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ShExStatements: Simplifying Shape Expressions for Wikidata

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ABSTRACT
Wikidata recently supported entity schemas based on shape expressions (ShEx). They play an important role in the validation of items belonging to a multitude of domains on Wikidata. However, the number of entity schemas created by the contributors is relatively low compared to the number of WikiProjects. The past couple of years have seen attempts at simplifying the shape expressions and building tools for creating them. In this article, ShExStatements is presented with the goal of simplifying writing the shape expressions for Wikidata.

CCS CONCEPTS
• Software and its engineering → Software libraries and repositories; • Information systems → Web data description languages: Wikis.

KEYWORDS
Wikidata, Shape Expressions, Data validation

ACM Reference Format:

1 INTRODUCTION
Entity schemas based on ShEx (Shape Expressions) [10, 13, 15] were recently introduced on Wikidata [17]. One of the main advantages of Shape Expressions is that they can be used for RDF validation [7, 14, 16]. Several tools and scripts currently exist that can be used to visualize and validate a subset of data on Wikidata using ShEx. One such tool is shex.js [4], which let the Wikidata contributors easily check entities against any particular schema. A SPARQL query is used to select a subset of relevant data from Wikidata and the validation is run on this prefetched data. Thus users can both test and explore the current state of the data related to the SPARQL query. They may propose new modifications to the entity schema or even correct the data items.

In the case of Wikidata, WikiProjects are used to identify and discuss relevant properties for the items to a particular domain. For example, WikiProject Informatics identifies properties for software, hardware, programming languages, file systems, algorithms, etc. The number of WikiProjects is an interesting indicator for measuring the use of entity schemas since WikiProjects are managed by dedicated contributors interested in a particular domain. At the time of writing, there are only less than 300 shape expressions on Wikidata. This number is quite low compared to the number of WikiProjects on Wikipedia [9] and Wikidata [6].

Therefore any tool for shape expressions must take into consideration such WikiProjects and propose ways to integrate the information present in these tools to build shape expressions. One possible approach is to propose a smaller subset of shape expressions that can be used to build simple shape expressions in a manner that closely resembles some of the existing templates. These simple expressions can take into account the WikiProjects for validating whether the items belonging to a given domain have all the necessary statements. Considering the multilingual nature, another important aspect is to let the communities describe relevant domains in their local languages. ShExStatements [12] was developed to answer these requirements. It was developed in a manner similar to the QuickStatements and OpenRefine [9] to ensure a simpler interface using tabular formats or CSV files.

In this article ShExStatements [12] is presented, explaining how a tabular format or a CSV file format was developed for simplifying writing shape expressions, especially for the new comers. In section 2, state of the art is presented. Taking an example, the grammar of ShExStatements is described in section 3. Section 4 presents the development and use of ShExStatements. Section 6 concludes the article.

2 RELATED WORKS
Several WikiProjects are currently available on Wikidata related to open government data, culture, history, sports, birds, agriculture, tourism, etc. Some of these WikiProjects take into consideration the infoboxes of Wikipedia belonging to different languages to identify the different properties used to describe the objects belonging to a certain class. These infobox properties are then mapped to appropriate Wikidata properties. WikiProjects, therefore, play an important role in identifying the key Wikidata properties. However, WikiProjects alone cannot be used to automatically validate the existing Wikidata items.

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\footnotesize{1https://www.wikidata.org/wiki/Wikidata:WikiProject_Informatics
3https://www.wikidata.org/wiki/Template:List_of_properties/Row
4https://shexstatements.toolforge.org/
5https://quickstatements.toolforge.org/
6https://openrefine.org/
7https://www.wikidata.org/wiki/Wikidata:WikiProjects}
Though Wikidata supports property constraints\(^8\), their usage is limited to specifying how properties can be used. Wikidata items use multiple properties and schemas are needed to describe and validate the items belonging to different classes. This is very important in multilingual and multi-domain context. Therefore, validation of RDF \([7, 14, 16]\) is important to ensure data present in a semantic knowledge base is following the proposed ontology or schema.

Several tools have been proposed that take into consideration the expressivity \([15]\) of shape expressions. These tools can be classified in the way shape expressions can be created. The first approach is to automatically generate schema expressions from existing RDF data. Designer \([1]\), Wikidata Shape Expressions Inference\(^9\), and sheXer\(^10\) are some examples. Visual interfaces have also been suggested to understand, modify and create new shape expressions. YASHE\(^11\) and ShExAuthor\(^12\) are examples of some visual tools for creating Shape Expressions. Finally, there are approaches that propose a smaller subset of the ShEx language. SheX-Lite\(^13\) \([2]\), ShExML \([5]\), and ShExStatements belong to this category. ShExML is a language developed to integrate multiple heterogeneous data sources. SheX-Lite is meant to be an independent language, maintaining compatibility with ShEx, and can be used to generate object models in object-oriented programming languages. ShExStatements, on the other hand, is a language developed to generate ShEx from CSV files and tabular formats.

3 SHELXSTATEMENTS

To explain the grammar of ShExStatements, an example is given below in Figure 6. It describes the ShExStatements of a human language on Wikidata.

```
wd,<http://www.wikidata.org/entity/>,,,
wdt,<http://www.wikidata.org/prop/direct/>,,,
@language,wdt:P31,wd:Q34770,,# instance of a language
@language,wdt:P1705,LITERAL,,# native name
@language,wdt:P17,.,# spoken in country
@language,wdt:P2989,.,# grammatical cases
@language,wdt:P282,.,# writing system
@language,wdt:P1098,.,# speakers
@language,wdt:P1999,.,# UNESCO language status
@language,wdt:P2341,.,# indigenous to
```

Figure 1: ShExStatements of a human language on Wikidata

There are two parts, separated by a blank line. This is also shown in Figure 2. The first part consists of prefixes, i.e., the namespaces that are going to be used in the second part. The prefixes in this example include `wd` and `wdt`.

In the second part, there are eight statements. Each statement starts with a node \([15]\), i.e., a string starting with @. In this example, `@language` is a node.

The second part has a simple syntax, with 5 columns, with the values separated by a separator (,).

<table>
<thead>
<tr>
<th>Prefix</th>
<th>URL</th>
<th>Node Property</th>
<th>Value</th>
<th>Cardinality</th>
<th>Comment</th>
</tr>
</thead>
</table>

Figure 2: ShExStatements example with its two parts. First part is used for specifying prefixes and the second part for statements

If these five columns are present in the CSV file, column 1 is used for specifying the node name, column 2 for specifying the property value, column 3 for possible values, column 4 for cardinality (+), and column 5 for comments. Comments start with #. Columns 1, 2, 3 are mandatory. Column 5 can be a special value like `@` indicating any value. Columns 3, 4 are empty for prefixes.

Consider the first statement in the second part. It states that a language must be an instance of \((wdt:P31)\) a language \((wd:Q34770)\). The fourth value, cardinality is intentionally left blank. The fifth value starts with a # indicating a comment.

Cardinality can be any one of the following values

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. * : zero or more values</td>
</tr>
<tr>
<td>2. ? : zero or one</td>
</tr>
<tr>
<td>3. + : one or more values</td>
</tr>
<tr>
<td>4. m : m number of values</td>
</tr>
<tr>
<td>5. m,n : any number of values between m and n</td>
</tr>
</tbody>
</table>

Take the fifth statement that states a language can have one or more writing systems, hence the use of + in the fourth column.

But the third column can also be another node. A ShExStatements file can also use delimiters like vertical bar (|) or semicolons (;).

This example is a ShExStatements of a TV series. The first statement describes that a TV series is an instance of \(wd:Q5398426\) (television series). The second statement states that a TV series has zero or more genres \(wdt:P136\). However, to describe a genre, we need additional statements. The third statement describes a genre to be

---

\(^8\)https://www.wikidata.org/wiki/Help:Property_constraints_portal
\(^9\)https://wd-shex-infer.toolforge.org/
\(^10\)http://shexer.weso.es/
\(^11\)https://github.com/weso/YASHE
\(^12\)https://github.com/weso/shex-author
\(^13\)https://github.com/weso/shex-lite
@tvseries|wdt:P31|wd:Q5398426| # instance of a tvseries
@tvseries|wdt:P136|@genre|*|# genre
@genre|wdt:P31|wd:Q201658,wd:Q15961987| # instance of genre

**Figure 3: ShExStatements of a TV series on Wikidata**

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Symbol(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SEP</td>
<td>;</td>
</tr>
<tr>
<td>2</td>
<td>COLON</td>
<td>:</td>
</tr>
<tr>
<td>3</td>
<td>CARET</td>
<td>^</td>
</tr>
<tr>
<td>4</td>
<td>STAR</td>
<td>*</td>
</tr>
<tr>
<td>5</td>
<td>PLUS</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>QUESTIONMARK</td>
<td>?</td>
</tr>
<tr>
<td>7</td>
<td>PERIOD</td>
<td>.</td>
</tr>
</tbody>
</table>

Table 1: Significance of different terms

Now, the grammar of ShExStatements can be formalized.

As described above, in this article, we have given a grammar that shows a statement must have a comment. However, a comment can be omitted.

A nodeproperty is a combination of node and property, separated by SEP( ).

Listing 3: ShExStatements: node property

nodeproperty : node SEP prop SEP

There can be one or more prefixes.

Listing 4: ShExStatements: prefixes

prefixes : prefix

A prefix consists of two string separated by SEP.

Listing 5: ShExStatements: prefix

prefix : STRING SEP STRING

A propertyvalue in the third column may be a value, a node, a type, or a special term (e.g., LITERAL above).

Listing 6: ShExStatements: property value

propertyvalue : value
               | node
               | type
               | specialterm

A node consists of a word starting with @ (NODENAME), possibly separated by a colon from another word.

Listing 7: ShExStatements: node

node : NODENAME
       | NODENAME COLON STRING

Special terms include period(.) or types like LITERAL, IRI, BNode, etc.

Listing 8: ShExStatements: special term

specialterm : PERIOD
             | NODEKIND

As described above, cardinality values include *, ?, etc.

Listing 9: ShExStatements: cardinality

cardinality : PLUS
             | STAR
             | QUESTIONMARK
             | NUMBER
             | NUMBER COMMA
             | NUMBER COMMA NUMBER

To specify types other than LITERAL, we need a special case to distinguish values from types.

Take, for example, in the example given below, we want to specify that a painting must have creation date of type xsd:string. Unlike...
values, this is a special case. Here we do not know any possible value, but we know the type of those values.

@painting, wdt:P571, @xsd:dateTime, #date of creation

Figure 4: ShExStatements of a painting on Wikidata

A type consists of a word starting with @@ (TYPESTRING), possibly separated by a colon from another word.

Listing 10: ShExStatements: type
type : TYPESTRING
    | TYPESTRING COLON STRING

A value is a non-whitespace string which has no characters like @ in the beginning.

Listing 11: ShExStatements: value
value : STRING

A comment is a string starting with #.

Listing 12: ShExStatements: comment
comment : COMMENT

A prop is just a value or value followed by ^ . This is interesting to specify cases, where we wish to specify that the statement with the given property must not hold.

Listing 13: ShExStatements: property
prop : value
    | CARET value

A comma separated value list is a list of values separated by a comma.

Listing 14: ShExStatements: list of comma separated values
comma separated value list : value COMMA value
    | value COMMA comma separated value list

A comma separated type list is a list of types separated by a comma.

Listing 15: ShExStatements: list of comma separated types
comma separated type list : type COMMA type
    | type COMMA comma separated type list

A delimited list is a list of types separated by a comma or a list of values separated by a comma.

Listing 16: ShExStatements: list of comma separated types or values
delimited list :
    comma separated type list
    | comma separated value list

4 DEVELOPMENT

ShExStatements is developed in Python and has multiple interfaces. It can be executed from the command line. There is also a web interface as shown in Figure 5 and an API that allows users to generate shape expressions from CSV files.

It uses the library ply\(^{14}\) for writing the grammar as described above and the parser for parsing CSV files or input. The web interface is built using Flask\(^{15}\) and pyshex\(^{16}\) is used to generate ShEx\(^{17}\) from ShExStatements.

Figure 5: Web interface for ShExStatements

ShEx generation

ShExStatements is also available on Python package index\(^{18}\) and therefore can be installed using pip. Once ShExStatements is installed, run the following command with the above example written in a file (for example, language.csv). This file contains an example description of a language on Wikidata and uses comma as a delimiter to separate the values.

$ ./shexstatements.sh language.csv

ShExStatements will generate the following Shape Expression (ShEx). It is also possible to use shexstatements in Python programs. The method generate_shex_from_csv takes as input a CSV file containing shexstatements and a delimiter. In this example, we use "," as a delimiter.

Listing 17: ShExStatements: Using Python library
from shexstatements.shexfromcsv import CSV
shex = CSV.generate_shex_from_csv("language.csv",
delim="",")
print(shex)

ShExStatements has also a public API that can be easily accessed both on a local installation as well as on the public interface. It has one operation that takes as input a JSON array with two elements as given below:

\[ \text{delimeter} \]

\(^{14}\)https://pypi.org/project/ply/
\(^{15}\)https://pypi.org/project/Flask/
\(^{16}\)https://pypi.org/project/PyShEx/
\(^{17}\)https://shexspec.github.io/primer/ShEx/
\(^{18}\)https://pypi.org/project/shexstatements/
The recently introduced shape expressions (ShEx) is a major step for creating new entity schemas, it can also be used for specifying prefixes or even imports. EntitySchema:E210 is one such example which was generated from Wikipedia and Wikidata.

Validation of data is important, especially for Wikidata considering the multilingual and multi-domain nature of the knowledge base. The recently introduced shape expressions (ShEx) is a major step for creating new entity schemas, it can also be used for specifying prefixes or even imports. EntitySchema:E210 is one such example which was generated from Wikipedia and Wikidata.

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PROJECT TEAM

The author would like to thank the contributors of Wikidata and ShExStatements, especially the organizers and participants of WikiPedia and Wikidata.


