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Reengineering the Industrial CMMI

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Abstract
Through this research, I have established general strategy to appraise an organization against a scale of five process maturity levels whilst maintaining a strong mechanics of CMMI. Reengineering of industrial CMMI proposes a novel method for industrial competence ranking of those organizations/companies which are targeting various CMMI levels. This approach uses SCAMPI assessment techniques to rank different organizations that fall below certain level of CMMI model. Furthermore, it adds the trusting factors, i.e., score, reliance and confidence level for an organization's maturity. The advantage of using the proposed model is that an organization can set its objectives to achieve target level of CMMI model, and it could be differentiated from less mature organizations. This technique not only reclassifies the CMMI levels but also exposes various confidence factors.

Keywords: Maturity organization, Capability Maturity Model Integration (CMMI), industrial competence ranking, SCAMPI assessment.

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1. Introduction

Industrial capability of an organization is measured against CMMI model. It is used to appraise an organization against a scale of five process maturity levels. CMMI model is mainly classified into 5 distinct levels i.e. Level 1 through 5, Initial, Managed, Defined, Quantitatively Managed and Optimized respectively. Each level ranks the organization according to its consistency of processes in desire domain. These 5 levels show capability of an organizations or capability maturity level. It offers the integrated procedure for process improvement whilst dropping redundancy, complexity and especially the cost.

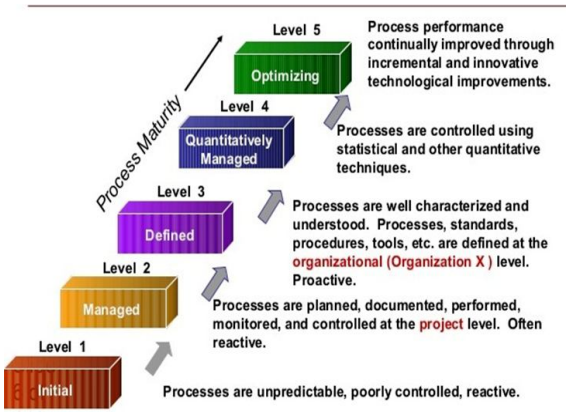

Figure 1: CMMI Staged representation-5 Maturity levels

CMMI or Capability Maturity Model Integration is not only a fine grained system improvement technique that is implemented at a process level but now it befalls training and appraisal programs as well. It's a joint venture of Software Engineering Institute (a subsidiary of ISACA, Carnegie Mellon University or CMU); with industry and the government. While is being administered by SEI.

CMMI models provide guidance for developing or improving processes that meet the business goals of an organization. In U.S. it's an essential part of Government and Department of Defense contracts, particularly in Information and Technology sphere. Software Engineering Institute (SEI, 2008) claims CMMI can be used to guide process improvement across a project, division, or an entire organization. It ensures by helping in:

- Integrating conventionally separate organizational roles
- Lay down process improvement goals and priorities
- Provide support for quality processes and
- Provide a point of reference for assessing existing processes

It can be used as a process maturity evaluating framework. Initially it was only concerned with software industry but with the passage of time become very popular in other domains. Though the CMM was only and directly effectual within the sphere of software but CMMI turn out to be a rebellion to encompass variety of areas. This generality of enhancement in the model makes CMMI enormously conceptual. Thus opened the door for further enhancements and reengineering of the said model. In March 2016, the CMMI Institute was acquired by ISACA.

For a non-technical person capability is the measure of expertise. The expertise or skills are directly proportional to capability level and vice versa.

Country	Number of Appraisals	Maturity Level 1 Reported	Maturity Level 2 Reported	Maturity Level 3 Reported	Maturity Level 4 Reported	Maturity Level 5 Reported	Country	Number of Appraisals	Maturity Level 1 Reported	Maturity Level 2 Reported	Maturity Level 3 Reported	Maturity Level 4 Reported	Maturity Level 5 Reported
Argentina	64		45	12	2	3	Malaysia	96		20	31		5
Australia	32	1	7	5	2	4	Mauritius	10 or fewer					
Austria	10 or fewer						Mexico	57		24	25	3	4
Bahrain	10 or fewer						Morocco	10 or fewer					
Bangladesh	10 or fewer						Nepal	10 or fewer					
Belarus	10 or fewer						Netherlands	10 or fewer					
Belgium	10 or fewer						New Zealand	10 or fewer					
Brazil	106	1	50	42	1	9	Norway	10 or fewer					
Bulgaria	10 or fewer						Pakistan	25	1	18	4		1
Canada	51	1	12	22	5	3	Panama	10 or fewer					
Chile	30		17	10		2	Peru	10 or fewer					
China	745	1	117	540	27	41	Philippines	21		2	11		7
Colombia	22		7	11	1	2	Poland	10 or fewer					
Costa Rica	10 or fewer						Portugal	10 or fewer					
Czech Republic	10 or fewer						Romania	10 or fewer					
Denmark	10 or fewer						Russia	10 or fewer					
Dominican Republic	10 or fewer						Saudi Arabia	10 or fewer					
Egypt	34	1	17	11	2	2	Singapore	19		3	10	1	4
Finland	10 or fewer						Slovakia	10 or fewer					
France	141	4	81	45	1	2	South Africa	10 or fewer					
Germany	64	9	32	11	1	1	Spain	105	1	60	35	2	4
Greece	10 or fewer						Sri Lanka	10 or fewer					
Hong Kong	18		2	11		5	Sweden	10 or fewer					
Hungary	10 or fewer						Switzerland	10 or fewer					
India	409		14	191	24	166	Taiwan	117	1	74	38		2
Indonesia	10 or fewer						Thailand	27		12	13		1
Ireland	10 or fewer						Turkey	14			12		2
Israel	17		3	10		2	Ukraine	10 or fewer					
Italy	31		14	14			United Arab Emirates	10 or fewer					
Japan	267	17	75	121	13	16	United Kingdom	93	3	42	30	1	3
Korea, Republic Of	138	1	47	61	13	7	United States	1272	27	448	462	21	124
Latvia	10 or fewer						Uruguay	10 or fewer					
Lithuania	10 or fewer						Viet Nam	12			9	1	2
Luxembourg	10 or fewer												

Figure 2: A Worldwide ranking of various organizations by SEI

At Level 1 i.e the initial level practices are out of scope. To improve from level 1 to next level; it takes a lot of time and resources. To achieve next level there are several formal process areas need to be practiced accordingly, these areas are further divided into many endorsed activities.

2. CMMI Levels

Below are the key process areas under each level.

1. Initial or Maturity Level 1

i. No Process Area

2. Managed or Maturity Level 2

i. Configuration Management
ii. Measurement and Analysis
iii. Project Monitoring and Control
iv. Project Planning
v. Process and Product Quality Assurance
vi. Requirements Management
vii. Supplier Agreement Management

3. Defined or Maturity Level 3

i. Decision Analysis and Resolution
ii. Integrated Project Management
iii. Organizational Process Definition
iv. Organizational Training
v. Organizational Process Focus
vi. Product Integration
vii. Requirements Development
viii. Risk Management
ix. Technical Solution
x. Validation
xi. Verification

4. Quantitatively Managed or Maturity Level 4

i. Organizational Process Performance
ii. Quantitative Project Management

5. Optimizing or Maturity Level 5

xii. Causal Analysis and Resolution
xiii. Organizational Performance Management

The above levels are strictly defined and are distinct process areas of CMMI levels. For stirring to subsequent level from the prior level an organization has to work through several different process areas. An organization that has worked on many process areas (but not on all), still considered on previous level, though practically it is more capable than the one that doesn't worked even on single process area.

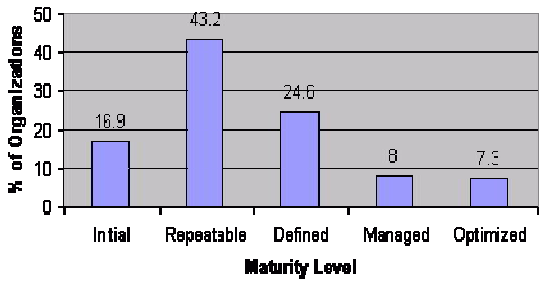

Figure 3: Maturity Level

Organizations with enormous capability difference are still considered on same level, hence not desired anyways. In this paper the said issue is being resolved by Reengineering the Industrial CMMI (Capability Maturity Model Integration) Using SCAMPI (Standard CMMI Appraisal Method for Process Improvement).

3. Proposed Model

Generally client is never interested in development technicalities of the product rather he is concerned about the skills and expertise of the developer's organization. For gigantic size projects customer needs higher CMMI levels, whereas for smaller projects lower levels are also acceptable. Idea behind this research paper is to categorize the difference of maturity and capabilities of organizations working at same level of CMMI, using a well-known technique called SCAMPI. It answers the following question. How to rank different organizations that fall under the same level of CMMI model?

Furthermore, it adds the trusting factors, i.e., Score, Reliance and Confidence level for an organization's capability.

3.1. The SCAMPI

Here we are using an SEI's legendary technique named SCAMPI (Standard CMMI Appraisal Method for Process Improvement). It presents benchmarks for quality scoring to CMMI models. These techniques are not only useful to mark the effectiveness of the current processes but also unveil their limitations. SCAMPI identify the assessment process as consisting of grounding;

- On-site behavior;
- Foundation clarification, conclusion, and ratings;
- Final reporting; and
- Ensuing activities.

The set of credentials related with a meticulous edition of the CMMI incorporates a requirements design called the Appraisal Requirements for CMMI (ARC). ARC lays down 3 levels of rule for appraisals i.e. Class 'A', 'B', and 'C'. The Class 'A' SCAMPIs are accomplished by SEI's official Lead Appraisers who employ the SCAMPI A Method Definition Document (MDD), this rating ranges from Level 1 (lowest) to Level 5 (highest).

4. SCAMPI Assessments

To evaluate CMMI level of an organization CMMI Institute introduced three assessment classes. The class 'A' is more formal and thus results in a complete Capability Maturity Level Rating of an organization, called "*SCAMPI A Assessment*". While class B and class C are not very formal and results in just overview of practices being followed.

4.1. Score

After the 'SCAMPI "A" Assessment' for CMMI Level, score for each process area is calculated. The score is the number of goals achieved against the total number of goals (both specific goals and generic goals). The Process Area Score or simply score is represented in percentage.

Table 1: Process Area Score or simply score

Process Area	Abbreviations	Score
Initial		
No Process Area	NA	
Managed		
Requirements Management	REQM	0-100
Project Planning	PP	0-100
Process and Product Quality Assurance	PPQA	0-100
Configuration Management	CM	0-100
Project Monitoring and Control	PMC	0-100
Measurement and Analysis	MA	0-100
Supplier Agreement Management	SAM	0-100
Defined		
Decision Analysis and Resolution	DAR	0-100
Integrated Project Management	IPM	0-100
Organizational Process Definition	OPD	0-100
Organizational Training	OT	0-100
Organizational Process Focus	OPF	0-100
Product Integration	PI	0-100
Requirements Development	RD	0-100
Risk Management	RSKM	0-100
Technical Solution	TS	0-100
Validation	VAL	0-100
Verification	VER	0-100
Quantitatively Managed		
Organizational Process Performance	OPP	0-100
Quantitative Project Management	QPM	0-100
Optimizing		
Causal Analysis and Resolution	CAR	0-100
Organizational Performance Management	OPM	0-100

4.2. Competence

Nowhere are we going to define the internal capability of an individual CMMI Level using SCAMPI and call it Competence Rank. If an organization is already assessed using SCAMPI 'A' assessment, then it could be re-assessed using SCAMPI B assessment for Competence ranking. To find the Competence ranking for an individual CMMI level we need to know the scoring of each process area. Then we calculate the geometric mean of all the scores, which is 'Competence Rank' for CMMI Level. Competence rank shows the capability of an organization working below certain CMMI level. The introduction of Competence Ranking technique has opened a door to distinguish the higher capability against the lower one, working under same level of CMMI.

- **Targeting level 2**

$$(REQMM \times PP \times PPQA \times CM \times PCM \times MA \times SAM)^{1/7}$$

- **Targeting level 3**

$$(DAR \times IPM \times OPD \times OT \times OPF \times PI \times RD \times RSKM \times TS \times VAL \times VER)^{1/11}$$

- **Targeting level 4**

$$(OPP \times QPM)^{1/2}$$

- **Targeting level 5**

$$(CAR \times OPM)^{1/2}$$

4.3. Confidence Level

In the next step we are going to find the confidence level of an organization. Minimum score of the process area among all processes areas is called the confidence level. It assures that all process areas are working higher than said level and thus increases the confidence of customer.

- **Targeting level 2**

Min (REQMM × PP ×PPQA × CM × PCM × MA× SAM)

- **Targeting level 3**

Min (DAR x IPM x OPD x OT x OPF x PI x RD x RSKM x TS x VAL x VER)

- **Targeting level 4**

Min (OPP x QPM)

- **Targeting level 5**

Min (CAR x OPM)

4.4. RELIANCE

Now we calculate the Standard Deviation (SD or σ "sigma") of the scores of all process areas. This SD is called as reliance of an individual CMMI Level. If reliance is zero, it means that organization is working to improve all the process areas equally. It has gained the same capability and maturity in all process areas. While on the other hand, if it has higher reliance then it means for some process areas it has more capability than other Process areas. Need of this interesting term varies project to project. In some projects higher capability of few PAs is required while in other cases same capability is worthier. Now unlike other factors (i.e Competence, Score and Confidence level) the decision is left to customer. After knowing the other factors he himself will decide whether he needs high or low reliance; as per project's need.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} \qquad (1)$$

5. PROPOSED CLASSIFICATION

To better visualize the concept of above discussion, a general classification of organization's capability (working beneath, certain CMMI's Level) is sketched below. Similarly we may define for the rest of the levels. This is not the final classification but a proposed model to understand the purpose of research. Using this technique we can design many other models depending upon our needs.

The following tables summarize the proposed models.

Table 2. Competence Rank of CMMI Level 4 targeting Level 5

S#	Competence Rank Interval	Confidence Level (equal or greater)	Class
0	100	100	CMMI 5
1	80-100	70	L4A
2	60-80	50	L4B
3	40-60	30	L4C
4	20-40	10	L4D
5	10-20	5	L4E

Table 3. Competence Rank of CMMI Level 3 targeting Level 4

S#	Competence Rank Interval	Confidence Level (equal or greater)	Class
0	100	100	CMMI 4
1	80-100	70	L3A
2	60-80	50	L3B
3	40-60	30	L3C
4	20-40	10	L3D
5	10-20	5	L3E

Table 4. Competence Rank of CMMI Level 2 targeting Level 3

S#	Competence Rank Interval	Confidence Level (equal or greater)	Class
0	100	100	CMMI 3
1	80-100	70	L2A
2	60-80	50	L2B
3	40-60	30	L2C
4	20-40	10	L2D
5	10-20	5	L2E

Table 5. Competence Rank of CMMI Level 1 targeting Level 2

S#	Competence Rank Interval	Confidence Level (equal or greater)	Class
0	100	100	CMMI 2
1	80-100	70	L1A
2	60-80	50	L1B
3	40-60	30	L1C
4	20-40	10	L1D
5	10-20	5	L1E

6. Conclusion

Despite the vast research in evaluating the capability and maturity of various organizations, still there exist vast uncategorized holes. The overall image that emerges from the literature is not enough to conquer this dilemma. This reengineering reveals the innovative assessment through CMMI manifesto. This paper introduces the interesting capability factors i.e Score, Competence Rank, Confidence Level and the Reliance. These factors are used to make a distinction between higher and lower capabilities of organizations, practicing below certain CMMI Level. Thus provides more details about an organization than CMMI model. This way customer is more flexible and contented for selecting development organization, without being endured the depth of mechanics. A new and more incredible aspect of this approach is to redesign the number of different classification models for different purposes. Like the one we drew above in which capabilities are classified into five classes' i.e A – E depending upon performed practices of CMMI Levels. For a common person we can call Expertise or skills classification model of different organizations or Expertise Level of an organization.

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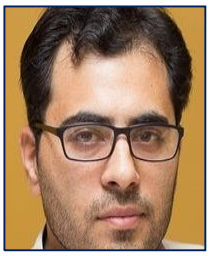

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