Getting Started with Schematron & SQF

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<oXygen/> XML Editor

Overview

- Schematron history
- Schematron step-by-step
- Schematron in the development process
- Schematron for technical and non-technical users
- Schematron Quick Fixes

What is Schematron?

- A natural language for making assertions in documents

Schematron is an Open Standard

- Schematron is an Open Standard adopted by hundreds of major projects in the past decade

Schematron History

- Schematron was invented by Rick Jelliffe
  - Schematron 1.0 (1999), 1.3 (2000), 1.5 (2001)
  - ISO Schematron (2006, 2010, 2016)

Why Schematron?

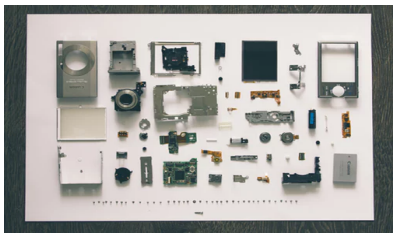
- You can express constraints in a way that you cannot perform with other schemas (like XSD, RNG, or DTD).
  - XSD, RNG, and DTD schemas define structural aspects and data types of the XML documents
  - Schematron allows you to create custom rules specific to your project

Schematron Usage

- Verify data inter-dependencies
- Check data cardinality
- Perform algorithmic checks

Used in Multiple Domains

- Financial
- Insurance
- Government
- Technical publishing



Schematron is Very Simple

- There are only 6 basic elements:

assert

report

rule

pattern

schema

ns

Schematron Step-by-Step

XML

A list of books from a bookstore:

```
...
<book price="75">
   <title>XSLT 2.0 Programmer's Reference</title>
   <author>Michael Kay</author>
   <isbn>0764569090</isbn>
</book>
...
```

<assert>

An **assert** generates a message when a test statement evaluates to **false**

```
<assert test="@price > 10">The book price is too small</assert>
```

<report>

A **report** generates a message when a test statement evaluate to **true**.

```
<report test="@price > 1000">The book price is too big</report>
```

<rule>

A **rule** defines a context on which a list of assertions will be tested, and is comprised of one or more **assert** or **report** elements.

```
<rule context="book">
   <assert test="@price > 10">The book price is too small</assert>
   <report test="@price > 1000">The book price is too big</report>
</rule>
```

<pattern>

A set of rules giving constraints that are in some way related

```
<pattern>
   <rule context="book">
    <assert test="@price > 10">The book price is too small</assert>
     <report test="@price > 1000">The book price is too big</report>
   </rule>
</pattern>
```

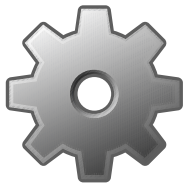
<schema>

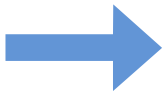
The top-level element of a Schematron schema.

```
<schema xmlns="http://purl.oclc.org/dsdl/schematron">
  <pattern>
    <rule context="book">
      <assert test="@price > 10">The book price is too small</assert>
       <report test="@price > 1000">The book price is too big</report>
    </rule>
  </pattern>
</schema>
```

Apply Schematron

```
<schema xmlns="http://purl.oclc.org/dsdl/schematron">
  <pattern>
    <rule context="book">
      <assert test="@price > 10">The book price is too small</assert>
       <report test="@price > 1000">The book price is too big</report>
    </rule>
  </pattern>
</schema>
```





⚠ The price is too small

```
...
<book price="7">
   <title>XSLT 2.0 Programmer's Reference</title>
   <author>Michael Kay</author>
   <isbn>0764569090</isbn>
</book>
...
```

<ns>

Defines a namespace prefix and URI

```
<schema xmlns="http://purl.oclc.org/dsdl/schematron">
   <ns uri="http://book.example.com" prefix="b"/>
   <pattern>
      <rule context="b:book">
       <assert test="@price > 10">The book price is too small</assert>
        <report test="@price > 1000">The book price is too big</report>
      </rule>
   </pattern>
</schema>
```

Schematron Uses XPath

- XPath it is very important in Schematron:
  - Rule context is expressed using an XPath expression

```
<rule context="book">
```

  - Assertions are expressed using XPath expressions that are evaluated as *true* or *false*

```
<assert test="@price > 10">
```

- *@queryBinding – determines the XPath version*

```
<schema queryBinding="xslt2">
```

  - *Possible values: xslt, xslt2, xslt3*

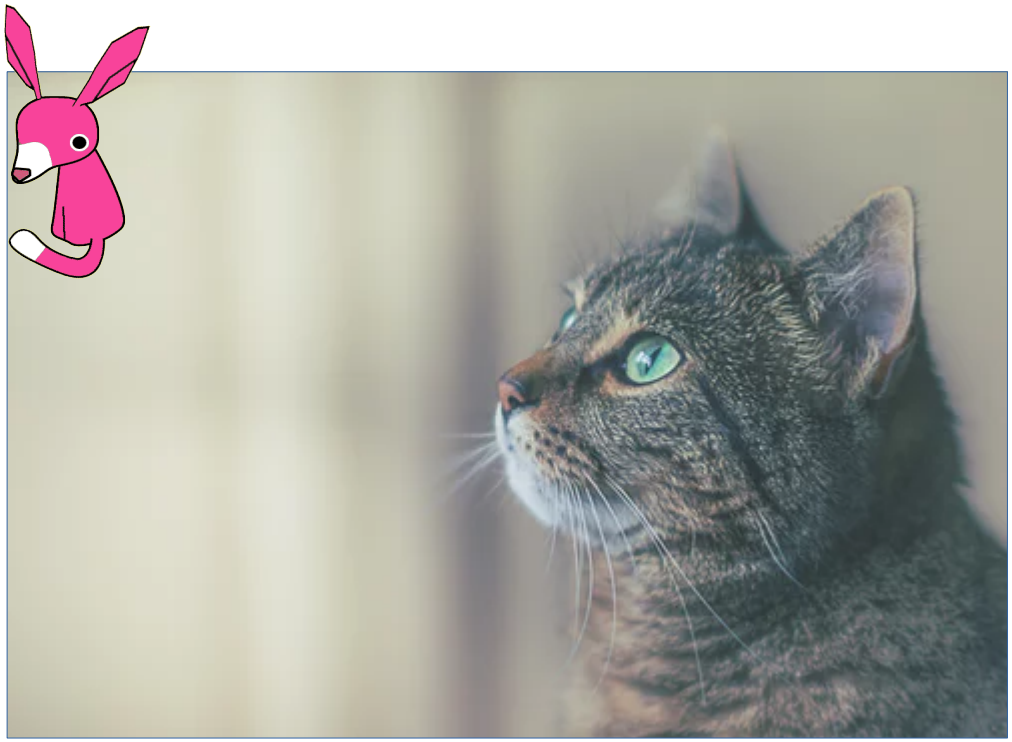
What is XPath?

- A language for addressing parts of an XML document (XML Path Language)
- A W3C Recommendation in 1999
  www.w3.org/TR/xpath
- XPath versions 1.0, 2.0, 3.0, 3.1 (2017)

- Tutorials:
  - www.data2type.de/en/xml-xslt-xslfo/xpath/
  - www.xfront.com/xpath/
  - www.zvon.org/comp/m/xpath.html

Conclusion

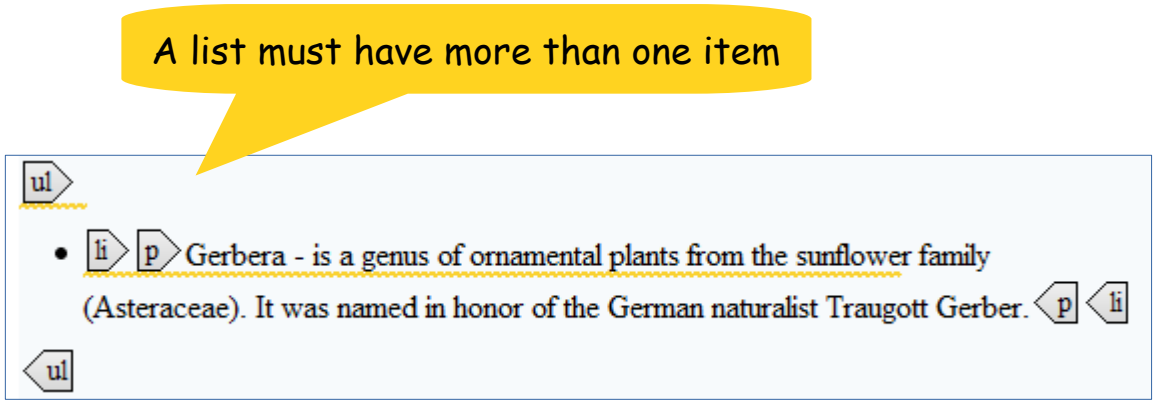
- Schematron is simple (6 basic elements)
- Used in multiple domains
- Schematron uses XPath



Examples of Schematron Rules

Check Number of List Items

- Example of a rule that checks the number of list items in a list



Check Number of List Items

- The number of list items from an unordered list should be greater than one

```
<sch:rule context="ul">
   <sch:assert test="count(li) > 1">
      A list must have more than one item</sch:assert>
</sch:rule>
```

Styling in Titles

- Example rule that checks for styling in titles

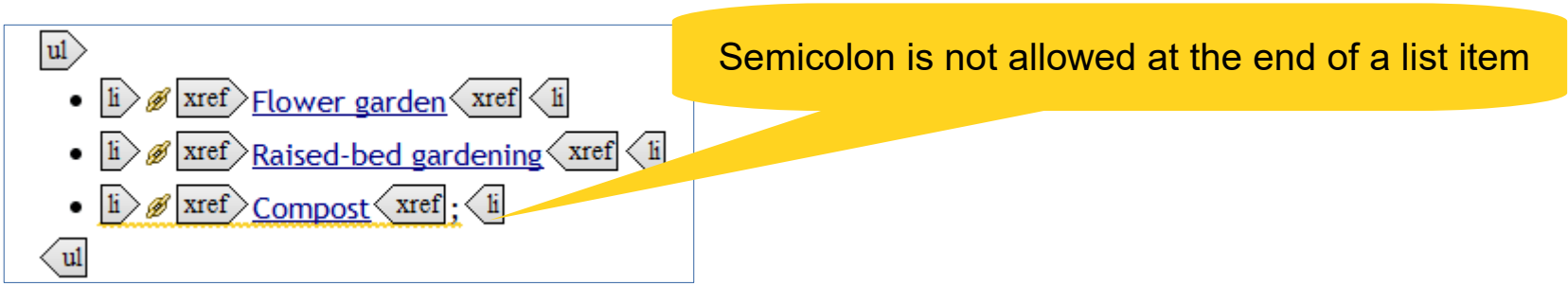
Styling in Titles

- The b element should not be used in a title or short description

```
<sch:rule context="title | shortdesc">
   <sch:report test="b">
     Bold is not allowed in <sch:name/> element</sch:report>
</sch:rule>
```

Semicolon at End of List Items

- Example of rule that checks if a semicolon is at the end of a list item



Semicolon at End of List Items

- The last text from a list item should not end with semicolon

```
<sch:rule context="li">
   <sch:report test="ends-with(text()[last()], ';')">
      Semicolon is not allowed after list item</sch:report>
</sch:rule>
```

Check External Link Protocol

- Example of rule that check the external link protocol

The external link should start with http(s)

p Most of the information was taken from xref www.wikipedia.org/ xref, the free encyclopedia. p

Check External Link Protocol

- The @href attribute value it is an external link and should start with http or https.

```
<rule context="xref">
   <sch:assert test="matches(@href, '^http(s?)://')">
     An link should start with http(s).</sch:assert>
</rule>
```

Missing Tables Cells

- Missing cells in a table

Cells are missing from table

Flower	Type	
Chrysanthemum	perennial	well drained
Gardenia	perennial	
Gerbera	annual	sandy, well-drained
Iris		

Missing Tables Cells

- Check that are the same number of cells on each row

```
<sch:rule context="table">
  <sch:let name="minColumsNo" value="min(.//row/count(entry))"/>
  <sch:let name="reqColumsNo" value="max(.//row/count(entry))"/>

  <sch:assert test="$minColumsNo >= $reqColumsNo">
    Cells are missing. (The number of cells for each row must be
    <sch:value-of select="$reqColumsNo"/>)
  </sch:assert>
</sch:rule>
```

Link in Text Content

- Links are added directly in text content

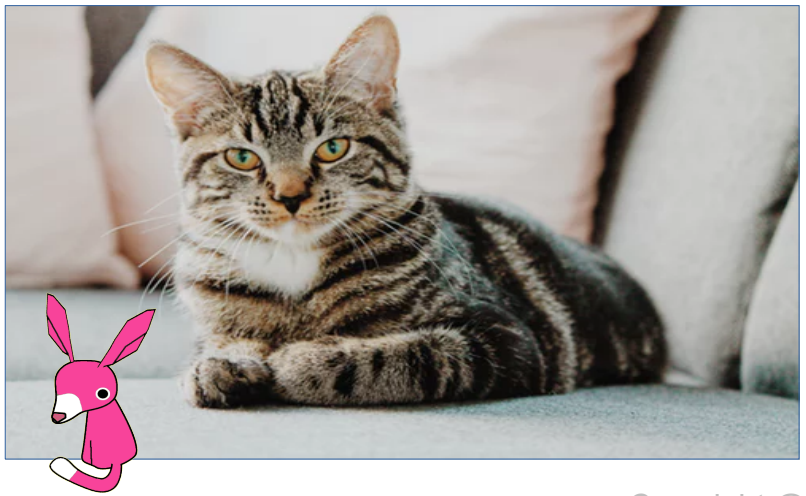
Link in Text Content

- Check if a link is added in text content but is not tagged as a link

```
<sch:rule context="text()">
  <sch:report test="matches(., '(http|www)\S+')
                    and local-name(parent::node()) != 'xref'">
    The link should be a xref element</sch:report>
</sch:rule>
```

Conclusion

- Simple to complex Schematron rules
- Additional Schematron elements used:
  - <let> - A declaration of a named variable
  - <value-of> - Finds or calculates values from the instance document
  - <name> - Provides the names of nodes from the instance document



Integrating Schematron in the Development Process

Validate XML with Schematron

- Associate Schematron in the XML file

```
<?xml-model href="books.sch" type="application/xml"
                schematypens="http://purl.oclc.org/dsdl/schematron"?>
```

- Use tool-specific association options
  - Associate Schematron file with a set of XML files (all files with a specific namespace, or from a directory)
  - Associate Schematron with all XML files from a project

Embed Schematron in XSD or RNG

- Schematron can be added in the XSD **appinfo** element

```
<xsd:appinfo>
  <sch:pattern>
    <sch:rule context="...">
        <sch:assert test="...">Message.</sch:assert>
    </sch:rule>
  </sch:pattern>
</xsd:appinfo>
```

- Add Schematron checks in any element on any level of an RNG schema

```
<grammar
    xmlns="http://relaxng.org/ns/structure/1.0"
    xmlns:sch="http://purl.oclc.org/dsdl/schematron"
    <sch:pattern>
      <sch:rule context="...">
        <sch:assert test="...">Message.</sch:assert>
      </sch:rule>
    </sch:pattern>
    <start>
     ..............
    </start>
</grammar>
```

Run Schematron Validation

- From an XML editing framework
  - Check the XML files as you type
  - Run the Schematron validation on multiple files
- Using W3C's XProc pipeline language through its "validate-with-schematron" step

- Using Apache Ant, from bat/shell

  https://github.com/Schematron/ant-schematron

Schematron Validation Result

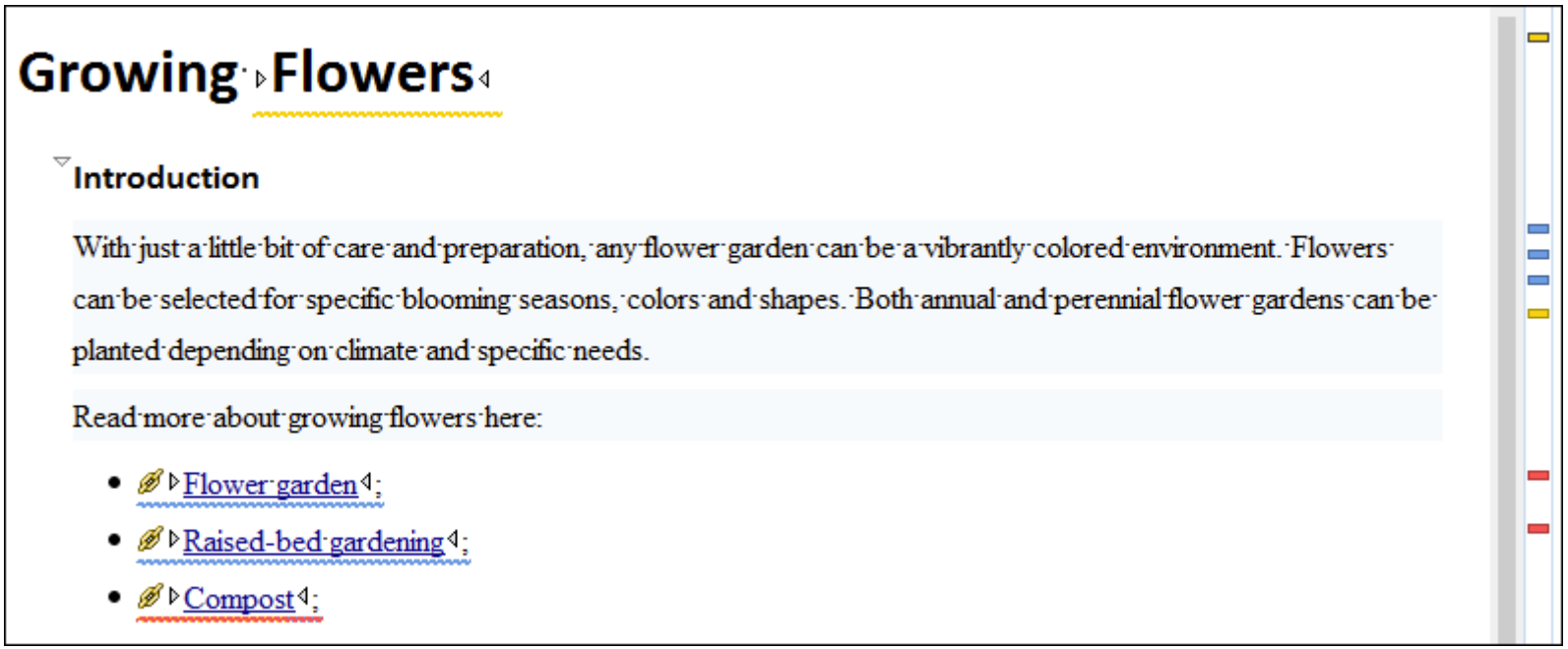
- Messages presented in the editing framework

- As an XML file describing the validation errors, normally in Schematron Validation Reporting Language (SVRL)

```
<svrl:failed-assert test="matches(@href, '^http(s?)://')" role="warn"
                    location="/topic[1]/body[1]/section[1]/p[3]/xref[1]">
   <svrl:text>An external link should start with http(s).</svrl:text>
</svrl:failed-assert>
```

Schematron Messages Severity

- Severity level can be set in the value of the @role attribute from an assert or report element (fatal, error, warn, or info)
- Depending on the severity, the message can be rendered differently in an editing framework



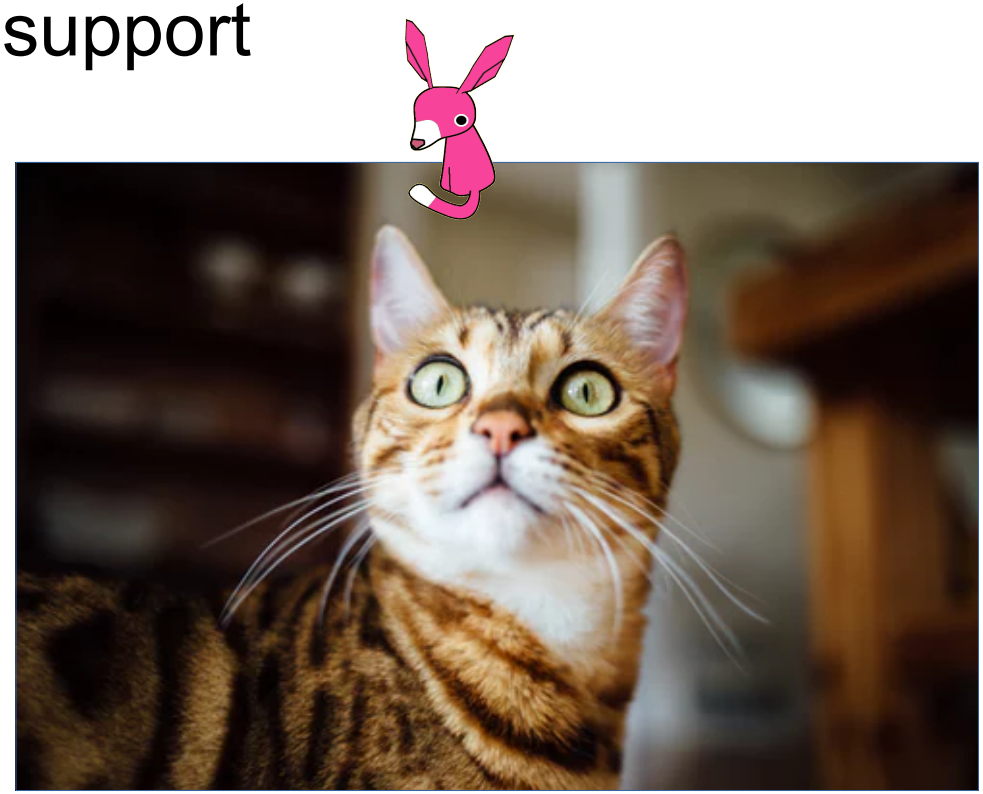
Multilingual Support in Schematron

- Based on the Schematron diagnostic element
- A diagnostic element is used for each language
- Multilingual support defined in the Schematron specification

```
<sch:assert test="bone" diagnostics="d_en d_de">
  A dog should have a bone.
 </sch:assert>
....
<sch:diagnostics  xml:lang="en">
   <sch:diagnostic id="d_en">A dog should have a bone.<sch:diagnostic>
</sch:diagnostics>
<sch:diagnostics  xml:lang="de">
   <sch:diagnostic id="d_de">Das Hund muss ein Bein haben.</sch:diagnostic>
</sch:diagnostics>
```

Conclusion

- Multiple ways to associate and apply the validation
- Validation results as you type or in a report
- Messages with different severity
- Multilingual support



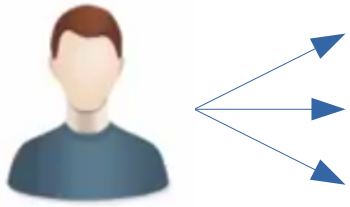
Schematron for Non-Technical and Technical Users

Schematron for Non-Technical Users

- Schematron is used in multiple domains
- There are more and more non-technical users that want to develop their own rules
- Providing a user interface to create the Schematron rules will be more appropriate for them

Library of Rules

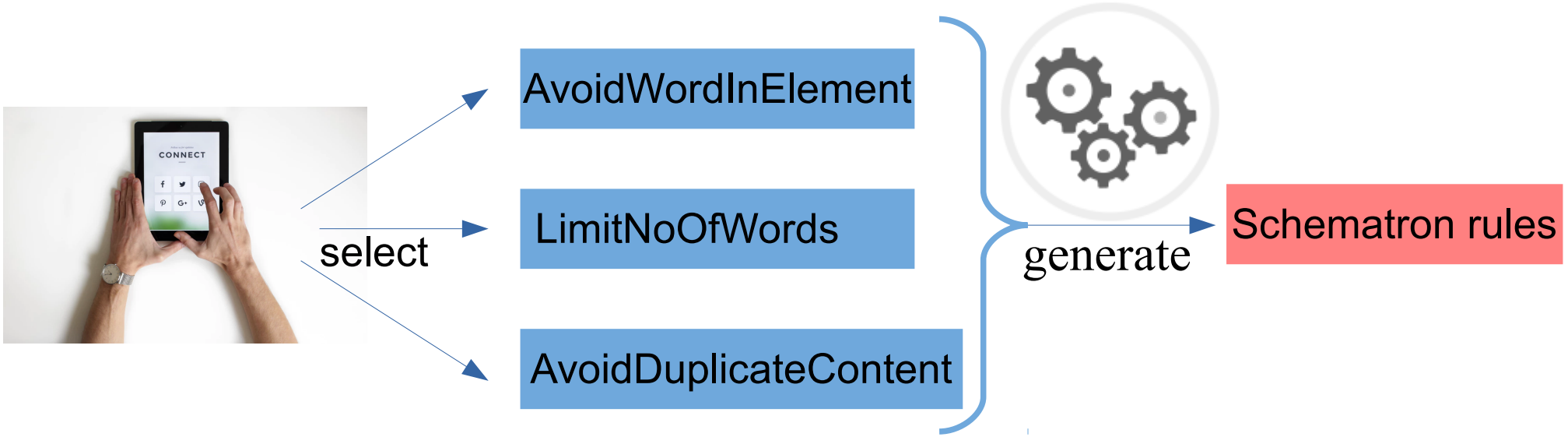
- A solution can be to provide a library of rules
- The user can choose the rule that he wants to add



Avoid a word in a certain element
Limit the number of words
Avoid duplicate content

Abstract Patterns

- Library of rules implemented using abstract patterns



Abstract Pattern

- Allows to reuse patterns by making them generic

```
<pattern id="LimitNoOfWords" abstract="true">
   <rule context="$parentElement">
    <let name="words" value="count(tokenize(normalize-space(.), ' '))"/>
    <assert test="$words le $maxWords">
     $message You have <value-of select="$words"/> word(s).
    </assert>
    <assert test="$words ge $minWords">
     $message You have <value-of select="$words"/> word(s).
   </assert>
  </rule>
</pattern>
```

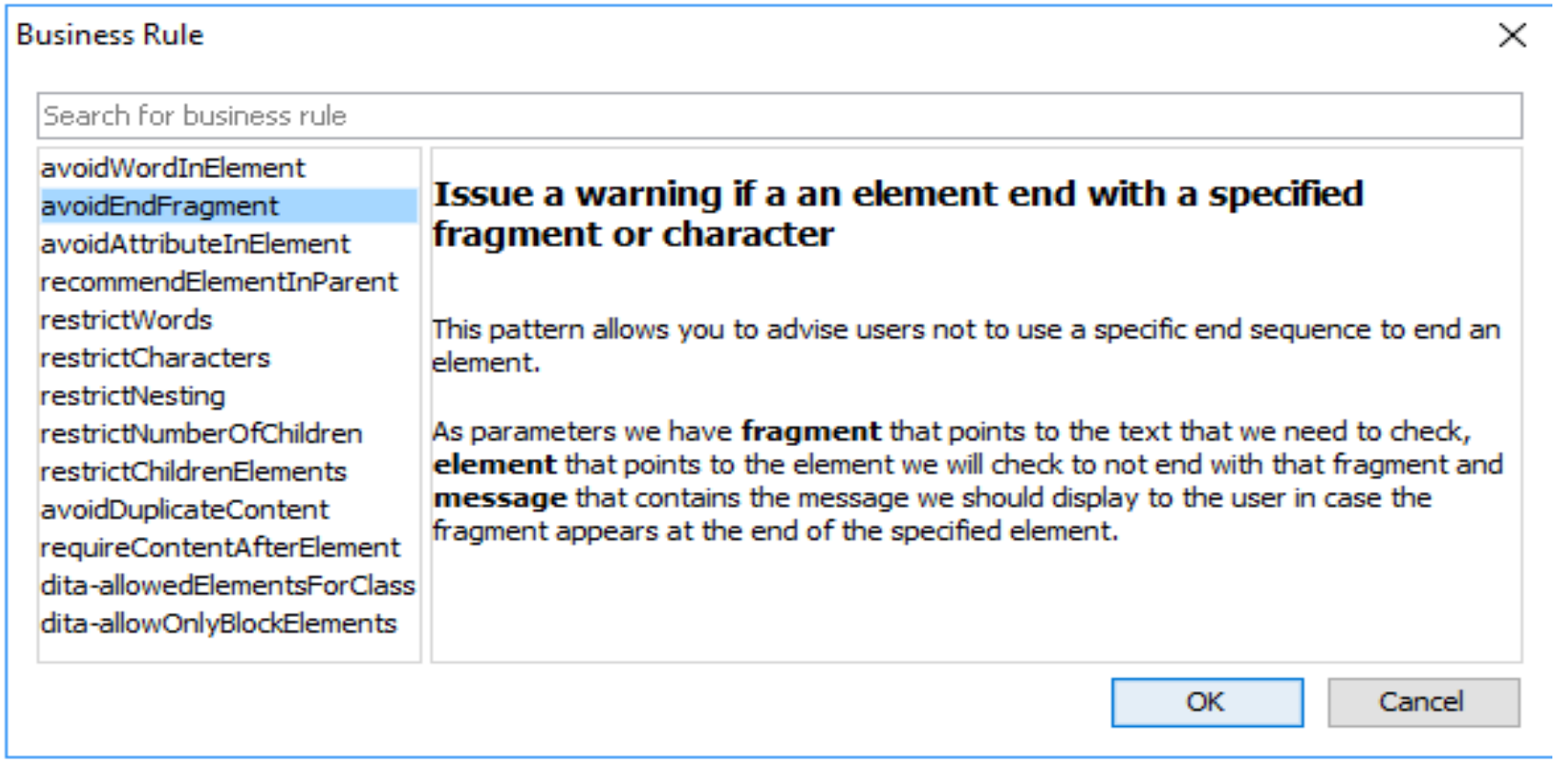
Pattern Instantiation

- Refer an abstract pattern and specifies values for parameters

```
<pattern is-a="LimitNoOfWords">
   <param name="parentElement" value="shortdesc"/>
    <param name="minWords" value="1"/>
    <param name="maxWords" value="50"/>
    <param name="message" value="Keep short descriptions between 1 and 50 words!"/>
</pattern>
```

```
<pattern is-a="LimitNoOfWords">
   <param name="parentElement" value="title"/>
     <param name="minWords" value="1"/>
     <param name="maxWords" value="8"/>
     <param name="message" value="Keep titles between 1 and 8 words."/>
</pattern>
```

Create Business Rules Using DIM



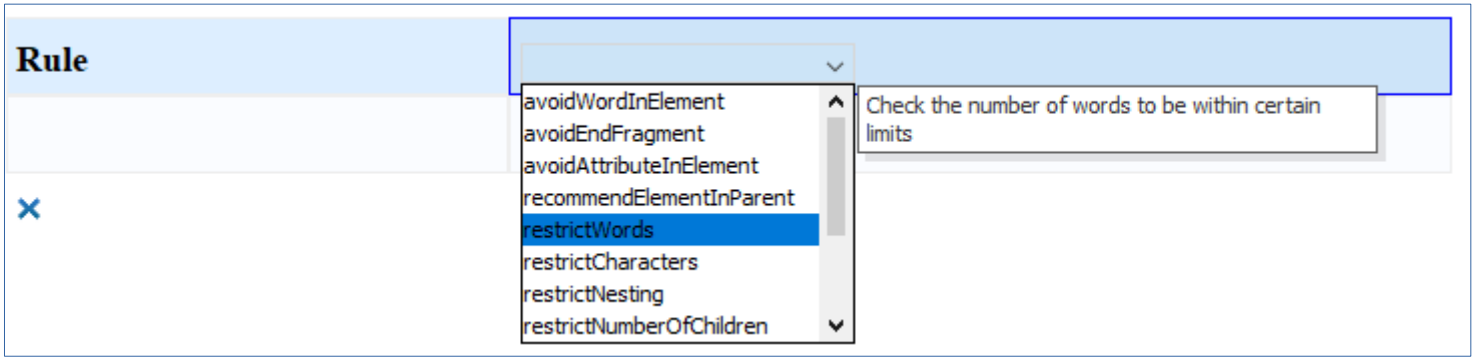
Rule	avoidEndFragment
element	li
fragment	;
message	Avoid ; at the end of a list item

Dynamic Information Model (DIM)

- An implementation of an intelligent style guide
- Describes and enforces rules
- Open-source project available on GitHub
  https://github.com/oxygenxml/dim

Intelligent Integrated Styleguide

- Evolution of Dynamic Information Model (DIM)
- Open-source project available on GitHub https://github.com/oxygenxml/integrated-styleguide



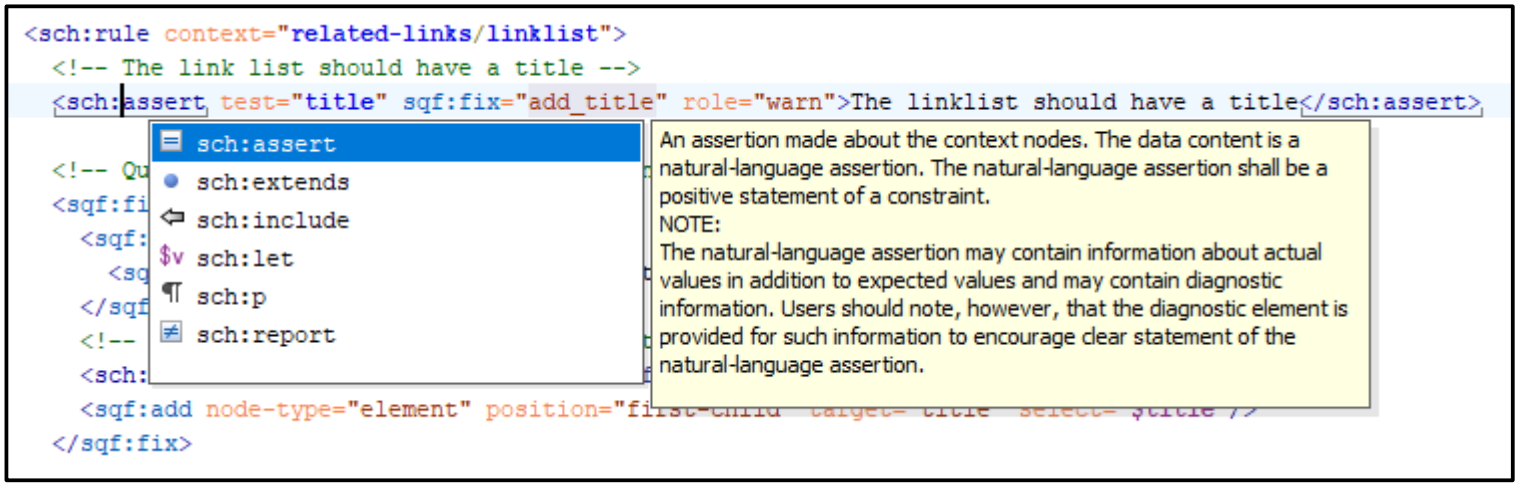
Schematron for Technical Users

Environment to develop Schematron schemas

- Editor
- Validation
- Search and refactoring
- Working with modules
- Unit testing

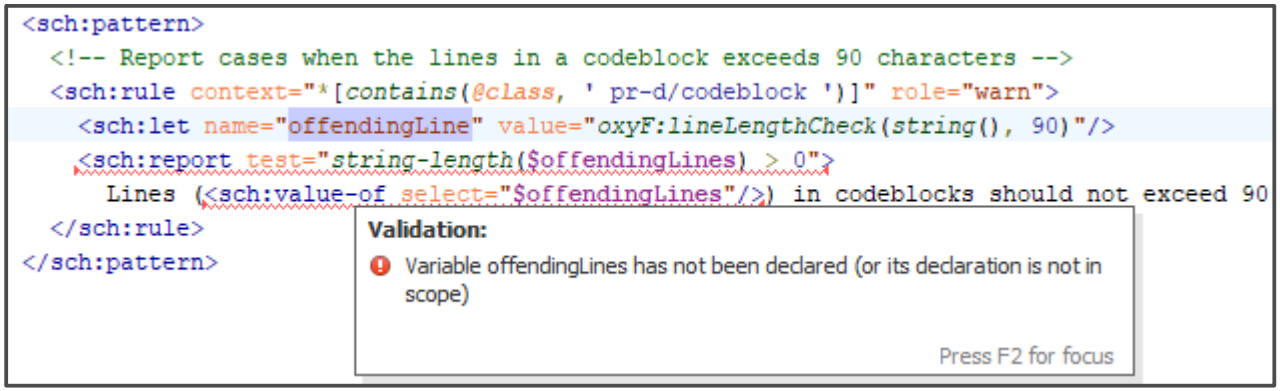
Editor

- Syntax highlighting - to improve the readability of the content
- Content completion assistant - offering proposals that are valid at the cursor position
- Documentation - with information about the particular proposal



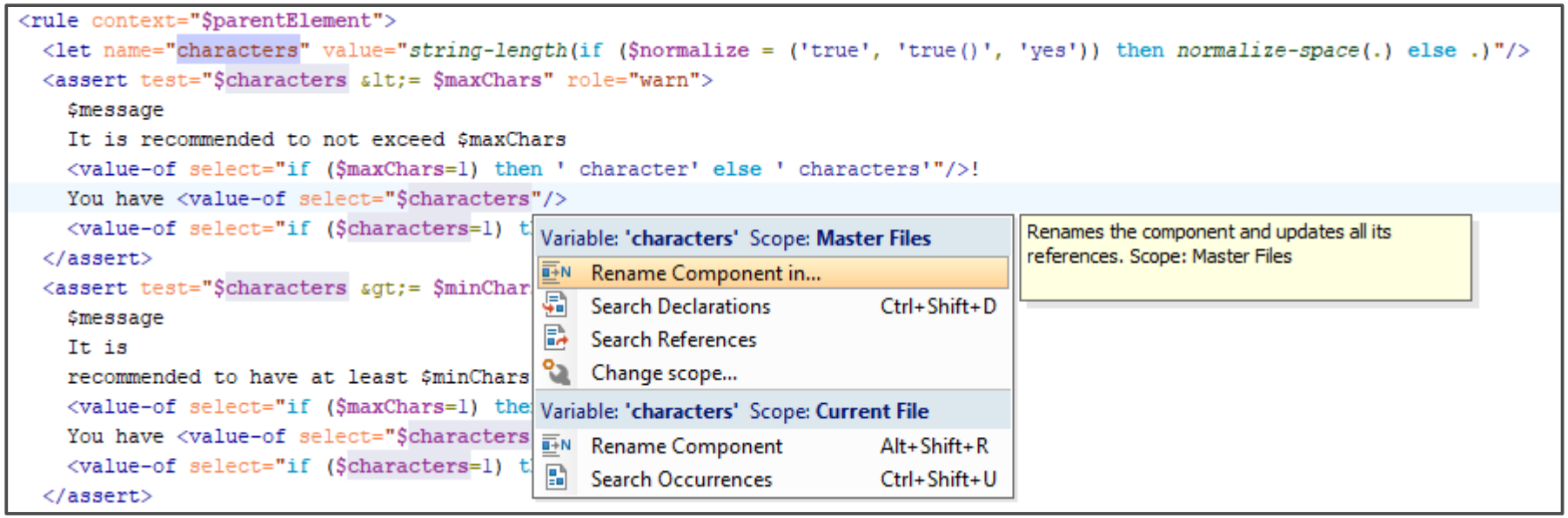
Validate

- Validate Schematron schemas, and highlight problems directly in the editor
- Validate Schematron modules in context
- Support for validation as you type



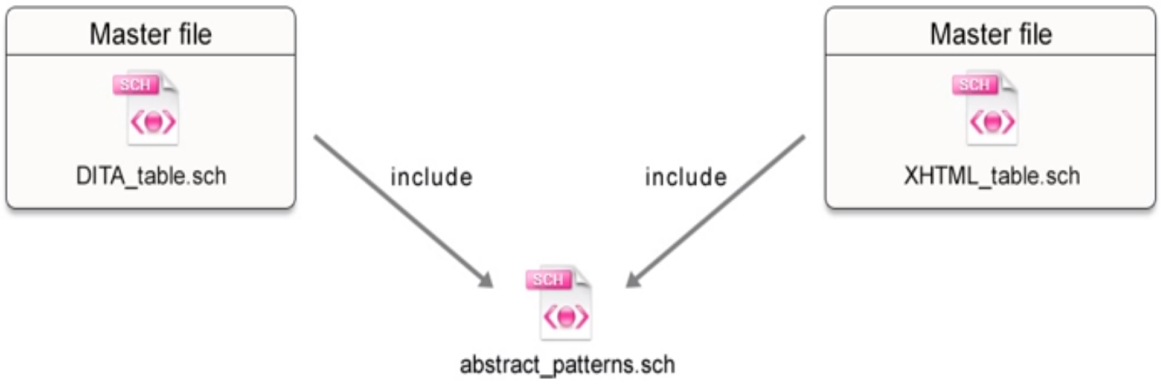
Search and Refactoring

- Find references to variables, pattern, phases, or diagnostics
- Support for renaming all references from the current document, or in the entire hierarchy
- Preview the changes



Working with Modules

- Visualize the hierarchy of modules
- Support for editing a Schematron module in the context
- Moving and renaming modules



Test Schematron Rules

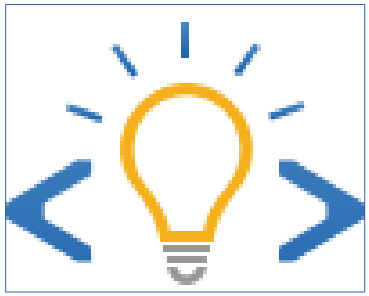
- Developing Schematron schema also involves testing
- Make sure Schematron rules work as expected
- Apply multiple XML examples over the Schematron rules and check the results

XSpec

- Solution to create Schematron unit tests
- Unit test and BDD (Behaviour Driven Development) framework
    - https://github.com/xspec/xspec/
- Oxygen XSpec Helper View plugin
    - github.com/xspec/oXygen-XML-editor-xspec-support
- Tutorials
    - github.com/xspec/xspec/wiki/Getting-Started-with-XSpec-and-Schematron
    - oxygenxml.com/events/2018/webinar_xspec_unit_testing_for_xslt_and_schematron.html

Conclusion

- Library of rules using abstract patterns
- User interface for non-technical users
- Editing, validation, and refactoring support for technical users
- Test cases for Schematron



Schematron Quick Fixes

Schematron Fix Proposals

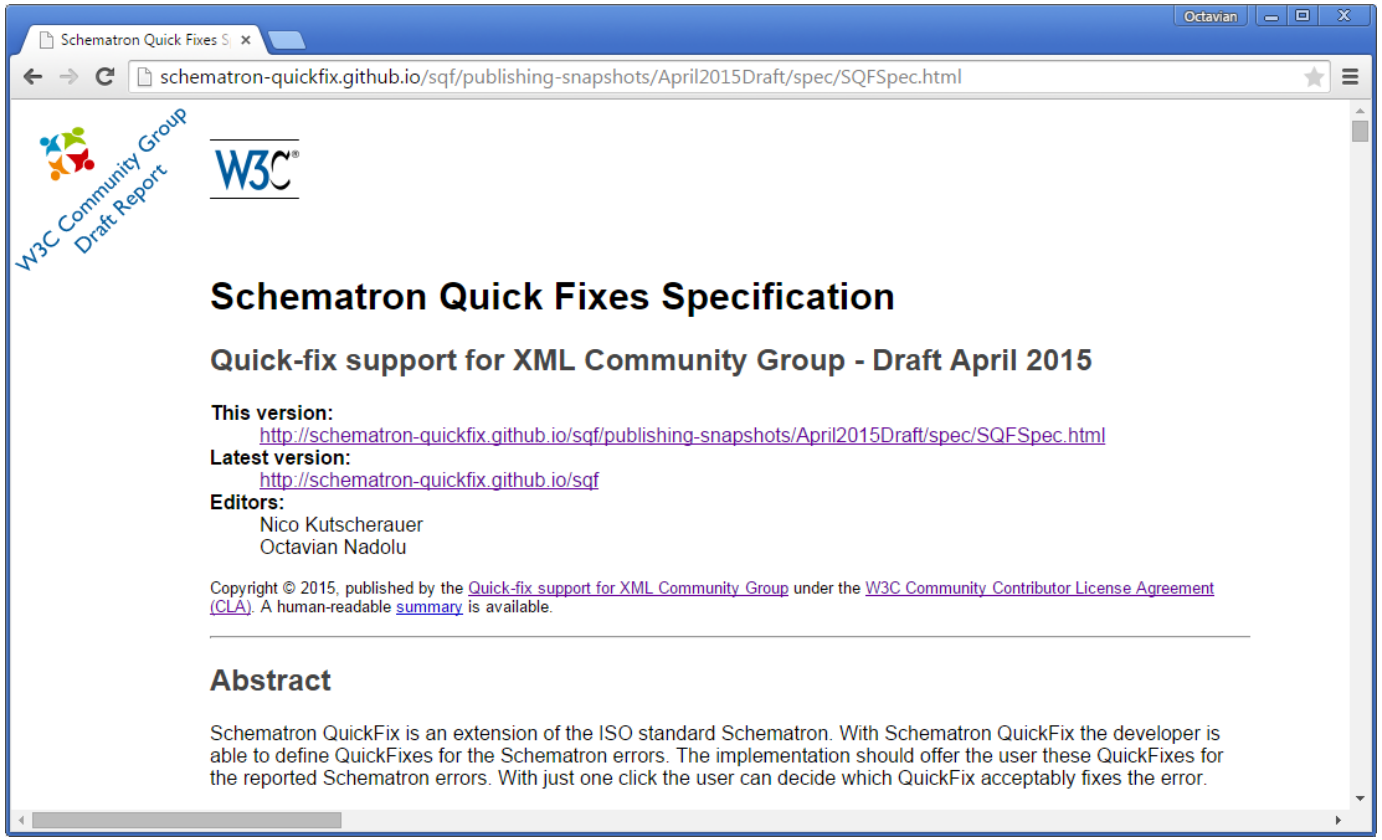
- Schematron assertion messages are not always enough for the user to find a solution
- It is better to have some proposals to correct the Schematron reported problem
- Similar to spell check proposals

Schematron Quick Fix Proposals

- User-defined fixes for Schematron errors
- Schematron Quick Fix (SQF) language
  - Extension of the Schematron language
  - SQF initiated by Nico Kutscherauer

www.schematron-quickfix.com
github.com/schematron-quickfix/sqf

Schematron Quick Fixes Spec



www.w3.org/community/quickfix

schematron-quickfix.github.io/sqf

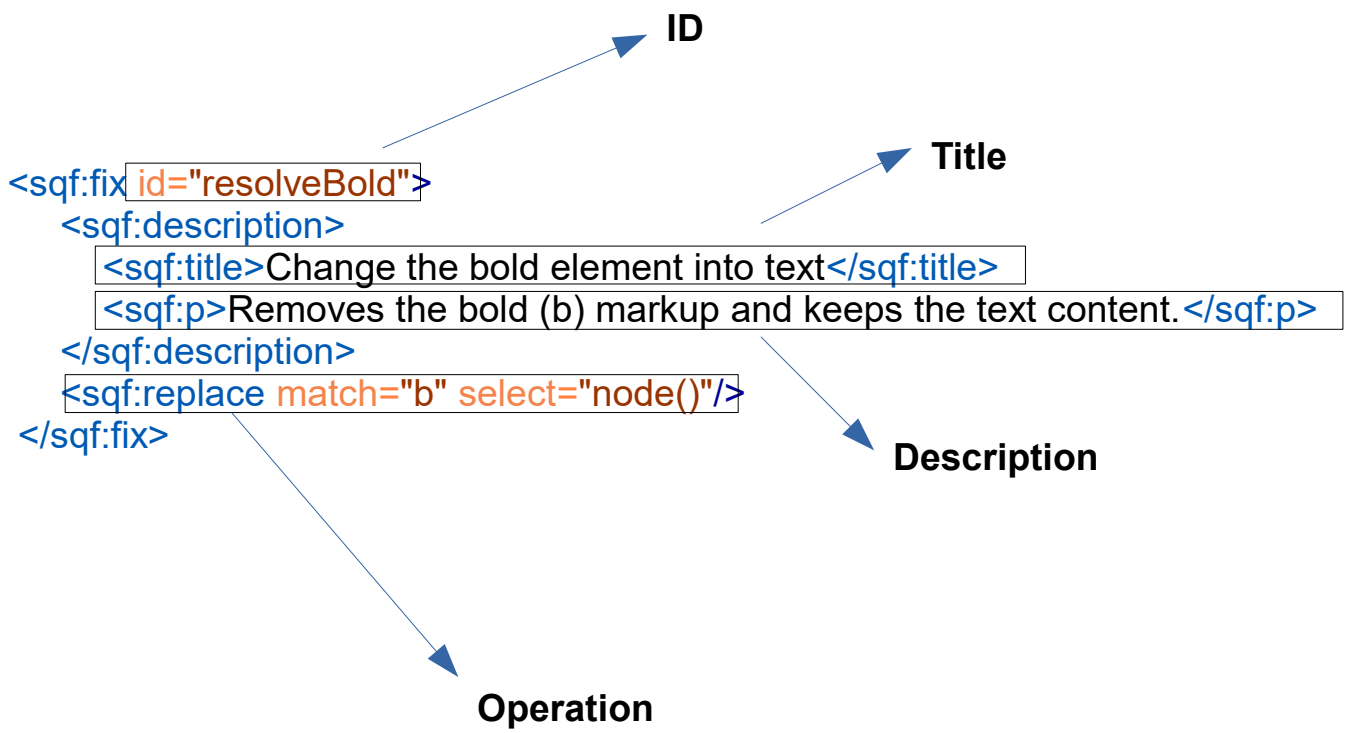
SQF Extension of Schematron

- Added as Schematron annotations
- Associate fixes with assert and report elements

```
<rule context="title">
    <report test="b" sqf:fix="resolveBold">
       Bold is not allowed in title element</report>

    <sqf:fix id="resolveBold">
       <sqf:description>
          <sqf:title>Change the bold element into text</sqf:title>
          <sqf:p>Removes the bold (b) markup and keeps the text content.</sqf:p>
       </sqf:description>
       <sqf:replace match="b" select="node()"/>
    </sqf:fix>
 </rule>
```

Schematron Quick Fix (SQF)



SQF Operations

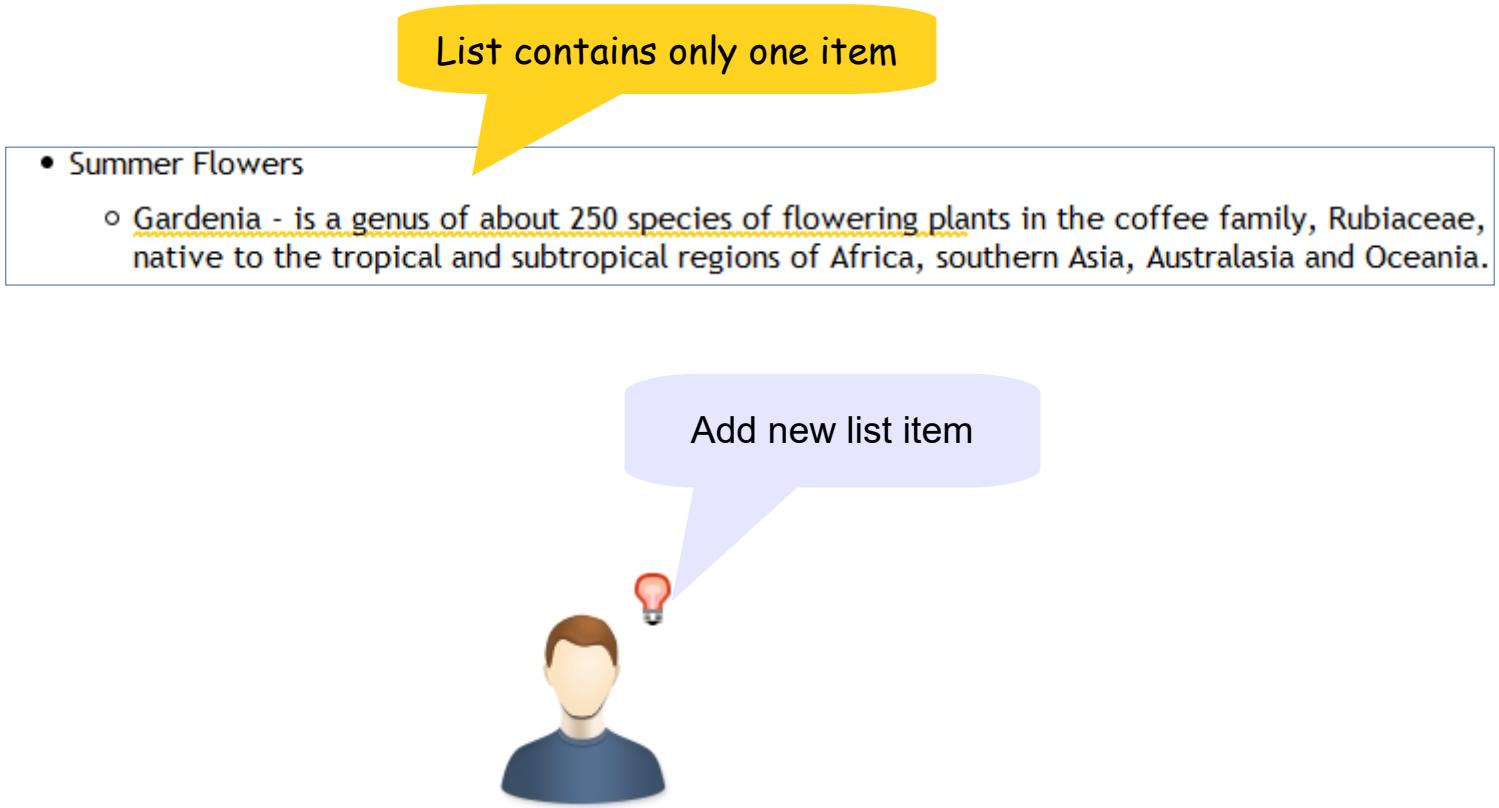
The following 4 types of operations are supported:

- <sqf:add> - To add a new node or fragment in the document
- <sqf:delete> - To remove a node from the document
- <sqf:replace> - To replace a node with another node or fragment
- <sqf:stringReplace> - To replace text content with other text or a fragment

Introduction to SQF Through Examples

1. SQF “add” Operation

- Example of using the “add” operation: add new list item in a list



1. SQF “add” Operation

- <sqf:add> element allows you to add one or more nodes to the XML instance

```
<rule context="ul">
   <assert test="count(li) > 1" sqf:fix="addListItem">A list must have more
  than one item.</assert>

   <sqf:fix id="addListItem">
      <sqf:description>
         <sqf:title>Add new list item</sqf:title>
      </sqf:description>
      <sqf:add node-type="element" target="li" position="last-child"/>
   </sqf:fix>
</rule>
```

2. SQF “delete” Operation

- Example of using the “delete” operation: remove redundant link text

2. SQF “delete” Operation

- <sqf:delete> element specifies the nodes for the deletion

```
<rule context="xref">
   <report test="@href = text()" sqf:fix="removeText">
      Link text is same as @href attribute value. Please remove.</report>

   <sqf:fix id="removeText">
      <sqf:description>
         <sqf:title>Remove redundant link text</sqf:title>
      </sqf:description>
      <sqf:delete match="text()"/>
   </sqf:fix>
</rule>
```

3. SQF “replace” Operation

- Example of using the “replace” operation: replace bold element with text

3. SQF “replace” Operation

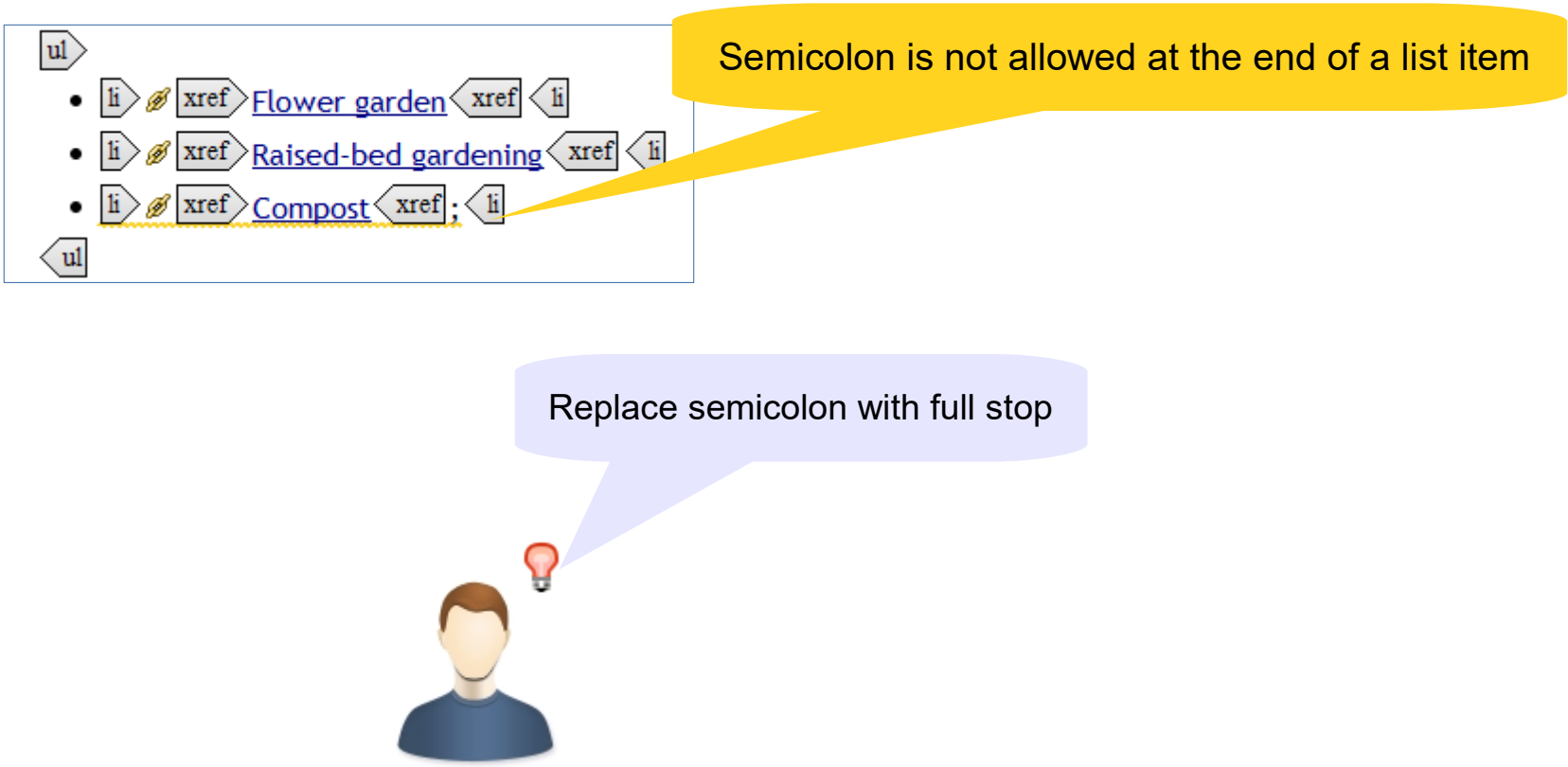
- <sqf:replace> element specifies the nodes to be replaced and the replacing content

```
<rule context="title">
   <report test="b" sqf:fix="resolveBold">
      Bold is not allowed in title element.</report>

   <sqf:fix id="resolveBold">
      <sqf:description>
         <sqf:title>Change the bold into text</sqf:title>
      </sqf:description>
      <sqf:replace match="b" select="node()"/>
   </sqf:fix>
</rule>
```

4. SQF “stringReplace” Operation

- Example of using the “stringReplace” operation: replace semicolon with full stop



4. SQF “stringReplace” Operation

- <sqf:stringReplace> element defines the nodes that will replace the substrings

```
<rule context="li">
  <report test="ends-with(text()[last()], ';')" sqf:fix="replaceSemicolon">
     Semicolon is not allowed after list item</report>

  <sqf:fix id="replaceSemicolon">
     <sqf:description>
        <sqf:title>Replace semicolon with full stop</sqf:title>
     </sqf:description>
     <sqf:stringReplace match="text()[last()]" regex=";$" select="'.'"/>
  </sqf:fix>
</rule>
```

Conclusions

- Schematron Quick Fix language is simple
- You can define custom fixes for your project
- Just 4 types of operations

SQF Implementations

- <oXygen/> XML Editor validation engine

  http://www.oxygenxml.com
- Escali Schematron engine

  http://schematron-quickfix.com/escali_xsm.html
  - Escali Schematron command-line tool
  - Oxygen plugin for invoking Escali Schematron

Projects Using SQF

Thieme - publishing company uses a custom framework to create and edit XML documents

parsX - a product developed by pagina GmbH used to facilitate EPUB production

ART-DECOR - an open-source tool suite that supports SDOs active in the healthcare industry
Sample SQF embedded in XSD

ATX custom framework – used by a major automotive manufacturer

Resources

- Schematron official site
- Schematron specification
- Schematron Quick Fix specification

- Sample files: github.com/octavianN/Schematron-step-by-step

THANK YOU!

Any questions?

<oXygen/> XML Editor
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