Towards Model Driven Architecture in Academic Quality Assurance Information System Development

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Abstract—**In this research, we present the use of a Model Driven Architecture (MDA) in academic quality assurance (AQA) domain. To provide a detailed analysis of MDA, we show how the paradigm of MDA can be configured to implement the AQA application software based on information system (IS) platform. An extensive analysis of AQA models is constructed to extract the concepts and simultaneously created a metamodel that can be reused for similar projects. The six-stepwise of Othman and Beydoun metamodelling development is used to develop the metamodel. Then, the demonstration of usefulness of the metamodel is shown through instantiation and conformance process. The future development of AQA Knowledge Repository (AQA-KR) will ensures that users can use the stored knowledge to develop AQA solutions as AQA contexts vary**

Index Terms—**Quality Assurance; Model Driven Architecture; Information System; Metamodelling.**

I. INTRODUCTION

Model Driven Architecture® (MDA®) which was adopted by Object Management Group™ (OMG™) in 2001 is an architectural framework for software development [1]. The key factors of MDA adoption are portability, interoperability and reusability through separation of architectural framework. Other than that, MDA allows systems to be considered at higher levels of abstraction without concerning the programming language details or the specifics of execution platforms. Therefore, the development of a new system or adoption of a system to a new platform is cheaper and it reduces the cost of time. MDA is also popular in software development due to the use of model to separate between businesses, softwares and technological platforms. Various fields have adopted MDA to develop the IS solutions such as in disaster management [2], in health care management [3] and enterprise architecture framework [4] but none from the quality management. Therefore, the contribution of this study is to highlight between the used of MDA paradigm in creating AQA metamodel and demonstration of the validated metamodel in solving the problem domain. To discuss further on MDA approach, this paper is organised as follows. In Section 2, we present the notion of academic quality assurance management system in higher education. Section 3 discusses the methodology used in developing a metamodel, while Section 4 demonstrates the findings and use of AQA metamodel based on users' view. Finally, Section 5 concludes the paper with a discussion of our findings and future work.

II. RELATED WORKS

A. Academic Quality Assurance (AQA) at Glance

Quality assurance is one of the quality management system components that ensures the quality of the process, product, service or management to achieve the necessary standards. It has been adopted by higher education institutions and systems in order to monitor performance against objectives, and to ensure the achievement of the quality outputs namely the graduates [5]. Quality assurance in higher education has risen to the top of the policy agenda in many nations to prepare students with skills, knowledge and competency to enter a complex and interdependent world [6]. Mainly, the systems aim to provide appropriate evidence to substantiate claims made about the quality of academic and to gain confidence from the key stakeholders in the management level. Mostly, each of the country has their own quality assurance agency. In Southeast ASEAN countries, the agencies' functions may vary; at regional (nurture network and construct frameworks), national (provide qualification framework and develop standard) and higher learning institution (HLI) (accreditation, external and internal quality assurance) levels [7]. The agencies were established to monitor the implementation of quality of higher education by HLIs at benchmark standard setting and aim for enhanced standard. Additionally, the existence of AQA framework works as a catalyst for effectiveness of the educational system at the tertiary level. Each country has its framework and it is monitored by the respective authorities. For example, universities in Australia have an AQA framework monitored by Australia Tertiary Education Quality and Standards Agency (TEQSA) while in Malaysia, it is monitored by the Malaysian Qualification Agency (MQA).

To gain competitive quality assurance, it is necessary but insufficient for HLIs to only rely on quality assurance system developed that focuses on documentation. HLIs must also consider how the implementations take place. Research has shown that quality assurance is positively related to a

reduction of the mistakes or defect and which fits best with its purposes. Many researchers have had a lot of discourses on the development of education quality in HLIs [8][9]. The discussion has moved beyond awareness to a deeper level of concern. Southeast Asian Minister of Education [7] suggested the development of a regional quality assurance system as a means of developing both internal quality assurance and national systems. To overcome this challenge, the first step to move forward is by creating and structuring the quality assurance knowledge and developing a metamodel comprise of AQA domain concepts. However, due to the complexity of the endeavour, there are some missing links of elements, concepts or requirements that are essential to support the current practical implementations. Therefore, MDA paradigm is chosen because its aims completeness and generic concepts in the domain. Thus, this paradigm will take into account the overall concepts of domain related to producing the best knowledge society.

B. The Quality Assurance Evaluation Criteria Model

In AQA system, there are evaluation criteria used to measure the performance of quality in academic management. It is set by the authority for each of the countries. There are many evaluation models of programme accreditation to access quality in higher education. From the models, we extracted the evaluation criteria and chose the best criteria that are related to the core business of academic. For example, in Malaysia, there are nine of evaluations criteria but only five are related to this study, which are: [a] vision, mission, educational goals and learning outcomes; [b] curriculum design and delivery; [c] assessment of students; [d] programme monitoring and review; and [e]continual quality improvement. Other than that, ASEAN University Network Quality Assurance (AUN-QA) listed six criteria in AQA but only teaching and learning criteria is related to the core business which includes course curriculum, academic staff, student assessment, and learning process. While TEQSA has nine criteria, teaching and learning (processes for programme approval and monitoring) is the best criteria used to evaluate AQA. Based on the 10 models and framework chosen, there are five criteria used as a guideline for structuring the AQA concepts. There are curriculum design, curriculum delivery, student assessment, programme monitoring-review and continual quality improvement. The criteria perspective is used as a lens to understand AQA domain in details.

C. Model-Driven Architecture in the Academic Quality Assurance

The MDA is an architectural framework broadly supports different types of application domains and technology platforms, either platform-independent models or platform-specific model [10]. For example, *System A* is called platform-independent model while *System A using Java* is called platform-specific model. Figure 1 demonstrates how a model-driven approach is used in software development to solve a problem domain.

The system development is in a lifecycle process starting from gathering requirements, analysing, designing and implementing. The activity of each phases is connected using dashed arrows. Meanwhile, there are three models used in MDA; computation independent model (CIM), platform independent model (PIM) and platform specific model (PSM). CIM is also called domain model,

corresponds to capture the domain requirements of the system. PIM consists of domain model (CIM) without referring to its implementation and independency of any platform. It is usually represented using UML models, while PSM describes the operation of domain model based on a specific platform. The PSM corresponds to the specification perspective's design model. The model-driven approach uses model perspective to construct a solution.
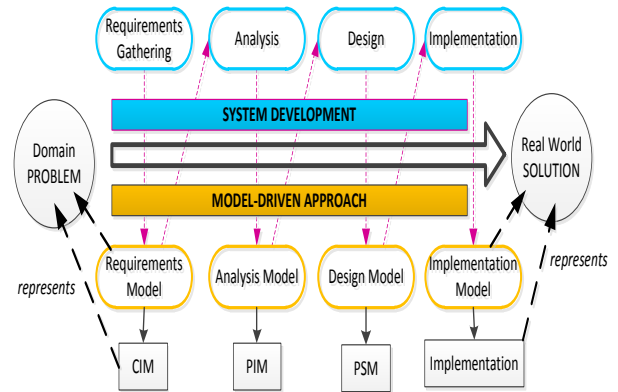

Figure 1: Foundational concept of MDA in Software Development Lifecycle (extended from [10] [11]).

III. METHODOLOGY

A. The 6-Stepwise of Metamodelling Development

The following section describes a model-driven software development or metamodelling stepwise based on the MDA delineated, which is used to develop applications on the AQA domain. The steps are adapted from Othman & Beydoun [12] because it is well explained and very detailed. The development process is divided into three phases; metamodel creation (Step 1-5), metamodel validations (Step 6) and metamodel conformance to demonstrate the usefulness (as in Figure 2).

Step 1: Preliminary observation and synthesis against problem domain. The understanding of the domain is important to identify the collection of models. One of the approaches used to gather information beside document analysis is stakeholder analysis. The stakeholder view is analysed to achieve the expressiveness at different levels. The list of possible stakeholders and their roles in AQA domain that can be used to develop the metamodel namely: (i) authority - to provide a guideline for quality assurance system in higher education, (ii) higher learning institution - to improve and sustain the quality assurance system guided by authority, (iii) quality assurance team - to develop programme accreditation reports and manage the AQA process, (iv) students - to provide constructive feedback on teaching, learning and other academic activities, (v) employers - to give feedback to the institutions for quality improvement, (vi) examination team - to manage the examination process from setting the examination schedule until the result is published, (vii) academic staff - to support academic activities in quality assurance management system such as curriculum design and delivery, student assessment and programme monitoring and review, and (viii) administrative - to support administrative activities in quality assurance system such as documenting the student information.
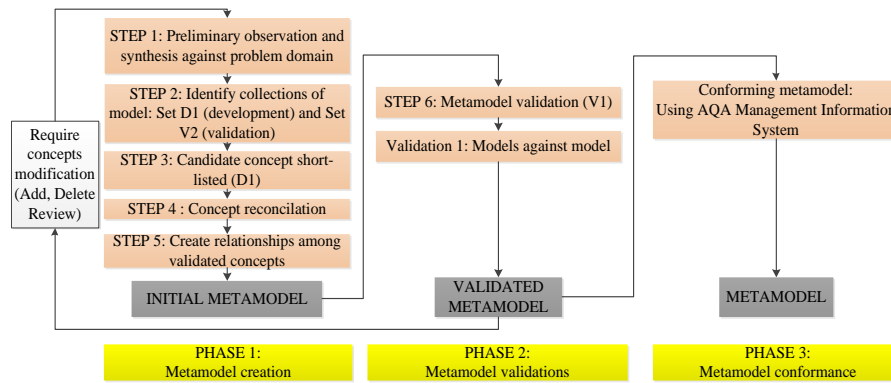
Figure 2: 6-Stepwise of metamodelling development

Step 2: Identifying models by using document analysis to find the best collection of AQA models. A set of ten high impact models (DI) is identified for development and five models (VI) for the validation (Table 1). $Y_{published}$ is the year of the model was published and coverage is the ratio of models' coverage. Value 0.1 means the model only covers one criteria out of five criteria in AQA. While 0.2 covers two or three criteria and 0.3 covers four to five criteria listed.

Step 3: From the 10 models identified from Step 2, all general concepts are extracted. The concepts chosen are based on the criteria of evaluation view which are only related to the academic. Supported criteria are omitted, for example leadership, staff management, student admission management, research and innovation and facilities and resources. The short-listed concepts are represented in Table 2. There are 66 concepts which are designated into five AQA criteria.

Step 4: Reconciliation of concepts and definitions where possible. If there is any inconsistency in the definition of concept, we choose the concept which has a more coherent definition and usage.

Step 5: Identification of relationships within and across concepts based on five criteria of evaluation chosen. The examples of relationships used are association and aggregation. An aggregation is a collection of composed of other classes. On the other hand, association is a reference based relationship between two classes. Examples of relationships are (i) concept *ProgrammeMonitoringPlan* to *ProgrammeMonitoringOrganisation* is *IsAGroupOf*, (ii) concept *CurriculumDesignPlan* to *CurriculumDesignGoal* is *has* (iii) *AssessmentTask* to *AssessmentPractice* is *contain*.

Step 6: Validating the metamodel. In this study, we used comparison models against model as a validation technique. There are five models used as validation to compare concepts in initial metamodel (in Table 2) against model in Set V1 (in Table 1). Due to the page limitation, we only show a snippet summary of the validation result for two models; V1.1 UTM and V1.4 GPKKPP (Table 3). If the concept does not exist in the AQA domain, it is added in the initial metamodel. The validation is for completeness and semantic richness of the metamodel.concept does not exist in the AQA domain, it is added in the initial metamodel. The validation is for completeness and semantic richness of the metamodel.

IV. RESULT AND FINDINGS

A. Demonstration of AQA Metamodel

Once the metamodel is validated, the next phase is the demonstration of the metamodel. In this study, we use instantiation and conformance to demonstrate the usefulness of a metamodel. Conformance is a derivation of a model from its metamodel. Through the conformance process, a new instance in M1 level can be achieved and it can be used as an instance in M0 level. Then, it can be stored in the AQA Knowledge Repository for future use. For the AQA metamodel conformance, we choose AQA Assessment-phase as denoted in UML class diagram in Figure 3. There are 24 concepts in use to demonstrate the generic assessment metamodel (M2 level) in AQA. The instantiation of M2 is On-going Assessment (M1 level) is depicted in Figure 4. As for M0, On-going assessment for Programme X at University A is used as a sample (in Figure 5). These are the examples of conformance of metamodel against real application.

V. DISCUSSION AND CONCLUSION

The objective of this paper is to show how a Model Driven Architecture can be used as a comprehensive approach for deriving domain knowledge of the information system in AQA domain. We have discussed the development phases of a metamodel through metamodelling approach (MDA) and its link to the software development lifecycle. The used of UML modeling technique and MDA framework could leverage change and complexity for a complex problem domain through capturing knowledge encoded in models [10]. The development of a metamodel is not complete without the validation and conformance process. These processes produced a complete, reliable and useful metamodel.

In conclusion, an AQA metamodel contributes these advantages to various levels of users: (a) providing a comprehensive structure for AQA educational improvement models (e.g., Academic Quality Assurance Monitoring Model or Programme Assessment Model), (b) maximizing communication across education domain, as metamodel correspondence to generic semantic domain, (c) assisting users in decision making, if the knowledge repository is developed and shared based on the metamodel notion, and (d) enabling users to customize or create new AQA models solutions because the syntax and semantic rules have already existed in the metamodel. To be useful, the concepts in a metamodel must adequately correspond with reality.

Table 1
Collections of Models for Metamodel Development (Set DI) and Validation (Set VI)

SET DI (To be used to develop the initial AQAM)	$Y_{published}$	$R_{coverage}$	Coverage of Model (Criteria)
1. AUN-QA [12]	2004	0.3	All criteria
2. Quality Assurance evaluation for Malaysia Higher Education [13]	2008	0.3	All criteria
3. BDNAC Brunei Darussalam [14]	2009	0.3	All criteria
4. Accreditation Body in Indonesia [15]	2011	0.3	All criteria
5. NCAAA, Saudi Arabia [16]	2011	0.3	All criteria
6. SAMEOA [7]	2012	0.3	All criteria
7. Quality Assurance in Japan [17]	2012	0.3	All criteria
8. Academic Quality Agency New Zealand[18]	2013	0.3	All criteria
9. TEQSA [19]	2015	0.3	All criteria
10. European Higher Education (ESG) [20]	2015	0.3	All criteria
SET V1 (To be used to validate the AQAM – Validation I)			
1. UTM Self-Accreditation Portfolio [21]	2009	0.3	All criteria
2. Guidelines to Good Practice: Curriculum Design and Delivery (GGPCDD) [22]	2011	0.2	Curriculum design and delivery
3. Guideline of Good Practice, University of Tasmania [23]	2011	0.1	Assessment
4. Garis Panduan Kesetaraan Kualiti Penilaian Pelajar UiTM (GPKKPP) [24]	2012	0.1	Assessment
5. Guidelines of Good Practices: Monitoring, Reviewing and Quality Improvement [25]	2014	0.2	Programme monitoring and quality improvement

Table 2
Shortlisted Concepts Are Designated Into Five AQA Criteria

AQA Phase	Concepts	Total
Curriculum design	*CurriculumDesignPlan; CurriculumDesignOrganisation; CurriculumDesignGoal; CurriculumDesignModel; HLIFramework; Employability; Communicate; Resource; Dissemination; CurriculumDesignStructure; CurriculumDesignTeam; ResourcePerson*	12
Curriculum delivery	*CurriculumDeliveryPlan; CurriculumDeliveryOrganisation; Resource; Evaluate; ContinualQualityImprovement; ExternalStakeHolders; Lecturer; Student; StrategicPlanning*	9
Assessment	*AssessmentPlan; AssessmentOrganisation; AssessmentPhilosophy; AssessmentGoal; AssessmentTask; AssessmentSystem; AssessmentMethod; AssessmentPractice; Measurement; Examination; AssessmentType; ExaminationTeam; Lecturer; Students; Authority; Resource; AssessmentMonitoring; LearningOutcome; QFDomain; Feedback; ExternalExpert; AppealSystem; GradingSystem; AssessmentOutcome.*	24
Programme Monitoring	*ProgrammeMonitoringPlan; ProgrammeMonitoringOrganisation; ContinualQualityImprovement; Programme Assessment; Programme Review; Evaluation; Report; Monitoring Unit*	8
Quality Improvement	*Action Plan; ImprovementOrganisation; Assessment; QualityAssuranceActivities; QualityAssuranceTeam; KPI; AssessmentType; Accreditation; AchievementReport; CorrectiveAction; PreventiveAction; Communication; Coordination*	13

Figure 3: AQA Assessment-phase class of concept (M2 level)
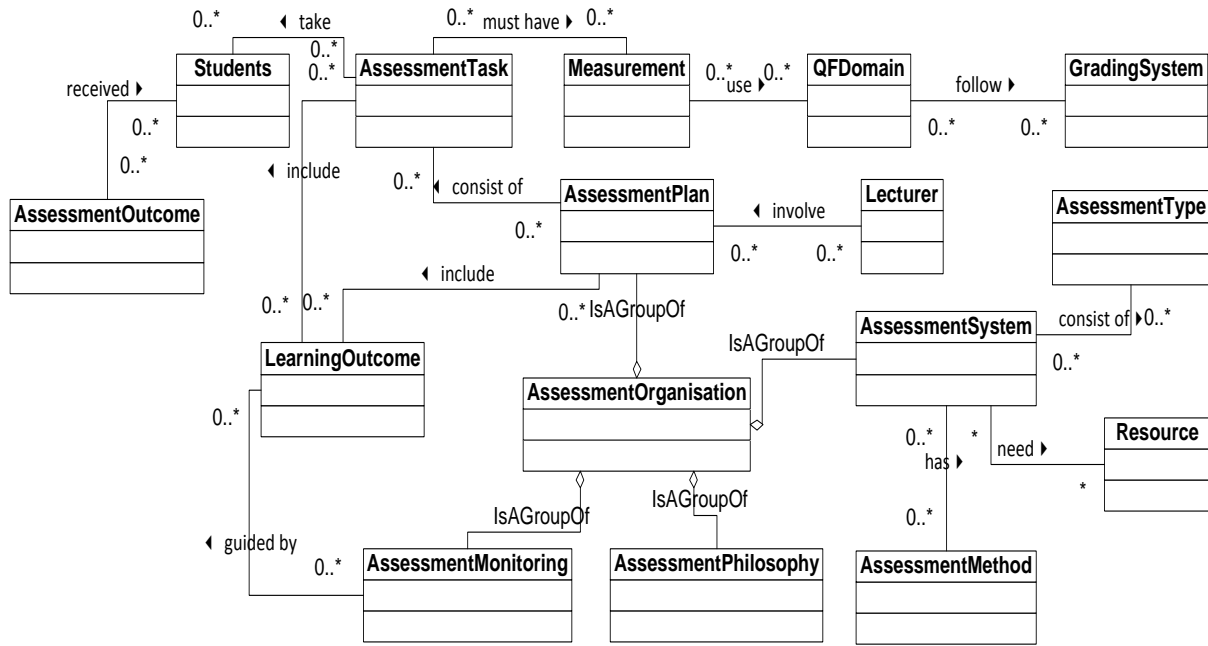
Figure 4: On-going Assessment class of concept (M1 level)
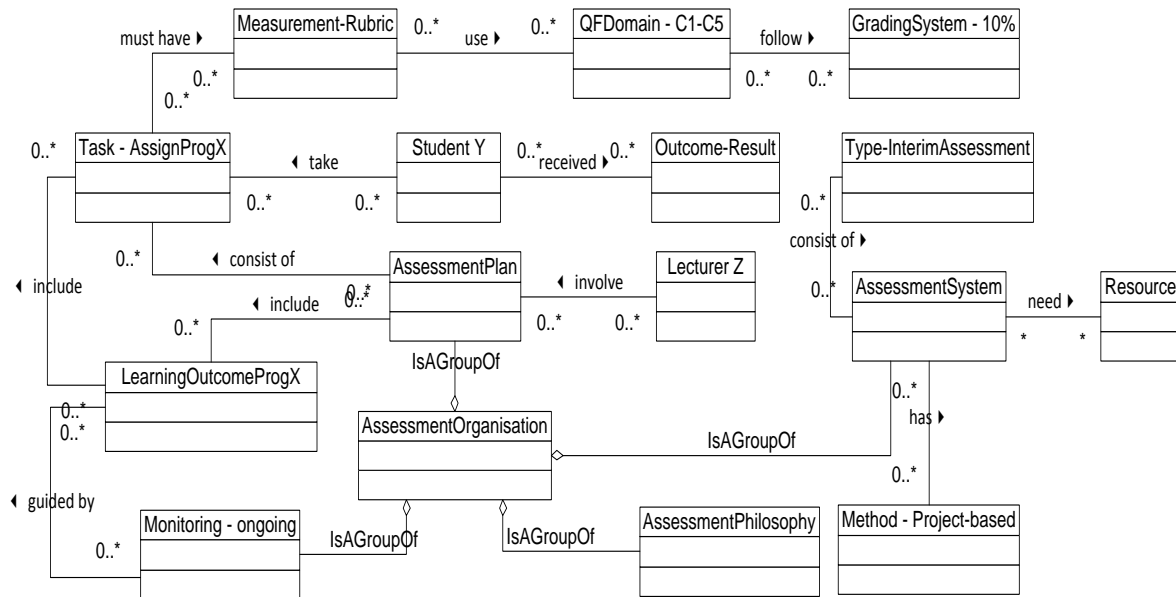

Figure 5: Ongoing Assessment for Programme X at University A (M0 level)

Table 3
Snippet of the Summary for Comparison Models Against Model Validation

Model in V1 set	AQA Support concept in V1 (concept in Assessment Metamodel)		Assessment - AQA Lack of Support	Assessment modification
V1.1 UTM	Assessment principle (*Assessment philosophy*) Assessment method (*Assessment method*) *Course/ programme learning outcome Malaysian Qualification Framework (MQF) domain Monitor student assessment*	Validity, reliability, fairness (*Assessment philosophy*) *Feedback* Documentation (*Resource*) Examination regulations (*Examination*) Best practices (*Assessment Practice*) Authority (*Authority*) *Appeal policy* Examination preparation flow (*Examination*)	Course / programme learning outcome MQF domain Monitor student assessment Assessment Feedback information Appeal policy	Add: "Learning outcome" Add: "QF domain" Add: "Assessment monitoring" Add: "Feedback" Add: "Appeal system"
V1.4 GPKKPP	Assessment type (*Assessment type*) Assessment management (*Assessment system*)	Examination question paper system (*Examination*) *Monitoring quality standard*	Monitoring quality standard concept	Add: "Assessment monitoring"

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