

NPRG036

XML Technologies



Lecture 7

Schematron, RELAX NG

16. 4. 2018

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Lecture Outline

- XML schema languages
 - Best practices
 - **RELAX NG**
 - **Schematron**
-

Best Practices

Best Practices

- How to define XML schemas for various use cases
 - *Are we going to use the schema locally or share it with others?*
 - *Will the schema evolve?*
 - *Are we going to preserve multiple versions of schemas?*
 - There are many recommendations
 - Fact: The W3C specification does not recommend anything
-

Basic Recommendations

- ❑ Use the XML features fully:
- ❑ Use your own elements and attributes



```
<?xml version="1.0"?>
<element name="order">
  <attribute name="number" value="ORD001" />
  <element name="employee">
    ...
  </element>
  ...
</element>
```

Basic Recommendations

- Use the XML features fully:
 - Maximize readability of XML documents using reasonable element and attribute names
 - Even though the names are longer
 - We can use (XML-specific) compression

```
<?xml version="1.0"?>
<o n="ORD001">
  <e><nm>Martin Necasky</nm></e>
  <i1>
    <i><m>5</m><c>5</c></i>
  </i1>
  ...
</o>
```



Basic Recommendations

- Use the XML features fully:
 - Do not use dot notation instead of XML tree hierarchy



```
<?xml version="1.0"?>
<order number="ORD001">
  <customer.name.first>Martin</customer.name.first>
  <customer.name.surname>Necasky</customer.name.surname>
  <customer.address.street>Malostranské nám.</customer.address.street>
  <customer.address.number>25</customer.address.number>
  ...
</order>
```

Basic Recommendations

- Use the XML features fully:
 - Do not use references instead of tree hierarchy
 - They usually have less efficient processing
 - (Of course, in some cases it might make sense)
 - XML data model != relational data model



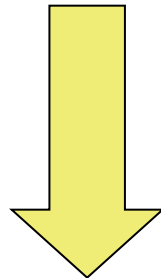
```
<?xml version="1.0"?>
<selling>
  <order number="ORD001"><employee ref="Z002"/>...</order>
  <order number="ORD002"><employee ref="Z001"/>...</order>
  <employee id="Z001">...</employee>
  <employee id="Z001">...</employee>
</selling>
```


Elements vs. Attributes

- ❑ When to use elements and when attributes?
 - ❑ There is no general rule, but:
 - An attribute can be specified only once for each element
 - An attribute can not have a complex structure
 - ❑ If we assume new versions of schema, where complex structure or repetition is expected, element is a better choice
 - If we use attributes, we must:
 - ❑ Transform all existing documents
 - ❑ Change all XPath paths
 - ❑ ...
 - Repetition can be solved using a multivalue attribute, but its further parsing is more difficult
-

Elements vs. Attributes

```
<?xml version="1.0"?>
<order number="ORD001">
  <employee name="Martin Necasky" email="martinnec@gmail.com" />
</order>
```



```
<?xml version="1.0"?>
<order number="ORD001">
  <employee>
    <name><first>Martin</first><surname>Necasky</surname></name>
    <email>martinnec@gmail.com</email>
    <email>necasky@ksi.mff.cuni.cz</email>
  </employee>
</order>
```

Elements vs. Attributes

- If we want to prefer value A to value B, we use for A element and for B attribute
 - B says something about A, it contains metadata

```
<?xml version="1.0"?>
<menu>
  <item>
    <portion unit="it">6</portion>
    <name lang="jp">Maguro Maki</name>
    <name lang="cz">Maki Tuňák</name>
  </item>
  <item>
    <portion unit="g">200</portion>
    <name lang="jp">Sake Nigiri</name>
    <name lang="cz">Nigiri Losos</name>
  </item>
</menu>
```



Elements vs. Attributes

- The decision may also depend on the API we use for data access
 - SAX: all attribute values are provided in a single event **startElement**
 - May be useful, when we do not want to wait for reading of subelements
 - The resulting code will be simpler and more lucid
-

Elements vs. Attributes

- Anything that can be an attribute, can be also an element
 - In general: Use attributes so that the work with the data is suitable for the particular application
-

Namespaces

- Use them!
 - When you do not use them, you limit others in usage of your schemas
 - A namespace is identified with a URI
 - It is good when you can put there something related
 - Documentation of the schema, examples, references to related schemas, ...
 - The schema itself also, but it is not compulsory
 - Note: URI does not mean that it is an address of the schema! It is an identifier!
-

Namespaces

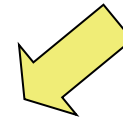
- Usually in a single system you will design multiple related schemas and re-use existing
 - In this context there are three key approaches for work with namespaces
 - Heterogeneous
 - Homogeneous
 - Chameleon
 - Example:
 - order.xsd uses
 - customer.xsd
 - product.xsd
-

Heterogeneous Design of XSDs

- Each schema has its own target namespace (attribute `targetNamespace` of element `schema`)

```
<xsd:schema
  targetNamespace=
    "http://www.customer.org">
  ...
</xsd:schema>
```

```
<xsd:schema
  targetNamespace=
    "http://www.product.org">
  ...
</xsd:schema>
```



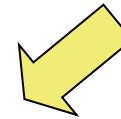
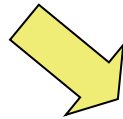
```
<xsd:schema
  targetNamespace="http://www.order.org">
  <xsd:import namespace="http://www.customer.org"
    schemaLocation="customer.xsd"/>
  <xsd:import namespace="http://www.product.org"
    schemaLocation="product.xsd"/>
  ...
</xsd:schema>
```


Homogeneous Design of XSDs

- One namespace for all schemas

```
<xsd:schema
  targetNamespace=
    "http://www.order.org">
  ...
</xsd:schema>
```

```
<xsd:schema
  targetNamespace=
    "http://www.order.org">
  ...
</xsd:schema>
```




```
<xsd:schema
  targetNamespace="http://www.order.org">
  <xsd:include schemaLocation="customer.xsd"/>
  <xsd:include schemaLocation="product.xsd"/>
  ...
</xsd:schema>
```

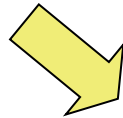

Chameleon Design of XSDs

- ❑ Chameleons do not have target namespace
 - No attribute `targetNamespace`
- ❑ Chameleons become a part of namespace into which they are included

```
<xsd:schema>  
  ...  
</xsd:schema>
```



```
<xsd:schema>  
  ...  
</xsd:schema>
```



```
<xsd:schema  
  targetNamespace="http://www.order.org">  
  <xsd:include schemaLocation="customer.xsd"/>  
  <xsd:include schemaLocation="product.xsd"/>  
  ...  
</xsd:schema>
```


Namespaces – Recommendations

- Homogeneous approach:
 - For XML schemas which are conceptually linked
 - i.e. describe the same problem domain and have a common administrator
 - There are no conflicts among element / attribute names
 - Collision: Two globally defined elements / attributes with the same name but different type
 - There are no conflicts among types
 - Collision: Two globally defined data types with the same name but different content model
-

Namespaces – Recommendations

- Heterogeneous approach:
 - If the XML schemas describe **domains of different problems**
 - If the XML schemas have **distinct administrators**
 - If there **may occur a collision** of elements / attributes / types
-

Namespaces – Recommendations

-  :
 - If the XML schema defines **general types** which do not have a special semantics or which can be **used regardless the problem domain**
 - e.g. data types for an address, name, e-mail, ...
 - e.g. general data types like array / list of items, string of a particular length, ...
-

XML Schema Versioning

- Your XML schemas will evolve over time
 - Users have new requirements
 - The world is changing
 - ...
 - If we use XML data format, we usually have to manage multiple versions of each schema
 - The users must be provided with the version they are interested in and want to use
 - And, of course, the XML documents valid against the selected version
-

XML Schema Versioning

- 1st option: XML Schema attribute `version` of element `schema`
 - Problem: XML documents do not know this information
 - This version cannot be directly checked

```
<xsd:schema version="BFLM.PSFVZ">
  <element name="order"
           type="Order"/>
  ...
</xsd:schema>
```

```
<?xml version="1.0"?>
<order ... >
</order>
```

This is NOT the version

XML Schema Versioning

- 2nd option: own versioning attribute declared for the root element
 - XML documents must have correct version of XML schema in the root element
 - If not, validation reveals it
 - Problem: XML documents must change also in case when it is not necessary (the version must change)

```
<xsd:schema>
  <xsd:element name="order"
              type="Order"/>
  <xsd:complexType name="Order">
    ...
    <xsd:attribute name="version"
                  type="string"
                  fixed="AEIO.U"/>
  </xsd:complexType>
  ...
</xsd:schema>
```

```
<?xml version="1.0"?>
<order version="AEIO.U" >
</order>
```


XML Schema Versioning

- **3rd option:** including the number of version into the value of attribute `targetNamespace`
 - XML documents can use the namespace (with particular version) suitable for particular situation

```
<xsd:schema
  targetNamespace=
    ".../orders/1.0">
  ...
</xsd:schema>
```

```
<?xml version="1.0"?>
<order
  xsi:schemaLocation=".../orders/1.0
    Orders.xsd">

</order>
```

XML Schema Versioning

- Use versions for your XML schemas
 - Force the XML documents to contain version number of the schema
 - Somehow
 - Provide the users with all versions of XML schemas
 - Specify versioning notation so that the users know which changes influence validity of XML documents
 - E.g. $X.Y$, where:
 - New Y means that XML documents valid against $X.Y-1$ ARE valid against $X.Y$
 - New X means that XML documents valid against $X-1.Y$ DO NOT HAVE TO BE valid against $X.0$
-

XML Schema Versioning

□ Another problem:

- The provider of XML data has several versions of XML schemas ($1, \dots, n$)
- The consumer wants XML data valid against version i
- The provider does not want to store the XML data in all possible versions
 - Inefficient (space requirements, management, ...)

□ Solution:

- Internal representation such that:
 - The data are stored only once
 - We can export the data into the version required by user
 - Using XSLT | XQuery | SQL/XML
-

XML Schema Versioning

Customer 1:

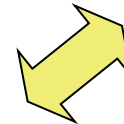
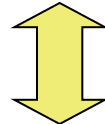
- number
- name
- email

Customer 2:

- code
- name
 - first
 - surname
- email+ | phone
- discount

Customer 3:

- code
- name
 - first
 - surname
- email*
- phone



Customer:

- number
 - first
 - surname
 - email*
 - phone?
 - discount?
-

Extensible Content Types

- A basic strategy is derivation of new data types from existing ones using `extension`
 - But, what if:
 - Authors want more freedom in extension of data types?
 - But they cannot modify the schema
 - We have insufficient information for definition of the type?
 - The variability of the content is so extensive that we cannot cover it in the schema?
 - The structure of data changes so fast that we cannot change it on time?
 - e.g. the domain of mobile phones
-

Extensible Content Types

□ If extension is insufficient, use any!

```
<complexType name="Publication">
  <sequence>
    <element name="name"/>
    <element name="price"/>
    <any namespace="##any" minOccurs="0"
      maxOccurs="unbounded"/>
    <element name="publisher"/>
  </sequence>
</complexType>
```

```
<?xml version="1.0"?>
<publication
  xmlns="http://www.publication.org"
  xmlns:rc="http://www.review.org">
  <name>
    King's speech
  </name>
  <price>LOW</price>
  <rc:review>
    ...
  </rc:review>
  <publisher>The best one</publisher>
</publication>
```

But...

Extensible Content Types

- Type `Publication` is nondeterministic!
 - When the parser validates `publisher`, it does not know where it is defined

```
<complexType name="Publication">
  <sequence>
    <element name="name"/>
    <element name="price"/>
    <any namespace="##any" minOccurs="0"
      maxOccurs="unbounded"/>
    <element name="publisher"/>
  </sequence>
</complexType>
```

```
<?xml version="1.0"?>
<publication
  xmlns="http://www.publication.org"
  xmlns="http://www.review.org">
  <name>
    King's speech
  </name>
  <price>LOW</price>
  <rc:review>
    ...
  </rc:review>
  <publisher>The best one</publisher>
</publication>
```

Extensible Content Types

□ Better:

```
<complexType name="Publication">
  <sequence>
    <element name="name"/>
    <element name="price"/>
    <element name="other">
      <complexType>
        <sequence><any .../></sequence>
      </complexType>
    </element>
    <element name="publisher"/>
  </sequence>
</complexType>
```

```
<?xml version="1.0"?>
<publication
  xmlns="http://www.publication.org"
  xmlns="http://www.review.org">
  <name>
    King's speech
  </name>
  <price>LOW</price>
  <other>
    <rc:review>
      ...
    </rc:review>
  </other>
  <publisher>The best one</publisher>
</publication>
```


Conclusion

- The provided set of cases was not complete, but a set of motivating examples
 - There are numerous other best practices, recommendations etc.
 - More or less reasonable
 - General advice: If you design a set of XML schemas, first think about the particular application and consequences
-

RELAX NG

RELAX NG

- Results from two older languages:
 - TREX (Tree Regular Expressions for XML)
 - James Clark
 - <http://www.thaiopensource.com/trex/>
 - RELAX (Regular Language Description for XML)
 - Murata Makoto
 - <http://www.xml.gr.jp/relax/>
 - ISO standard: ISO/IEC 19757-2:2002
 - Based on the idea of patterns
 - RELAX NG schema = a pattern of XML document
 - Note: XML Schema is considered to be based on types
-

General features

- ❑ Simple and easy-to-learn
 - ❑ Has two types of syntaxes: XML a compact (non-XML)
 - Mutually convertible
 - XML Schema does not have a compact version
 - ❑ Supports namespaces
 - DTD does not
 - ❑ Has unlimited support for unordered sequences
 - XML Schema does not
 - ❑ Has unlimited support for mixed content
 - DTD does not
 - ❑ It enables to use a wide set of simple data types
 - e.g. from XML Schema
-

XML vs. Compact Syntax

```
<element xmlns="http://relaxng.org/ns/structure/1.0"
          name="employee">
  <attribute name="id">
    <text/>
  </attribute>
  <element name="name">
    <text/>
  </element>
  <element name="surname">
    <text/>
  </element>
  <element name="salary">
    <text/>
  </element>
</element>
```

```
element employee {
  attribute id { text },
  element name { text },
  element surname { text },
  element salary { text } }
```

```
<employee id="101">
  <name>Irena</name>
  <surname>Holubova</surname>
  <salary>1000000</salary>
</employee>
```

Basic Patterns

- Arbitrary text:

```
<text/>
```

```
text
```

- Attribute:

```
<attribute name="note">  
  <text/>  
</attribute>  
  
<attribute name="note"/>
```

```
attribute note { text }
```

- Element with text content:

```
<element name="name">  
  <text/>  
</element>
```

```
element name { text }
```

Basic Patterns

□ Empty element:

```
<element name="hr">  
  <empty/>  
</element>
```

```
element hr { empty }
```

□ Element with an attribute (and text content):

```
<element name="person">  
  <attribute name="id"/>  
  <text/>  
</element>
```

```
<element name="person">  
  <text/>  
  <attribute name="id"/>  
</element>
```

```
element person {  
  attribute id { text },  
  text }  
element person {  
  text,  
  attribute id { text } }
```

The order is not important

Basic Patterns

- Element with subelements (and an attribute):

```
<element name="person">  
  <element name="name">  
    <text/>  
  </element>  
  <element name="surname">  
    <text/>  
  </element>  
  <element name="salary">  
    <text/>  
  </element>  
  <attribute name="id"/>  
</element>
```

```
element person {  
  element name { text },  
  element surname { text },  
  element salary { text },  
  attribute id { text } }
```


Basic Patterns

□ Optional pattern:

```
<element name="person">
  <element name="name">
    <text/>
  </element>
  <optional>
    <element name="fax">
      <text/>
    </element>
  </optional>
  <optional>
    <attribute name="note"/>
  </optional>
</element>
```

```
element person {
  element name { text },
  element fax { text }?,
  attribute note { text }? }
```

Basic Patterns

```
<element name="person">
  <element name="name">
    <text/>
  </element>
  <element name="surname">
    <text/>
  </element>
  <optional>
    <element name="fax">
      <text/>
    </element>
    <attribute name="note"/>
  </optional>
</element>
```

```
element person {
  element name { text },
  element surname { text },
  ( element fax { text },
    attribute note { text } )? }
```



Neither in DTD nor in XML
Schema 1.0 can be
expressed

- version 1.1: assert
-

Basic Patterns

□ Repeating patterns:

```
<element name="person">
  <element name="name">
    <text/>
  </element>
  <oneOrMore>
    <element name="phone">
      <text/>
    </element>
  </oneOrMore>
  <attribute name="id"/>
</element>
```

```
element person {
  element name { text },
  element phone { text }+,
  attribute id { text } }
```

zeroOrMore \Leftrightarrow *

Precise number of
occurrences as in DTD

■ Non-trivial

Advanced Patterns

□ Ordered sequences:

```
<element name="person">
  <element name="name">
    <text/>
  </element>
  <element name="surname">
    <text/>
  </element>
  <element name="email">
    <text/>
  </element>
</element>
```

```
<element name="person">
  <group>
    <element name="name">
      <text/>
    </element>
    <element name="surname">
      <text/>
    </element>
    <element name="email">
      <text/>
    </element>
  </group>
</element>
```

Advanced Patterns

□ Choice:

```
<element name="person">
  <element name="name">
    <text/>
  </element>
  <choice>
    <element name="email">
      <text/>
    </element>
    <element name="phone">
      <text/>
    </element>
  </choice>
</element>
```

```
element person {
  element name { text },
  ( element email { text } |
    element phone { text } ) }
```

Advanced Patterns

□ Unordered sequences:

```
<element name="person">
  <element name="name">
    <text/>
  </element>
  <interleave>
    <element name="email">
      <text/>
    </element>
    <element name="phone">
      <text/>
    </element>
  </interleave>
</element>
```

```
element person {
  element name { text },
  ( element email { text } &
    element phone { text } ) }
```

Contrary to XML
Schema no
restrictions

Advanced Patterns

□ Mixed content:

```
<element name="para">
  <interleave>
    <zeroOrMore>
      <element name="bold">
        <text/>
      </element>
    </zeroOrMore>
    <zeroOrMore>
      <element name="italic">
        <text/>
      </element>
    </zeroOrMore>
    <text/>
  </interleave>
</element>
```

```
element para {
  element pojem { bold }* &
  element odkaz { italic }* &
  text }
```

<text/> corresponds to
arbitrary number of text
nodes

- Does not need + or *



Advanced Patterns

```
<element name="para">  
  <mixed>  
    <zeroOrMore>  
      <element name="bold">  
        <text/>  
      </element>  
    </zeroOrMore>  
    <zeroOrMore>  
      <element name="italic">  
        <text/>  
      </element>  
    </zeroOrMore>  
  </mixed>  
</element>
```



```
<element name="para">  
  <mixed>  
    <group>  
      <zeroOrMore>  
        <element name="bold">  
          <text/>  
        </element>  
      </zeroOrMore>  
      <zeroOrMore>  
        <element name="italic">  
          <text/>  
        </element>  
      </zeroOrMore>  
    </group>  
  </mixed>  
</element>
```

```
element para {  
  mixed {  
    element bold { text }* &  
    element italic { text }* } }
```

group \Rightarrow interleave:

Data Types

- ❑ Built-in: string and token
- ❑ Typically we use XML Schema data types

```
<element name="price">  
  <data type="decimal"  
    datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes"/>  
</element>
```

```
<element name="coordinates"  
  datatypeLibrary="...">  
  <element name="x">  
    <data type="double"/>  
  </element>  
  <element name="y">  
    <data type="double"/>  
  </element>  
</element>
```

```
datatypes xs = "..."  
element price { xs:decimal }
```

```
element price { xsd:decimal }
```

xsd = default for XML Schema

Data Types

□ Parameters of data types:

```
<element name="salary">  
  <data type="decimal">  
    <param name="minInclusive">100000</param>  
    <param name="maxExclusive">1000000</param>  
  </data>  
</element>
```

```
element salary {  
  xsd:decimal {  
    minInclusive = "100000"  
    maxExclusive = "1000000" } },
```

□ Enumerations:

```
<attribute name="ports">  
  <choice>  
    <value>1001</value>  
    <value>1002</value>  
    <value>1003</value>  
  </choice>  
</attribute>
```

```
attribute ports {  
  "1001" | "1002" | "1003" }
```

Data Types

□ Negative enumeration:

```
<element name="color">  
  <data type="string">  
    <except>  
      <choice>  
        <value>black</value>  
        <value>white</value>  
      </choice>  
    </except>  
  </data>  
</element>
```

```
element color {  
  string - ( "black" | "white" ) }
```

Data Types

- Multivalue type:

```
<element name="vehicle">  
  <list>  
    <oneOrMore>  
      <data type="token"/>  
    </oneOrMore>  
  </list>  
</element>
```

```
element vehicle {  
  list { token+ }
```

```
<element name="vehicle">  
  <list>  
    <oneOrMore>  
      <choice>  
        <value>rickshaw</value>  
        <value>camel</value>  
        <value>elephant</value>  
      </choice>  
    </oneOrMore>  
  </list>  
</element>
```

```
element vehicle {  
  list { ("rickshaw" | "camel" | "elephant" )+ } }
```

```
<vehicle>rickshaw camel</vehicle>
```

Data Types

```
<attribute name="dimensions">
  <list>
    <data type="decimal"/>
    <data type="decimal"/>
    <data type="decimal"/>
    <choice>
      <value>cm</value>
      <value>mm</value>
    </choice>
  </list>
</attribute>
```

```
attribute dimensions {
  list { xsd:decimal,
         xsd:decimal,
         xsd:decimal,
         ("cm" | "mm" ) } }
```

```
dimensions="40 38.5 90 cm"
```

Conclusion

- Other schema components:
 - Naming of schema parts + repeatable usage
 - Usage of namespaces
 - Documentation and comments
 - Other sources of information:
 - RELAX NG Tutorial:
<http://www.relaxng.org/tutorial-20011203.html>
 - RELAX NG Compact Syntax Tutorial:
<http://www.relaxng.org/compact-tutorial-20030326.html>
 - <http://www.relaxng.org/>
-



Schematron



Schematron

- ISO standard: ISO/IEC 19757-3:2006
 - Based on the idea of patterns
 - Similar meaning as in XSLT
 - Does not define a grammar
 - DTD, XML Schema, RELAX NG are grammar-based
 - Defines a set of rules which must be followed by a valid XML document
 - Expressed using XPath
 - For validation we can use an XSLT processor
-

Structure of Schema

Root element `<schema xmlns="http://purl.oclc.org/dsdl/schematron">` contains:

- `<title>` – name of schema (optional)
 - `<ns prefix="..." uri="..." />` – declarations of namespace prefixes (arbitrary amount)
 - `<pattern>` – (at least one) pattern containing:
 - `<rule context="...">` – (at least one) rule applied in the context and containing subelements:
 - `<assert test="...">` – if XPath expression in attribute test does not return **true**, the result of validation is the content of assert
 - `<report test="...">` – if XPath expression in attribute test does return **true**, the result of validation is the content of report
-

Example

```
<?xml version="1.0" encoding="utf-8"?>
<schema xmlns="http://www.ascc.net/xml/schematron">
  <pattern name="The list of employees is not empty">
    <rule context="employees">
      <assert test="employee">There must be at least one employee in
        the list</assert>
      <report test="sum(employee/salary) > 500000">The sum of salaries
        can not be greater than 500.000</report>
    </rule>
  </pattern>
  <pattern name="Rules for an employee">
    <rule context="employee">
      <assert test="name">An employee must have a name.</assert>
      <assert test="surname"> An employee must have a surname.</assert>
      <assert test="email"> An employee must have an e-mail.</assert>
      <assert test="@id"> An employee must have an id.</assert>
    </rule>
  </pattern>
  ...
</schema>
```

Example

```
...
  <report test="name[2]|surname[2]">An employee can not have multiple
names.</report>
  </rule>
</pattern>
<pattern name="Duplicity of IDs">
  <rule context="employee">
    <report test="count(..employee[@id = current()/@id]) > 1">
      Duplicity in ID <value-of select="@id"/> of element
      <name/>.</report>
    </rule>
  </pattern>
</schema>
```

- <name> – name of current element
 - <value-of select="..."> – result of XPath expression in select
-

Validation

- Option A: Special SW / library for Schematron
 - Option B: Arbitrary XSLT processor
 - There exists an XSLT script which transforms Schematron schemas to XSLT scripts
 - The resulting XSLT script is applied on XML documents
 - The result is content of assert a report elements
-

Combination with XML Schema

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
            xmlns:sch="http://www.ascc.net/xml/schematron">
  <xs:element name="employees">
    <xs:annotation>
      <xs:appinfo>
        <sch:pattern name="Do we have enough for salaries?">
          <sch:rule context="employees">
            <sch:report test="sum(employee/salary) > 50000">The sum of
salaries can not be greater than 50.000.</sch:report>
          </sch:rule>
        </sch:pattern>
      </xs:appinfo>
    </xs:annotation>
    <xs:complexType>
      <!-- ... definition of element content in XSD ... -->
    </xs:complexType>
  </xs:element>
</xs:schema>
```

Combination with XML Schema

- Validation:
 - Option A: Special SW / library for Schematron
 - Option B: Using XSLT we extract a Schematron schema and validate it
-

Combination with RELAX NG

```
<?xml version="1.0" encoding="utf-8"?>
<element xmlns="http://relaxng.org/ns/structure/1.0"
  datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes"
  xmlns:sch="http://www.ascc.net/xml/schematron"
  name="employees">
  <sch:pattern name="Do we have enough for salaries?">
    <sch:rule context="employees">
      <sch:report test="sum(employee/salary) > 50000">The sum of
salaries can not be greater than 50.000.</sch:report>
    </sch:rule>
  </sch:pattern>
  <oneOrMore>
    <!-- ... definition of element content in XSD ... -->
  </oneOrMore>
</element>
```

Combination with RELAX NG

- There exists also a compact non-XML version:

```
namespace sch = "http://www.ascc.net/xml/schematron"  
[ sch:pattern [ name = " Do we have enough for salaries? "  
  sch:rule [ context = "employees"  
    sch:report [ test = "sum(employee/salary) > 50000"  
      "The sum of salaries can not be greater than 50.000." ] ] ] ]
```

- Validation:
 - Option A: Special SW / library for Schematron
 - Option B: Using XSLT we extract a Schematron schema and validate it
-

Conclusion

- A different approach to schema validation
 - Does not define a grammar
 - Usage of XPath + combination with other languages
 - The language itself has limitations – the grammar definition is still more user friendly
- Inspiration for XML Schema **assert** element
- Other information:

<http://www.schematron.com/>
