

Generating New Knowledge by Deductive Reasoning using Schematron

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3 Ways to Gain Knowledge

Here are 3 methods of reasoning or drawing conclusions:

1. **Analogy:** the essence of reasoning by analogy is to find a similar situation or circumstance and to argue that what is true for the similar case applies to the one in question.
2. **Induction:** the essence of reasoning by induction is to observe repeated instances of the same phenomenon and conclude that the phenomenon will always occur.
3. **Deduction:** the essence of reasoning by deduction is to combine accepted facts (axioms) in any way that compels acceptance of the conclusion.

Although all 3 methods of reasoning are important and useful, the deductive method is the only one that yields unquestionable, inescapable conclusions. Deductive reasoning is the gold standard of reasoning methods.

Schematron

Schematron can be used to perform deductive reasoning. Axioms are expressed using Schematron assertions. Each assertion reports when an axiom is fulfilled.

I show how to do deductive reasoning using Schematron in the following example of the Robber and the Speeder.

The Robber and the Speeder

A robbery takes place. The robber drops his gun while fleeing. This report is filed by the investigating police officers:

```
<RobberyEvent>  
  <datetime>2010-11-16T0500-00-00</datetime>  
  <description>Robbery occurred, gun was dropped while fleeing</description>  
  <evidence>  
    <Gun>  
      <serial>ABCD</serial>
```

```
</Gun>
</evidence>
<robber>
  <Person /> <!-- unknown person -->
</robber>
</RobberyEvent>
```

Later, a car is pulled over for speeding. The traffic officer files this report electronically while issuing a ticket:

```
<SpeedingOffense>
  <datetime>2010-11-16T0515-00-00</datetime>
  <description>Vehicle was doing 40 in a 25 mph zone</description>
  <speeder>
    <Person>
      <name>Fred Blogs</name>
      <driversLicenseNumber>ZXYZXY</driversLicenseNumber>
    </Person>
  </speeder>
</SpeedingOffense>
```

At police headquarters, a computer analyzes each report as it is filed. The computer uses the driver's license information to look up any associated records. It looks for any connection to the recent robbery. It searches through its gun licenses and discovers this one containing a matching driver's license:

```
<GunLicense>
  <registeredGun>
    <Gun>
      <serial>ABCD</serial>
    </Gun>
  </registeredGun>
  <holder>
    <Person>
      <driversLicenseNumber>ZXYZXY</driversLicenseNumber>
    </Person>
  </holder>
</GunLicense>
```

Can we conclude that the speeder is the robber?

Axioms

The following axioms will be used to deductively generate new knowledge. In this case, the axioms are used to determine whether the speeder is the robber.

1. Only one gun can have a particular serial number.
2. Only one person has a particular driver's license number.
3. A gun can be registered in only one gun license.
4. A gun license is registered to only one person.

Implementing Deductive Reasoning using Schematron

The speeding report is input into the Schematron deductive reasoning engine:

```
<SpeedingOffense>
  <datetime>2010-11-16T05:15:00-00:00</datetime>
  <description>Vehicle was doing 40 in a 25 mph zone</description>
  <speeder>
    <Person>
      <name>Fred Blogs</name>
      <driversLicenseNumber>ZXYZXY</driversLicenseNumber>
    </Person>
  </speeder>
</SpeedingOffense>
```

The Schematron document sets <driversLicenseNumber> as the context:

```
<sch:rule context="driversLicenseNumber">
  <!-- Generate reports using the axioms -->
</sch:rule>
```

A variable records the speeder's driver's license number:

```
<sch:let name="speeder-driversLicenseNumber" value="."/>
```

A second variable records the gun license that contains a driver's license number that matches the speeder's driver's license number. The gun licenses are stored in a folder called "GunLicenseFolder." Iterate over each gun license document in the folder:

```
<sch:let name="GunLicense"
  value="for $i in collection('GunLicenseFolder?select=*.xml;recurse=yes;on-error=ignore')
  return $i/GunLicense[//Person/driversLicenseNumber eq $speeder-driversLicenseNumber]"/>
```

Report if the speeder's driver's license number matches the driver's license number in the gun license:

```
<sch:report test="$speeder-driversLicenseNumber eq
    $GunLicense//Person/driversLicenseNumber">
```

The speeder's drivers license number matches the drivers license number in this gun license.

Axiom 2: Only one person has a particular driver's license number.

```
</sch:report>
```

Report if the serial number in the gun license matches the serial number on the gun found in the robbery:

```
<sch:report test="$GunLicense/registeredGun/Gun/serial eq
    doc('Robbery.xml')/RobberyEvent/evidence/Gun/serial">
```

The serial number in this gun license matches the serial number on the gun found in the robbery.

Axiom 1: Only one gun can have a particular serial number.

```
</sch:report>
```

Report that there is only one gun license that contains a driver's license number that matches the speeder's driver's license number:

```
<sch:report test="count($GunLicense) eq 1">
```

There is only one gun license that matches the speeder's drivers license.

Axiom 3: A gun can be registered in only one gun license.

```
</sch:report>
```

Report that the gun license is registered to only one person:

```
<sch:report test="count($GunLicense//Person) eq 1">
```

The gun license is registered to only one person.

Axiom 4: A gun license is registered to only one person.

```
</sch:report>
```

Create new knowledge. Report if all 4 axioms are met:

```
<sch:report test="($speeder-driversLicenseNumber eq
    $GunLicense//Person/driversLicenseNumber) and
    ($GunLicense/registeredGun/Gun/serial eq
    doc('Robbery.xml')/RobberyEvent/evidence/Gun/serial) and
    (count($GunLicense) eq 1) and
    (count($GunLicense//Person) eq 1)">
```

Therefore, `<sch:value-of select="parent::Person/child::name"/>` is the Robber.
`</sch:report>`

Here is the output that the officer at police headquarters sees:

The speeder's drivers license number matches the drivers license number in this gun license. Axiom 2: Only one person has a particular driver's license number.

The serial number in this gun license matches the serial number on the gun found in the robbery. Axiom 1: Only one gun can have a particular serial number.

There is only one gun license that matches the speeder's driver's license.
Axiom 3: A gun can be registered in only one gun license.

The gun license is registered to only one person.
Axiom 4: A gun license is registered to only one person.

Therefore, Fred Blogs is the Robber.

The officer that stopped the speeder arrests him for suspicion of robbery.

Complete Implementation

Want to run the Robber and Speeder example? Here is a [zip file containing the Robber and Speeder example](#).