The Model Maturity Pattern

Date: 2016-04-15
The Model Maturity Pattern

Contents

1 Introduction .......................................................................................................................... 2
  1.1 Pattern Aims .................................................................................................................. 2
2 Concepts ................................................................................................................................ 3
3 Viewpoints ........................................................................................................................... 4
  3.1 Overview ......................................................................................................................... 4
  3.2 Rules ............................................................................................................................... 5
  3.3 Maturity Level Definition Viewpoint (MLDVP) .............................................................. 5
    3.3.1 Description ............................................................................................................... 6
    3.3.2 Example Maturity Level Definition Viewpoint ......................................................... 7
  3.4 Factor Definition Viewpoint (FDVP) ............................................................................. 7
    3.4.1 Description ............................................................................................................... 8
    3.4.2 Example Factor Definition Viewpoint ...................................................................... 9
  3.5 Indicator Definition Viewpoint (IDVP) ......................................................................... 9
    3.5.1 Description ............................................................................................................... 10
    3.5.2 Example Indicator Definition Viewpoint ................................................................. 11
  3.6 Maturity Level Viewpoint (MLVP) .............................................................................. 12
    3.6.1 Description ............................................................................................................... 12
    3.6.2 Example Maturity Level Viewpoint ...................................................................... 13
4 Summary ............................................................................................................................. 14
5 Related Patterns ............................................................................................................... 14
6 References & Further Reading ........................................................................................... 14
1 Introduction

Working with models is an ongoing process as the model will evolve as the project progresses. Just because a model exists does not mean that it is fit for purpose or that it has been developed in a logical manner. It is desirable, therefore, to be able to assess the maturity of a model at any point in time.

The concept of maturity is not a new one and is applied in many other areas, such as:

- Processes that may be assessed using a maturity model, such as CMMI (Capability maturity Model Integrated) and ISO 15504 Software Process Assessment.
- People that may be assessed using a competency framework, such as the INCOSE Competency Framework and SFIA.
- Products using Technology Readiness Levels (TRLs) and their derivatives.

The Model Maturity Pattern provides a mechanism for assessing the maturity of any model and, therefore, provides a useful input to any maturity assessment exercise that is model-based. Models can be used to identify, specify, define, evaluate and analyse any artefact, including: software, systems, processes, competencies, requirements, architectures, etc. Therefore, any maturity assessment that may be applied to models, may potentially be applied to any artefact.

1.1 Pattern Aims

This pattern is intended to provide a mechanism to allow the maturity of a model to be assessed. The main aims of this pattern are shown in the Architectural Framework Context View (AFCV) in Figure 1.

![Figure 1 - Architectural Framework Context View showing Model Maturity Pattern aims](image)
The Model Maturity Pattern

The key aim of the Model Maturity Pattern is to provide a mechanism to ‘Assess the maturity of model’. This need is desirable for any ‘System Modeller’ and may be applied to any ‘Model’. This main Use Case includes the need to ‘Define assessment criteria’ that may be tailored for any specific application.

There is also a single constraint on this main aim which is that the assessment must ‘Apply to any aspect of the model’ in three ways:

- ‘Apply to ontologies’. The Ontology forms the backbone of any MBSE approach and, therefore, it is very useful to be able to determine how mature that Ontology is.
- ‘Apply to frameworks’. As the Framework contains the Viewpoints that dictate how the Views will be realised, it is important that the maturity of the underlying Framework may be assessed.
- ‘Apply to model views’. The actual content of the model, in the form of the Views must also be assessed in terms of its maturity.

This Pattern focuses on defining the assessment, rather than identifying distinct baselines, which is covered by the Epoch Pattern.

2 Concepts

The main concepts covered by the Model Maturity Pattern are shown in the Ontology Definition View (ODV) in Figure 2.

![Figure 2 - Ontology Definition View showing Model Maturity Pattern concepts](image)

The diagram here shows the main concepts associated with the Model Maturity Pattern.
The Model Maturity Pattern

The main concept in the Ontology is that of the ‘Maturity Level’ that defines the maturity of one or more ‘View’. Each ‘Maturity Level’ is qualified by one or more ‘Factor’ via a set of one or more ‘Indicator’. A set of one or more ‘Maturity Level’ is defined that provides a level of maturity of the model. The set of one or more ‘Factor’ describes the properties of the model that are being assessed, and the set of one or more ‘Indicator’ defines what is measured.

Each ‘Indicator’ is further described by having one or more piece of ‘Evidence’ associated with it that demonstrates that the Indicator has been satisfied, and one or more ‘State’ that provides the quality measure for the ‘Indicator’.

3 Viewpoints

This section describes the Viewpoints that make up the Model Maturity Pattern. It begins with an overview of the Viewpoints, defines Rules that apply to the pattern and then defines each Viewpoint.

3.1 Overview

The Model Maturity Pattern defines a number of Viewpoints as shown in the Viewpoint Relationship View (VRV) in Figure 3.

---

**Figure 3 - Viewpoint Relationship View showing Model Maturity Pattern Viewpoints**

The Model Maturity Pattern defines four Viewpoints which are:

- The ‘Maturity Level Definition Viewpoint’ that defines what Maturity Levels exist.
- The ‘Factor Definition Viewpoint’ that identifies and defines the Factors that are required to determine the Maturity Levels.
- The ‘Indicator Definition Viewpoint’, that identifies and defines the Indicators and associated types of Evidence and States required to carry out the assessment.
- The ‘Maturity Level Viewpoint’ that visualises the output of the maturity assessment exercise.

Each of these Viewpoints is described in more detail in the following sections. For each Viewpoint an example is also given.
### 3.2 Rules

Five Rules apply to the five Model Maturity Viewpoints, as shown in the Rules Definition View (RDV) in Figure 4.

There are five Rules that are applied to the Model Maturity Pattern, which are:

- ‘MM01 – Each Factor must be defined’, that requires a definition for each of the identified Factors.
- ‘MM02 – Each Maturity Level must be defined’ that ensures that each Maturity Level has a proper definition.
- ‘MM03 – Each Indicator must be defined’ that ensures that the Indicators that are used to qualify the Factors is properly defined.
- ‘MM04 – The set of Indicators must have a set of States defined that can be applied to all Indicators’, that ensures that each Indicator is properly defined in terms of its associated States.
- ‘MM05 - Each Indicator must have a State defined for it’ that ensures that each Indicator has a State set for it.

Note that the five Rules shown in Figure 4 are the minimum that are needed. Others could be added if required.

### 3.3 Maturity Level Definition Viewpoint (MLDVp)

The aims of the Maturity Level Definition Viewpoint are shown in the Viewpoint Context View in Figure 5.
The main aim of the Maturity Level Definition Viewpoint is to contribute to the ‘Define assessment criteria’ aim which itself contributes to the main aim of the Pattern which is to ‘Assess maturity of model’. This is achieved by the ‘Define maturity levels’ aim.

3.3.1 Description
The Viewpoint Definition View (VDV) in Figure 6 shows the Ontology Elements that appear on a Maturity Level Definition Viewpoint.
The Model Maturity Pattern

The Maturity Level Definition Viewpoint is a relatively simple one that consist of a number of Maturity Levels.

### 3.3.2 Example Maturity Level Definition Viewpoint

An example View that conforms to the Maturity Level Definition Viewpoint is shown in Figure 7.

The Maturity Level Definition View is visualised using a block diagram where blocks represent the Maturity Levels.

The diagram here shows how a number of Maturity Levels are defined that are being used as part of a Modelling Readiness Level application. The Maturity Levels in this example are called Model Readiness Levels, and are being defined here are used as part of a larger Systems Engineering management activity where a baseline of the Model is taken at various point of the project and then the maturity of the Model is defined. This allows managers to plot the evolution over time of the maturity of the System Model.

There are nine Maturity Levels defined, which are:

- ‘Modelling Readiness Level 1: Basic principles observed’
- ‘Modelling Readiness Level 2: Technology concept or application formulated’
- ‘Modelling Readiness Level 3: Characteristic proof of concept’
- ‘Modelling Readiness Level 4: Model defined based on concepts and proof’
- ‘Modelling Readiness Level 5: Model validated on relevant test applications’
- ‘Modelling Readiness Level 6: Model demonstration in relevant environment’
- ‘Modelling Readiness Level 7: Model demonstration in operational environment’
- ‘Modelling Readiness Level 8: Model completed and qualified’
- ‘Modelling Readiness Level 9: Model proven through successful mission operations’

This description of each Maturity Level is contained within its block on the View which may also be represented as a table. Using a good MBSE approach, this table may be automatically generated from the Model.

This View satisfies Rule MM02.

### 3.4 Factor Definition Viewpoint (FDVp)

The aims of the Factor Definition Viewpoint are shown in the Viewpoint Context View in Figure 8.
The main aim of the Factor Definition Viewpoint is to contribute to the ‘Define assessment criteria’ aim which itself contributes to the main aim of the Pattern which is to ‘Assess maturity of model’. This is achieved by the ‘Define factors’ aim.

3.4.1 Description
The Factor Definition Viewpoint (FDV) in Figure 9 shows the Ontology Elements that appear on an Interface Connectivity Viewpoint.
3.4.2 Example Factor Definition Viewpoint

Example Views that conform to the Factor Definition Viewpoint are shown in Figure 10.

![Figure 10 - ICV - Service-based Interface Connectivity](image)

The Factor Definition View is visualised using a block diagram where blocks represent the Factors.

There are nine Factors defined, which are:

- Source Information: Basic source information is gathered and collated as an input to demonstrating need
- Need Defined: Concept is defined through definition of needs model
- Validation Defined: Validation criteria for concept is defined, analysed and reviewed
- Approach: The model of the approach, based on the concepts and proof is defined and verified
- Test Application: Partial model of approach is applied to one or more test applications, such as established or predefined test application models
- Model Demonstration: Model of approach is completed and process is defined. Approach model is applied to one or more test applications, such as established or predefined test application models
- Case Study: Model is applied to one or more industrial case studies
- Tailored Model: Model tailored for specific industry and is applied on real industry projects
- Applied Approach: Model becomes part of industry approach, is measured and controlled by industry quality system

This description of each Factor is contained within its block on the View which may also be represented as a table. Using a good MBSE approach, this table may be automatically generated from the Model.

This View satisfies Rule MM01.

3.5 Indicator Definition Viewpoint (IDVp)

The aims of the Indicator Definition Viewpoint are shown in the Viewpoint Context View in Figure 11.

---

Scarecrow Consultants Limited ©2016

:: 9 ::
The main aim of the Factor Definition Viewpoint is to contribute to the ‘Define assessment criteria’ aim which itself contributes to the main aim of the Pattern which is to ‘Assess maturity of model’. This is achieved by two aims which are to ‘Define indicators’ and to ‘Define States’.

3.5.1 Description
The Viewpoint Definition View (VDV) in Figure 12 shows the Ontology Elements that appear on an Interface Definition Viewpoint.
The Model Maturity Pattern

Figure 12 - Viewpoint Definition View showing the Ontology Elements that appear on the Indicator Definition Viewpoint (IDVp)

The Indicator Definition Viewpoint is another simple descriptive Viewpoint that defines the set of one or more ‘Indicator’ and its associated set of one or more ‘State’.

Each ‘Indicator’ shows the assessor what to look for in the Model when performing the assessment, whereas each ‘State’ provides a qualification of the maturity that can be applied to each ‘Indicator’.

3.5.2 Example Indicator Definition Viewpoint

An example View that conforms to the Indicator Definition Viewpoint is shown in Figure 13.

Figure 13 – Example of Indicator Definition Viewpoint (IDVp)

The Indicator Definition Viewpoint is visualised by a block diagram where blocks are used to represent the Indicators and the States.

The Indicators are used to identify what type of information is required to be used during the assessment. The actual information that is presented by the assesseee to demonstrate that the Indicator has been satisfied is the Evidence.
In this example only three types of Indicator are shown for reasons of brevity whereas the complete model contains many more (indicated by the (incomplete) constraint). These Indicators are:

- ‘Description of Work’, such as a document that describes the scope of the work.
- ‘Source Information’, such as documents, models, books, emails, etc.
- ‘Source Element View’, which is, in this case the View taken from the ACRE approach to requirements modelling.

The quality measure for each of these is described by the following States:

- ‘Initial’, some artefacts exist but have not been reviewed and are not held under configuration management.
- ‘Updated’ – the artefacts have been reviewed and, where necessary, updated to reflect the results of the review. Artefacts are held under configuration management.
- ‘Incomplete’ – the artefacts produced have been reviewed but do not reflect the full set of artefacts for the approach.
- ‘Complete’ - the artefacts produced have been reviewed and reflect the full set of artefacts for the approach.
- ‘Tailored’ – the artefacts have been tailored for a specific industry.
- ‘Accepted’ – the artefacts produced have been reviewed and accepted as fit for purpose.
- ‘Adopted’ – the artefacts produced have been validated and accepted as fit for purposes and now form part of the industry Quality Management System.

This View satisfies Rules MM03 and MM04.

3.6 **Maturity Level Viewpoint (MLVp)**

The aims of the Maturity Level Viewpoint are shown in the Viewpoint Context View in Figure 14.

![Figure 14 - Viewpoint Context View showing Maturity Level Viewpoint aims](image)

The main aim of the Maturity Level Viewpoint is to ‘Assess the maturity of the model’ This aim represents the overall aim of the whole pattern and results in the output of the assessment exercise.

3.6.1 **Description**

The Viewpoint Definition View (VDV) in Figure 15 shows the Ontology Elements that appear on a Maturity Level Viewpoint.
The Maturity Level Viewpoint provides the final output of the assessment by showing each relevant ‘View’ and its associated ‘Maturity Level.

### 3.6.2 Example Maturity Level Viewpoint

An example View that conforms to the Maturity Level Viewpoint is shown in Figure 16

![Maturity Level Viewpoint Diagram](image)

**Figure 16 – Example of the Maturity Level Viewpoint**

The diagram here shows the visualisation of the Maturity Level Viewpoint by using a bar chart. Clearly, this is not a SysML diagram but, providing that the View is consistent with the underlying Pattern definition, then it is still a valid part of the Model.

The x-axis on the bar chart shows the relevant Views that have been assessed, whereas the y-axis shows the nine Maturity Levels that were defined in the Maturity Level Definition View – note that these names are abbreviated for reasons of clarity.

Each cell in the bar chart is either shaded or left blank to indicate which Maturity Level that View has achieved.
The Model Maturity Pattern

This View provides a good indication of the evolution of the maturity of the Model when combined with other instances of the View that have the same set of assessed Views. In order to show the evolution of maturity over time, the Epoch Pattern should be used to define an Epoch for each baseline of the model under assessment.

4 Summary
The Model Maturity Pattern provides a mechanism for assessing the maturity of a Model. This assessment may be applied to a whole Model or a specific set of Views that comprise part of the Model.

The Pattern defines four Viewpoints which allow the specification of the Maturity Levels, Factors, Indicators and their associated States.

The resulting Views are relatively simple being represented by *block diagrams* and a bar chart.

This Pattern provides a useful and powerful input to MBSE Project Management activities. When combined with the Epoch Pattern that can be used to define baselines, this Pattern enables the evolution of the Model over time to be plotted. The Maturity Level Views also provide a good input into risk assessment activities for the management of the project.

5 Related Patterns
If using the Interface Definition Pattern, the following patterns may also be of use:

- Epoch Pattern
- Evidence Pattern

This does not represent an exhaustive list of the related Patterns and the Patterns may be used in any combination.

6 References & Further Reading