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# A Contingency Based Capability Maturity Model for Developing Countries

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## Abstract

Although various methodologies exist for evaluating quality standards of software development firms, they usually pertain to medium or large sized firms in developed countries. In particular, there is no formal methodology for assessing the maturity level of software firms in developing countries. This paper introduces an approach, which uses a blend of the guidelines from International Standards Organization (ISO) and the Software Engineering Institute's Capability Maturity Model (CMM). A measurement instrument was devised to analyze the complete life cycle of a software project in particular and the firm's software process maturity in general. A pilot study was conducted to improve and validate this method. Finally, in depth studies of eight Pakistani software firms were conducted. Besides studying all the dimensions of the firms in general, one sample project for each firm was specified, and analyzed comprehensively.

It was realized that in a typical developing country such as Pakistan, ISO and CMM alone are not sufficient for evaluating any software firm; the market environment along with the client background also need to be considered. Different assessment techniques are needed for smaller firms (more oriented towards Project Management and Technology Injection) as opposed to larger firms (geared towards Process Management and Organizational Issues). Similarly, the domestic/foreign nature of the firms or of their clients, also effects the way they perform. This leads to the development of a Contingency Based Capability Maturity Model (CBCMM), which utilizes the relevant aspects of the methodologies of CMM and ISO.

## 1.0 Introduction

Various methodologies exist for evaluating quality standards of medium or large sized software development firms in developed countries. However, these methodologies are often inappropriate for software firms in developing countries, or small sized firms in developed countries. Two well known quality standards are ISO 9000 of the International Standards Organization, and the Capability Maturity Model (CMM) of the Software Engineering Institute. Several firms have already obtained ISO 9000 certification, while several others have assessed themselves on the CMM's scale of 1 to 5. Various comparative studies have been conducted which apply both these methodologies simultaneously. (Tan 1996) presents a gloomy picture for software developers of Asia, since in general they failed to meet international quality standards, but it suggests that such developers have certain advantages in selling their software globally. According to Tan (1996):

*"If Singapore, a more developed country in the Asia Pacific with a highly educated workforce and a more sophisticated approach to management techniques has still not quite met the basic requirements for software quality (as defined in the ISO standards and the CMM), then, would it be easy for other developing countries like India, China, the Philippines, or even the other Asian Tigers to institute and achieve software quality?"*

Our hypothesis is that when it comes to software development for the local market in developing countries, then ISO and CMM models fail to predict quality level of the firm. And when it comes to software development in developing countries for the purpose of export to the developed countries, then the quality and maturity level of the client forces the firm to improve its quality standards. Hence a third element is needed for assessing the quality standards, particularly in the developing countries, and that is the position and environment of the market. Just like it is the demand which drives supply,

it is the market requirements which pull up the quality of the software. This phenomenon is also applicable in the developed countries, as (Pijl 1996) refers to the situation in Netherlands:

*"A growing number of software developers use standards as a basis for their quality systems ... [such as] ISO 9000 and CMM... It is concluded that both standards are useful but there is a growing need for more situation specific standards... Quality certificates can give a wrong impression of the real capabilities of an organization... In the longer term, standards and certificates will have to take into account the diversity that exists in the real world. Standards and certificates will have to be attuned to this... It is concluded that both standards are useful but there is a growing need for more situation specific standards."*

It is this "situation specific" dimension, which our methodology injects into the ISO 9000 and CMM models. To test this methodology, a measurement instrument was devised to analyze the complete life cycle of a software project in particular and the firm's software process maturity in general. This instrument consisted of a interview based questionnaire.

As part of the validation process, this instrument was tested on a pilot project on a representative software development firm in Pakistan. Based on the results of the pilot study, modifications were made in the instrument. The revised instrument was then used to study eight firms. On average, there were 4 interviews per firm, each interview ranging from 2-4 hours.

Data analysis showed that different quality assessment techniques are needed for smaller firms (more oriented towards Project Management and Technology Injection) as opposed to larger firms (geared towards Process Management and Organizational Issues). Similarly, different approach is needed to evaluate those firms which have foreign ownership or which deal with overseas clients, as opposed to local firms with domestic clients. These findings led to the development of a detailed Contingency Based Capability Maturity Model, which can be applicable to most of the developing countries.

## **2.0 Related Work**

Posavac and Carey (1994) describe in detail *Program Evaluation and Assessment* for any type of organization in general. International Standards Organization, ISO, has published special standards for software developers (Schmauch 1994) which might be used as guidelines to evaluate software development firms. Pakistan Standards Institution has come up with guidelines for the application of their own standards, PS: 3001, for the development, supply and maintenance of software, specific to Pakistan. (Zultner 1991) has tried to modify the Deming's approach of success in Japanese firms, towards Software Quality. However, none of these touch the technical aspects of project management in software development. Such technical criteria are partly covered by the Capability Maturity Model, CMM, of the Software Engineering Institute, SEI (Paulk 1995) (Olson 1989). However, the CMM is geared towards very large organizations, especially in developed countries. There have been studies which compare the ISO 9001 and CMM (Paulk 1994) but these do not integrate the two and pay less emphasis on small and medium sized firms. Some studies have tried to describe the Total Quality Management (TQM) aspect (Dunn 1994) but emphasized solely the quality of the product, as opposed to the complete life cycle of product development.

When we initiated the study, to our knowledge, it was the first attempt to functionally integrate the ISO 9000 and CMM into one comprehensive model. However, literature searches revealed that others, such as Pijl (1996) Gibson (1996) and Tan (1996) are already working on similar lines. However, our work is the first one which provides a solid theoretical model based on empirical results, which can be used for a spectrum of firm-sizes, ranging from *Very Small* to *Medium*, but not *Very Large*, in a universal domain, more specifically for developing countries, but easily extendible to developed ones (once the necessary studies have been conducted in their environments).

## **3.0 Research Methodology**

The integral part of our study is our measurement instrument, which is a 16 page questionnaire designed to be filled by the interviewer during the course of the interview. We conducted a pilot study on representative medium-sized software firm to validate and refine the questionnaire. In this study, we interviewed 12 employees, ranging from Data Operators to the Managing Director.

We also sought advice from two experts in the fields of Measurements, Software Engineering, and MIS.

This was followed by a second detailed study, in which we interviewed 9 employees. Together, these 21 interviews on the first two firms were held over a span of 6 months, from September 1995 to February 1996.

These were followed by a series of six studies on firms which had offices in the cities of Lahore, Karachi, and the twin cities of Rawalpindi/Islamabad. A survey of 389 software firms in Pakistan showed that these four cities account for 86.5% of the total Pakistani software firms (DataLine 1996).

### 3.1 Measurement Instrument

The *Questionnaire* (Hassan 1996) seeks information on the following:

- Software Firm Background
- Client Background
- Project Background
- Process Description

It is the last category which is most important for Case-studies involving software development projects. For studying this category, we unified the two frameworks of ISO-9000 and SEI CMM. These two frameworks represent different aspects of the software development project, which are given below:

1: ISO-9000 Framework: This represents the managerial aspect of the project. The relevant personnel to question for this framework are from the Management.

2: SEI CMM Framework: This represents the technical aspect of the project. The relevant personnel to question for this framework include the Designers, the Project Manager, the Programmers and the Testing staff.

Both of these frameworks are further divided into two parts each. These are:

(a): Life Cycle: The questionnaire follows the life cycle chronologically going through each phase of the life cycle, from feasibility/contract to maintenance.

(b): Tasks: There are certain items (Tasks) which fall beyond the life cycle, since they apply either to more than one phase or they are not project specific.

ISO framework has 6 phases in its life cycle and 6 tasks. SEI framework has 4 phases in its life cycle and 4 tasks. These are listed in Table I. Phase 4 of the ISO life cycle (Implementation) represents the entire SEI life cycle.

**Table I: Phases and Tasks in the two frameworks**

ISO-9000 Framework	SEI Framework
<b>Life Cycle</b>	
Phase 1: Feasibility Proposal	Phase 1: Design
Phase 2: R&S, Contract	Phase 2: Coding
Phase 3: Development Planning	Phase 3: Code Reviews
Phase 4: Implementation	Phase 4: Testing
Phase 5: Delivery & Installation	
Phase 6: Maintenance	
<b>Tasks</b>	
Task 1: Quality Assurance	Task 1: Process Group
Task 2: Tracking	Task 2: Measurement
Task 3: Subcontract Management	Task 3: Estimation
Task 4: Configuration Management	Task 4: Code Reuse Libraries
Task 5: Training	
Task 6: Customer Coordination	

#### 4.0 Data from Pilot Projects

The data obtained from the interviews indicated several areas of similarities and differences between various firm and no two firms were exactly similar-there was always some variable which placed every two firms into a different category. We traced the sources of these differentiating variables, and found that they were almost always linked to the market position.

It was realized that the practices and processes followed by each firm depended upon the placement of the firm in the environment. Figure 1 shows the model which we eventually came up with. All the firms have something common due to the fact that they all belong to the Root Node # 00; they belong to the Pakistan's software industry and have common infrastructural and communication difficulties, draw labor from the same market pool, and receive similar benefits from the government, such as any tax breaks. Yet when we studied the practices and processes of the firms, we found that they could be clearly separated into two distinct groups: those which were subsidiaries of some foreign company (labeled as firms S1 through S3), and those which were purely indigenous (S4-S8).

But the five local firms (S4-S8) had also sharp differences leading to two such categories. However, the criteria for bifurcation was not related to the nature of the firm, but to the nature of its clients - a direct consequence of the market position. We found that the firm with the foreign clients had a sharp contrast with those firms which had local clientele.

A further division was observed between the firms with foreign clients that had just one client (typically the parent company), versus those who had multiple clients. On the same lines, another bifurcation was made between the firms with local clients which catered to small clients, versus those who dealt with large organizations. Finally, the latter category (large local clients) was divided into public and private sector clients.

The binary tree in Figure 1 shows that each bifurcation leads to a new level in the tree with two child nodes. Whereas each node is different than its sibling node, the two have something in common, which can be found in their parent node.

Our hypothesis is that the level of quality should not be absolute, but relative to the placement of the firm in this binary tree. Hence a firm with large clients or foreign clients would not necessarily have a higher quality level than one with small local clients. To gauge their quality level, we need to see what processes are required in that particular node, and what processes are *not* required since they might create unnecessary overheads. It is this '*not*' which differentiates our model from CMM or ISO 9000 frameworks, because these frameworks apply all the quality standards uniformly to all types of firms. Our model would allow us to compare the quality levels of only those firms which are within the same node.

This also implies that each node has its own unique position in the tree, and unlike other models, a transition to some other node does not signify any change in the quality standards but a changed market focus. Instead, a firm should improve within its own node, by following those quality processes which are essential to that specific node, (ignoring those processes which are not essential). It is possible for a firm to operate in two different nodes (such as S7), and in that case during evaluation, its different projects should be considered separately. Likewise, it is also possible for some Node to have no firms at all. In Figure 1, such nodes are marked with a cross (X) (instead of the firm label) and indicate that in the regional context currently there are no firms which fall under the category specified by that node.

Rest of this section picks up each of these nodes (labeled Node # 0 through Node # 44), and discusses the processes followed and the characteristics demonstrated by the firms representing those nodes. Based on data obtained, suggestions are made as to which processes might be deemed to be essential, and which might be irrelevant for each node.

Root Node # 00: Pakistan's Software Firms: The Pakistani software industry is in its adolescence, and faces several problems. These problems along with suggestions on overcoming them are documented in (Hassan 1996). The entire industry faces an acute shortage of skilled manpower. It is engulfed with weak economic conditions, where investors are unwilling to invest and banks are unwilling to offer financing. There are infrastructure constraints, such as power shortages,

telecommunication problems, lack of high speed data communications and absence of intellectual rights laws. The clients are also at a low maturity level, and often do not appreciate the advantages in purchasing slightly expensive software. Although these problems are common to all the software firms operating in this domain, yet those firms which are subsidiaries of some foreign multinational company are strikingly different than the local firms.

Node # 11: Foreign Firms operating in Pakistan: These firms start with a big advantage with vast capital resources at their disposal, and access to well defined quality processes from their parent companies overseas. This gives them a head start in maturity level, since the experience gained by their parent companies in various different countries and environments is partially transferred to them. However, these firms still have to customize themselves to the local environment.

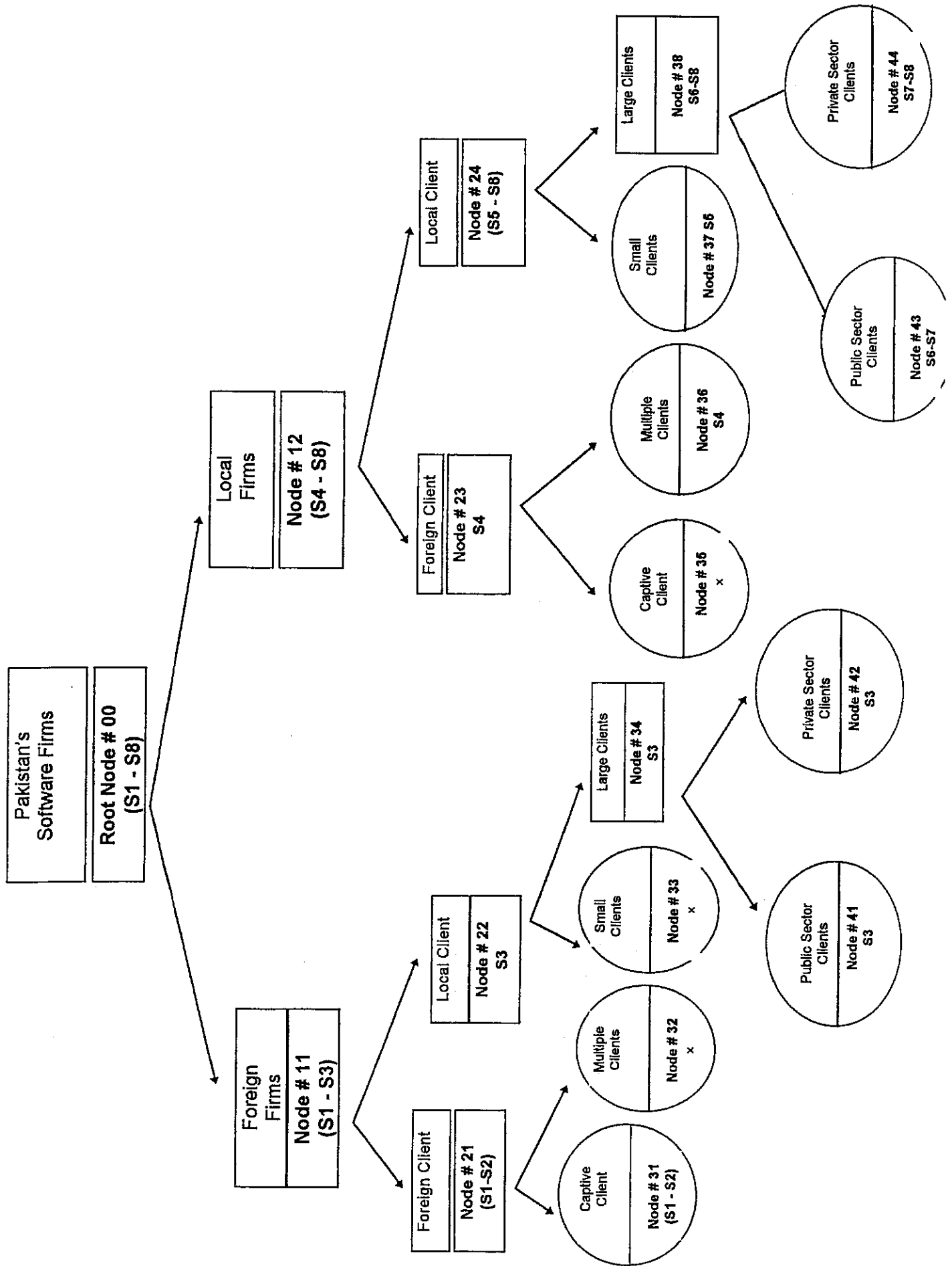
Our study revealed that such firms had extensive quality assurance policies and software engineering processes, but often these items were only followed superficially. For example, all the three firms studied in this category (S1-S3) had separate testing teams for product verification, as opposed to all the four local firms with local clients (S5-S8), that had no separate testing teams. Even S3, which dealt with local clients, had a separate testing team, because it happened to follow guidelines of its parent company overseas. Yet S3 was different in some aspects than S1 and S2, because S3 had local clients while the latter two exported software to foreign clients (explained in Nodes #21 and #22).

Node # 12: Local Firms of Pakistan: Local firms of Pakistan can easily be clustered together into two distinct groups. One group resembles Node # 11 (foreign firms) even though it itself consists of local firms. This is the group which though local, develops software for export purposes. Firm S4 falls in this category. This group has far superior processes and quality standards than the other group which caters to local clients only. In fact, our study of S4 showed that prior to joining export sector, when this firm competed in the local market, its processes were not defined, and some of its projects were miserable failures. However, after entering the export market, the maturity level of the foreign clients provided guidance, and hence forced improvement in its processes. Once this firm adopted these processes, it developed such a nature that it was no longer possible for it to work for domestic clients. This firm failed to compete with other local competitors for small scale projects of the domestic clients, such as inventory control, payroll and accountancy programs, simply because it had very high costs to sustain the expensive processes it had developed. Since these processes were designed for firms in the developed countries, they were not necessarily applicable for the local industry. Hence other local firms which did not adapt such processes could also deliver the same software with similar quality, at a much lower cost. Local industry is full of success stories, achieved without any of these processes. This means that working for foreign clients (see Node #23) requires different quality standards than those needed while working for foreign clients (see Node #24).

Node # 21: Foreign Firms operating in Pakistan, with Foreign Clients: When a foreign firm opens an office in some developing country, it may do so to capture local market or to get software developed for itself at a cheap labor cost. It is currently not happening that some foreign firm opens an office in Pakistan, and that office begins exporting software back to foreign clients other than its parent company. Hence Node # 32 is empty, since it refers to this scenario. The only possibility is then that the foreign client would be the parent company itself, which uses the Pakistani office as an in-house software development department. This implies that the Pakistani office has a captive client, which is its parent company abroad, which is discussed in Node # 31.

Our study revealed that often the parent company abroad eventually sells the software developed in their Pakistani offices to other foreign clients. However, the Pakistani offices are forbidden to interact with such foreign clients. Hence for all practical

Figure 1. Illustration of the Contingency Model



purposes, the Pakistani offices have only one client, which is their own parent company.

Node # 22: Foreign Firms operating in Pakistan, with Local Clients: Foreign firms do not open offices in Pakistan simply to develop software for local clients. However, often they have to develop software to complement the sale of their other items, such as hardware. S3 is such a firm, which is mainly an international hardware firm, but which also undertakes software development projects to promote its hardware sales. In Pakistan, such firms do not operate on small clients due to lower profit margins as compared to the heavy overheads of the processes which are imposed by the foreign parent company. Hence Node # 33 is empty. Large clients are discussed in Node # 34.

Node # 23: Local Firms of Pakistan, having Foreign Clients: Although our study has only one firm in this category, our past studies (Hassan 1996) have data on other similar firms in this category, and hence we can draw some generalizations. Such firms which originate in the local industry typically spend a couple of years in the domestic market, establishing themselves by forming proper teams, before going in for the export business. These firms often face initial difficulties in getting projects from abroad because initially they have processes more suitable for local clients. Foreign clients are usually skeptical in awarding them projects, because of lack of their experience and lack of mutual trust. This is why often only those firms succeed in exporting software which are run by Pakistanis who have either worked abroad and developed contacts there, or who open front offices abroad.

Our studies show that such firms initially work for only one foreign client, and try to consolidate themselves by transitioning their processes from local ones to foreign ones. Once they have completed a couple of successful projects, they feel more comfortable in chasing some other clients also. This means that for a brief period, these firms fall under the category of Node # 35, in which they have a captive client, or are rather held captive by one client. Gradually they transition to Node # 36, by increasing their clientele. These two nodes are discussed below.

Node # 24: Local Firms of Pakistan, having Local Clients: Majority of the firms of Pakistan probably fall under this category. This is why in our sample of eight firms, we have four from this group.

Our study shows that these firms have much in common. They begin a project with poor requirements and specifications and conduct design in an ad hoc manner. Design reviews are usually either skipped or are very informal. Estimation is very subjective, and there are several revisions in the cost and time estimates as the project progresses. The development plans are equally dynamic, and the team structure undergoes random employee shifting. There is absolutely no formal testing mechanism, and often the developers are the sole persons who test the product. The concept of code reviews is often unheard of. There is a lack of Quality Assurance personnel and Marketing Teams, and typically the upper management has no training of Project Management, Finance, Accounts, etc., but consist of computer scientists or engineer-turned-computer scientists. There are no formal design methodologies, and no life cycle models are followed. There is usually no concept of formal coordination with the customer, or with the subcontractor if applicable. We had the opportunity of studying firms which had serious conflicts with their clients as well as with their sub-contractors. We also encountered a case where a firm secretly subcontracted the work without informing the client. Finally, there are serious misunderstandings over the issue of maintenance. This happens when the contract fails to mention anything about the maintenance procedure, and the responsibility of the supplier in the maintenance process. Usually the customer is so computer illiterate that once s/he sees the product, s/he completely modifies the original requirements and specifications. Suppliers often yield in to such enhancement or modification requests in order to gain trust of the customer. But it is not the suppliers which are at the receiving end of the hardships. Often the customers are left with huge monetary losses and delays of time without obtaining any worthwhile software package.

Our data, however, shows that the problem is not so critical and several of the above mentioned items are not even needed if the project is very small. However, these problems do become serious when the client is medium or large. Hence we divided these firms into two groups, based on the sizes of their clients.



Firms with small clients are discussed in Node # 37 while those with large clients are discussed in Node # 38.

Node # 31: Foreign Firms operating in Pakistan, with Foreign Captive Clients: We studied two firms, S1 and S2, which fall under this category. Whereas S1 is chiefly a telecommunications and hardware firm and has been in Pakistan for a long period, S2 is purely a software firm and is in its first year. What was interesting to observe was that unlike other local firms, which in their first year have ad hoc and random processes, S2 initiated its work directly with a well defined process. This is because the process was already being carried out in the parent company overseas. Of course S2 had initial problems in acquiring this process, since it started afresh without any Quality Assurance or other teams. It still has not found a qualified Quality Assurance Manager. Nevertheless, S2 has an advantage of heavy financial backing, something which new local firms do not have. Hence S2 could afford to hire best programmers available in the market at 50-70% higher salaries than their competitors. It could also, for the first 4-6 months, work on dummy projects just for the sake of learning, something which local new companies cannot afford. S1 and S2 not only had well defined processes, but they also had a tendency to follow those processes, as opposed to S3, which also imported a defined process from abroad, but which had difficulties in following it since it was dealing with local clients. However, S1 and S2 had foreign clients, from whom they had received the processes in the first place, they followed quality standards and processes. S1 will soon become the first software firm in Pakistan to get ISO 9000 certification. This is because its mother company and sister companies in other countries, already have such a certification, and these companies deal with European and other clients which often require ISO 9000 certification. However, here we get a good example of the differences between the ISO 9000 framework and the CMM framework. Although S1 is now satisfying most of the ISO 9000 quality criteria, it lags behind in some key areas of CMM, such as Estimation and Measurements. This is not to state that S1 does not have formal estimation and measurement procedures; in fact they do. However, all the measurements and estimations revolve around the concept of person-hours per task, rather than on more technical items such as the program size or the functionality points.

Node # 32: Foreign Firms operating in Pakistan, with Multiple Foreign Clients: As discussed in the parent Node # 21, it is currently not happening that some foreign firm opens an office in Pakistan, and that office begins exporting software back to foreign clients other than its parent company. Hence Node # 32 is empty.

Node # 33: Foreign Firms operating in Pakistan, with Small Local Clients: As discussed in the parent Node # 22, whenever foreign firms develop software for local clients, they do not do so for small. Hence this node is empty.

Node # 34: Foreign Firms operating in Pakistan, with Large Local Clients: Large clients may be from Private or Public Sectors. These two sectors are inherently quite different than each other, and require completely different processes to be followed. This is why they are divided into two nodes, # 41 and # 42(discussed below.) Note that Public projects in Pakistan are always large, and hence there is currently no scope for Small Sized Public Clients.

Node # 35: Local Firms of Pakistan, having Captive Foreign Clients: As discussed in parent Node # 23, this node is only a temporary phase, after which firms migrate to multiple clientele. As soon as firms have established a foothold in the foreign market, they go after other clients. This is why this node is empty.

Node # 36: Local Firms of Pakistan, having Multiple Foreign Clients: This node probably describes the behavior (and this number is growing) of a vast majority of Indian software firms. Firm S4 is following these foot steps, and currently has three foreign clients. These clients have not only helped this firm adopt well defined processes, such as having proper life cycle models and test data generation processes, but have also forced it acquire latest technologies. In fact, S4 used to be a specialist in relational databases working under Oracle environment, but had to adapt an Object Oriented methodology

because of the client. The client even sent trainers to Pakistan to teach the employees of this firm the usage of this methodology. It also frequently sent senior management personnel to check the processes of S4, and as a result of this, it asked S4 to form a separate Quality Assurance/Testing team. This client also had high expectations in the level of Requirements and Specification documents, and Design documents and hence S4 had to carefully prepare these documents, something which it might not have done in the local market. This firm has hired a Ph.D. Software Engineer to lead its Software Process Group.

Does this mean that S4 has better quality standards than other local firms which operate in the local market? The answer again is that we cannot compare one node to some other node. For example, S4 does not require the process of Code Reviews or Peer Code Inspections, although its Software Process Group knows that they would be useful. Similarly, the configuration management plan is not properly documented or followed, code reused libraries are not properly stored, and the estimation process is still more subjective than objective. All these drawbacks show that S4 would not rate higher than somewhere between levels 2 and 3 of the CMM scale. Hence it still is a long way from optimizing its quality standards. Hence some CMM level 2 organization in some other node might be better than S4 simply because it might be meeting the quality prerequisites of that particular market.

Node # 37: Local Firms of Pakistan, having Small Local Clients: This category covers firms which use small sized projects involving one or two programmers for single user machines. Hence Firms hire small local software developers to develop packages specially customized to their needs as standard packages may not cater to their specific requirements of the local environment.

To remove the misconception that such simple projects have poor quality, let us give the example of one of the firms we studied. S5 was asked to develop a software package for a pharmaceutical company, which could control the inventory and payrolls, and also generate some receipts and reports. The pharmaceutical firm had a small staff of about 10 persons, and owned only one micro-computer (386). The project was to be done in Fox Pro on single user IBM-PC , and was estimated to take one to two programmers about 3 months of work. S5 was hired due to personal contacts with the customer, and it successfully completed the project. Of course, the estimates were wrong, and it actually took almost twice as much time (six months), but the client was happy since the product was not required immediately. What mattered to the client more was that a representative of the supplier was always accessible during and after the development for any complains or suggestions, and that the cost was low. The client was not too fond of read user manuals, and hence asked for a special tutorial, which was promptly arranged. According to the Chief Executive of S5, the success of the project can be gauged simply by observing that the client happily uses the package daily for all office work. In such cases, an expensive project from some large or foreign firm would not have served the purpose. This is not to say that such small firms need not improve: in fact, probably the majority of the failures in software projects occur in this category. But what we propose is that such a node needs its own quality evaluation methods, different than other nodes which consist of larger firms.

Node # 38: Local Firms of Pakistan, having Large Local Clients

This node can also be divided into two categories: firms with public sector clients (see Node # 43), and firms with private sector clients (see Node # 44). As we shall see below, the difference in these two categories is not only in the type of the projects, but also in the way the projects are acquired and they way they are executed. Since several of these characteristics are common to Nodes # 41 and 42 ( public and private sector clients for foreign firms).

Node # 41: Foreign Firms operating in Pakistan, with Large Public Sector Local Clients:

Currently we have data from only one foreign firm, S3, which operates in local market. Since firms which fall in this category are primarily non-software firms, they use software to promote hardware sales. S3 employs the same technique, except that it often uses some subcontractor to do the main software development work. In some cases it uses its own software developers also, but generally for

larger projects, it subleases the coding and low level design. High level design, Requirements and Specifications, along with product verification and testing are done by S3 itself.

Our study shows that S3 uses the processes and quality standards given to it from its parent company. However, because of the nature of the local market, it does not entirely follow these standards. In fact, when it subleases the coding and low level design work, it does not require the sub-contractor to follow the same standards. Since the sub-contractor is always a local firm, its own standards are not so well defined.

Public Sector projects in Pakistan are not only large, but they also have several complications red tapism, security measures, bureaucratic delays and bottlenecks. Further, public organizations do not trust small software developers, and prefer to go for big names, such as those of foreign firms. Public organizations have greater financial resources compared to their private counterparts, and are more likely to use a foreign firm. This is why over the past few years, such public organizations have developed a relationship based on trust with some selected large (local or foreign) software developers, and they prefer to reassign new projects to those tested firms again. In return, these firms have also developed an understanding of the complications in the public sector, and rather than complain about them (as several small developers do), they find ways to overcome or circumvent them.

Our study has also shown that the public sector clients are least concerned about the quality of the product. As long as the product is functionally complete, they are content. However, they are so poor in defining their own requirements and specifications that their list of functionality is never complete, and they always keep on requesting for further enhancements in the product once the Beta release has been made. The software developers are to be equally blamed for in this process if they had originally acted as the consultant in drawing the requirements and specifications. Our studies show that foreign firms working in local public market (e.g. S3) do a better job in defining such requirements than their competitive local firms working in local public market (e.g. S6 or S7). Again, this edge is obtained because of the better processes imported from abroad.

Node # 42: Foreign Firms operating in Pakistan, with Large Private Sector Local Clients: As discussed in Nodes # 22 and 34, S3 is the only example in our study which develops software for local industry (large clients only). Just like S3 did in public sector projects, it also subcontracts the work in the private sector projects. Private sector is more strict with its monetary policies.

Node # 43: Local Firms of Pakistan, having Large Public Sector Local Clients: Firms S6 and S7 fall in this category. Whereas S6 is an experienced firm, S7 is a new entrant with only a 3-4 year experience. S6 is famous for securing public sector projects because of contacts and relationships developed with government organizations over the past 15 years. However, S7 used personal contacts in the government to quickly grab a large public project. In either case, the requirements and specifications were documented, but not satisfying the criteria of ISO 9000, and the actual contract was only a two page document.

Both these firms faced bureaucratic delays and bottlenecks, which are a trade mark of public sector in Pakistan (see Node # 41 also). However, whereas S6 used its past experience to manage a handsome profit out of the project, S7 went into deficit. Primary reason for going into deficit was wrong estimation of time and cost. S7 complained that public sector employees were not genuinely interested in computerization, and deliberately concealed information at the requirements and specifications stage. Now that S7 has gone in loss, it expects to make money out of maintenance services. Since there is no maintenance contract, and since S7 keeps the ownership of the source code, it plans on charging high maintenance costs for each customer request after the completion of the project.

Typically public sector organizations in Pakistan have been famous for using mini-frames with COBOL language, as developing environment. In particular, S6 has specialized in this environment. Since several MIS employees of the public sector are familiar only with COBOL, they often require the developer to use

the same. One other reason which public sector firms give in favor of using this old platform is that it would be compatible (and eventually linked) with the same platforms used in other related government departments.

Node # 44: Local Firms of Pakistan, having Large Private Sector Local Clients: Firms in this category are typically those which have the resources to undertake big projects, but do not have contacts or relationships in the public sector. Such firms come from a diverse background, and often they haphazardly accept any project offered to them and end up working on too many projects without making significant profit in any. They usually spend their profits on expanding and buying new hardware. They believe that this initial expansion with low profits in the short term will help them in the long run. However, usually they expand themselves to such an extent that during the periods of crunch, they find it difficult even to sustain their employees, get frustrated with the local market, and begin effort for export. Those successful in finding some foreign customer move to Node # 35.

However, these firms are at a disadvantage because although they are in a different category with limited financial resources than the foreign firms (better reputation), they have to compete with the same firms in terms of finding skilled manpower. Similarly, government concessions, such as Tax relief in exports or duty relief in imports help the foreign firms (or local firms with foreign clients), a) who have the resources to go through the related Government red-tape more than the local ones.

## **5.0 Discussion**

The above data and discussion has clearly indicates the need to take a contingency based approach to a software firms capabilities. It is also clear that the key dimensions of contingency are market considerations (local, foreign, public, private, large, small), organisation characteristics (local or foreign, for example) and environmental issues (business conditions, infrastructure, for example).

Figure 2 illustrates the key dimensions that determine this contingency situation. We propose that the technical and managerial considerations captured in the CMM and ISO approach need to be adjusted based on the contingency (organisation, environment and market situation) (see Figure 3). This contingency based capability maturity model (CBCMM) requires formulation of different specific standards for each sub-category of firms (the nodes in our earlier discussion). Once we have completed more extensive analysis of our data we plan to formulate more detailed guidelines for this customization of standards.

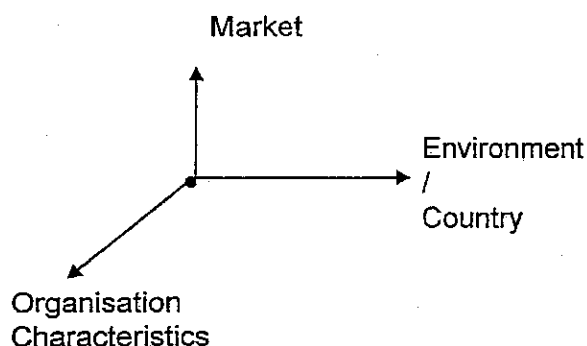


FIGURE 2. Main Dimensions of Contingency

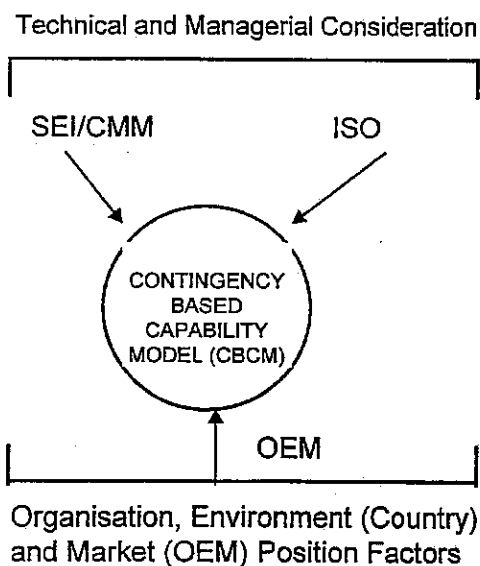


FIGURE 3. Components of CBCMM

### 6.0 Conclusion

We propose that different assessment techniques are needed for smaller firms (more oriented towards Project Management and Technology Injection) as opposed to larger firms (geared towards Process Management and Organizational Issues). It would be unfair to degrade a small firm just because it does not invest in the Process Management issues, though it might be very efficient in its own specialized field of Technology. Our results suggest that such a small specialized firm might be better off without the over-heads which it might incur due to the implementation of Process Management and Organizational Issues.

Hence we recommend that for quality evaluation, a Contingency Model is needed, which uses the necessary aspects of SEI's CMM, ISO 9000 and the contingency factors (see Figure 3). In the next phase of our study we plan to develop the specific CBCMMs for the situations identified in this paper (the nodes in Figure 1). Such a troika will be more helpful in assessing the maturity level of firms in the settings of a developing country, or in the environment of small sized industries in the developed countries. We recommend that studies on small sized firms be conducted in developed countries, and further data on other developing countries be also obtained, to test, validate and refine our model.

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