Fleet Rule Engine Design

Michael Walfall
Version 0.5.0

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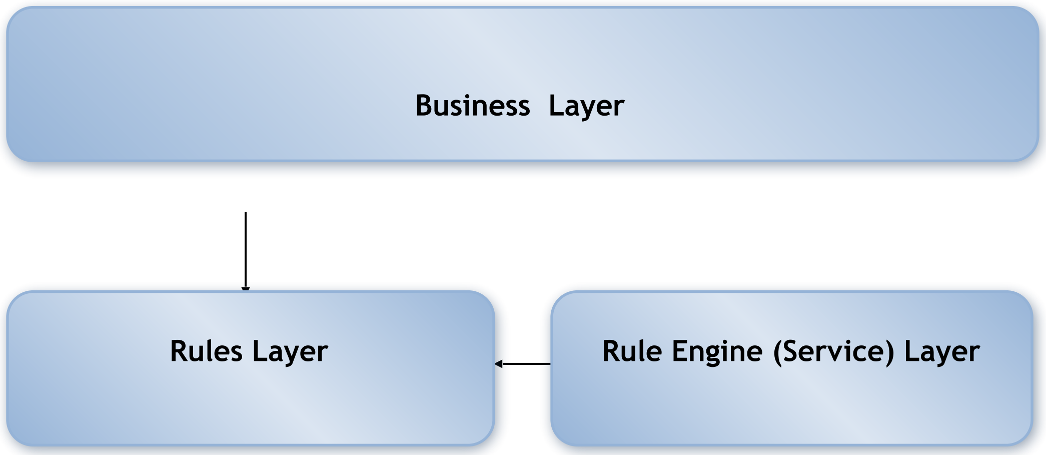
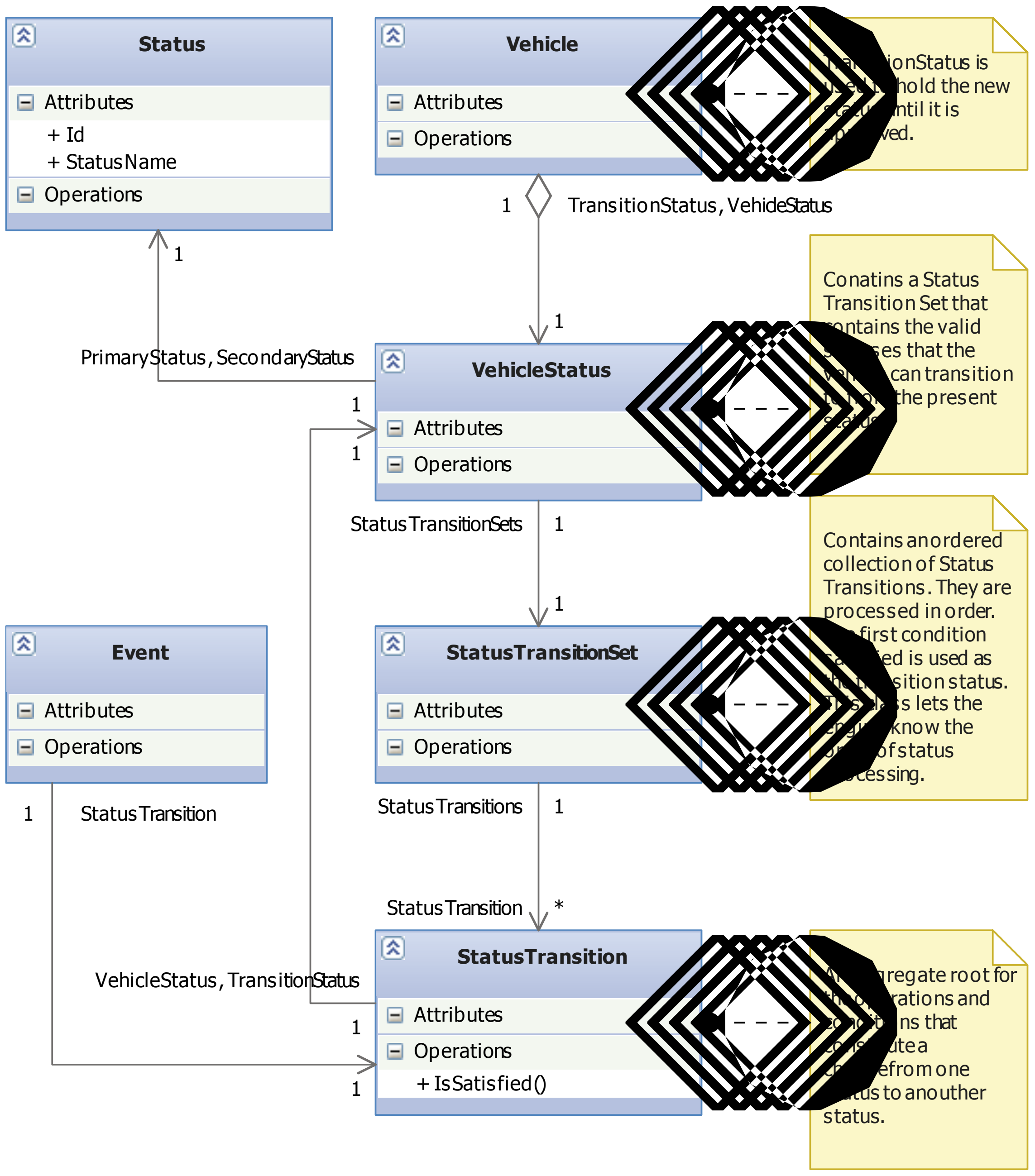
Requirements

- Given a present status, the application must be able to determine the new status of a vehicle when information is submitted for processing.
- A user can use an Event to change the status of a vehicle. When an Event is submitted, the application must be able to determine if a valid status transition is being requested.
- It must be possible to add a status and modify a status without writing code.
- It must be possible to add a rule and modify a rule without writing code.
- It should be possible to perform validation against different entity types without writing code to modify the rule engine.

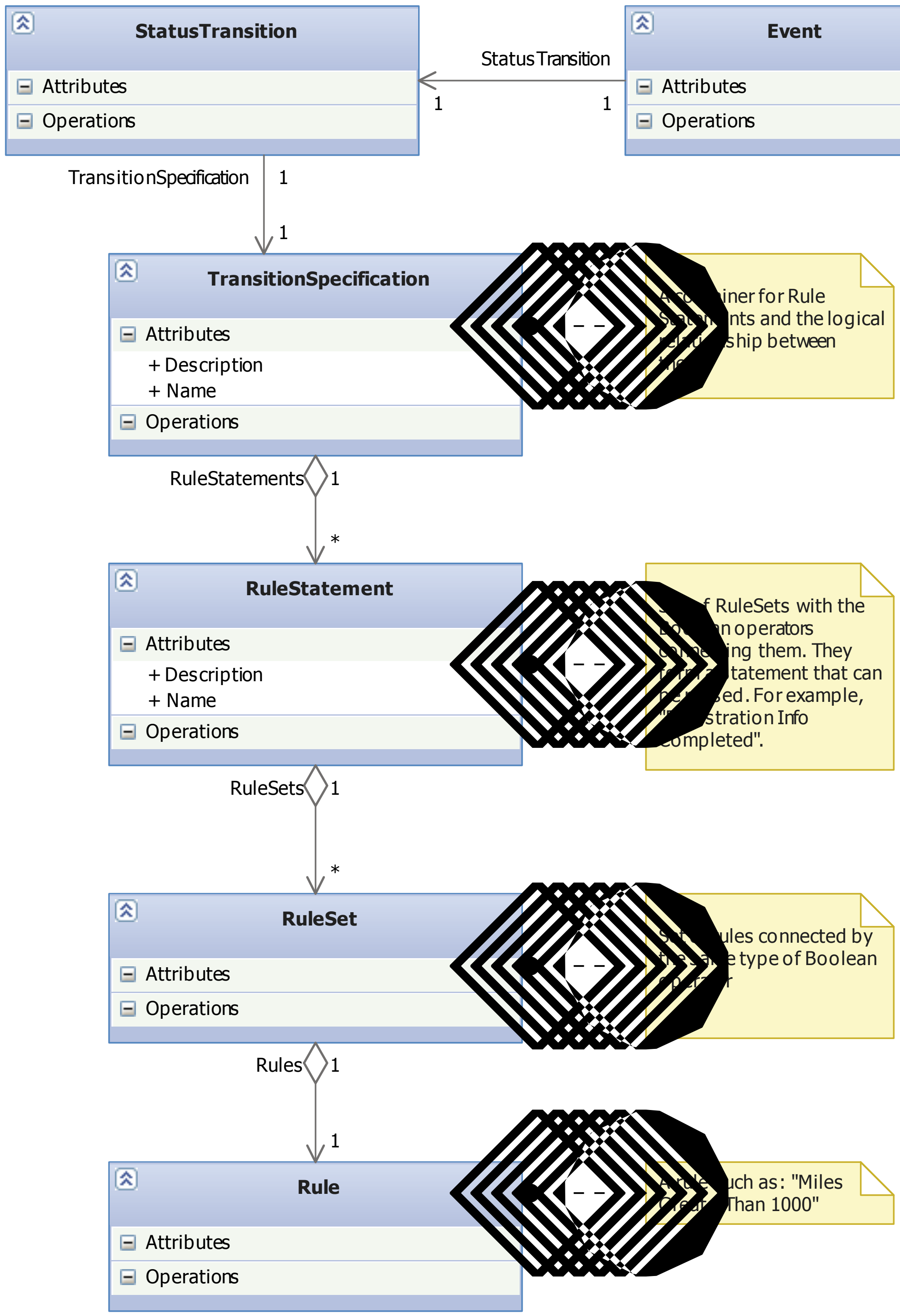
Component and Class Diagrams



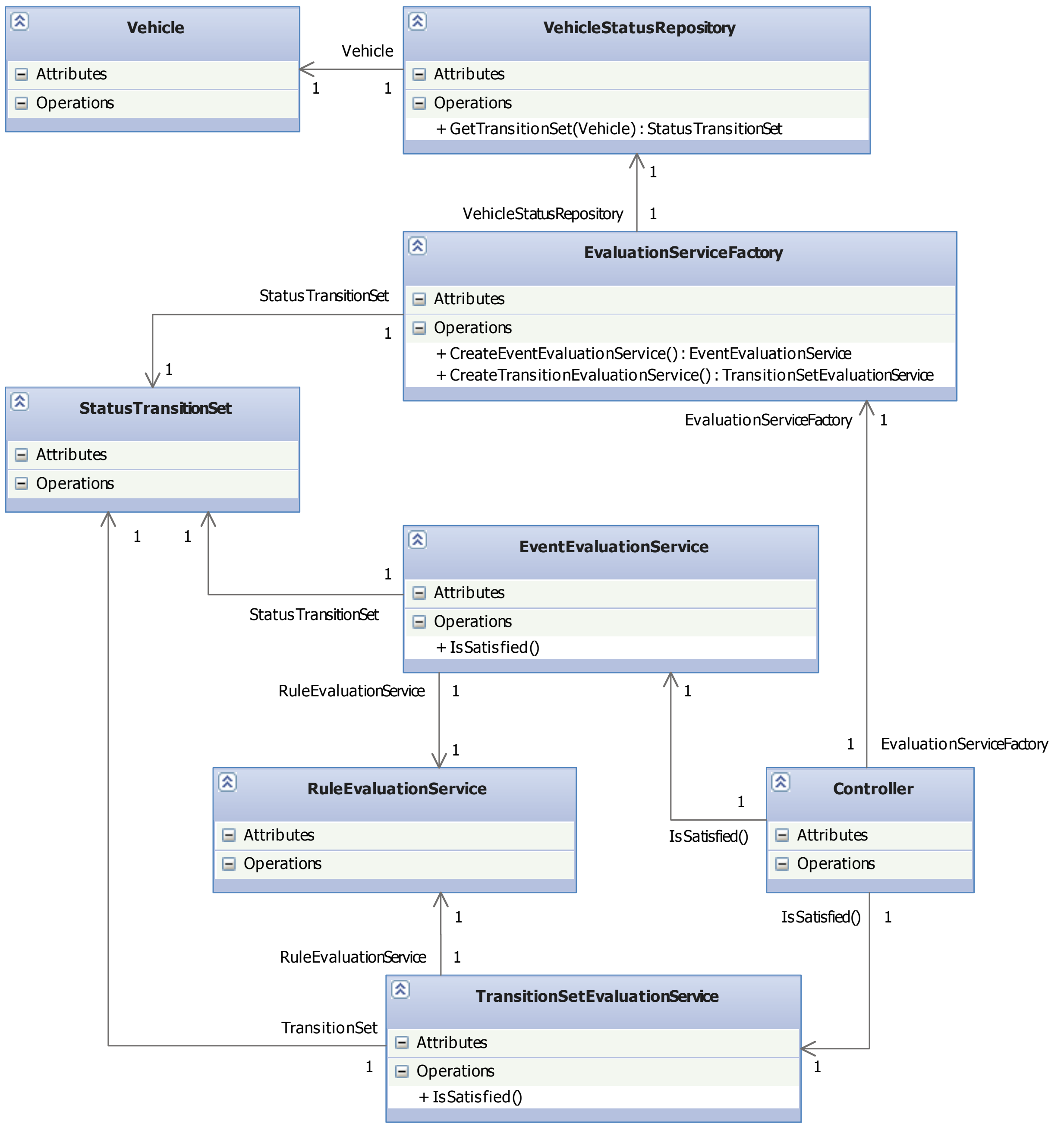
Business Layer Class Diagram



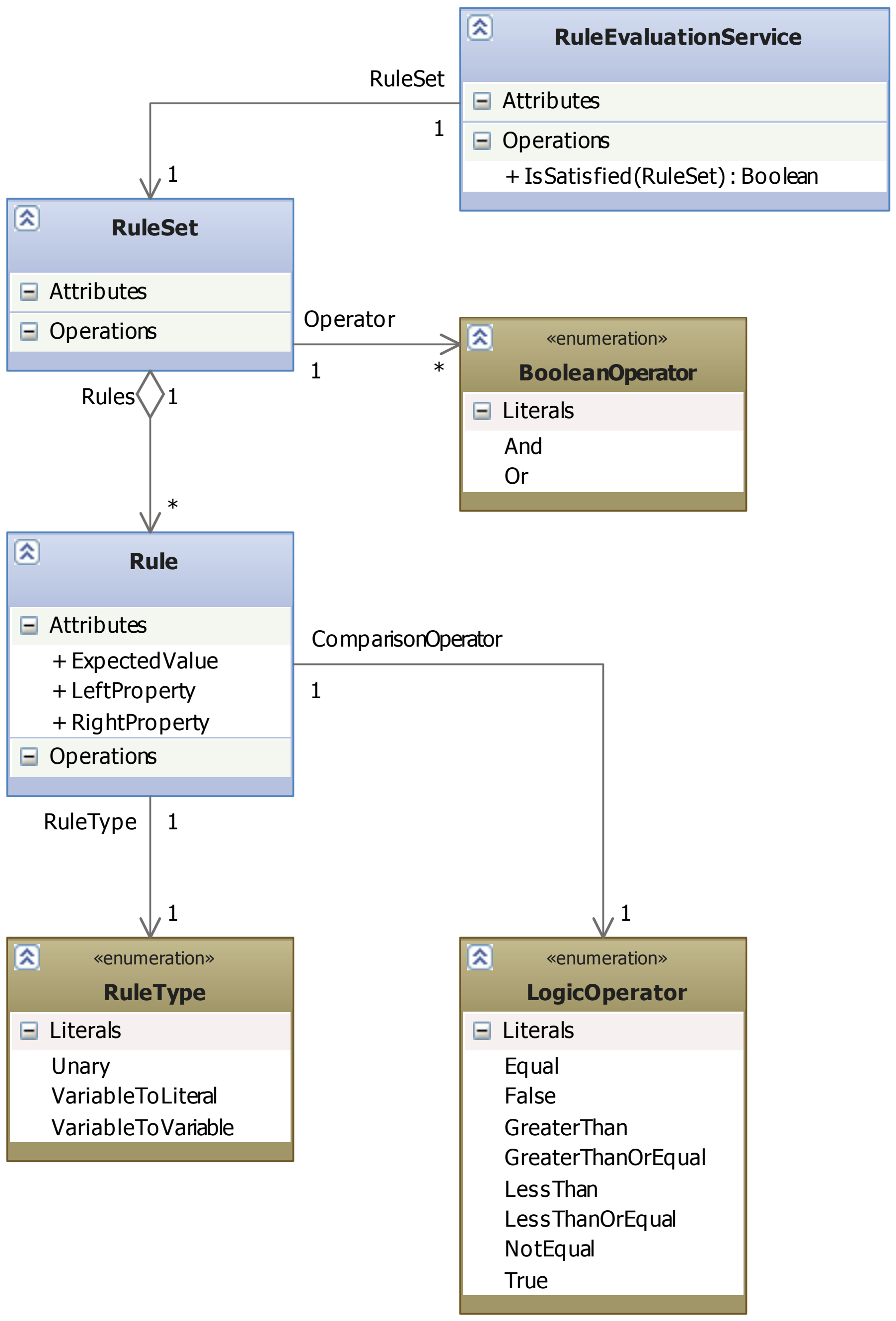
Rules Layer Class Diagram


StatusTransition
Attributes
Operations
Event
Attributes
Operations
StatusTransition
1
1
TransitionSpecification
1
1
TransitionSpecification
Attributes
+ Description
+ Name
Operations
A container for Rule Statements and the logical relationship between them
RuleStatements
1
*
RuleStatement
Attributes
+ Description
+ Name
Operations
Set of RuleSets with the Boolean operators connecting them. They form a statement that can be passed. For example, "Registration Info completed".
RuleSets
1
*
RuleSet
Attributes
Operations
Set of rules connected by the same type of Boolean operator
Rules
1
1
Rule
Attributes
Operations
A rule such as: "Miles Greater Than 1000"

Rules Engine (Service) Layer



Rules and RuleSets Class Diagram (Detailed)



Proof of Concept: And Operation Between Rules

In this section shows a proof of concept implementation of the AND operation between three rules.

Listed below are examples of rules. They are built using the .NET ExpressionType enumeration class. Each rule element will have a rule type that will inform the engine of how the element is to be processed.

Rule Examples	
Miles *GreaterThan* **1000**	RuleType.VariableToLiteral
ServiceDate *Equal* **ActivatedDate**	RuleType.VariableToVariable
ServiceDate *True*	RuleType.Unary

Rules will be housed within a rule set in accordance with the logical operation between them. The table below shows how the rules would be broken up into rule sets.

(A & B & C) | D	A,B,C in one RuleSet; D in one RuleSet.
(A & B) | (C & D)	A, B in one RuleSet; C, D in one RuleSet.

This sort of setup enables the application to take advantage of Linq Expressions to process the information. The Linq method **`All()`** can be used as an **AND** operator and the Linq method **`Any()`** can be used as an **OR** operator.

The following unit test serves as a proof of concept of the All() method being used as an AND operator between rules. The rule set being processed is as follows:

```
PlateNumber == “123-abc” AND Transmission != “2345678” AND Miles > 2000
```

The three rule objects are shown below. The vehicle and the rule set are passed as parameters to the `RuleValidationService.IsSatisfied()` method in the latter part of the code.

```
        [TestMethod()]
        public void IsSatisfiedTest()
        {
            Vehicle vehicle = new Vehicle
            {
                PlateNumber = "123-abc",
                Transmission = "2343678",
                Miles = 3000
            };

            List<Rule> ruleList = new List<Rule>{
                new Rule
                {   RuleType = RuleType.VariableToLiteral,
                    LeftPropertyName = "PlateNumber",
                    ComparisonOperator = LogicOperator.Equal,
                    ExpectedValue = "123-abc"
                },
                new Rule
                {
                    RuleType = RuleType.VariableToLiteral,
                    LeftPropertyName = "Transmission",
                    ComparisonOperator = LogicOperator.NotEqual,
                    ExpectedValue = "2345678"
                },
                new Rule
                {
                    RuleType = RuleType.VariableToLiteral,
                    LeftPropertyName = "Miles",
                    ComparisonOperator = LogicOperator.GreaterThan,
                    ExpectedValue = "1000"
                }
            };
            RuleSet ruleSet = new RuleSet(ruleList);

            RuleValidationService target = new RuleValidationService();
            target.IsSatisfied(vehicle, ruleSet);
            bool expected = true;
            bool actual;
            actual = target.IsSatisfied(vehicle, ruleSet);
            Assert.AreEqual(expected, actual);
        }
```

Unit Test of RuleValuationService with AND operation

Listed below is code that can perform the AND operation against the rules in the rule set. The `IsSatisfied()` method unpacks the rule set, builds a expression tree against the vehicle and performs an AND operation between the results of the rules via the Linq `All()` method.

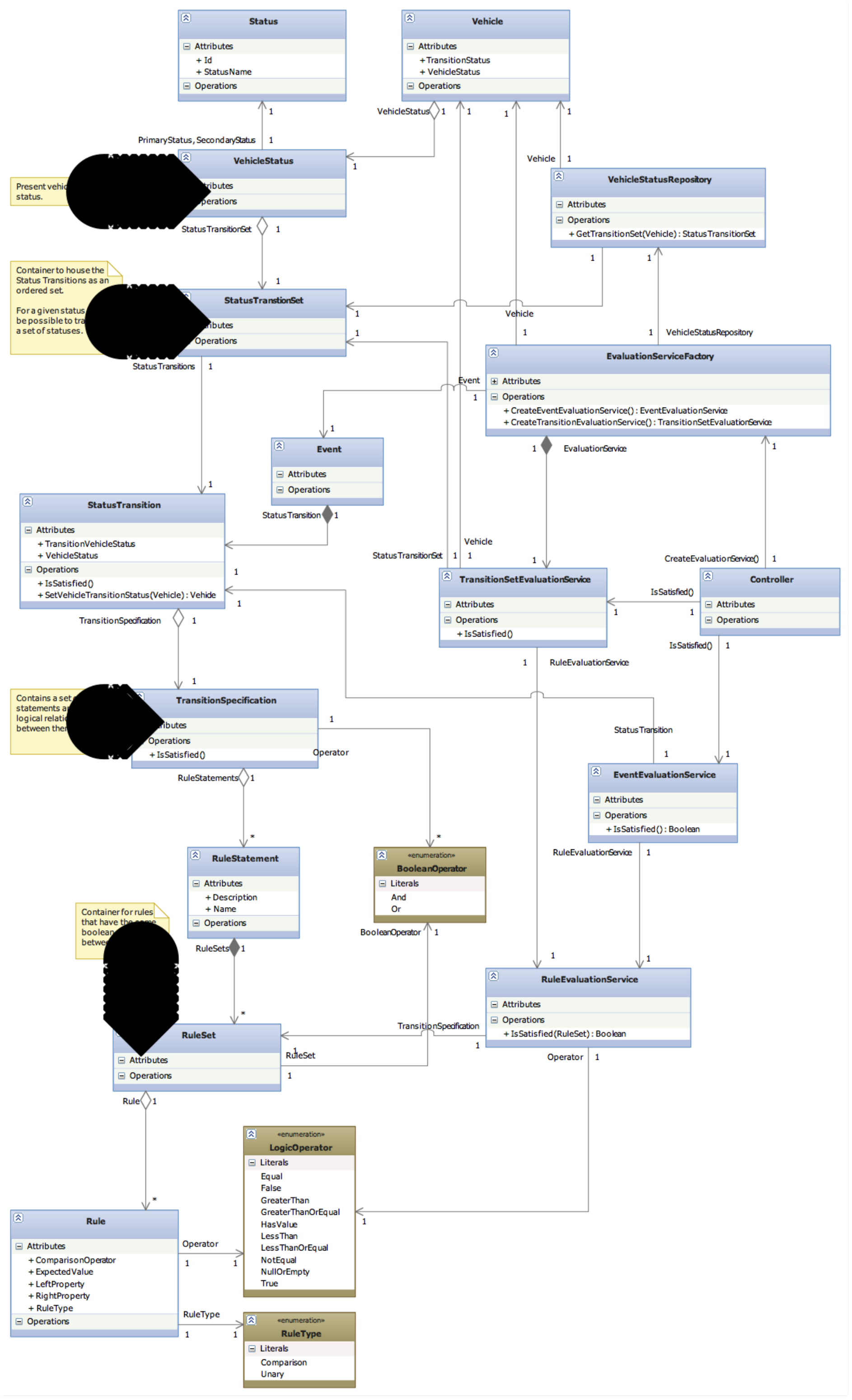
```
    public class RuleValidationService
    {
        public bool IsSatisfied(Vehicle vehicle, RuleSet ruleSet)
        {
            var rules = ruleSet.Rules;
            var compiledRules = rules.Select(r =>
CompileRule<Vehicle>(r)).ToList();
            return compiledRules.All(rule => rule(vehicle));
        }

        static Func<T, bool> CompileRule<T>(Rule r)
        {
            var paramExprNode = Expression.Parameter(typeof(T));
            Expression expr = BuildExpr<T>(r, paramExprNode);
            return Expression.Lambda<Func<T, bool>>(expr,
paramExprNode).Compile();
        }

        static Expression BuildExpr<T>(Rule r, ParameterExpression paramExprNode)
        {
            var left = MemberExpression.Property(paramExprNode,
r.LeftPropertyName);
            var leftPropertyType = typeof(T)
                                   .GetProperty(r.LeftPropertyName)
                                   .PropertyType;
            ExpressionType tBinary;
            //Is operator a known .NET operator
            if (ExpressionType.TryParse(r.ComparisonOperator, out tBinary))
            {
                var right = Expression.Constant(Convert.ChangeType(
                                                r.ExpectedValue,
leftPropertyType));
                return Expression.MakeBinary(tBinary, left, right);
            }
            else
            {
                var method = leftPropertyType.GetMethod(r.ComparisonOperator);
                var tParam = method.GetParameters()[0].ParameterType;
                var right = Expression.Constant(Convert.ChangeType(
                                                     r.ExpectedValue, tParam));
                // Use a method call, e.g. 'Contains' n.tag.Contains(something)
                return Expression.Call(left, method, right);
            }
        }
    }
```

Proof of Concept: RuleEvaluationEngine code to handle AND operation between Rules

Complete Rules Engine Class Diagram


Status
Attributes
+ Id
+ StatusName
Operations
Vehicle
Attributes
+ TransitionStatus
+ VehicleStatus
Operations
PrimaryStatus, SecondaryStatus
VehicleStatus
VehicleStatus
Present vehi
status.
Vehicle
VehicleStatusRepository
Attributes
Operations
+ GetTransitionSet(Vehicle) : StatusTransitionSet
StatusTransitionSet
Container to house the Status Transitions as an ordered set.
For a given status
be possible to tra
a set of statuses.
StatusTransitionSet
Operations
Vehicle
VehicleStatusRepository
EvaluationServiceFactory
Attributes
Operations
+ CreateEventEvaluationService() : EventEvaluationService
+ CreateTransitionEvaluationService() : TransitionSetEvaluationService
Event
Status Transitions
Event
Attributes
Operations
EvaluationService
StatusTransition
Attributes
+ TransitionVehicleStatus
+ VehicleStatus
Operations
+ IsSatisfied()
+ SetVehicleTransitionStatus(Vehicle) : Vehicle
Status Transition
Vehicle
StatusTransitionSet
CreateEvaluationService()
TransitionSetEvaluationService
Attributes
Operations
+ IsSatisfied()
IsSatisfied()
Controller
Attributes
Operations
TransitionSpecification
IsSatisfied()
RuleEvaluationService
Contains a set
statements a
logical relati
between the
TransitionSpecification
Operations
+ IsSatisfied()
Operator
Status Transition
EventEvaluationService
Attributes
Operations
+ IsSatisfied() : Boolean
RuleStatements
RuleStatement
Attributes
+ Description
+ Name
Operations
«enumeration»
BooleanOperator
Literals
And
Or
RuleEvaluationService
Container for rules
that have the
boolean
betwe
RuleSets
BooleanOperator
RuleEvaluationService
Attributes
Operations
+ IsSatisfied(RuleSet) : Boolean
TransitionSpecification
RuleSet
Attributes
Operations
RuleSet
Operator
Rule
«enumeration»
LogicOperator
Literals
Equal
False
GreaterThan
GreaterThanOrEqual
HasValue
LessThan
LessThanOrEqual
NotEqual
NullOrEmpty
True
Rule
Attributes
+ ComparisonOperator
+ ExpectedValue
+ LeftProperty
+ RightProperty
+ RuleType
Operations
Operator
RuleType
«enumeration»
RuleType
Literals
Comparison
Unary