Toward a Maturity Model Development Process for Information Systems *(MMDePSI)*

Mina ELMAALLAM[1], Abdelaziz KRIOUILE[2]

**[1] IMS Team, SIME Lab., ENSIAS, University Mohammed V-Souissi
Rabat, Morocco**

**[2] IMS Team, SIME Lab., ENSIAS, University Mohammed V-Souissi
Rabat, Morocco**

Abstract

Maturity models are significant tools to ensure continuous improvement of systems and activities. They allow self-assessment and provide a means benchmark of these activities in relation to best practices. This article proposes the *MMDePSI* process for the development of new models of maturity in information systems. It begins by presenting the existing methods and approaches. Then he describes the *MMDePSI* process and the corresponding meta-model. Before concluding and presenting prospects of this work, it evaluates the proposed process.

Keywords: *Maturity, Maturity model, Information system, Design science research.*

1. Introduction

Maturity models have become an important topic in both Information Systems (IS) research and practice [1]. However, the methods and theories dedicated to the design of these models are not plentiful and their use is not rather frequent. Although there are many maturity models reported in scientific and non-scientific literature, the act of how to develop a maturity model is for the most part unexplored. Many maturity models simply – and vaguely – build on their, often well-known, predecessors without critical discourse about how appropriate the assumptions are that form the basis of these models [2]. This report is supported by [3]. The latter asserts that there are only few works focusing on the process of designing a model of maturity. In the same order of idea, [4] think that the development of new models, is, in several articles, often grounded in existing ones. The Nolan's [5] stages-of-growth model of the evolution of data processing is a landmark reference of this the later [6]. Model Crosby [7] called QMMG (Quality Management Maturity Grid, is also a good reference in terms of maturity models in the field of quality. This grid contains the "elementary bricks" which are used until today [8] and which the definitions are qualified as being a generic base for the maturity levels.

CMM (Capability Maturity Model), although it is based on the foundations of models and Nolan Crosby, is also with his successor, CMMI (Capability Maturity Model Integration), references in terms of maturity model software development. There are the most dominant foundations of past IS research on maturity models ([4], [9]). The notion of model of maturity owes a big part of its fame to the appearance in 1980 of the CMM [4].

2. Related work

The literature shows the existence of a relatively small number of design approaches maturity models in information system research. The use of the DSR (Design Science Research) is dominant in the development of these approaches.

The literature review will begin with a brief description of the CMMI model given that a large number of studies considered it as the basis for the construction of new models of maturity.

The CMM is a guide for improving practices in development and maintenance of software.

It is composed of key practices that express the best way to produce a good quality of software, with increased productivity and in accordance with the budget and deadlines. CMMI is an extension of the CMM. His creation is a response to the fear of confusion following the emergence of several models whose objectives differ from the original purpose of CMM (Example: SE-CMM (for System Engineering), SA-CMM (for Software Acquisition), IPD-CMM (for Integrated Product Development) and People-CMM, (for management human resources)).

Figure 1 shows a UML modeling of the structural core CMMI

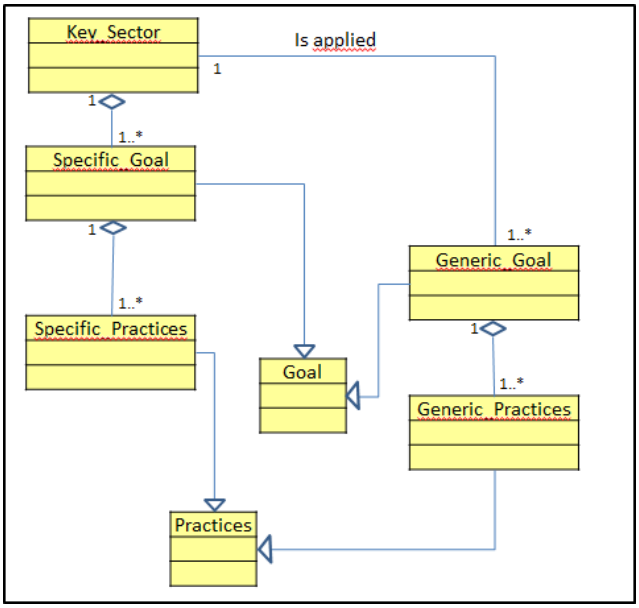

Figure 1 Modelling UML of the structural core of CMMI (Translated of [8])

The structure of CMMI uses the following components [8]:

- Best Practices : According to the OMG "a good practice represents a way which showed its ability or a strategy to realize a task with the aim of reaching a goal which would have a positive impact on the products of the work or on the quality of the involved processes" [8].
  CMMI distinguishes two types of practices: specific and generic [8].
  - Specific practices: specific practices aim to satisfy the purpose of a particular area of process. Two areas of different processes can not contain the same practices [8].
  - Generic practices: generic practices are transverse to all process areas. It helps to ensure that the associated process is effective and reproducible [8].
- Goal: a set of practice can help to achieve a given objective. The latter is also divided into generic and specific goal.
- Key Sector: A key area (PA - Process Area1) is, meanwhile, a particular area on which an organization should focus on to improve its software process [8]. In CMMI, key areas are groupings of objectives [8].

CMMI can be used in two types of representation: continuous and staged. The staged representation expresses the evolution of practices based on a more holistic view or organizational [15]. This change is made according to five levels of maturity: (1) Level 1: "initial" (2) Level 2: "Disciplined" (3) Level 3: "Adjusted" (4) Level 4: "Managed quantitatively" and (5) Level 5: "In optimization". As for the continuous representation, she is interested in the evolution of the process rather than the entire organization. The concept of organizational maturity is replaced by the ability of a process. Indeed, the continuous representation expresses the capacity or ability of each process separately within the organization [10]. This ability is rated on a scale from 0 to 5. The continuous representation allows greater leeway for the organization because it allows him to choose the order of implementation of key sectors [11].

[12] proposes a six-step process for developing a maturity model: (1) defining the scope, (2) design of the model by defining its architecture and deployment process, (3) power of the model by defining "what is to be measured" and "how it can be measured," (4) test the model structure, (5) model deployment, and (6) Maintenance of development and evolution of the model.

[13] build a staged model of maturity, according to a process in three axes: (1) people, (2) processes, and (3) object. This process involves three stages: (1) identification of the problem and motivation, (2) defining objectives, and (3) design and development of the model where the fields are defined, level of maturity and the measuring and deployment.

As for [14] they use the guidelines of design science [15] to define the process of designing a model of maturity. They define the following steps: (1) specification of the problem, (2) comparison of existing solutions, (3) definition of development strategy, (4) development of the model structure, (5) specification of methods of evaluation and deployment, (6) implementation of deployment actions, and (7) evaluation of deployment actions.

[16] provide a guide for the development and implementation "maturity grids for assessing organizational capabilities". The steps for this guide are: (1) planning, (2) development (3) Assessment, and (4) Maintenance.

[17] uses the process DSR proposed by [18] to propose an approach of maturity "focus area model" design. Maturity models based on the Focus Area are originally developed to support the continuous and progressive improvement of software testing ([19], [20]).
A Focus Area is a well-defined coherent subset of a Functional Domain [17]. The total set of focus areas is a partition of the functional domain, i.e. different focus areas are disjoint and the union of all these focus areas is the complete functional domain [17]. In this category of models each focus area has its own number of specific

maturity levels. The overall maturity of an organization is expressed as a combination of the maturity levels of these focus areas. The approach proposed by [17] consists of four steps: (1) Scoping: identify and scope domain, (2) design model: determine focus area, determine capabilities, determine dependencies, position capabilities in matrix, (3) Instrument development: develop assessment instrument and define improvement actions, (4) implementation and exploitation: implement maturity model, improve matrix iteratively and communicate results.
The proposed approach is modeled using the notation presented by [21], which is based on standard UML conventions, with some minor adjustments.
(Figure 2).

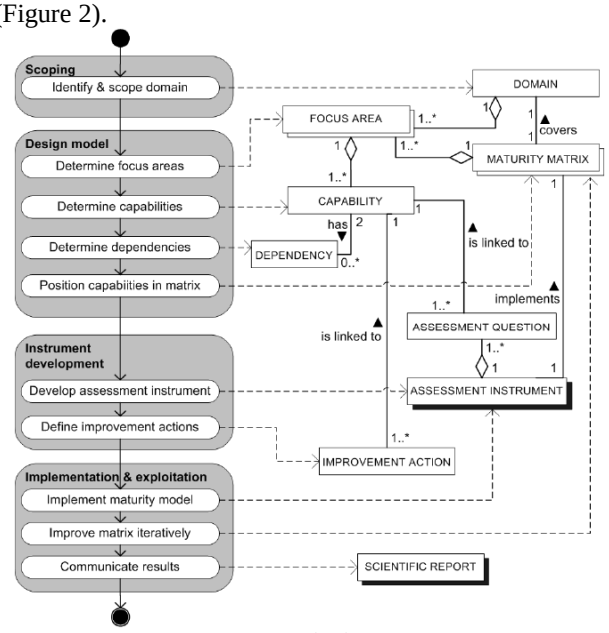

Figure 2: The development method for focus area maturity models [17]

The maturity matrix is the key deliverable of the design phase. It includes capabilities for FA based on their order and dependencies. It provides the level of maturity once the instrument designed and also defines improvement paths. Figure 3 shows an example of this matrix.

Maturity Scale / Focus Area	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Development of architecture		A			B			C						
Use of architecture			A			B				C				
Alignment with business		A				B				C				
Alignment with the development process			A				B		C					
Alignment with operations					A			B			C			
Relationship to the as-is state					A				B					
Roles and responsibilities				A		B					C			
Coordination of developments							A			B				
Monitoring				A		B		C		D				
Quality management								A		B			C	
Maintenance of the architectural process							A		B		C			
Maintenance of architectural deliverables					A			B					C	
Commitment and motivation		A					B		C					
Architectural roles and training				A		B			C			D		
Use of an architectural method				A						B				C
Consultation			A		B				C					
Architectural tools							A				B			C
Budgeting and planning				A							B		C	

Figure 3: Example of FA model maturity matrix

An organization reaches maturity level overall 'l' (o <= l <= max levels defined in matrices) If:

- All the capabilities of all FA located in the column corresponding to the level 'l' are verified,
- All the capabilities of all the FA to the left of the column corresponding to the level 'l' are verified,
- There is at least one capacitor on the right column of the column corresponding to the level 'l' that is unverified.

[3] leads his reflection with the introduction of so-called elements "parameters of decision". It starts from the principle that at each stage of the construction process of the model, the designer needs to decide on some elements before continuing reflection on good foundation. The proposed elements are illustrated in Figure 4.

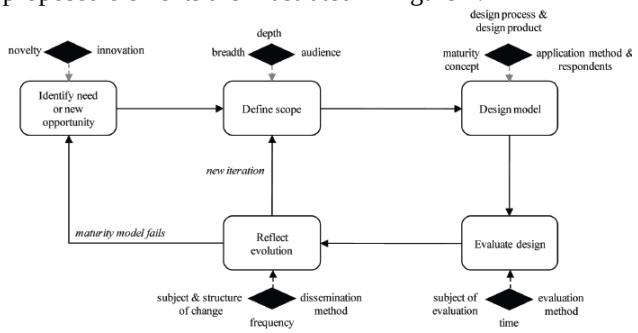

Figure 4: Paramètres de décision [3]

[22] presents the design process maturity models in two perspectives: development and application. The model is seen in the two roles: designer and user. It considers that the full development cycle consists of four phases: (1) scoping, (2) design of the model, (3) evaluation of the design, and (4) development reflexive. It also considers that the successful application of a maturity model normally goes through four phases: (1) model selection, (2) preparation for deployment, (3) application of the model, and (4) implementation of actions remedial.
For each phase of the two perspectives, it offers decision elements necessary for its accomplishment and success.

The process based on initial work of the authors [23] consists of five steps and is based on a combination of both theoretical and empirical aspects. This association appears to each of his first four steps as shown in Figure 5.

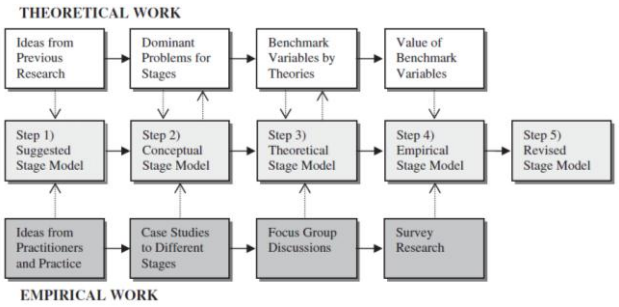

Figure 5: Processus de conception de modèle de maturité [23]

This model consists on five steps [23]:

- Suggested Stage Model. The initial stage model is based on ideas from both research and practice. Research literature has defined evolutionary aspects of the phenomenon, and practitioners perceive different maturity levels for the phenomenon [23].
- Conceptual Stage Model. The number of stages and the contents of stages are developed in an iterative cycle involving dominant problems that seem different at various stages. Case studies are applied to illustrate content characteristics of each stage, as well as significant differences between stages, where preceding and following stages have different kinds of dominant problems [23].
- Theoretical Stage Model. Relevant theories are applied to explain stages, their contents, and the evolution from one stage to the next stage. Benchmark variables are derived from these theories. At the same time, theories and benchmark variables are discussed in focus groups [23].
- Empirical Stage Model. Each benchmark variable is assigned a benchmark value for each stage of growth. A survey is carried out, where stages, evolution, and benchmark values are empirically tested [23].
- Revised Stage Model. Based on the empirical test from survey research, the empirical stage model is revised [23].

The literature review reveals the increasing importance given to the development of maturity models in the IS discipline. However, the proposed approaches are not generic in terms of choice of architecture. There are not sufficiently documented and does not sufficiently support the specific areas to be assessed through the target model.

3. Description of *MMDePSI*

The development of this process is driven by the need for method / unified process for the design of a maturity model. It is also motivated by the desire to address some aspects that represent a lack in existing methods.
The design is based on the study of literature. Both theoretical and practical aspects are taken into account through the studies and proposed approaches for the development of maturity models and case studies or returns on corresponding experiments. It is also based on the requirements proposed by [14]. These requirements are built on the guidelines of design science [15] and described in table 1.

Table 1: Model maturity development requirements [15]

Exigence	Evaluation
R1 – comparison with existing maturity models	The need for the development of a new maturity model must be substantiated by a comparison with existing models.
R2 – Iterative Procedure	Maturity models must be developed iteratively, i. e., step by step.
R3 – Evaluation	All principles and premises for the development of a maturity model, as well as usefulness, quality and effectiveness of the artifact must be evaluated iteratively.
R4 – Multi-methodological Procedure	The development of maturity models employs a variety of research methods, the use of which needs to be well-founded and finely attuned.
R5 – Identification of Problem Relevance	The relevance of the problem solution proposed by the projected maturity model for researchers and/or practitioners must be demonstrated.
R6 – Problem Definition	The prospective application domain of the maturity model, as well as the conditions for its application and the intended benefits, must be determined prior to design.
R7 – Targeted Presentation of Results	The presentation of the maturity model must be targeted with regard to the conditions of its application and the needs of its users.
R8 – Scientific Documentation	The design process of the maturity model needs to be documented in detail, considering each step of the process, the parties involved, the applied methods, and the results.

The figure 6 describes the *MMDePSI* steps.

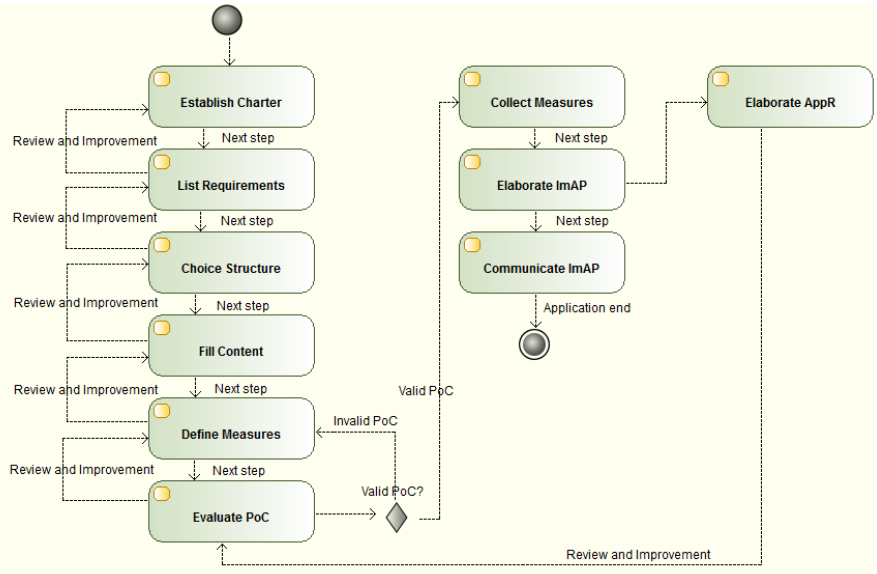

Figure 6: *MMDePSI* steps

The process is divided into three blocks: (1) design, (2) implementation, and (3) continuous improvement.

3.1 Block 1: Design Steps

The first block presents the design stages. There are six stages.

- Establish charter: Charter lists the defining elements of the model: (1) origin of the idea, (2) scope of the model and (3) Purpose of the model.
- List requirements: in this phase are set requirements that must be met to develop the model.
- Select structure: the structure is selected or newly designed according to the need and the predefined requirements. The choice must be justified and documented. Existing structures are: (1) staged (2) continuous or (3) depending on the architecture "Focus Area".

  The staged architecture is adapted to the case where the objective is to assess the overall maturity of the organization in relation to a given discipline. It can be a good choice if the purpose of the evaluation is to benchmark.

  The objective of the continuous architecture is the continuous improvement of the area studied by improving its subdomains. These are evaluated according to predefined levels and generic evolution, called "capacity". These are common to all subdomains. This allows comparing the subdomains and their evolution.

  The third architecture is adopted to assess the maturity of the organization in relation to a given domain through the evaluation of its subdomains. Unlike continuous architecture, capabilities are defined specifically for each subdomain according to its own growth cycle. There are not any more generic but depend on the definition, the characteristics, the objectives and the cycle of growth of the corresponding subdomain. On the other hand, the definition given to the capabilities makes this architecture better adapted to consider their interdependencies.
- Fill the content: the content is defined according to the structure adopted. The proposed process meta-model describes the major elements of existing architectures.
- Define the measurement system: in this step the elements of the measuring system are defined. These elements are
  - (1) The process of measurement: eg questionnaires, interviews,

    (2) Evaluation: the human element is the core of the measurement system. It is essential at this stage to identify the requirements of this element which can be under three aspects: skill, function or attributions, behavioral shutter which can be translated by the motivation, the commitment and the membership to the project of continuous improvement through the evaluation of the maturity. The participation in this exercise must be accepted and should not present an additional work and especially should not be

hidden for the team of evaluation. The communication and the awareness of the team are important. A quiz can be used to measure the adhesion of the team before starting the assessment,

- (3) Measurement tools: these tools support the exploitation of the new maturity model,
- (4) Sources of information: It is important at this stage to define and analyze the sources of information to ensure the reliability of the measurements and results of the evaluation. The measurement system must also take into account the elements depending on contexts of organizations.

- Evaluate MM (PoC: Proof of Concept): The objective of this evaluation is to check whether the model designed meets the requirements specified in step 2:

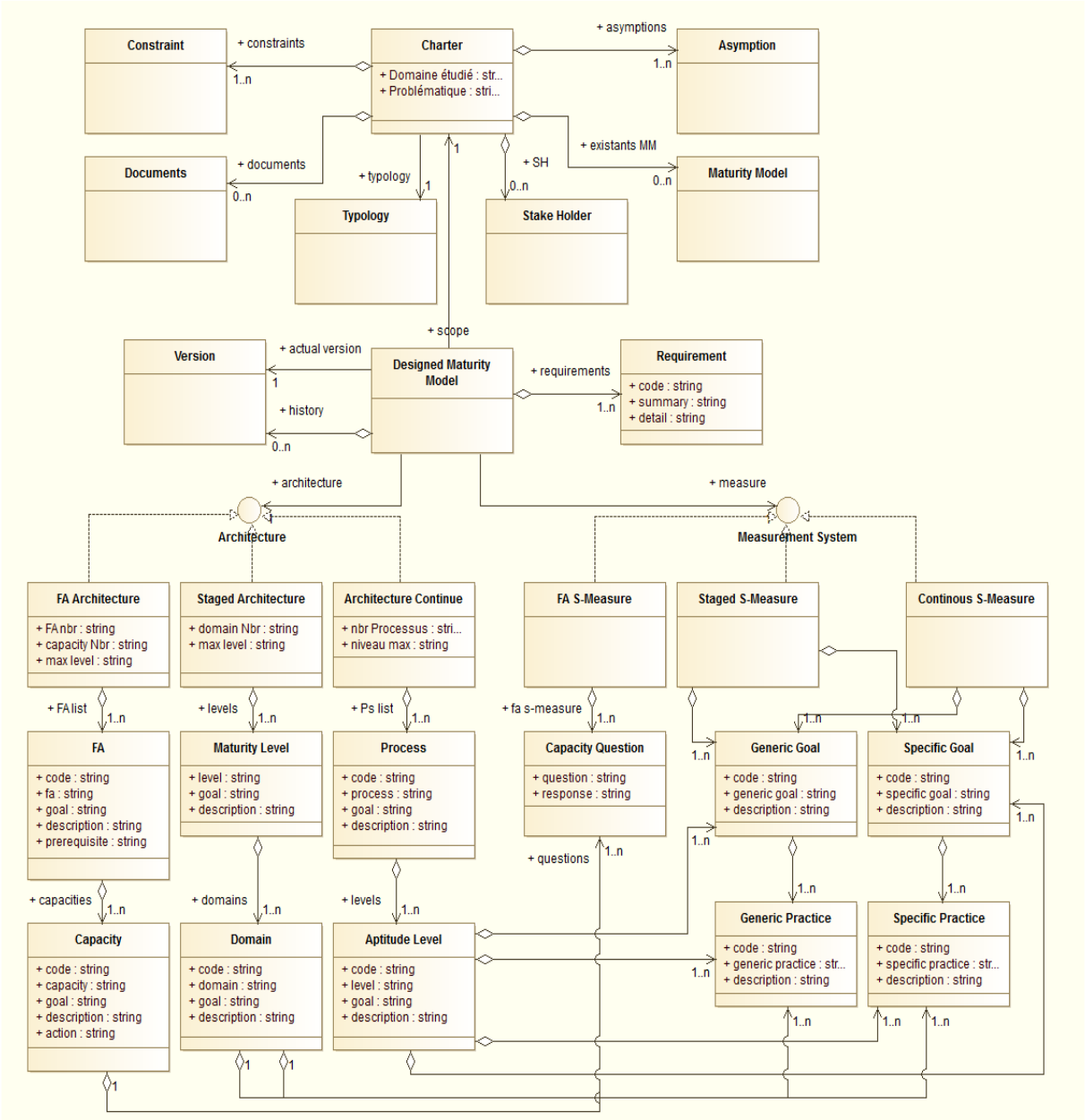

Figure 7: *MMDePSI Meta Model*

"List requirements". The evaluation can be made through the progress of a study case example. If the evaluation is satisfactory, the maturity model developed is implemented. Otherwise, a second iteration is started. The recovery was made from the stage representing the source of the problem.

3.2 Block 2: Implementation

The second block guide the implementation of the maturity model designed. It consists of three steps.

- Prepare the evaluation of the maturity: this phase consists in applying the measurement system. It is a question of instantiating the elements of the latter in particular the constitution of the team of evaluation according to the previously defined requirements. It is also a question of defining the method of implementation of the measurement system. An automation of some or all of the metrics may be considered at this stage to facilitate evaluation.
- Elaborate ImAP (Improvement Action Plan): Once the evaluation made, a list of improvement scenarios is established. These scenarios represent the possible improvement paths. Responsible for the implementation of designed maturity model must select the most optimal path meeting the objectives and constraints of the organization. Optimization algorithms can be used to give more rigorous improvement plan. The optimization of the paths of improvement can require defining the elements needed for calculation of effort of improvement. it can involve in particular the estimation of the cost, the estimation of the work and the impact of implementation of the actions of improvement.
- Communicate the ImAP: it is about the definition of mechanisms and communication plan of the results of evaluation and about the plan of improvement.

3.3 Block 3: Process improvement

The third block is dedicated to improving the process. This block consists of two steps.
The first step is: "Developing the AppR (Application Review)." AppR is used to record the findings and observations from the implementation phase.
The second step is "Defining actions to improve the model." The AppR is an input for improvement process.

4. Meta Model of the *MMDePSI*

To illustrate the various concepts used in the design of the *MMDePSI*, we propose a meta modele described in figure 7.

5. Evaluation of *MMDePSI*

The table below presents an evaluation of the process *MMDePSI* based on the requirements proposed by [15].

Table 2: *MMDePSI Evaluation*

Exigence	Evaluation
R1 – comparison with existing maturity models	This is ensured in the early stages of development of the charter. At this point are studied existing models and the strategy for the development of the new model (new, improved, combination of existing models...)
R2 – Iterative Procedure	The process builds the desired maturity model iteratively. For each phase, a review is carried out. This review may result in an improvement.
R3 – Evaluation	Two evaluations are performed by the proposed process. Phase "Achieving the POC" is an assessment of the design block. "Establishing the BAP" is used to assess the phase of implementation.
R4 – Multi-methodological Procedure	A multitude of method is proposed during the development phases of the model: Literature review, exploratory approach: Quiz, interview, focus group Optimization approach for the definition of improvement paths
R5 – Identification of Problem Relevance	The process allows to develop models of maturity specific and adapted to the studied domains. The relevance and the added value of the developed model is defined at the level of the first stage: define the charter of MM.
R6 – Problem Definition	The problem which has to answer MM is defined in the first stage: define the charter of MM.
R7 – Targeted Presentation of Results	This is ensured by the requirements definition phase.
R8 – Scientific Documentation	Documentation is provided in all phases of the process. The process offers templates and provided the information necessary to document the development of MM.

The process *MMDePSI* complies with the requirements on which it is built, and fills the gap in terms of unified approaches Development Maturity Model.

6. Conclusion and perspectives

The maturity assessment in the various disciplines related to information systems is very important. However, existing methods have limitations such as their lack of genericity, poor documentation and not taking into account the specific characteristics of the areas concerned. The process *MMDePSI* is designed to address these limitations. It proposes a generic approach for the development of new

maturity model information system, which is documented and takes into account the specifics of the organization and discipline involved. The model is based on three blocks: design, implementation and continuous improvement. His assessment is based on criteria developed by [14] and based on the seven lines of the Director DSR [15].

In perspective, a natural *MMDePSI* evaluation is planned through the development of a new maturity model for information system risk management.

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Mina ELMAALLAM received the Engineer of state degree in Software Engineering from ENSIAS in 2000. He is currently a PhD student in the IMS (Models and Systems Engineering) Team of SIME Laboratory at ENSIAS. Her research interests are Information System, Information System Risk Management, and Maturity Model for Information System.

Abdelaziz Kriouile is a full Professor in the Software engineering Department and a member of SI2M Laboratory at National Higher School for Computer Science and Systems Analysis (ENSIAS), Rabat. He is also a Head of the SI3M Formation and Research Unit. His research interests include integration of viewpoints in Object-Oriented Analysis/Design, Service-Oriented Computing, and speech recognition by Markov models. He has directed several Ph.D thesis in the context of Franco-Moroccan collaborations.