using natural language. Natural language encodings are often ambiguous and sometimes incomplete, thus allowing for a potential range of interpretations. In contrast, computable policies (CPs) are typically written using frameworks that govern policy structures to ensure machine-readability, and allowfor automatic evaluation using evaluation engine software. CPs are found in many contexts such as access control (e.g. XACML [1]) and healthcare (e.g GEM [7]).

Most CP frameworks, however, are domain-specific, and using them outside the intended domain(s) often require extensive configuration as well as some customized extensions. Reuse can be difficult and the required updates can create unintended consequences, and sometimes errors. One solution would be to make use of declarative domain knowledge stored in an extensible and machine understandable format stored within the CPs. This would preserve machine-readability, mitigate inconsistencies, and enable the use of domain knowledge within evaluation. Most frameworks do not readily provide this capacity, and those that do lack tools to help work within those frameworks.

* Code and video demo: `https://tetherless-world.github.io/adapt/`

For these reasons we introduce ADAPT, a domain-agnostic policy tool that leverages the domain knowledge stored using recommended standards for ontologies (OWL) and provenance (PROV) on the web. We store the content in a knowledge graph (KG). Our solution enables the construction, visualization, and management of CPs that include machine understandable domain knowledge. This approach can be used to reduce terminology inconsistencies and augment the policy evaluation process.

2 ADAPT Architecture

The ADAPT system architecture is depicted in Figure 1. ADAPT uses a full stack architecture consisting of a web-based user interface (UI), a backend REST API, and a knowledge store to store policy and KG data. The role of the knowledge store is fulfilled by the Tetherless World Knowledge Store (TWKS[1]). Policies created in ADAPT follow a generalization of the CP framework introduced by Santos et al. in [5]. CPs that use this framework are both machine-readable, and capable of using OWL reasoners to classify requests.

The API handles the extraction and construction of valid policy components, based on information in the knowledge store, and a sequence of SPARQL queries. The UI takes these components and allows the user to build functioning policies within the CP framework. A similar process is used for visualization. ADAPT also aims to allow users to configure their domain by supplying their own domain KGs, and edit browse, and visualize policies that they create.

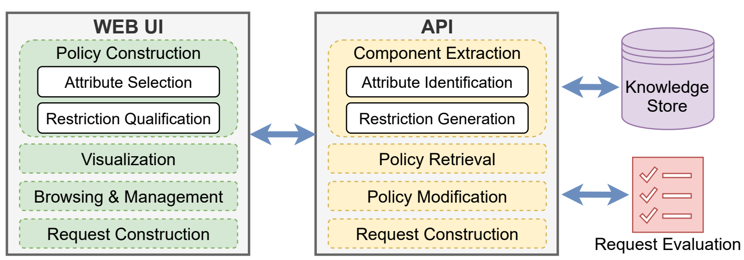

Fig. 1: ADAPT Architecture Diagram

3 Demonstration: Healthcare Guidelines

We will illustrate the utility of ADAPT by recreating a guideline (i.e. policy) for diabetes patients, published by the American Diabetes Association (ADA) [2]. Consider Recommendation 5.32, which reads:

> *Advise all patients not to use cigarettes and other tobacco products or e-cigarettes. (Evidence Rating = A)*

[1] `https://github.com/tetherless-world/twks`

A policymaker must define the necessary information within the generalization of the framework in [5]. Policy *rules* are defined as restrictions on PROV classes (`Activity`, `Entity`, `Agent`). The Semanticscience Integrated Ontology [3] is used when creating attribute rules, which are defined as restrictions on `sio:hasAttribute`. Terms from existing KGs can be reused by adding assertions. Here, we assume a background KG where `Smoking` / `NotRecommended` and `Diabetes` are assumed to be sub-classes of `prov:Activity` and `sio:Attribute`, respectively. We use `EvidenceRating` to denote precedence.

```
Class: Recommendation-5.32
  EquivalentTo: SmokingCigarettes and (wasAssociatedWith some
        (hasAttribute some Type1Diabetes))
  SubClassOf: EvidenceRating-A, NotRecommended
```

Listing 1.1: Example Policy (Manchester Syntax)

To construct the policy (Listing 1.1), we first load the required KGs and definitions into the knowledge store. ADAPT handles discovery and preparation of valid rule structures. We then take these steps in the UI (see Fig. 2): (1) specify the *Source*, *ID*, *Label*, and *Definition*; (2) specify *Smoking* for the action; (3) add a rule under *Rules* and select *Type 1 Diabetes*; (4) select *Evidence Rating A* for *Precedence*; and finally, (5) select *Not Recommended* for the *Effect*. Upon finishing these steps, ADAPT saves the policy to the knowledge store and displays a graph-based representation of the policy.

Fig. 2: A portion of the ADAPT UI for policy construction

4 ADAPT and Other Computable Policy Tools

CP tools exist to aid in creating and editing policies. Both InfoBeyond's Security Policy Tool[2] (SPT) for XACML policies, and GEM Cutter[3] for clinical guidelines, provide these capabilities. The GEM framework, however, is limited to the medical domain, and XACML requires extensive configuration for re-use. With ADAPT, users configure the tool to their domain by supplying domain knowledge from KGs. The benefit of this approach is that users can leverage domain knowledge from the many already-existing domain KGs.

As for leveraging KGs, XACML does not readily provide the ability to read KGs. Protégé [4] excels in manipulating KGs, making it virtually domain-agnostic. Protégé can be used to write CPs that leverage KGs, so long as the

[2] `https://securitypolicytool.com/`

[3] `http://gem.med.yale.edu/GEM_CutterII/gem_cutterii.htm`

framework is written using OWL. This means that Protégé relies on users being proficient in OWL. By comparison, ADAPT aims to minimize the OWL proficiency requirement outside of the initial configuration (i.e. providing definitions).

Santos et al. [6] introduces a tool for building CPs in the dynamic-spectrum access (DSA) domain, and uses the framework from [5]. ADAPT improves upon this tool by enabling usage in domains beyond DSA.

5 Conclusion

We introduced ADAPT: a domain-agnostic tool for creating and visualizing computable policies that leverage domain knowledge graphs. ADAPT employs standards in Semantic Web technology to empower practitioners to create policies that maintain standards for terminology and incorporate domain knowledge during policy evaluation.

Further work involves additional policy management features. We also plan to make extensions aimed at supporting broader reuse in a wide range of domains around loading and reuse of knowledge graphs.

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