Introduction to CGMES rules with SHACL

Scope:

The authors have modeled/implemented all CGMES rules.
In this introduction, the authors have addressed only level 3 for pedagogical reasons.
For any question contact us: **cimcgmes@gmail.com**
Any kind of feedback is welcome.

Introduction:

SHACL is a W3C standard for the validation of RDF models against conditions or restrictions. The specification of this standard is in the following link of the w3c https://www.w3.org/TR/shacl/.

Set up the application:

Download cgmesvalidation.zip.

Unzip the downloaded file, for example, in the C:\cgmesvalidation folder

Type the command as follows:

C:\cgmesvalidation> java -jar cgmesrules.jar

It should appear the following output.

```
----------------------
Select an option:
1: Validate CGMES rules:
2: Exit
----------------------
Op:
```

Developing a CGMES rule example:

Download test cases from this link:
https://www.entsoe.eu/Documents/CIM_documents/Grid_Model_CIM/TestConfigurations_packageCASv2.0.zip

Unzip TestConfigurations_packageCASv2.0.zip

Inside the SmallGrid folder, open the BusBranch folder and unzip CGMES_v2.4.15_SmallGridTestConfiguration_BaseCase_Complete_v3.0.0.zip, where the SmallGridTestConfiguration_BC_EQ_v3.0.0.xml file can be retrieved.

rule.ttl is the file where is modeled CATieFlow rule, specified from "QUALITY OF CGMES DATASETS AND CALCULATIONS FOR SYSTEM OPERATIONS **3.2** EDITION":

Rule: CATieFlow

Level: 3

Severity: ERROR Template: RuleObject

Details: For every instance of cim:ControlArea for which the value of cim:ControlArea.type is

cim:ControlAreaTypeKind.Interchange, cim:TieFlow instances must be provided. Justification: This is necessary to compute interchange.

Message: cim:TieFlows must be defined for cim:ControlArea, no cim:TieFlows found

SHACL definition of the rule is depicted in the file **rule.ttl** and is as follows:

```
@base <http://iec.ch/TC57/2013/CIM-schema-cim16#> .
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix cim: <http://iec.ch/TC57/2013/CIM-schema-cim16#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix qodc: <http://entsoe.eu/CGMES2_4_15/QoCDC/3/0#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix entsoe: <http://entsoe.eu/CIM/SchemaExtension/3/1#> .
@prefix ccs: <http://entsoe.eu/CIM/iso31661Code/schema#> .
@prefix cc: <http://entsoe.eu/CIM/iso31661Code/codes#> .
@prefix cims: <http://iec.ch/TC57/1999/rdf-schema-extensions-19990926#> .
@prefix md: <http://iec.ch/TC57/61970-552/ModelDescription/1#> .


#   Rule:
#       CATieFlow
#   Level:
#       3
#   Severity:
#       ERROR Template: RuleObject
#   Details:
#       For every instance of cim:ControlArea for which the value of  cim:ControlArea.type is
#       cim:ControlAreaTypeKind.Interchange,  cim:TieFlow instances must be provided.   Justification:   Th
is is necessary to
```

```
25: #       compute interchange.
26: #   Message:
27: #       cim:TieFlows must be defined for cim:ControlArea, no cim:TieFlows found
28:
29:
30: qodc:CATieFlow a sh:PropertyShape;
31:     sh:message "cim:TieFlows must be defined for cim:ControlArea, no cim:TieFlows found";
32:     sh:severity qodc:ERROR;
33:     sh:targetClass cim:ControlArea;
34:         sh:or (
35:         [
36:             sh:not [
37:                 sh:path  cim:ControlArea.type;
38:                 sh:in (cim:ControlAreaTypeKind.Interchange);
39:             ]
40:         ]
41:         [
42:             sh:path [ sh:inversePath cim:TieFlow.ControlArea ];
43:             sh:minCount 1;
44:         ]
45:     )
46: .
```

From line 1 to line 13, needed prefixes are declared.
From line 16 to line 27, the CGMES rule is described.
Line 30 *qodc:CATieFlow a sh:PropertyShape;* declares a shape named *qodc:CATieFlow* which is of type *sh:PropertyShape*.
Line 31 *sh:message "cim:TieFlows must be defined for cim:ControlArea, no cim:TieFlows found";*

Declares the message that will be shown when the rule is violated.
Line 32 *sh:severity qodc:ERROR;* severity is declared.
Line 33 *sh:targetClass cim:ControlArea*; specify the target class for the shape. It represents the objects that act as focus nodes for the SHACL processor.

The text rule is as follows:

```
23: #       For every instance of cim:ControlArea for which the value of  cim:ControlArea.type is
24: #       cim:ControlAreaTypeKind.Interchange,  cim:TieFlow instances must be provided.   Justification:   Th
is is necessary to
25: #       compute interchange.
```

A Boolean expression that corresponds to the rule described above, can be defined as follows:

∀ca ∈ cim:ControlArea ((ca cim:controlArea.type cim:controlAreaTypeKind.Interchange) => (∃ tf ∈ cim:TieFlow | tf cim:TieFlow.ControlArea ca))

It is an implication statement [p => q].

SHACL grammar does not support the implication construct, however (p => q) <=> (¬p ∨ q)

Therefore, the Boolean expression is written as follows:

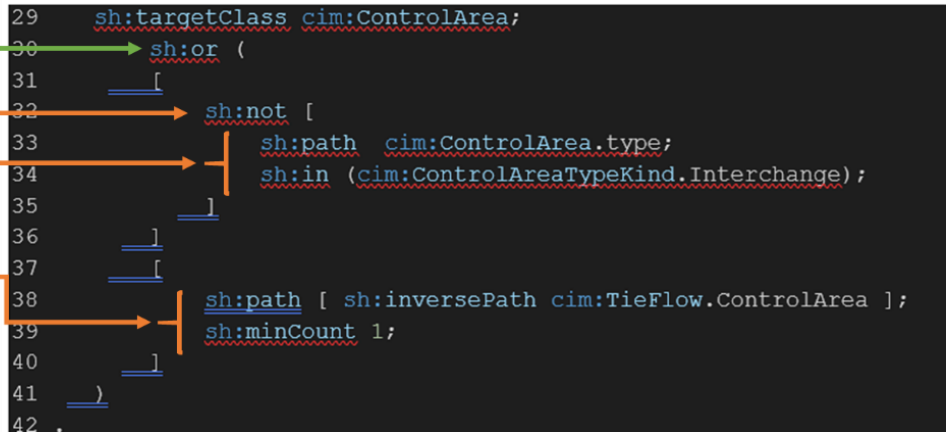
∀c ∈ cim:ControlArea (¬ (ca cim:controlArea.type cim:controlAreaTypeKind.Interchange) ∨ (∃ tf ∈ cim:TieFlow | tf cim:TieFlow.ControlArea ca))

Its corresponding definition in SHACL is as follows:

(p => q)

<=>

(¬p ∨ q)



```
29    sh:targetClass cim:ControlArea;
30      sh:or (
31        [
32          sh:not [
33            sh:path  cim:ControlArea.type;
34            sh:in (cim:ControlAreaTypeKind.Interchange);
35          ]
36        ]
37        [
38          sh:path [ sh:inversePath cim:TieFlow.ControlArea ];
39          sh:minCount 1;
40        ]
41    )
42  .
```

Type the following command to run the application.

java -jar cgmesrules.jar

Select an option:

1: Validate CGMES rules:

2: Exit

Op: 1

Validating CGMES rules:

Enter the path of data model:

SmallGridTestConfiguration_BC_EQ_v3.0.0.xml

Enter the path of SHACL rules:

rules.ttl

Validating \

Validation report:

```
@prefix entsoe: <http://entsoe.eu/CIM/SchemaExtension/3/1#> .
@prefix cc:     <http://entsoe.eu/CIM/iso31661Code/codes#> .
@prefix cims:   <http://iec.ch/TC57/1999/rdf-schema-extensions-19990926#> .
@prefix owl:    <http://www.w3.org/2002/07/owl#> .
@prefix cim:    <http://iec.ch/TC57/2013/CIM-schema-cim16#> .
@prefix xsd:    <http://www.w3.org/2001/XMLSchema#> .
@prefix qodc:   <http://entsoe.eu/CGMES2_4_15/QoCDC/3/0#> .
@prefix dm:     <http://iec.ch/TC57/61970-552/DifferenceModel/1#> .
@prefix rdfs:   <http://www.w3.org/2000/01/rdf-schema#> .
@prefix ccs:    <http://entsoe.eu/CIM/iso31661Code/schema#> .
@prefix rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix sh:     <http://www.w3.org/ns/shacl#> .
@prefix md:     <http://iec.ch/TC57/61970-552/ModelDescription/1#> .

[ a             sh:ValidationReport ;
  sh:conforms   false ;
  sh:result     [ a                             sh:ValidationResult ;
                  sh:focusNode                  <urn:uuid:1f9ecd81-e069-4040-bd64-f34b0fac3a60> ;
                  sh:resultMessage              "cim:TieFlows must be defined for cim:ControlArea, no cim:TieFlows found" ;
                  sh:resultSeverity             qodc:ERROR ;
                  sh:sourceConstraintComponent  sh:OrConstraintComponent ;
                  sh:sourceShape                qodc:CATieFlow ;
                  sh:value                      <urn:uuid:1f9ecd81-e069-4040-bd64-f34b0fac3a60>
                ]
```

```
25: ] .
```

Line 1 to line 13, prefixes are declared.

Line 15 *a sh:ValidationReport;* declares a blank node of type sh:ValidationReport which represents the validation report.

Line 16 *sh:conforms false;* indicates the conformity of the rules for the model.

Line 18 *sh:focusNode <urn:uuid:1f9ecd81-e069-4040-bd64-f34b0fac3a60> ;* indicates the node where the rule is violated.

Line 19 *sh:resultMessage "cim:TieFlows must be defined for cim:ControlArea, no cim:TieFlows found" ;* shows the feedback of the violation.

Line 22 *sh:sourceShape qodc:CATieFlow ;* indicates the rule id that was violated.

If the following RDF/XML code is added to the model file, the model will be compliant with the rule.

(Note: the code could be added at the end of the file before the last tag)

```
  <cim:TieFlow rdf:about="urn:uuid:b41a1687-9401-36ba-caa3-201f29dad134">
    <cim:TieFlow.positiveFlowIn>true</cim:TieFlow.positiveFlowIn>
    <cim:TieFlow.ControlArea rdf:resource="urn:uuid:1f9ecd81-e069-4040-bd64-f34b0fac3a60" />
    <cim:TieFlow.Terminal rdf:resource="urn:uuid:97f0304c-e6b1-0273-4b81-89274c11b4f8" />
  </cim:TieFlow>
```

```
  <cim:ControlArea rdf:ID="_1f9ecd81-e069-4040-bd64-f34b0fac3a60">
    <cim:IdentifiedObject.name>_CA_GB</cim:IdentifiedObject.name>
    <cim:ControlArea.type rdf:resource="http://iec.ch/TC57/2013/CIM-schema-
cim16#ControlAreaTypeKind.Interchange" />
  </cim:ControlArea>
```

And validate the model once again selecting the option 1 from the menu.

```
----------------------
Select an option:
1: Validate CGMES rules:
2: Exit
----------------------
Op: 1
----------------------
Validating CGMES rules:
----------------------
Enter the path of data model:
SmallGridTestConfiguration_BC_EQ_v3.0.0.xml
Enter the path of SHACL rules:
rule.ttl
 Validating /
----------------------
Validation report:
----------------------
@prefix entsoe: <http://entsoe.eu/CIM/SchemaExtension/3/1#> .
@prefix cc:     <http://entsoe.eu/CIM/iso31661Code/codes#> .
@prefix cims:   <http://iec.ch/TC57/1999/rdf-schema-extensions-19990926#> .
@prefix owl:    <http://www.w3.org/2002/07/owl#> .
@prefix cim:    <http://iec.ch/TC57/2013/CIM-schema-cim16#> .
@prefix xsd:    <http://www.w3.org/2001/XMLSchema#> .
@prefix qodc:   <http://entsoe.eu/CGMES2_4_15/QoCDC/3/0#> .
@prefix dm:     <http://iec.ch/TC57/61970-552/DifferenceModel/1#> .
@prefix rdfs:   <http://www.w3.org/2000/01/rdf-schema#> .
@prefix ccs:    <http://entsoe.eu/CIM/iso31661Code/schema#> .
@prefix rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
```

```
@prefix sh:     <http://www.w3.org/ns/shacl#> .
@prefix md:     <http://iec.ch/TC57/61970-552/ModelDescription/1#> .

[ a             sh:ValidationReport ;
  sh:conforms   true
] .
```

The above validation report shows that the model is compliant with the rule. [`sh:conforms  true`]

For more detailed explanation about this topic do not hesitate contact us: cimcgmes@gmail.com