SOFTWARE TESTING

Interview Questions

S. Koirala & S. Sheikh

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SOFTWARE TESTING
Interview Questions

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This book is printed on acid-free paper.

S. Koirala & S. Sheikh, Software Testing *Interview Questions*
ISBN: 978-1-934015-24-7
ISBN: 978-0-7637-8297-9 (e)
8480

Library of Congress Cataloging-in-Publication Data
Koirala, Shivprasad.
Software testing interview questions / Shivprasad Koirala, Sham Sheikh.
p. cm.
ISBN 978-1-934015-24-7 (softcover)
1. Electronic data processing–Examinations, questions, etc 2. Computer software–Testing. I. Sheikh, Sham. II. Title.
QA76.28.K635 2008
005.1'4–dc22

2008022567

8 9 0 4 3 2 1

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What's on the CD

The CD contains all that you need for software testing:

- Sample resumes which can help you improve your own resume.
- testcomplete512demo setup is a software automation tool. In the automation chapter we explain this tool. You can get the latest update for this automated testing tool from http://www.automatedqa.com/downloads/testcomplete/index.asp
- Estimation TPA sheet.
- Free estimation PDF book.

About this book

- As the name suggests "Software Testing Interview Questions," is mainly meant for new testers as well as professionals who are looking for opportunities in the software testing field.
- Other than software testing basics, this book also covers software processes and interview questions (i.e., Six Sigma and CMMI) which are important from SQA point of view. SQA is a position which every tester eventually wants to reach on a senior level.
- This book also goes one step farther and covers software estimation and includes topics such as function points and TPA analysis.
- Automation testing is one of the most covered sections during software testing interviews. It is covered in this book using testing software.
- From a senior level point of view metrics form an important part of the software testing interviews. A complete chapter is dedicated to it which covers the most frequently used metrics such as DRE, spoilage, phage, defect density, and so on.
- During software testing interviews the quality of a tester is judged by the various testing techniques previously used. This book has dedicated a complete chapter to complicated concepts such as Boundary Value Analysis (BVA), equivalence, exploratory, random/monkey testing, and pair-wise, orthogonal, and decision tables.
- This book also covers non-technical aspects such as resume creating, salary negotiations, and points to be remembered (why do want to leave the organization?, where do you see yourself in 3 years, and so on) during the process.
- With the book we also have an accompanying CD which has a test complete software testing tool setup, free software estimation PDF book, interview rating sheet, and more.
- With the CD we have also provided an interview rating sheet which can be used to judge for yourself to what extent you are ready for software testing interviews.
- On the CD we have also provided a sample resume which can help prepare your resume.

ORGANIZATIONAL HIERARCHY

It's very important during the interview to be clear about what position you are targeting. Depending on the position you are targeting the interviewer will ask you specific questions. For example, if you are looking for a project manager testing position you will be asked around 20% technical questions and 80% management questions.

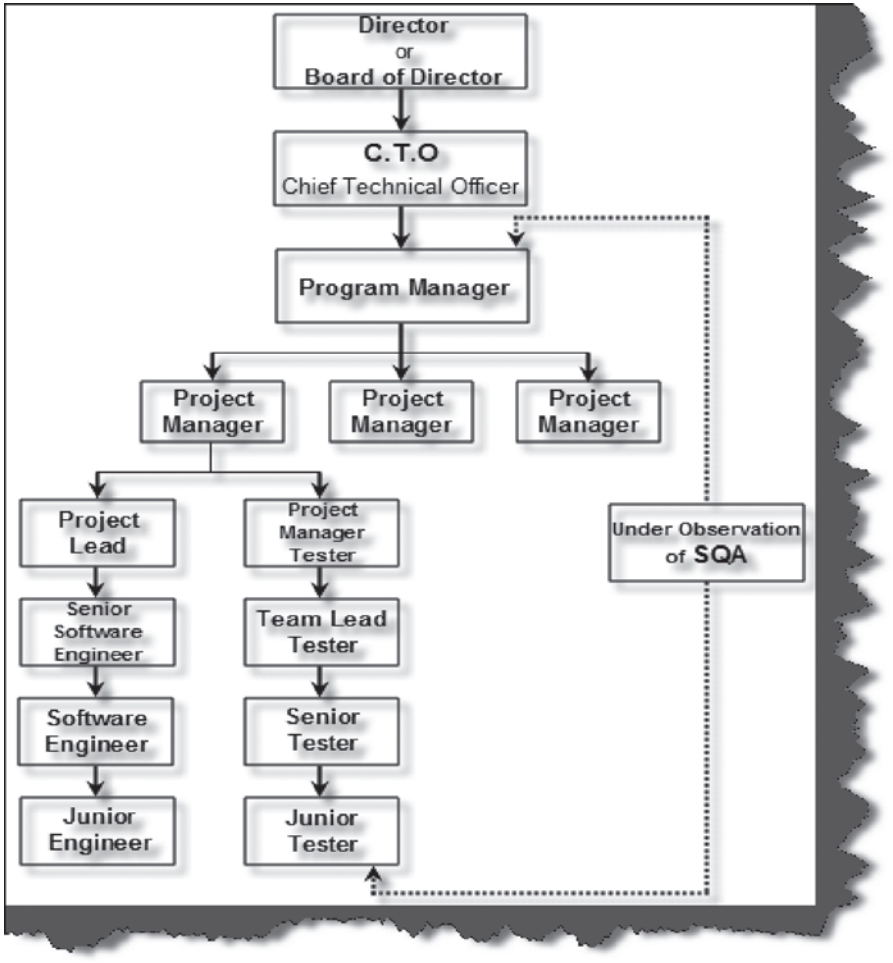


FIGURE 1 **Organizational hierarchy**

Note: In small software houses and mid-scale software companies there are times when they expect a program manager to be very technical. But in big software houses the situation is very different; interviews are conducted according to position.

Figure 1 shows the general hierarchy across most IT companies.

Note: There are many small and medium software companies which do not follow this hierarchy and have their own adhoc way of defining positions in the company.

An employer is looking for a suitable candidate and a candidate is looking for a better career. Normally in interviews the employer is very clear about what type of candidate he is looking for. But 90% of the time the candidate is not clear about the position he is looking for. How many times has it happened to you that you have given a whole interview and when you mentioned the position you were looking for you get this answer, "we are not hiring for that position?" So be clear about the position you are looking for right from the start of the interview.

There are basically two teams in a software organization: project teams and quality teams. Project teams are those who execute the project and quality teams are comprised of testers and SQA. The quality team looks after the quality part of the project. Director and CTO are on the top of the hierarchy of the company. The main role of the director is to handle finances; he is responsible of all happenings in the company. The CTO's (chief technical officer) main role is to have a bird's eye view of technical as well as management operations in the project. He is closely involved with the director in reporting, budgeting, and people management across the organization. The program manager comes below the CTO and is mostly involved in interacting with the project managers to see to higher level day-to-day operations in every project. The program manager normally does not interact directly with the developers or testers (serious scenarios are an exception); he only takes daily reports and metrics from project managers and monitors the health of the project. Now

let's look at both project and quality team hierarchies. The following are the number of years of experience according to position for the projects team:

- Junior engineers are especially new and work under software engineers.
- Software engineers have around 1 to 2 years of experience. Interviewers expect software engineers to be technically at a medium level.
- Senior software engineers have around 2 to 4 years of experience. Interviewers expect them to technically be very strong.
- Project leads handle the majority of technical aspects of the project and should have around 4 to 8 years of experience. They are also indirect architects of the project. Interviewers expect them to be technically strong and in terms of architecture to be decent. Interviewers also expect them to have people management skills.
- Project managers are expected to be around 40% technically strong and should have experience above 10 years. But they are more interviewed from the aspect of project management, client interaction, people management, proposal preparation, etc. So now judge where you stand, and where you want to go.

The quality hierarchy for various reasons comes under the project manager of the project. Let's start from the bottom of the hierarchy:

- **Junior tester:** junior testers normally have 1 to 2 years of experience or are entry level.Their main task is executing test procedures prepared by seniors.
- **Senior tester:** senior testers generally have 2 to 4 years of experience and are expected to know how to prepare test plans. They are also aware of various metrics and testing techniques which help them to communicate project health. But the main expectation from a senior tester is that he should independently prepare test plans based on the requirement documents.
- **Team lead tester:** team lead testers mainly help and guide the senior testers. They are primarily involved in deciding the

testing strategy, what kind of automation tool used, etc. They also act as a bridge between the project manager and the other team members.

- **Project test manager:** the main job of a project test manager is to collect accurate metrics and report them to the project manager. He is also responsible for interacting with SQA to give updates on the quality of the project. They are also involved in the requirement phase.
- **SQA:** If you are starting your career as a tester then you would surely aim to become an SQA leader somewhere down the line. The main job of SQA is to define the quality standard of the organization and to ensure that every project follows the quality process.

RESUME PREPARATION GUIDELINES

Note: The first impression is the last impression.

A sample resume is provided in the "Sample Resume" folder on the CD.

Even before the interviewer meets you he will meet your resume. The interviewer looking at your resume is 20% of the interview happening without you even knowing it. With this in mind the following checklist should be considered:

- Use plain text when you are sending resumes through email. For instance, if you sent your resume using Microsoft Word and the interviewer is using Linux, he will never be able to read your resume.
- Attaching a cover letter really impresses and makes you look traditionally formal. Yes, even if you are sending your CV through email send a cover letter.

The following should be included in your resume:

- Start with an objective or summary, for instance:
  - Worked as a senior tester for more than 4 years. Implemented testing automation in projects.
  - Followed the industry's best practices and adhered and implemented processes, which enhanced the quality of technical delivery.
  - Pledge to deliver the best technical solutions to the industry.
- Specify your core strengths at the start of your resume so the interviewer can decide quickly if you are eligible for the position.

For example:

- Looked after SQA and testing department independently.
- Played a major role in software testing automation.
- Worked extensively in software testing planning and estimation.
- Well-versed with the CMMI process and followed it extensively in projects.
- Looking forward to work as an SQA or in a senior manager position. (This is also a good place to specify your objective or position, which makes it clear to the interviewer that he should call you for an interview.)

For instance, if you are looking for a senior position specify it explicitly: 'looking for a senior position.' Any kind of certification such as CSTE, etc., you should make visible in this section.

- Once you have specified briefly your goals and what you have done it's time to specify what type of technology you have worked with. For instance, BVA, automated QA, processes (Six Sigma, CMMI), TPA analysis, etc.
- After that you can give a run through of your experience company-wise, that is, what company you have worked with, year/month joined and year/month left. This will give an overview to the interviewer of what type of companies you have associated yourself with. Now it's time to mention all the

projects you have worked on untill now. It is best to start in descending order, that is, from your current project backward.

For every project include these things:

- Project name/client name (It's sometimes unethical to mention a client's name; I leave it to the readers.)
- Number of team members.
- Time span of the project.
- Tools, languages, and technology used to complete the project.
- Brief summary of the project. Senior people who have much experience tend to increase their CV by putting in summaries for all projects. It is best for them to just put descriptions of the first three projects in descending order and the rest they can offer verbally during the interview.
- Finally, include your education and personal details.
- If working in a foreign country, remember your passport number.
- Your resume should not be more than 4 to 5 pages.
- Do not mention your salary in your CV. You can talk about it during the interview.
- When you are writing summaries of projects make them effective by using verbs such as managed a team of 5 members, architected the project from start to finish, etc.
- Make 4 to 5 copies of your resume as you will need them.

SALARY NEGOTIATION

Here are some points:

- What is the salary trend? Do some research and have some kind of baseline in mind. What is the salary trend based on number of years of experience? Discuss this with your friends.
- Let the employer first make the salary offer. Try to delay the salary discussion untill the end.
- If you are asked your expectations come with a figure a little high and say negotiable. Remember never say negotiable on

a number you have aimed for; HR guys will always bring it down. Negotiate on AIMED SALARY + something extra.
- The normal trend is to look at your current salary and add a little to it so that they can pull you in. Do your homework and be firm about what you want.
- Do not be harsh during salary negotiations.
- It's good to aim high, but at the same time, be realistic.
- Some companies have hidden costs attached to salaries. Clarify rather than be surprised.
- Many companies add extra performance compensation in your base salary which can be surprising at times. Ask for a detailed breakdown.
- Talk with the employer about the frequency of raises.
- Get everything in writing and, look it over with a cool head. Is the offer worth leaving your current employer?
- Do not forget: once you have the job in hand you can come back to your current employer for negotiation.
- The best negotiation ground is not the new company where you are going but the old company which you are leaving. So once you have an offer in hand get back to your old employer and show them the offer and then make your next move.
- Remember somethings are worth more than money: **JOB SATISFACTION**. So whatever you negotiate, if you think you can get more, go for it.

INTERVIEW RATING SHEET

On the CD we have provided an interview rating Excel spreadsheet. This sheet will help you by providing insight about how ready you are for software testing, JAVA, .NET, or SQL server interviews. In the spreadsheet there are nine sections:

- Guidelines
- JAVA
- JAVA results
- .NET
- .NET results

- SQL server
- SQL server results
- Software testing
- Software testing results

The guidelines sheet defines the guidelines for the ratings. For every question you can give a 1 to 5 rating. Ratings are based on the following guidelines:

- 0-You have no knowledge of the question.
- 1-You know only the definition.
- 2-You know the concept but don't have in-depth knowledge of the subject.
- 3-You know the concept and have partial knowledge of the concept.
- 4-You know the concept and have in-depth knowledge of the subject.
- 5- You are an expert in this area.

The remaining eight sections are questions and results. For instance, we have a software testing section and a software testing results section. The software testing section will take in the rating inputs for every question and software testing results will show the output. The same holds true for the .NET, JAVA, and SQL server sections.

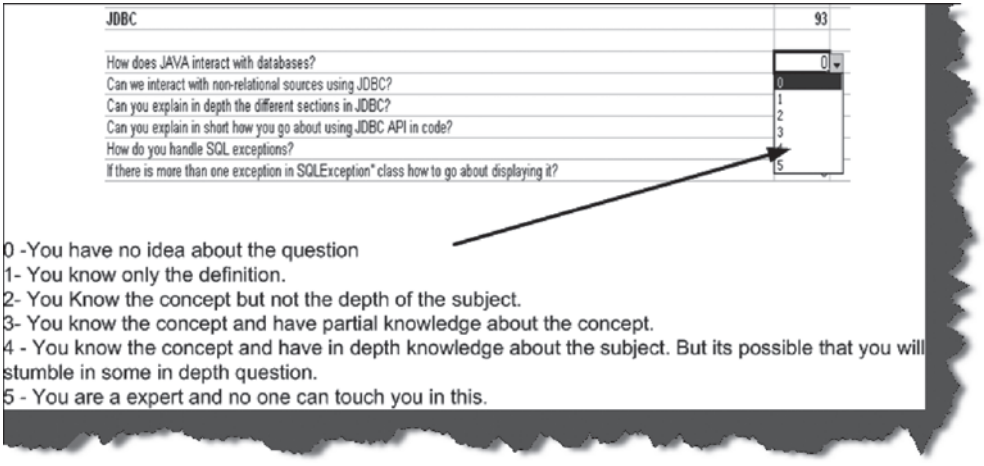


FIGURE 2 **Choose rating**

For every question you need to select ratings. So go through every question and see how much you know. You do not have anyone to govern you but you do have to clear the interview so answer honestly and know your results beforehand.

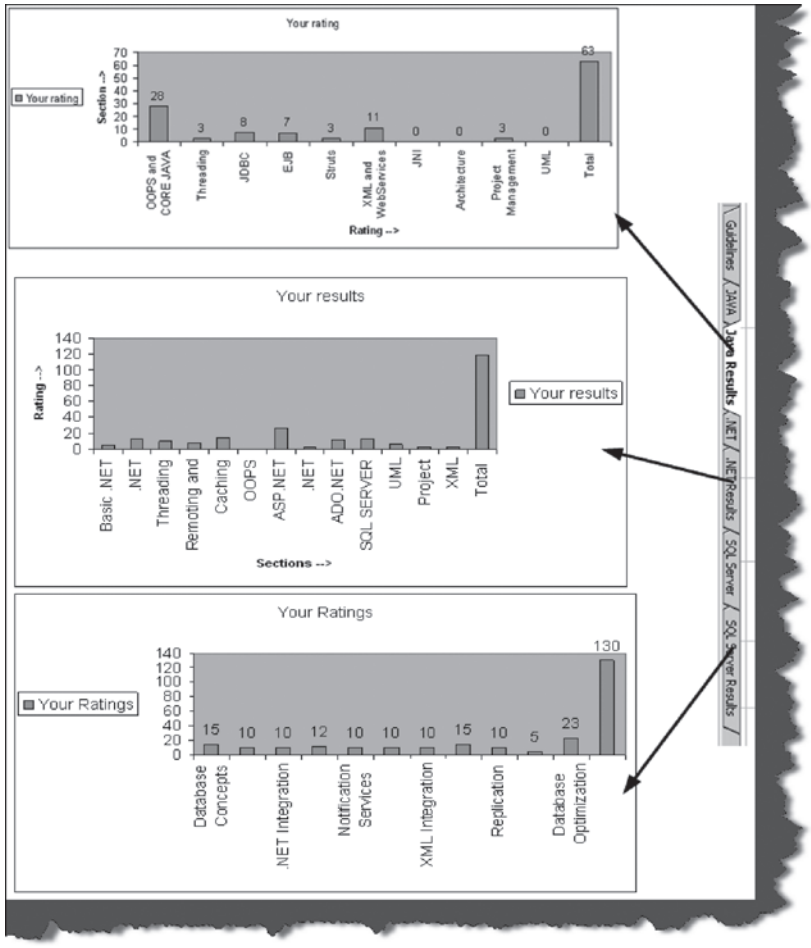


FIGURE 3 **Overall rating values**

The figure shows how you have performed in every category and your overall rating.

COMMON QUESTIONS ASKED DURING INTERVIEWS

- One of the first questions asked during an interview is "Can you tell me something about yourself?"
- Can you describe yourself and some of your achievements?
- Why do you want to leave your current company?
- Where do you see yourself in three years?
- How well do you rate yourself in software testing, on a scale of one to ten?
- Are you looking for onsite opportunities?
- Why have you changed jobs so many times? (Prepare a decent answer; do not blame companies and individuals).
- Have you worked with software automation?
- What do you know about our company?
- Can you describe the best project you have worked on?
- Do you work on Saturday and Sunday?
- What is the biggest team size you have worked with?
- Can you describe your most recent project?
- How much time will you need to join our organization?
- What certifications do you have?
- What motivates you?
- Which type of job gives you the greatest satisfaction?
- What type of environment are you looking for?
- Do you have experience in software testing project management?
- Do you like to work on a team or as an individual?
- Describe the best project manager you have worked with.
- Why should I hire you?
- Have you ever been fired or forced to resign?
- Can you explain some important points that you have learned from your past projects?
- Have you worked on some unsuccessful projects, if yes can you explain why the project failed?
- Will you be comfortable with location changes?

How to Read This Book

The book provides some legends that will make your reading more effective. Every question has simple tags which mark the rating of the questions.

These ratings are given by the author and vary according to particular companies and individuals. The questions all categorized as follows:

(B) Basic Questions: These are fundamental questions and should be answered. Example: Can you explain unit testing? People stumbling on this question will rarely pass software testing interviews.

(I) Intermediate Questions: These are mid-level questions and will be expected to be answered if you are looking for a higher position in the company.

(A) Advanced Questions: These are advanced level questions which are expected when the interviewer is looking for a specialist in the field.

Note: While reading you will come across "Note" sections which highlight special points.

Contents

Chapter 1

Software Testing Basics

(B) IN WHICH SOFTWARE LIFE CYCLE PHASE DOES TESTING OCCUR?

OR

(B) CAN YOU EXPLAIN THE PDCA CYCLE AND WHERE TESTING FITS IN?

Software testing is an important part of the software development process. In normal software development there are four important steps, also referred to, in short, as the PDCA (Plan, Do, Check, Act) cycle.

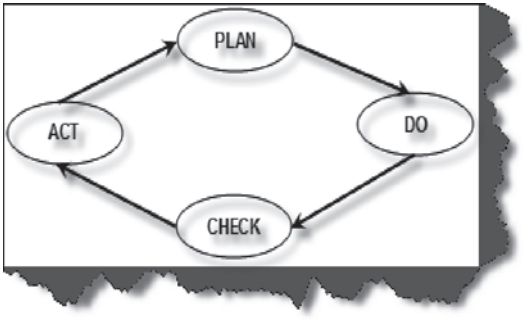


FIGURE 4 **PDCA cycle**

Let's review the four steps in detail.

1) **Plan:** Define the goal and the plan for achieving that goal.
2) **Do/Execute:** Depending on the plan strategy decided during the plan stage we do execution accordingly in this phase.
3) **Check:** Check/Test to ensure that we are moving according to plan and are getting the desired results.
4) **Act:** During the check cycle, if any issues are there, then we take appropriate action accordingly and revise our plan again.

So now to answer our question, where does testing fit in….you guessed it, the check part of the cycle. So developers and other stakeholders of the project do the "planning and building," while testers do the check part of the cycle.

(B) WHAT IS THE DIFFERENCE BETWEEN WHITE BOX, BLACK BOX, AND GRAY BOX TESTING?

Black box testing is a testing strategy based solely on requirements and specifications. Black box testing requires no knowledge of internal paths, structures, or implementation of the software being tested.

White box testing is a testing strategy based on internal paths, code structures, and implementation of the software being tested. White box testing generally requires detailed programming skills.

There is one more type of testing called *gray box* testing. In this we look into the "box" being tested just long enough to understand how it has been implemented. Then we close up the box and use our knowledge to choose more effective black box tests.

The following figure shows how both types of testers view an accounting application during testing. Black box testers view the basic accounting application. While during white box testing the tester knows the internal structure of the application. In most scenarios white box testing is done by developers as they know the internals of the application. In black box testing we check the overall functionality of the application while in white box testing we do code reviews, view the architecture, remove bad code practices, and do component level testing.

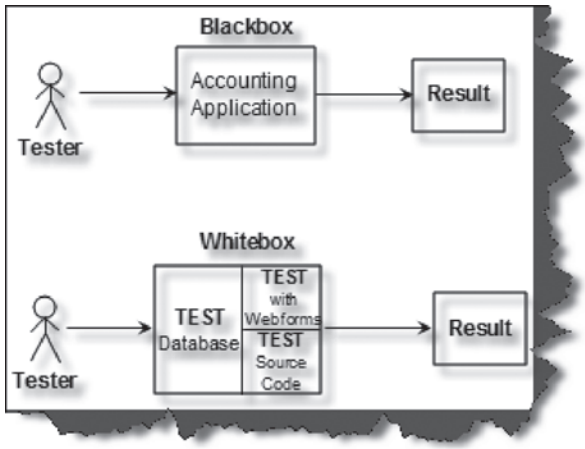


FIGURE 5 White box and black box testing in action

(B) WHAT IS THE DIFFERENCE BETWEEN A DEFECT AND A FAILURE?

When a defect reaches the end customer it is called a failure and if the defect is detected internally and resolved it's called a defect.

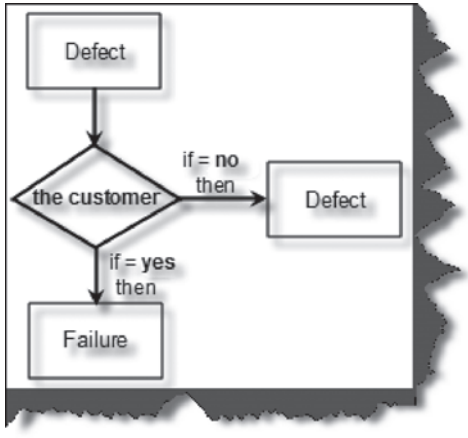


FIGURE 6 Defect and failure

(B) WHAT ARE THE CATEGORIES OF DEFECTS?

There are three main categories of defects:

Wrong: The requirements have been implemented incorrectly. This defect is a variance from the given specification.

Missing: There was a requirement given by the customer and it was not done. This is a variance from the specifications, an indication that a specification was not implemented, or a requirement of the customer was not noted properly.

Extra: A requirement incorporated into the product that was not given by the end customer. This is always a variance from the specification, but may be an attribute desired by the user of the product. However, it is considered a defect because it's a variance from the existing requirements.

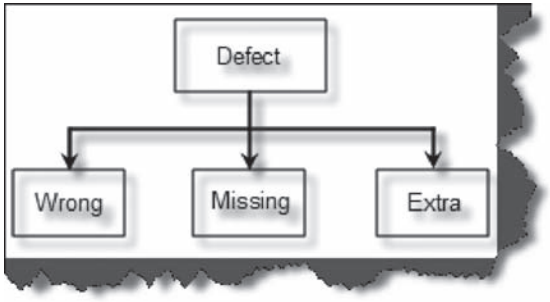


FIGURE 7 **Broader classification of defects**

(B) WHAT IS THE DIFFERENCE BETWEEN VERIFICATION AND VALIDATION?

Verification is a review without actually executing the process while validation is checking the product with actual execution. For instance, code review and syntax check is verification while actually running the product and checking the results is validation.

(B) HOW DOES TESTING AFFECT RISK?

A risk is a condition that can result in a loss. Risk can only be controlled in different scenarios but not eliminated completely. A defect normally converts

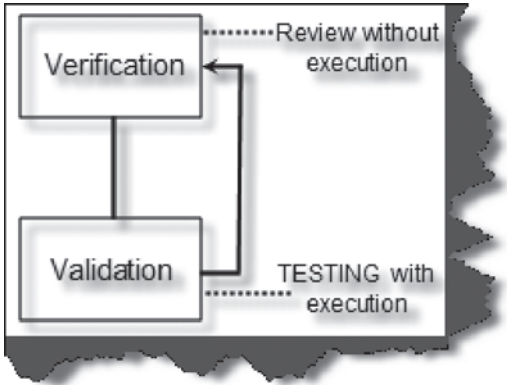


FIGURE 8 **Verification and validation**

to a risk. For instance, let's say you are developing an accounting application and you have done the wrong tax calculation. There is a huge possibility that this will lead to the risk of the company running under loss. But if this defect is controlled then we can either remove this risk completely or minimize it. The following diagram shows how a risk gets converted to a risk and with proper testing how it can be controlled.

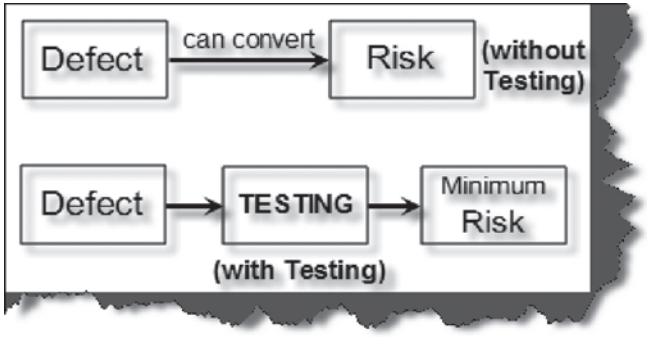


FIGURE 9 **Defect and risk relationship**

(B) DOES AN INCREASE IN TESTING ALWAYS IMPROVE THE PROJECT?

No an increase in testing does not always mean improvement of the product, company, or project. In real test scenarios only 20% of test plans are critical

from a business angle. Running those critical test plans will assure that the testing is properly done. The following graph explains the impact of under testing and over testing. If you under test a system the number of defects will increase, but if you over test a system your cost of testing will increase. Even if your defects come down your cost of testing has gone up.

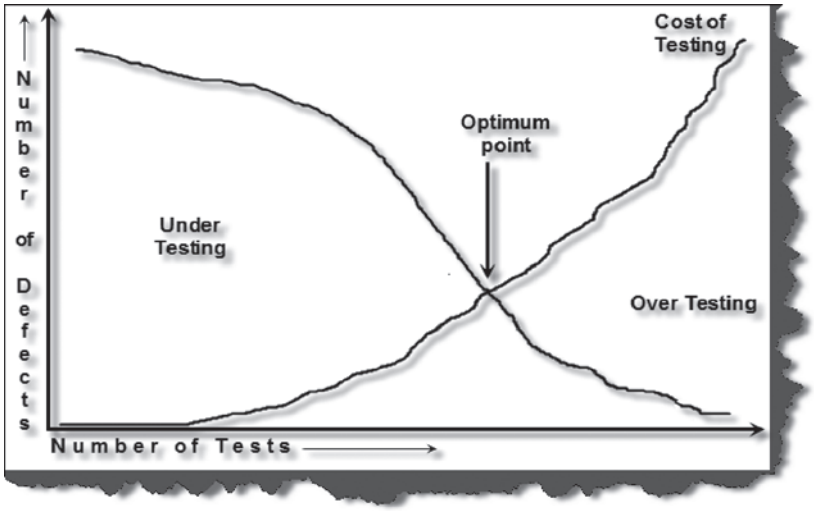


FIGURE 10 Testing cost curve

(I) HOW DO YOU DEFINE A TESTING POLICY?

Note: This question will be normally asked to see whether you can independently set up testing departments. Many companies still think testing is secondary. That's where a good testing manager should show the importance of testing. Bringing in the attitude of testing in companies which never had a formal testing department is a huge challenge because it's not about bringing in a new process but about changing the mentality.

The following are the important steps used to define a testing policy in general. But it can change according to your organization. Let's discuss in detail the steps of implementing a testing policy in an organization.

Definition: The first step any organization needs to do is define one unique definition for testing within the organization so that everyone is of the same mindset.

How to achieve: How are we going to achieve our objective? Is there going to be a testing committee, will there be compulsory test plans which need to be executed, etc?.

Evaluate: After testing is implemented in a project how do we evaluate it? Are we going to derive metrics of defects per phase, per programmer, etc. Finally, it's important to let everyone know how testing has added value to the project?.

Standards: Finally, what are the standards we want to achieve by testing. For instance, we can say that more than 20 defects per KLOC will be considered below standard and code review should be done for it.

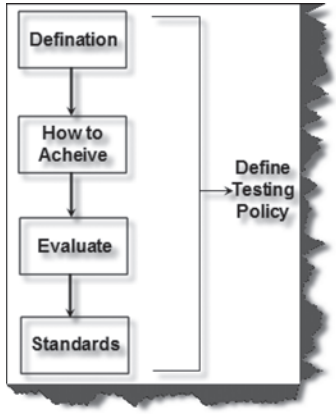


FIGURE 11 **Establishing a testing policy**

The previous methodology is from a general point of view. Note that you should cover the steps in broader aspects.

(B) SHOULD TESTING BE DONE ONLY AFTER THE BUILD AND EXECUTION PHASES ARE COMPLETE?

Note: This question will normally be asked to judge whether you have a traditional or modern testing attitude.

In traditional testing methodology (sad to say many companies still have that attitude) testing is always done after the build and execution phases. But that's a wrong way of thinking because the earlier we catch a defect, the more cost effective it is. For instance, fixing a defect in maintenance is ten times more costly than fixing it during execution.

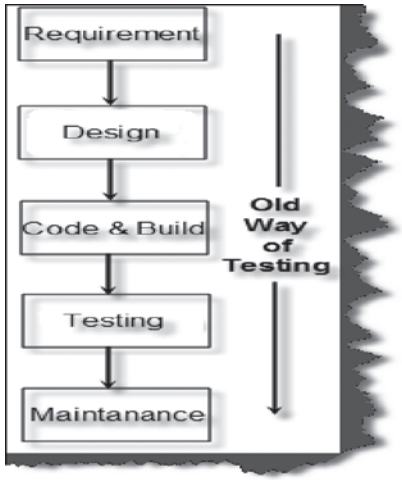


FIGURE 12 **Traditional way of testing**

Testing after code and build is a traditional approach and many companies have improved on this philosophy. Testing should occur in conjunction with each phase as shown in the following figure.

In the requirement phase we can verify if the requirements are met according to the customer needs. During design we can check whether the design document covers all the requirements. In this stage we can also generate rough functional data. We can also review the design document from the architecture and the correctness perspectives. In the build and execution phase we can execute unit test cases and generate structural and functional data. And finally comes the testing phase done in the traditional way. i.e., run the system test cases and see if the system works according to the requirements. During installation we need to see if the system is compatible with the software. Finally, during the maintenance phase when any fixes are made we can retest the fixes and follow the regression testing.

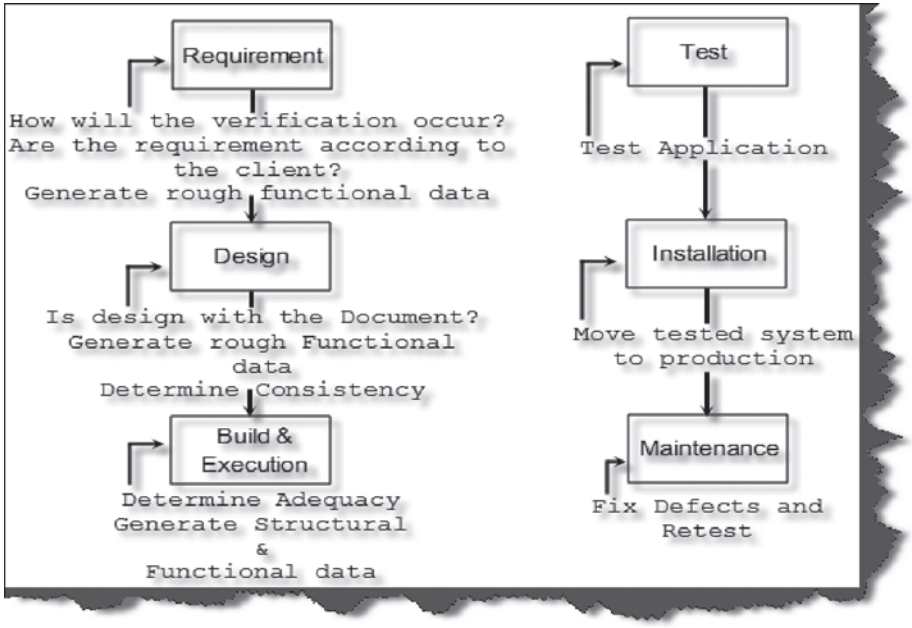


FIGURE 13 **Modern way of testing**

(B) ARE THERE MORE DEFECTS IN THE DESIGN PHASE OR IN THE CODING PHASE?

Note: This question is asked to see if you really know practically which phase is the most defect prone.

The design phase is more error prone than the execution phase. One of the most frequent defects which occur during design is that the product does not cover the complete requirements of the customer. Second is wrong or bad architecture and technical decisions make the next phase, execution, more prone to defects. Because the design phase drives the execution phase it's the most critical phase to test. The testing of the design phase can be done by good review. On average, 60% of defects occur during design and 40% during the execution phase.

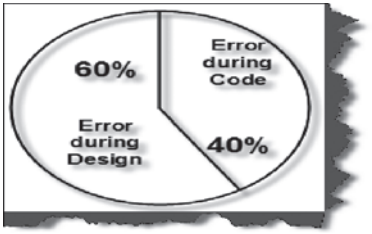


FIGURE 14 **Phase-wise defect percentage**

(B) WHAT KIND OF INPUT DO WE NEED FROM THE END USER TO BEGIN PROPER TESTING?

The product has to be used by the user. He is the most important person as he has more interest than anyone else in the project. From the user we need the following data:

- The first thing we need is the acceptance test plan from the end user. The acceptance test defines the entire test which the product has to pass so that it can go into production.
- We also need the requirement document from the customer. In normal scenarios the customer never writes a formal document until he is really sure of his requirements. But at some point the customer should sign saying yes this is what he wants.
- The customer should also define the risky sections of the project. For instance, in a normal accounting project if a voucher entry screen does not work that will stop the accounting functionality completely. But if reports are not derived the accounting department can use it for some time. The customer is the right person to say which section will affect him the most. With this feedback the testers can prepare a proper test plan for those areas and test it thoroughly.
- The customer should also provide proper data for testing. Feeding proper data during testing is very important. In many scenarios testers key in wrong data and expect results which are of no interest to the customer.

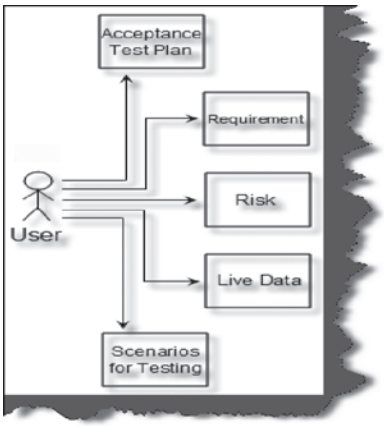


FIGURE 15 **Expectations from the end user for testing**

(B) WHAT IS THE DIFFERENCE BETWEEN LATENT AND MASKED DEFECTS?

A latent defect is an existing defect that has not yet caused a failure because the exact set of conditions were never met.

A masked defect is an existing defect that hasn't yet caused a failure just because another defect has prevented that part of the code from being executed.

The following flow chart explains latent defects practically. The application has the ability to print an invoice either by laser printer or by dot matrix printer. In order to achieve it the application first searches for the laser printer. If it finds a laser printer it uses the laser printer and prints it. If it does not find a laser printer, the application searches for dot matrix printer. If the application finds a dot matrix printer (DMP) the application prints using or an error is given.

Now for whatever reason this application never searched for the dot matrix printer. So the application never got tested for the DMP. That means the exact conditions were never met for the DMP. This is called a latent defect.

Now the same application has two defects: one defect is in the DMP search and the other defect is in the DMP print. But because the search of the DMP fails the print DMP defect is never detected. So the print DMP defect is a masked defect.

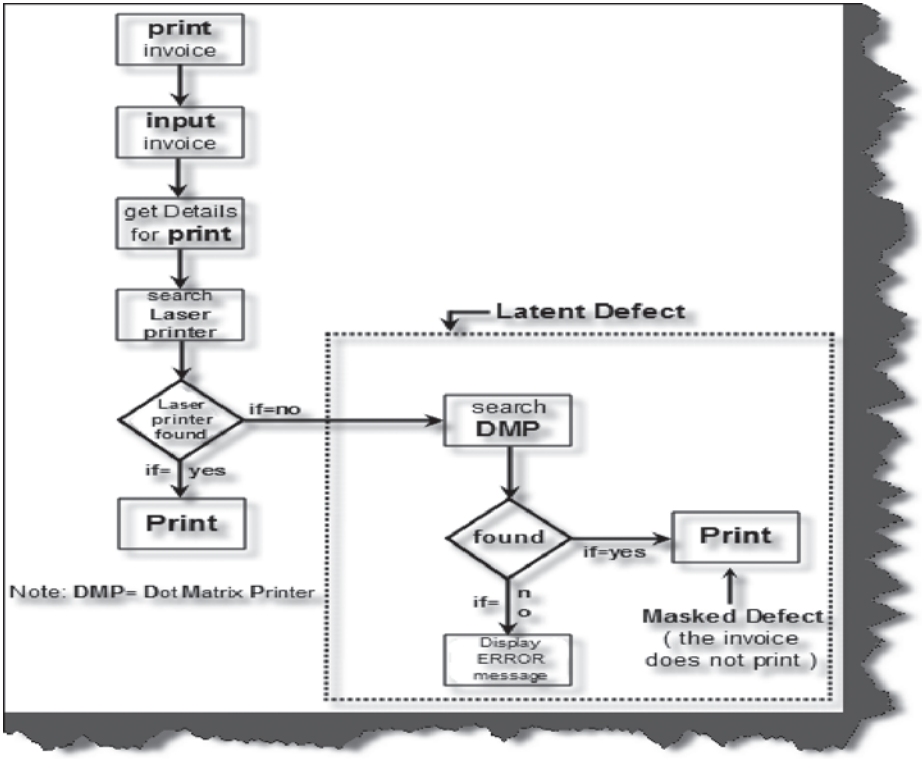


FIGURE 16 **Latent and masked defects**

(B) A DEFECT WHICH COULD HAVE BEEN REMOVED DURING THE INITIAL STAGE IS REMOVED IN A LATER STAGE. HOW DOES THIS AFFECT COST?

If a defect is known at the initial stage then it should be removed during that stage/phase itself rather than at some later stage. It's a recorded fact that if a defect is delayed for later phases it proves more costly. The following figure shows how a defect is costly as the phases move forward. A defect if identified and removed during the requirement and design phase is the most cost effective, while a defect removed during maintenance is 20 times costlier than during the requirement and design phases. For instance, if a defect is identified during requirement and design we only need to change the documentation, but if identified during the maintenance phase we not only

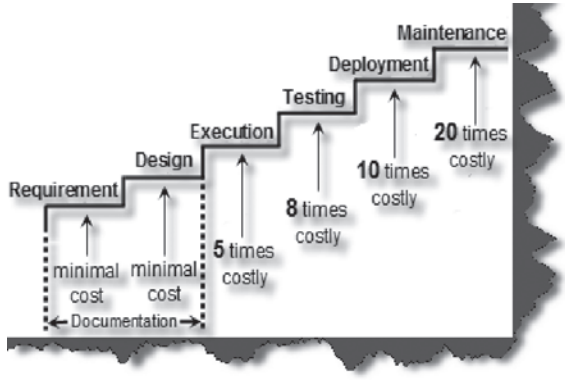


FIGURE 17 **Cost of defect increases with each phase**

need to fix the defect, but also change our test plans, do regression testing, and change all documentation. This is why a defect should be identified/removed in earlier phases and the testing department should be involved right from the requirement phase and not after the execution phase.

(I) CAN YOU EXPLAIN THE WORKBENCH CONCEPT?

In order to understand testing methodology we need to understand the workbench concept. A Workbench is a way of documenting how a specific activity has to be performed. A workbench is referred to as phases, steps, and tasks as shown in the following figure.

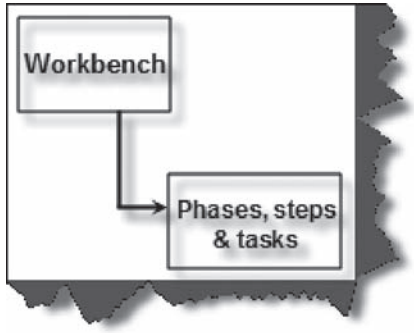


FIGURE 18 **Workbench with phases and steps**

There are five tasks for every workbench:

- **Input**: Every task needs some defined input and entrance criteria. So for every workbench we need defined inputs. Input forms the first steps of the workbench.
- **Execute**: This is the main task of the workbench which will transform the input into the expected output.
- **Check**: Check steps assure that the output after execution meets the desired result.
- **Production output**: If the check is right the production output forms the exit criteria of the workbench.
- **Rework**: During the check step if the output is not as desired then we need to again start from the execute step.

The following figure shows all the steps required for a workbench.

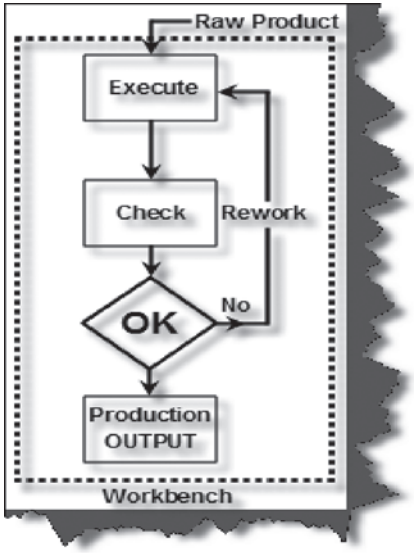


FIGURE 19 **Phases in a workbench**

In real scenarios projects are not made of one workbench but of many connected workbenches. A workbench gives you a way to perform any kind

of task with proper testing. You can visualize every software phase as a workbench with execute and check steps. The most important point to note is we visualize any task as a workbench by default we have the check part in the task. The following figure shows how every software phase can be visualized as a workbench. Let's discuss the workbench concept in detail:

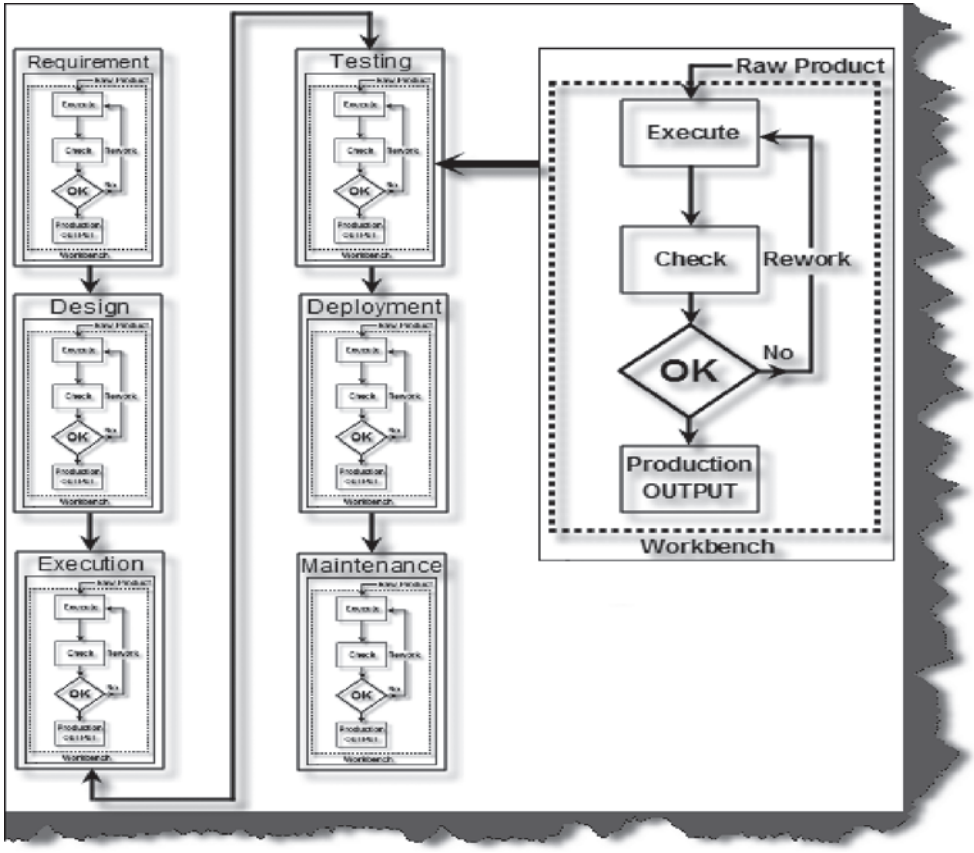


FIGURE 20 **Workbench and software lifecycles**

Requirement phase workbench: The input is the customer's requirements; we execute the task of writing a requirement document, we check if the requirement document addresses all the customer needs, and the output is the requirement document.

Design phase workbench: The input is the requirement document, we execute the task of preparing a technical document; review/check is done to see if the design document is technically correct and addresses all the requirements mentioned in the requirement document, and the output is the technical document.

Execution phase workbench: This is the actual execution of the project. The input is the technical document; the execution is nothing but implementation/coding according to the technical document, and the output of this phase is the implementation/source code.

Testing phase workbench: This is the testing phase of the project. The input is the source code which needs to be tested; the execution is executing the test case and the output is the test results.

Deployment phase workbench: This is the deployment phase. There are two inputs for this phase: one is the source code which needs to be deployed and that is dependent on the test results. The output of this project is that the customer gets the product which he can now start using.

Maintenance phase workbench: The input to this phase is the deployment results, execution is implementing change requests from the end customer, the check part is nothing but running regression testing after every change request implementation, and the output is a new release after every change request execution.

(B) WHAT'S THE DIFFERENCE BETWEEN ALPHA AND BETA TESTING?

Alpha and beta testing has different meanings to different people. Alpha testing is the acceptance testing done at the development site. Some organizations

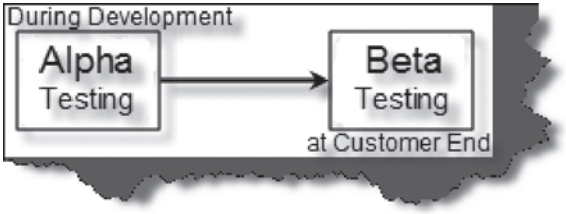


FIGURE 21 **Alpha and beta testing**

have a different visualization of alpha testing. They consider alpha testing as testing which is conducted on early, unstable versions of software. On the contrary beta testing is acceptance testing conducted at the customer end. In short, the difference between beta testing and alpha testing is the location where the tests are done.

(I) CAN YOU EXPLAIN THE CONCEPT OF DEFECT CASCADING?

OR

(B) CAN YOU EXPLAIN HOW ONE DEFECT LEADS TO OTHER DEFECTS?

Defect cascading is a defect which is caused by another defect. One defect triggers the other defect. For instance, in the accounting application shown here there is a defect which leads to negative taxation. So the negative taxation defect affects the ledger which in turn affects four other modules.

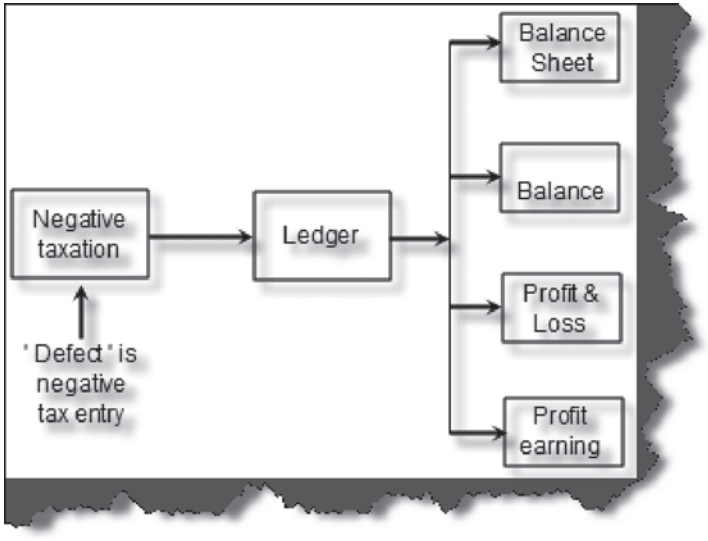


FIGURE 22 **Defect cascading**

(B) CAN YOU EXPLAIN USABILITY TESTING?

Usability testing is a testing methodology where the end customer is asked to use the software to see if the product is easy to use, to see the customer's perception and task time. The best way to finalize the customer point of view for usability is by using prototype or mock-up software during the initial stages. By giving the customer the prototype before the development start-up we confirm that we are not missing anything from the user point of view.

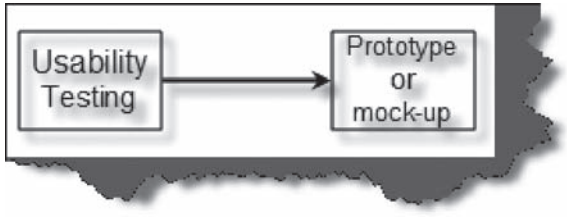


FIGURE 23 **Prototype and usability testing**

(B) WHAT ARE THE DIFFERENT STRATEGIES FOR ROLLOUT TO END USERS?

There are four major ways of rolling out any project:

Pilot: The actual production system is installed at a single or limited number of users. Pilot basically means that the product is actually rolled out to limited users for real work.

Gradual Implementation: In this implementation we ship the entire product to the limited users or all users at the customer end. Here, the developers get instant feedback from the recipients which allow them to make changes before the product is available. But the downside is that developers and testers maintain more than one version at one time.

Phased Implementation: In this implementation the product is rolled out to all users in incrementally. That means each successive rollout has some added functionality. So as new functionality comes in, new installations occur and the customer tests them progressively. The benefit of this kind of rollout is that customers can start using the functionality and provide valuable feedback progressively. The only issue here is that with each rollout and added functionality the integration becomes more complicated.

Parallel Implementation: In these types of rollouts the existing application is run side by side with the new application. If there are any issues with the new application we again move back to the old application. One of the biggest problems with parallel implementation is we need extra hardware, software, and resources.

The following figure shows the different launch strategies for a project rollout.

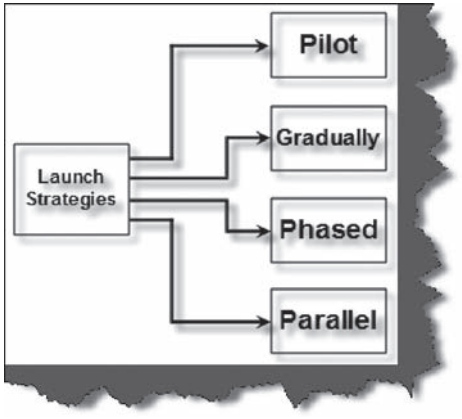


FIGURE 24 **Launch strategies**

(I) CAN YOU EXPLAIN REQUIREMENT TRACEABILITY AND ITS IMPORTANCE?

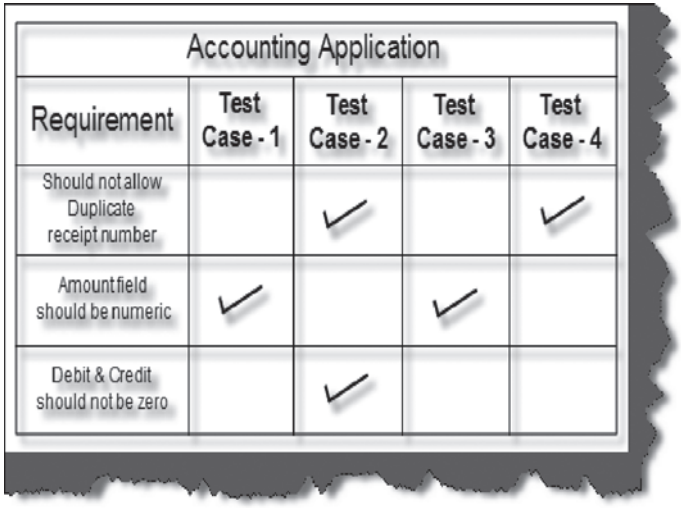
In most organizations testing only starts after the execution/coding phase of the project. But if the organization wants to really benefit from testing, then testers should get involved right from the requirement phase.

If the tester gets involved right from the requirement phase then requirement traceability is one of the important reports that can detail what kind of test coverage the test cases have.

The following figure shows how we can measure the coverage using the requirement traceability matrix.

We have extracted the important functionality from the requirement document and aligned it on the left-hand side of the sheet. On the other side,

at the top, we have mapped the test cases with the requirement. With this we can ensure that all requirements are covered by our test cases. As shown we can have one or more test cases covering the requirements. This is also called requirement coverage.



Accounting Application				
Requirement	Test Case - 1	Test Case - 2	Test Case - 3	Test Case - 4
Should not allow Duplicate receipt number		✓		✓
Amount field should be numeric	✓		✓	
Debit & Credit should not be zero		✓		

FIGURE 25 **Requirement Traceability**

Note: Many professionals still think testing is executing test cases on the application. But testing should be performed at all levels. In the requirement phase we can use the review and traceability matrix to check the validity of our project. In the design phase we can use the design review to check the correctness of the design and so on.

(B) WHAT IS THE DIFFERENCE BETWEEN PILOT AND BETA TESTING?

The difference between pilot and beta testing is that pilot testing is nothing but actually using the product (limited to some users) and in beta testing we do not input real data, but it's installed at the end customer to validate if the product can be used in production.

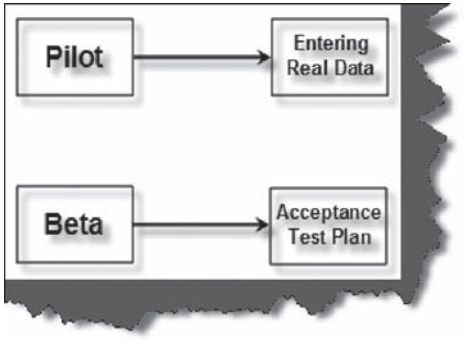


FIGURE 26 **Pilot and beta testing**

(B) HOW DO YOU PERFORM A RISK ANALYSIS DURING SOFTWARE TESTING?

OR

(B) HOW DO YOU CONCLUDE WHICH SECTION IS MOST RISKY IN YOUR APPLICATION?

Note: Here the interviewer is expecting a proper approach to rating risk to the application modules so that while testing you pay more attention to those risky modules, thus minimizing risk in projects.

The following is a step by step approach for testing planning:

- The first step is to collect features and concerns from the current documentation and data available from the requirement phase. For instance, here is a list of some features and concerns:

Features

Add a user
Check user preferences
Login user
Add new invoice
Print invoice

Continued

Concerns
Maintainability
Security
Performance

TABLE 1 Features and concerns

The table shows features and concerns. Features are functionalities which the end user will use, while concerns are global attributes of the project. For instance, the security has to be applied to all the features listed.

- Once we have listed the features and concerns, we need to rate the probability/likelihood of failures in this feature. In the following section we have rated the features and concerns as low, high, and medium, but you can use numerical values if you want.

Features	Probability of failure
Add a user	Low
Check user preferences	Low
Login user	Low
Add new invoice	High
Print invoice	Medium
Concerns	**Probability of failure**
Maintainability	Low
Security	High
Performance	High

TABLE 2 Probability rating according to features and concerns

- Once we have rated the failure probability, we need to rate the impact. Impact means if we make changes to this feature, how many other features will be affected? You can see in the following table that we have marked the impact section accordingly.

Features	Probability of failure	Impact
Add a user	Low	Low
Check user preferences	Low	Low
Login user	Low	High
Add new invoice	High	High
Print invoice	Medium	High
Concerns	**Probability of failure**	**Impact**
Maintainability	Low	Low
Security	High	High
Performance	High	Low

TABLE 3 Impact and probability rating

- We also need to define the master priority rating table depending on the impact and probability ratings. The following table defines the risk priority.

Probability of failure	Impact	Risk Priority
Low	Low	1
Low	High	2
Medium	High	3
High	High	4

TABLE 4 Priority rating

- Using the priority rating table we have defined priority for the following listed features. Depending on priority you can start testing those features first.
- Once the priority is set you can then review it with your team members to validate it.

Features	Probability of failure	Impact	Priority
Add a user	Low	Low	1
Check user preferences	Low	Low	1
Login user	Low	High	2
Add new invoice	High	High	4
Print invoice	Medium	High	3
Concerns	**Probability of failure**	**Impact**	
Maintainability	Low	Low	1
Security	High	High	4
Performance	High	Low	3

FIGURE 27 **Priority set according to the risk priority table**

The following figure shows the summary of the above steps. So list your concerns, rate the probabilities of failures, provide an impact rating, calculate risk/priority, and then review, review, and review.

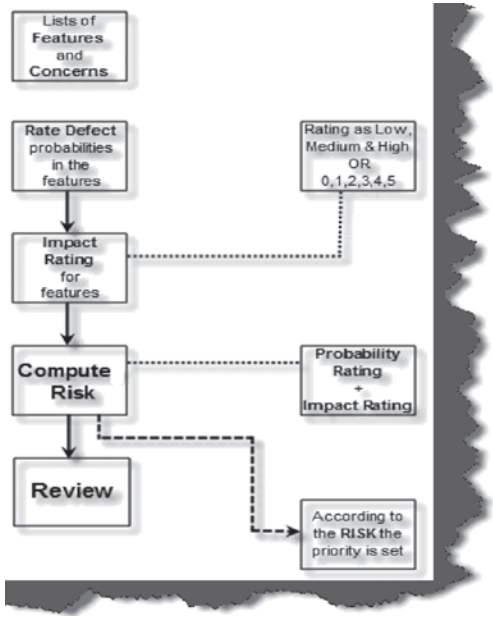


FIGURE 28 **Testing analysis and design**

(B) WHAT DOES ENTRY AND EXIT CRITERIA MEAN IN A PROJECT?

Entry and exit criteria are a must for the success of any project. If you do not know where to start and where to finish then your goals are not clear. By defining exit and entry criteria you define your boundaries. For instance, you can define entry criteria that the customer should provide the requirement document or acceptance plan. If this entry criteria is not met then you will not start the project. On the other end, you can also define exit criteria for your project. For instance, one of the common exit criteria in projects is that the customer has successfully executed the acceptance test plan.

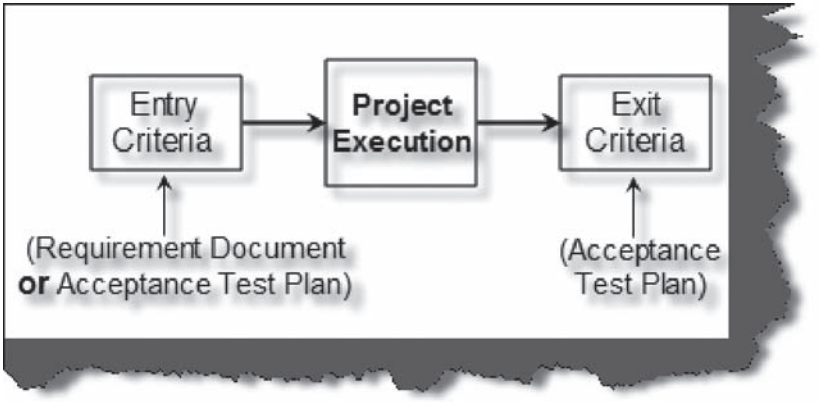


FIGURE 29 **Entry and exit criteria**

(B) ON WHAT BASIS IS THE ACCEPTANCE PLAN PREPARED?

In any project the acceptance document is normally prepared using the following inputs. This can vary from company to company and from project to project.

- Requirement document: This document specifies what exactly is needed in the project from the customers perspective.
- Input from customer: This can be discussions, informal talks, emails, etc.
- Project plan: The project plan prepared by the project manager also serves as good input to finalize your acceptance test.

Note: In projects the acceptance test plan can be prepared by numerous inputs. It is not necessary that the above list be the only criteria. If you think you have something extra to add, go ahead.

The following diagram shows the most common inputs used to prepare acceptance test plans.

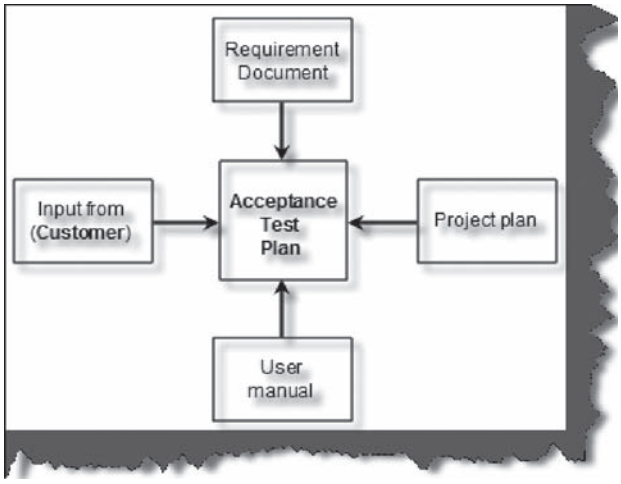


FIGURE 30 **Acceptance test input criteria**

(B) WHAT'S THE RELATIONSHIP BETWEEN ENVIRONMENT REALITY AND TEST PHASES?

Environment reality becomes more important as test phases start moving ahead. For instance, during unit testing you need the environment to be partly real, but at the acceptance phase you should have a 100% real environment, or we can say it should be the actual real environment. The following graph shows how with every phase the environment reality should also increase and finally during acceptance it should be 100% real.

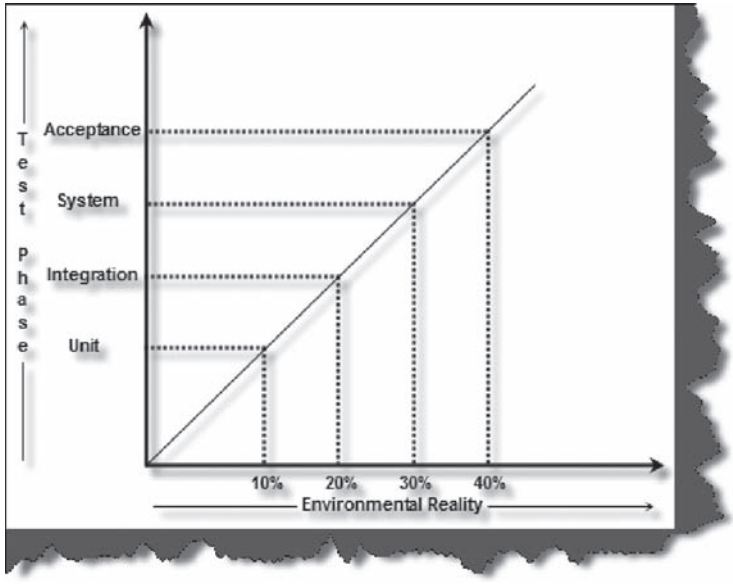


FIGURE 31 **Environmental reality**

(B) WHAT ARE DIFFERENT TYPES OF VERIFICATIONS?

OR

(B) WHAT'S THE DIFFERENCE BETWEEN INSPECTIONS AND WALKTHROUGHS?

As said in the previous sections the difference between validation and verification is that in validation we actually execute the application, while in verification we review without actually running the application. Verifications are basically of two main types: Walkthroughs and Inspections. A walkthrough is an informal form of verification. For instance, you can call your colleague and do an informal walkthrough to just check if the documentation and coding is correct. Inspection is a formal procedure and official. For instance, in your organization you can have an official body which approves design documents for any project. Every project in your organization needs to go through an inspection which reviews your design documents. If there are issues in the

design documents, then your project will get a NC (non-conformance) list. You cannot proceed without clearing the NCs given by the inspection team.

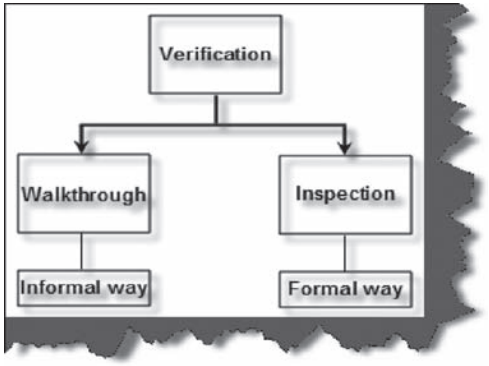


FIGURE 32 **Walkthrough and inspection**

(B) CAN YOU EXPLAIN REGRESSION TESTING AND CONFIRMATION TESTING?

Regression testing is used for regression defects. Regression defects are defects occur when the functionality which was once working normally has stopped working. This is probably because of changes made in the program or the environment. To uncover such kind of defect regression testing is conducted.

The following figure shows the difference between regression and confirmation testing. If we fix a defect in an existing application we use

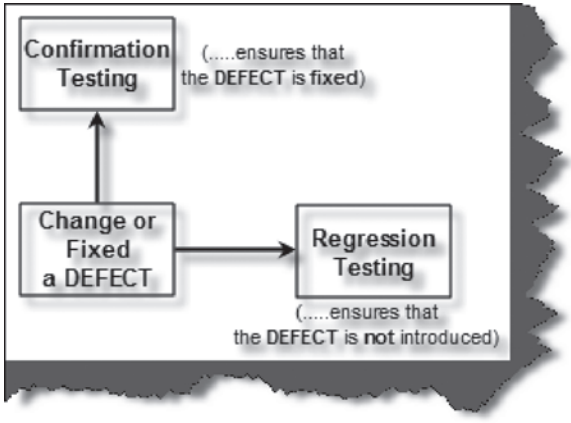


FIGURE 33 **Regression testing in action**

confirmation testing to test if the defect is removed. It's very possible because of this defect or changes to the application that other sections of the application are affected. So to ensure that no other section is affected we can use regression testing to confirm this.

(I) WHAT IS COVERAGE AND WHAT ARE THE DIFFERENT TYPES OF COVERAGE TECHNIQUES?

Coverage is a measurement used in software testing to describe the degree to which the source code is tested. There are three basic types of coverage techniques as shown in the following figure:

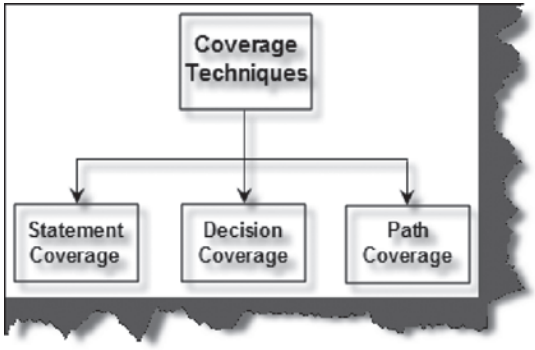


FIGURE 34 **Coverage techniques**

- Statement coverage: This coverage ensures that each line of source code has been executed and tested.
- Decision coverage: This coverage ensures that every decision (true/false) in the source code has been executed and tested.
- Path coverage: In this coverage we ensure that every possible route through a given part of code is executed and tested.

(A) HOW DOES A COVERAGE TOOL WORK?

Note: We will be covering coverage tools in more detail in later chapters, but for now let's discuss the fundamentals of how a code coverage tool works.

While doing testing on the actual product, the code coverage testing tool is run simultaneously. While the testing is going on, the code coverage tool monitors the executed statements of the source code. When the final testing is completed we get a complete report of the pending statements and also get the coverage percentage.

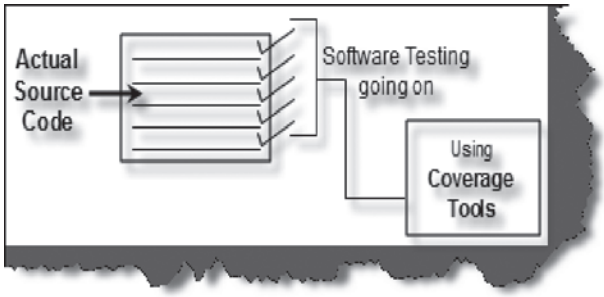


FIGURE 35 **Coverage tool in action**

(B) WHAT IS CONFIGURATION MANAGEMENT?

Configuration management is the detailed recording and updating of information for hardware and software components. When we say components we not only mean source code. It can be tracking of changes for software documents such as requirement, design, test cases, etc.

When changes are done in adhoc and in an uncontrolled manner chaotic situations can arise and more defects injected. So whenever changes are done it should be done in a controlled fashion and with proper versioning. At any moment of time we should be able to revert back to the old version. The main intention of configuration management is to track our changes if we have issues with the current system. Configuration management is done using baselines.

Note: Please refer the baseline concept in the next question.

(B) CAN YOU EXPLAIN THE BASELINE CONCEPT IN SOFTWARE DEVELOPMENT?

Baselines are logical ends in a software development lifecycle. For instance, let's say you have software whose releases will be done in phases,

i.e., Phase 1, Phase 2, etc. You can baseline your software product after every phase. In this way you will now be able to track the difference between Phase 1 and Phase 2. Changes can be in various sections. For instance, the requirement document (because some requirements changed), technical (due to changes in the architecture), source code (source code changes), test plan changes, and so on.

For example, consider the following figure which shows how an accounting application had undergone changes and was then baselined with each version. When the accounting application was released it was released with ver 1.0 and baselined. After some time some new features where added and version 2.0 was generated. This was again a logical end so we again baselined the application. So now in case we want to trace back and see the changes from ver 2.0 to ver 1.0 we can do so easily. After some time the accounting application went through some defect removal, ver 3.0 was generated, and again baselined and so on.

The following figure depicts the various scenarios.

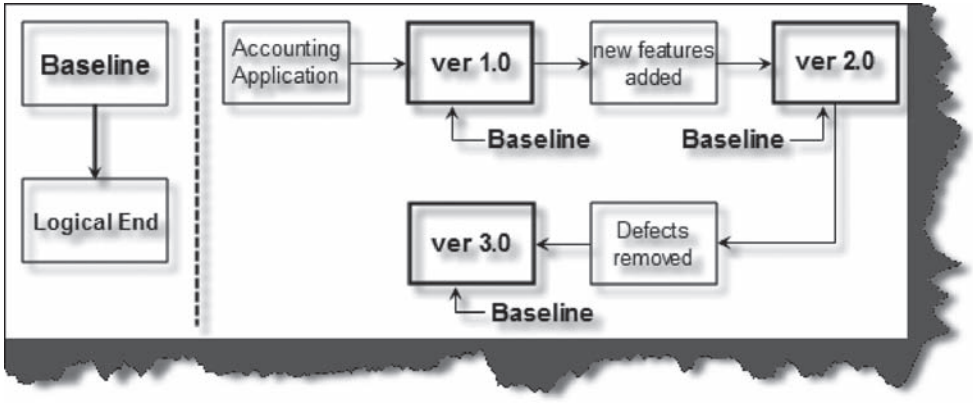


FIGURE 36 **Baseline**

Baselines are very important from a testing perspective. Testing on a software product that is constantly changing will not get you anywhere. So when you actually start testing you need to first baseline the application so that what you test is for that baseline. If the developer fixes something then create a new baseline and perform testing on it. In this way any kind of conflict will be avoided.

(B) WHAT ARE THE DIFFERENT TEST PLAN DOCUMENTS IN A PROJECT?

Note: This answer varies from project to project and company to company. You can tailor this answer according to your experience. This book will try to answer the question from the authors view point.

There are a minimum of four test plan documents needed in any software project. But depending on the project and team members agreement some of the test plan documents can be deleted.

Central/Project test plan: The central test plan is one of the most important communication channels for all project participants. This document can have essentials such as resource utilization, testing strategies, estimation, risk, priorities, and more.

Acceptance test plan: The acceptance test plan is mostly based on user requirements and is used to verify whether the requirements are satisfied according to customer needs. Acceptance test cases are like a green light for the application and help to determine whether or not the application should go into production.

System test plan: A system test plan is where all main testing happens. This testing, in addition to functionality testing, has also load, performance, and reliability tests.

Integration testing: Integration testing ensures that the various components in the system interact properly and data is passed properly between them.

Unit testing: Unit testing is done more on a developer level. In unit testing we check the individual module in isolation. For instance, the developer can check his sorting function in isolation, rather than checking in an integrated fashion.

The following figure shows the interaction between the entire project test plan.

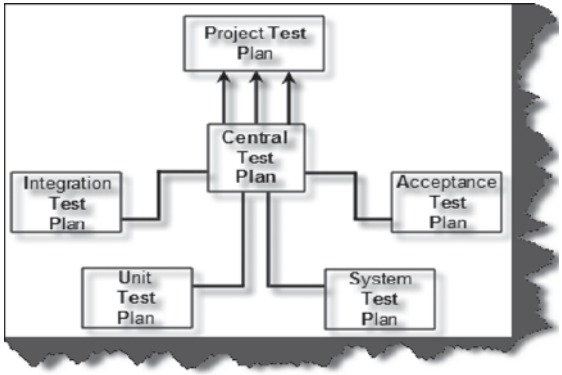


FIGURE 37 **Different test plans in a project**

(B) HOW DO TEST DOCUMENTS IN A PROJECT SPAN ACROSS THE SOFTWARE DEVELOPMENT LIFECYCLE?

The following figure shows pictorially how test documents span across the software development lifecycle. The following discusses the specific testing

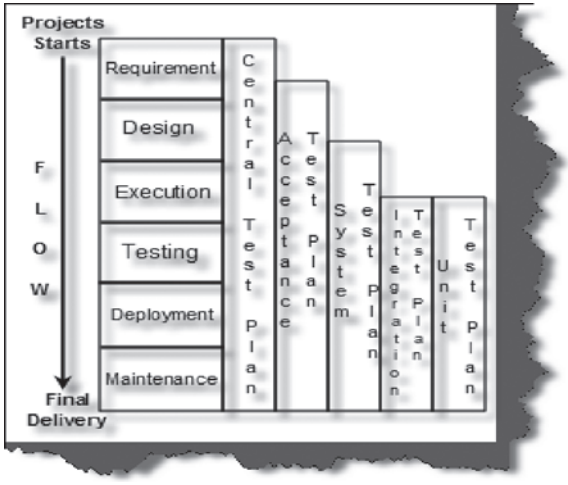


FIGURE 38 **Test documents across phases**

documents in the lifecycle:

Central/Project test plan: This is the main test plan which outlines the complete test strategy of the software project. This document should be prepared before the start of the project and is used until the end of the software development lifecyle.

Acceptance test plan: This test plan is normally prepared with the end customer. This document commences during the requirement phase and is completed at final delivery.

System test plan: This test plan starts during the design phase and proceeds until the end of the project.

Integration and unit test plan: Both of these test plans start during the execution phase and continue until the final delivery.

Note: The above answer is a different interpretation of V-model testing. We have explained the V-model in this chapter in more detail in one of the questions. Read it once to understand the concept.

(A) CAN YOU EXPLAIN INVENTORIES?

OR

(A) HOW DO YOU DO ANALYSIS AND DESIGN FOR TESTING PROJECTS?

OR

(A) CAN YOU EXPLAIN CALIBRATION?

The following are three important steps for doing analysis and design for testing:

Test objectives: These are broad categories of things which need to be tested in the application. For instance, in the following figure we have four broad categories of test areas: polices, error checking, features, and speed.

Inventory: Inventory is a list of things to be tested for an objective. For instance, the following figure shows that we have identified inventory such as

FIGURE 39 **Software testing planning and design**

add new policy, which is tested for the object types of policies. Change/add address and delete customer is tested for the features objective.

Tracking matrix: Once we have identified our inventories we need to map the inventory to test cases. Mapping of inventory to the test cases is called calibration.

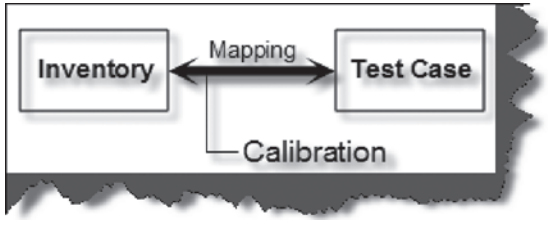


FIGURE 40 **Calibration**

The following is a sample inventory tracking matrix. "Features" is the objective and "add new policy," "change address," and "delete a customer" are the inventory for the objective. Every inventory is mapped to a test case. Only the "delete a customer" inventory is not mapped to any test case. This way we know if we have covered all the aspects of the application in testing.

The inventory tracking matrix gives us a quick global view of what is pending and hence helps us to also measure coverage of the application. The following figure shows the "delete a customer" inventory is not covered by any test case thus alerting us of what is not covered.

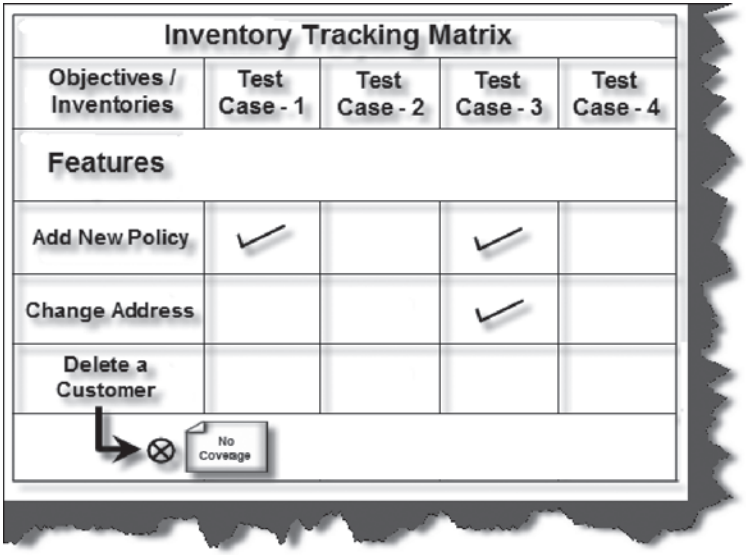


FIGURE 41 **Inventory tracking matrix**

Note: During the interview try to explain all of the above three steps because that's how testing is planned and designed in big companies. Inventory forms the main backbone of software testing.

(B) WHICH TEST CASES ARE WRITTEN FIRST: WHITE BOXES OR BLACK BOXES?

Normally black box test cases are written first and white box test cases later. In order to write black box test cases we need the requirement document and, design or project plan. All these documents are easily available at the initial start of the project. White box test cases cannot be started in the initial phase of the project because they need more architecture clarity which is not available at the start of the project. So normally white box test cases are written after black box

test cases are written. Black box test cases do not require system understanding but white box testing needs more structural understanding. And structural understanding is clearer in the later part of project, i.e., while executing or designing. For black box testing you need to only analyze from the functional perspective which is easily available from a simple requirement document.

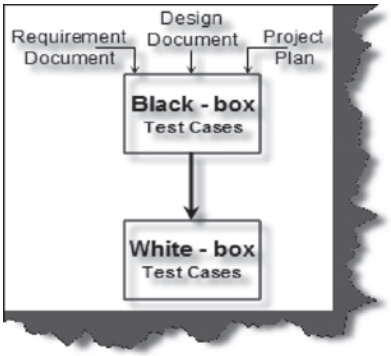


FIGURE 42 **White box and black box test cases**

(I) CAN YOU EXPLAIN COHABITING SOFTWARE?

When we install the application at the end client it is very possible that on the same PC other applications also exist. It is also very possible that those applications share common DLLs, resources etc., with your application. There is a huge chance in such situations that your changes can affect the cohabiting software. So the best practice is after you install your application or after any changes, tell other application owners to run a test cycle on their application.

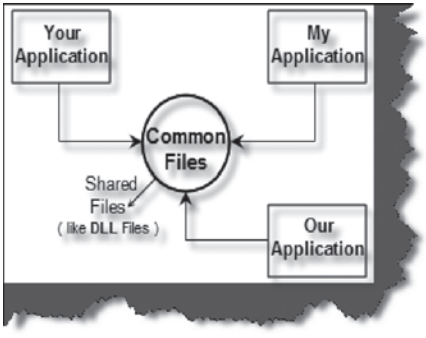


FIGURE 43 **Cohabiting software**

(B) WHAT IMPACT RATINGS HAVE YOU USED IN YOUR PROJECTS?

Normally, the impact ratings for defects are classified into three types:

- Minor: Very low impact but does not affect operations on a large scale.
- Major: Affects operations on a very large scale.
- Critical: Brings the system to a halt and stops the show.

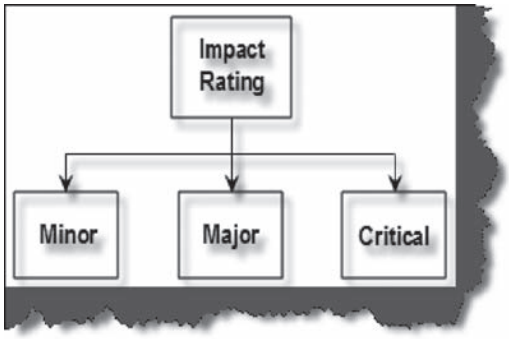


FIGURE 44 **Test Impact rating**

(B) WHAT IS A TEST LOG?

The IEEE Std. 829-1998 defines a test log as a chronological record of relevant details about the execution of test cases. It's a detailed view of activity and events given in chronological manner. The following figure shows a test log and is followed by a sample test log.

FIGURE 45 **Test Log**

ID	TIME	Activity and Event Entries
1	08:00	Kicked off data entry for all banks
2	09:30	System has issues and crashed
3	10:00	Banking application recovered
4	10:05	Restarted data entry for all banks

FIGURE 46 **Sample test log**

(I) EXPLAIN THE SDLC (SOFTWARE DEVELOPMENT LIFECYCLE) IN DETAIL.

OR

(I) CAN YOU EXPLAIN THE WATERFALL MODEL?

OR

(I) CAN YOU EXPLAIN THE BIG-BANG WATERFALL MODEL?

OR

(I) CAN YOU EXPLAIN THE PHASED WATERFALL MODEL?

OR

(I) EXPLAIN THE ITERATIVE MODEL, INCREMENTAL MODEL, SPIRAL MODEL, EVOLUTIONARY MODEL AND THE V-MODEL?

OR

(I) EXPLAIN UNIT TESTING, INTEGRATION TESTS, SYSTEM TESTING AND ACCEPTANCE TESTING?

Every activity has a lifecycle and the software development process is no exception. Even if you are not aware of the SDLC you are still following

it unknowingly. But if a software professional is aware of the SDLC he can execute the project in a controlled fashion. The biggest benefit of this awareness is that developers will not start execution (coding) which can really lead to the project running in an uncontrolled fashion. Second, it helps customer and software professionals to avoid confusion by anticipating the problems and issues before hand. In short, the SDLC defines the various stages in a software lifecycle.

But before we try to understand what SDLC is all about we need to get a broader view of the beginning and ending of the SDLC. Any project started if it does not have a start and end then its already in trouble. It's like if you go out for a drive you should know where to start and where to end or else you are moving around endlessly.

The figure shows a more global view of the how the SDLS starts and ends. Any project should have entry criteria and exit criteria. For instance, a proper estimation document can be an entry criteria condition. That means if you do not have a proper estimation document in place the project will not start. It can also be more practical. If half payment is not received the project will not start. There can be a list of points which need to be completed before a project starts. Finally, there should be an end to the project which defines when the project will end. For instance, if all the test scenarios given by the

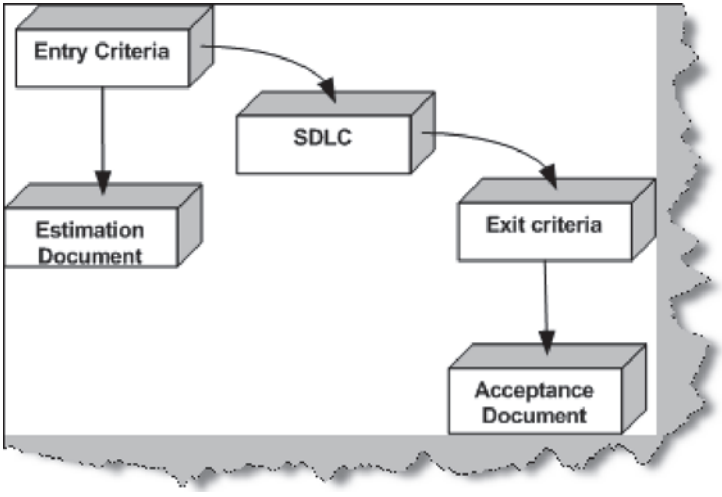


FIGURE 47 **Entry, SDLC, and Exit in action**

end customer are completed the project is finished. In the figure we have the entry criteria as an estimation document and the exit criteria as a signed document by the end client saying the software is delivered.

The following figure shows the typical flow in the SDLC which has six main models. Developers can select a model for their project.

- Waterfall model
- Big bang model
- Phased model
- Iterative model
- Spiral model
- Incremental model

Waterfall Model

Let's have a look at the Waterfall Model which is basically divided into two subtypes: Big Bang waterfall model and the Phased waterfall model.

As the name suggests waterfall means flow of water which always goes in one direction so when we say Waterfall model we expect that every phase/stage is frozen.

Big Bang Waterfall Model

The figure shows the Waterfall Big Bang model which has several stages and are described below:

- Requirement stage: During this stage basic business needs required for the project which are from a user perspective are produced as Word documents with simple points or may be in the form of complicated use case documents.
- Design stage: Use case document/requirement document is the input for this stage. Here we decide how to design the project technically and produce a technical document which has a class diagram, pseudo code, etc.
- Build stage: This stage uses technical documents as input so code can be generated as output at this stage. This is where the actual execution of the project takes place.
- Test stage: Here, testing is done on the source code produced by the build stage and the final software is given the greenlight.

- Deliver stage: After succeeding in the test stage the final product/project is finally installed at client end for actual production. This stage is the beginning of the maintenance stage.

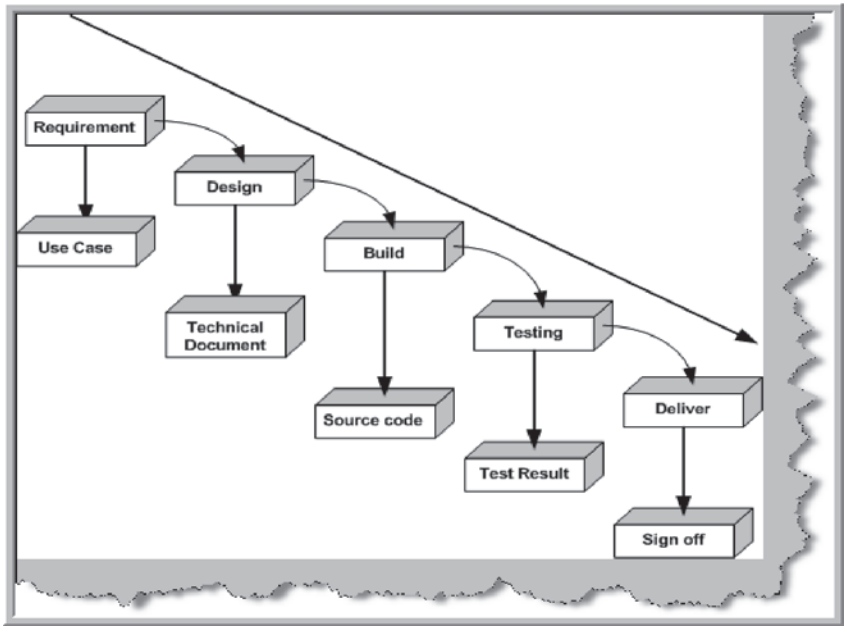


FIGURE 48 **The SDLC in action (Waterfall Big Bang model)**

In the Waterfall Big Bang model, it is assumed that all stages are frozen which means it's a perfect world. But in actual projects such processes are impractical.

Phased Waterfall Model

In this model the project is divided into small chunks and delivered at intervals by different teams. In short, chunks are developed in parallel by different teams and get integrated in the final project. But the disadvantage of this model is that improper planning may lead to project failure during integration or any mismatch of co-ordination between the team may cause failure.

Iterative Model

The Iterative model was introduced because of problems occuring in the Waterfall model.

Now let's take a look at the Iterative model which also has a two subtypes:

Incremental Model

In this model work is divided into chunks like the Phase Waterfall model but the difference is that in the Incremental model one team can work on one or many chunks unlike in the Phase Waterfall model.

Spiral Model

This model uses a series of prototypes which refine our understanding of what we are actually going to deliver. Plans are changed if required per refining of the prototype. So everytime refining of the prototype is done the whole process cycle is repeated.

Evolutionary Model

In the Incremental and Spiral model the main problem is for any changes done in the between the SDLC we need to iterate a whole new cycle. For instance, during the final (deliver) stage, if the customer demands a change we have to iterate the whole cycle again which means we need to update all the previous (requirement, technical documents, source code & test plan) stages.

In the Evolutionary model, we divide software into small units which can be delivered earlier to the customer's end. In later stages we evolve the software with new customer needs.

Note: The Vs model is one of the favorite questions asked by interviews.

V-model

This type of model was developed by testers to emphasize the importance of early testing. In this model testers are involved from the requirement stage itself. The following diagram (V-model cycle diagram) shows how for every stage some testing activity is done to ensure that the project is moving forward as planned.

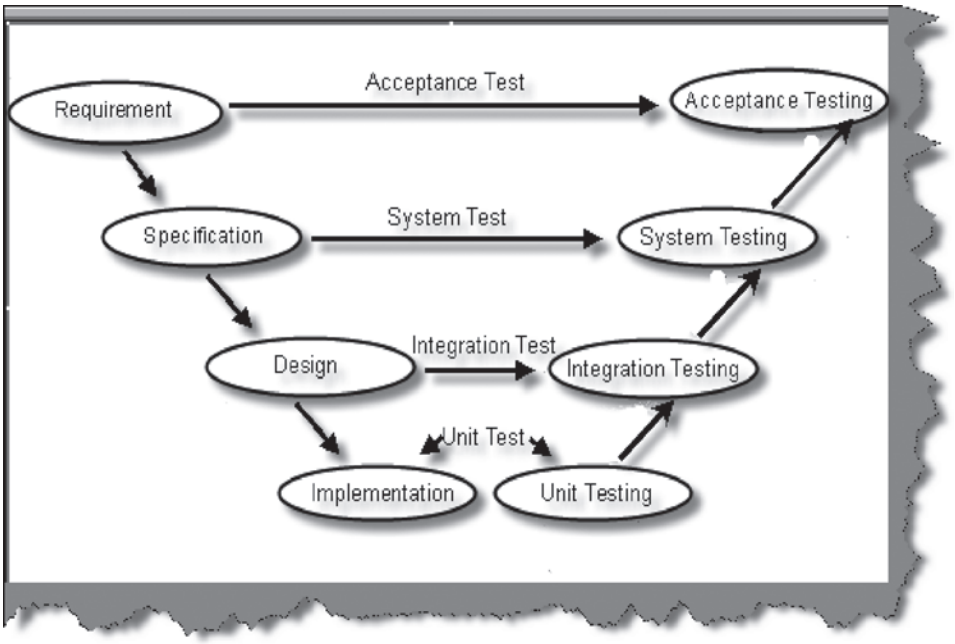


FIGURE 49 **V-model cycle flow**

For instance,

- In the requirement stage we have acceptance test documents created by the testers. Acceptance test documents outline that if these tests pass then the customer will accept the software.
- In the specification stage testers create the system test document. In the following section, system testing is explained in more detail.
- In the design stage we have the integration documents created by testers. Integration test documents define testing steps for how the components should work when integrated. For instance, you develop a customer class and product class. You have tested the customer class and the product class individually. But in a practical scenario the customer class will interact with the product class. So you also need to test to ensure the customer class is interacting with the product class properly.
- In the implement stage we have unit documents created by the programmers or testers.

Let's take a look at each testing phase in more detail.

Unit Testing

Starting from the bottom the first test level is "Unit Testing." It involves checking that each feature specified in the "Component Design" has been implemented in the component.

In theory, an independent tester should do this, but in practice the developer usually does it, as they are the only people who understand how a component works. The problem with a component is that it performs only a small part of the functionality of a system, and it relies on cooperating with other parts of the system, which may not have been built yet. To overcome this, the developer either builds, or uses, special software to trick the component into believing it is working in a fully functional system.

Integration Testing

As the components are constructed and tested they are linked together to make sure they work with each other. It is a fact that two components that have passed all their tests, when connected to each other, produce one new component full of faults. These tests can be done by specialists, or by the developers.

Integration testing is not focused on what the components are doing but on how they communicate with each other, as specified in the "System Design." The "System Design" defines relationships between components.

The tests are organized to check all the interfaces, until all the components have been built and interfaced to each other producing the whole system.

System Testing

Once the entire system has been built then it has to be tested against the "System Specification" to see if it delivers the features required. It is still developer focused, although specialist developers known as systems testers are normally employed to do it.

In essence, system testing is not about checking the individual parts of the design, but about checking the system as a whole. In fact, it is one giant component.

System testing can involve a number of special types of tests used to see if all the functional and non-functional requirements have been met. In addition

to functional requirements these may include the following types of testing for the non-functional requirements:

- Performance - Are the performance criteria met?
- Volume - Can large volumes of information be handled?
- Stress - Can peak volumes of information be handled?
- Documentation - Is the documentation usable for the system?
- Robustness - Does the system remain stable under adverse circumstances?

There are many others, the need for which is dictated by how the system is supposed to perform.

(I) WHAT'S THE DIFFERENCE BETWEEN SYSTEM TESTING AND ACCEPTANCE TESTING?

Acceptance testing checks the system against the "Requirements." It is similar to System testing in that the whole system is checked but the important difference is the change in focus:

System testing checks that the system that was specified has been delivered. Acceptance testing checks that the system will deliver what was requested.

The customer should always do Acceptance testing and not the developer. The customer knows what is required from the system to achieve value in the business and is the only person qualified to make that judgment. This testing is more about ensuring that the software is delivered as defined by the customer. It's like getting a greenlight from the customer that the software meets expectations and is ready to be used.

(I) WHICH IS THE BEST MODEL?

In the previous section we looked through all the models. But in actual projects, hardly one complete model can fulfill the entire project requirement. In real projects, tailored models are proven to be the best, because they share features from The Waterfall, Iterative, Evolutionary models, etc., and can fit into real life time projects. Tailored models are most productive and beneficial for many organizations. If it's a pure testing project, then the V model is the best.

(I) WHAT GROUP OF TEAMS CAN DO SOFTWARE TESTING?

When it comes to testing everyone in the world can be involved right from the developer to the project manager to the customer. But below are different types of team groups which can be present in a project.

Isolated test team: This is a special team of testers which do only testing. The testing team is not related to any project. It's like having a pool of testers in an organization, which are picked up on demand by the project and after completion again get pushed back to the pool. This approach is costly but the most helpful because we have a different angle of thinking from a different group, which is isolated from development.

Outsource: In outsourcing, we contact an external supplier, hire testing resources, and do testing for our project. Again, there are it has two sides of the coin. The good part is resource handling is done by the external supplier. So you are freed from the worry of resources leaving the company, people management, etc. But the bad side of the coin is outsourced vendors do not have domain knowledge of your business. Second, at the initial stage you need to train them on domain knowledge, which is again, an added cost.

Inside test team: In this approach we have a separate team, which belongs to the project. The project allocates a separate budget for testing and this testing team works on this project only. The good side is you have a dedicated team and because they are involved in the project they have strong knowledge of it. The bad part is you need to budget for them which increases the project cost.

Developers as testers: In this approach the developers of the project perform the testing. The good part of this approach is developers have a very good idea of the inner details so they can perform good level of testing. The bad part of this approach is the developer and tester are the same person, so it's very likely that many defects can be missed.

QA/QC team: In this approach the quality team is involved in testing. The good part is the QA team is involved and a good quality of testing can be expected. The bad part is that the QA and QC team of any organization is also involved with many other activities which can hamper the testing quality of the project.

The following diagram shows the different team approaches.

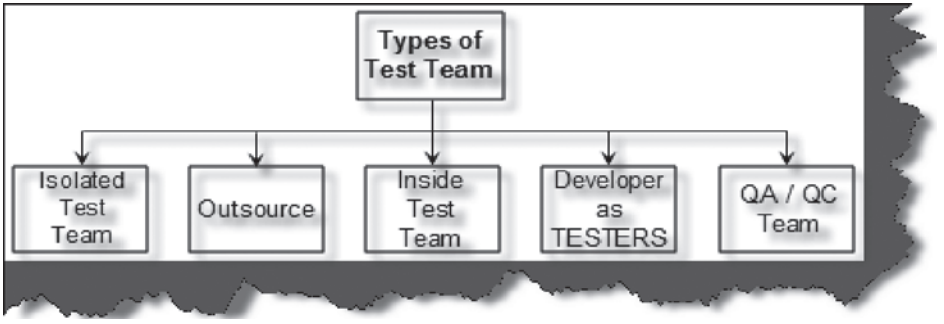


FIGURE 50 **Types of teams**

Chapter 2

TESTING TECHNIQUES

(B) CAN YOU EXPLAIN BOUNDARY VALUE ANALYSIS?

OR

(B) WHAT IS A BOUNDARY VALUE IN SOFTWARE TESTING?

In some projects there are scenarios where we need to do boundary value testing. For instance, let's say for a bank application you can withdraw a maximum of 25000 and a minimum of 100. So in boundary value testing we only test the exact boundaries rather than hitting in the middle. That means we only test above the max and below the max. This covers all scenarios. The following figure shows the boundary value testing for the bank application which we just described. TC1 and TC2 are sufficient to test all conditions for the bank. TC3 and TC4 are just duplicate/redundant test cases which really do not add any value to the testing. So by applying proper boundary value fundamentals we can avoid duplicate test cases, which do not add value to the testing.

(B) CAN YOU EXPLAIN EQUIVALENCE PARTITIONING?

In equivalence partitioning we identify inputs which are treated by the system in the same way and produce the same results. You can see from the following figure applications TC1 and TC2 give the same results (i.e., TC3 and TC4 both give the same result, Result2). In short, we have two redundant test cases. By applying equivalence partitioning we minimize the redundant test cases.

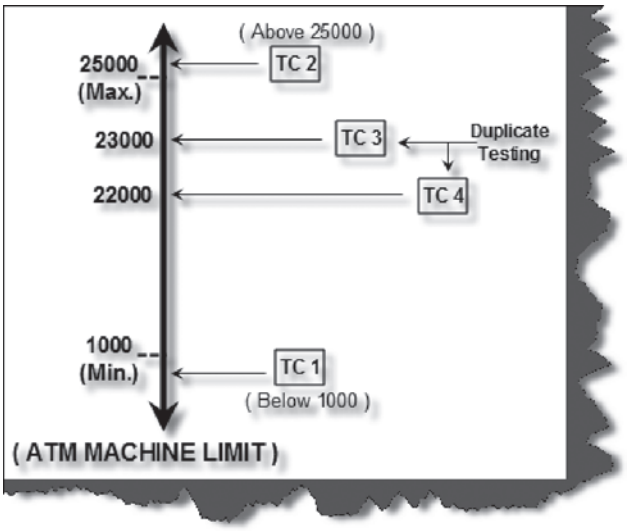


FIGURE 51 **Boundary value analysis**

So apply the test below to see if it forms an equivalence class or not:

- All the test cases should test the same thing.
- They should produce the same results.
- If one test case catches a bug, then the other should also catch it.
- If one of them does not catch the defect, then the other should not catch it.

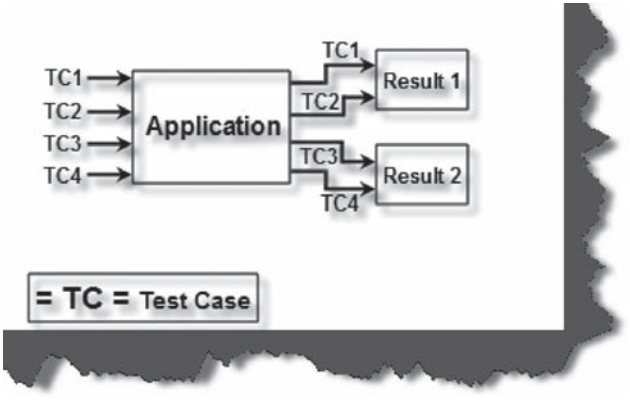


FIGURE 52 **Equivalence partitioning**

The following figure shows how the equivalence partition works. Below, we have a scenario in which valid values lie between 20 and 2000.

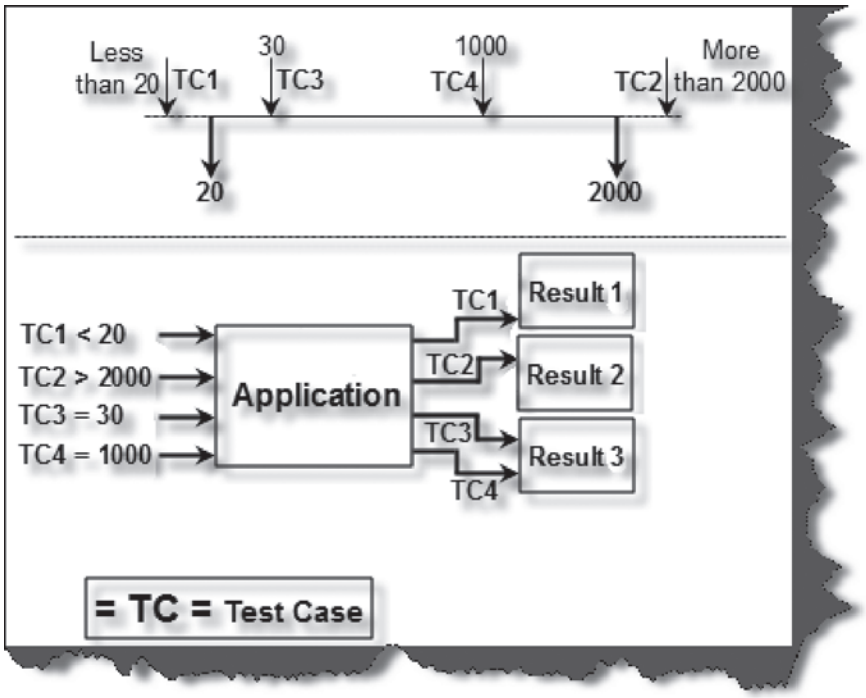


FIGURE 53 **Sample of equivalence partitioning**

Any values beyond 2000 and below 20 are invalid. In the following scenario the tester has made four test cases:

- Check below 20 (TC1)
- Check above 2000 (TC2)
- Check equal to 30 (TC3)
- Check equal to 1000 (TC4)

Test cases 3 and 4 give the same outputs so they lie in the same partition. In short, we are doing redundant testing. Both TC3 and TC4 fall in one equivalence partitioning, so we can prepare one test case by testing one value in between the boundary, thus eliminating redundancy testing in projects.

(B) CAN YOU EXPLAIN HOW THE STATE TRANSITION DIAGRAMS CAN BE HELPFUL DURING TESTING?

Before we understand how state transition diagrams can be useful in testing, let's understand what exactly a state and transition. The result of a previous input is called a state and transitions are actions which cause the state to change from one state to another.

The following figure shows a typical state transition diagram. The arrows signify the transition and the oval shapes signify the states. The first transition in the diagram is the issue of the check that it is ready to be deposited. The second transition is the check is deposited of which we can have two states: either the check cleared or it bounced.

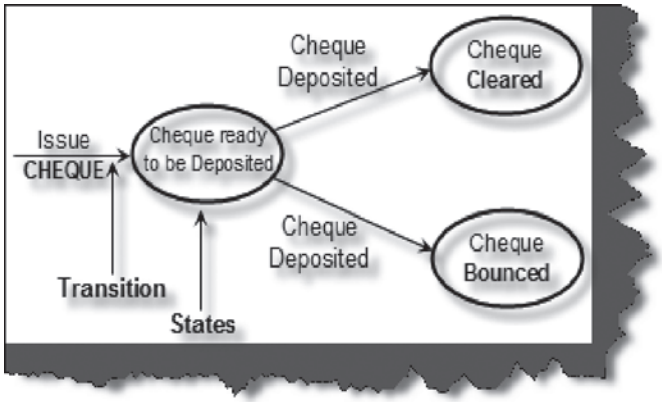


FIGURE 54 **Sample state transition diagram**

Now that we are clear about state and transition, how does it help us in testing? By using states and transitions we can identify test cases. So we can identify test cases either using states or transitions. But if we use only one entity, i.e., either state or transition, it is very possible that we can miss some scenarios. In order to get the maximum benefit we should use the combination of state and transition. The following figure shows that if we only use state or transition in isolation it's possible that we will have partial testing. But the combination of state and transition can give us better test coverage for an application.

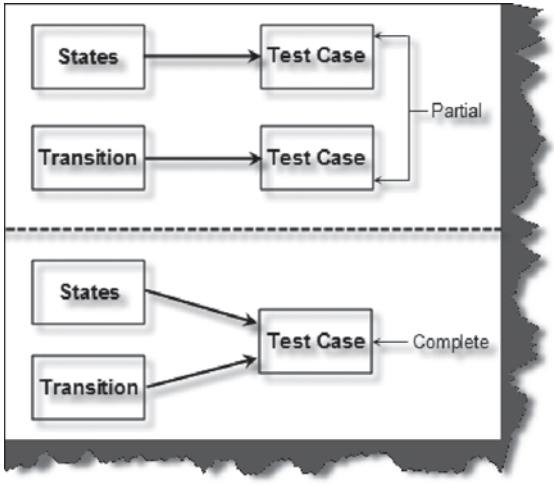


FIGURE 55 **State, transition, and test cases**

(B) CAN YOU EXPLAIN RANDOM TESTING?

OR

(B) CAN YOU EXPLAIN MONKEY TESTING?

Random testing is sometimes called *monkey testing*. In Random testing, data is generated randomly often using a tool. For instance, the following figure shows how randomly-generated data is sent to the system. This data is generated either using a tool or some automated mechanism. With this randomly generated input the system is then tested and results are observed accordingly.

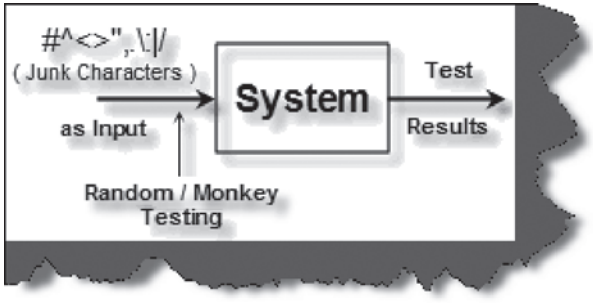


FIGURE 56 **Random/Monkey testing**

Random testing has the following weakness:

- They are not realistic.
- Many of the tests are redundant and unrealistic.
- You will spend more time analyzing results.
- You cannot recreate the test if you do not record what data was used for testing.

This kind of testing is really of no use and is normally performed by newcomers. Its best use is to see if the system will hold up under adverse effects.

(B) WHAT IS NEGATIVE AND POSITIVE TESTING?

A negative test is when you put in an invalid input and recieve errors.

A positive test is when you put in a valid input and expect some action to be completed in accordance with the specification.

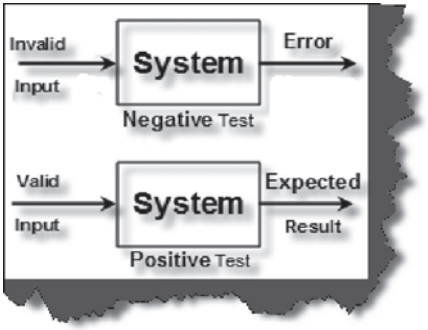


FIGURE 57 **Negative and Positive testing**

(I) CAN YOU EXPLAIN EXPLORATORY TESTING?

Exploratory testing is also called *adhoc testing*, but in reality it's not completely adhoc. Ad hoc testing is an unplanned, unstructured, may be even an impulsive journey through the system with the intent of finding bugs. Exploratory testing is simultaneous learning, test design, and test execution. In other words, exploratory testing is any testing done to the extent that the tester proactively controls the design of the tests as those tests are performed and

uses information gained while testing to design better tests. Exploratory testers are not merely keying in random data, but rather testing areas that their experience (or imagination) tells them are important and then going where those tests take them.

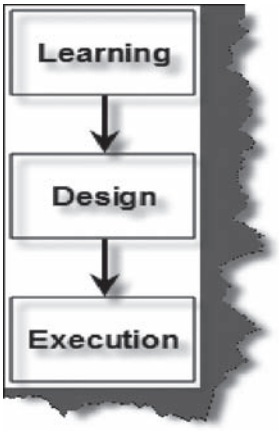


FIGURE 58 **Exploratory testing**

(A) WHAT ARE SEMI-RANDOM TEST CASES?

As the name specifies semi-random testing is nothing but controlling random testing and removing redundant test cases. So what we do is perform random test cases and equivalence partitioning to those test cases, which in turn removes redundant test cases, thus giving us semi-random test cases.

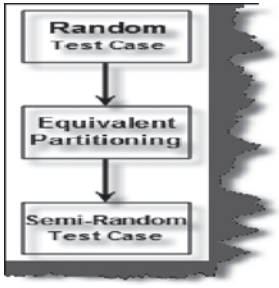


FIGURE 59 **Semi-random test cases**

(I) WHAT IS AN ORTHOGONAL ARRAYS?

OR

(I) CAN YOU EXPLAIN A PAIR-WISE DEFECT?

Orthogonal array is a two-dimensional array in which if we choose any two columns in the array and all the combinations of numbers will appear in those columns. The following figure shows a simple L_9 (3^4) orthogonal array. In this the number 9 indicates that it has 9 rows. The number 4 indicates that it has 4 columns and 3 indicates that each cell contains a 1, 2, and 3. Choose any two columns. Let's choose column 1 and 2. It has (1,1), (1,2), (1,3), (2,1), (2,2), (2,3), (3,1), (3,2), (3,3) combination values. As you can see these values cover all the values in the array. Compare the values with the combination of column 3 and 4 and they will fall in some pair. This is applied in software testing which helps us eliminate duplicate test cases.

	1	2	3	4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

FIGURE 60 **Sample orthogonal array**

Now let's try to apply an orthogonal array in actual testing field. Let's say we have a scenario in which we need to test a mobile handset with different plan types, terms, and sizes. Below are the different situations:

- Handset (Nokia, 3G and Orange).
- Plan type (4 x 400, 4 x 300, and 2 x 270).

- Term (Long-term, short-term, and mid-term).
- Size (3, 4, and 5 inch).

We will also have the following testing combinations:

- Each handset should be tested with every plan type, term, and size.
- Each plan type should be tested with every handset, term, and size.
- Each size should be tested with every handset, plan type, and term.

So now you must be thinking we have 81 combinations. But we can test all these conditions with only 9 test cases. The following is the orthogonal array for it.

$L_9(3^4)$

Test Case	Handset	Plan Type	Term	Size
1	Nokia	4 x 400	Long Term	3 inch
2	Nokia	4 x 300	Mid Term	4 inch
3	Nokia	2 x 270	Short Term	5 inch
4	3G	4 x 400	Mid Term	5 inch
5	3G	4 x 300	Short Term	3 inch
6	3G	2 x 270	Long Term	4 inch
7	Orange	4 x 400	Short Term	4 inch
8	Orange	4 x 300	Long Term	5 inch
9	Orange	2 x 270	Mid Term	3 inch

$L_9(3^4)$

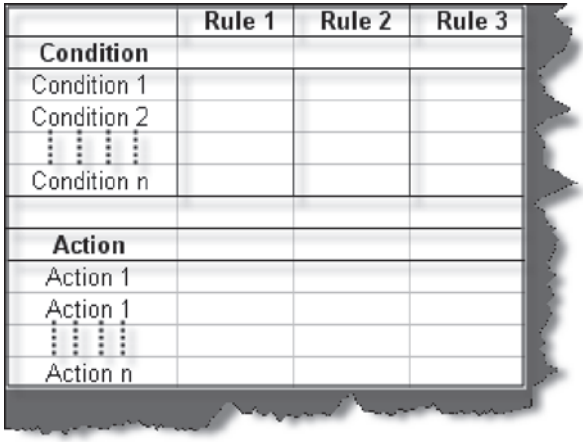
- 9 indicates it has 9 rows
- 4 indicates it has 4 columns
- 3 indicates each cell in the array contains 1, 2 or 3

FIGURE 61 **Orthogonal array in actual testing**

Orthogonal arrays are very useful because most defects are pairs-wise defects and with orthogonal arrays, we can reduce redundancy to a huge extent.

(I) CAN YOU EXPLAIN DECISION TABLES?

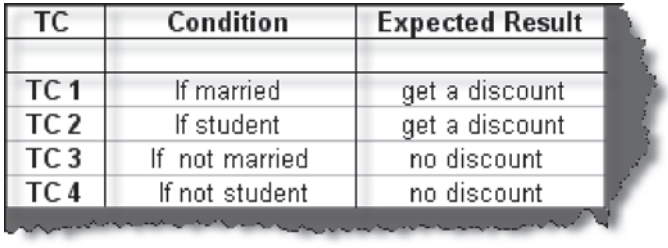
As the name suggests they are tables that list all possible inputs and all possible outputs. A general form of decision table is shown in the following figure. Condition 1 through Condition N indicates various input conditions. Action 1 through Condition N are actions that should be taken depending on various input combinations. Each rule defines unique combinations of conditions that result in actions associated with that rule.



	Rule 1	Rule 2	Rule 3
Condition			
Condition 1			
Condition 2			
⋮			
Condition n			
Action			
Action 1			
Action 1			
⋮			
Action n			

FIGURE 62 **General decision tables**

The following is a sample decision table for a discount which depends on age. Discounts are only allowed if you are married or a student. The following is the decision table accordingly. Using the decision table we have also derived our test cases. Because this is a sample example we cannot see the importance of the



TC	Condition	Expected Result
TC 1	If married	get a discount
TC 2	If student	get a discount
TC 3	If not married	no discount
TC 4	If not student	no discount

FIGURE 63 **Discount Decision table**

decision table. But just imagine that you have a huge amount of possible inputs and outputs. For such a scenario decision tables gives you a better view.

The following is the decision table for the scenarios described above. In the top part we have put the condition and below are the actions which occur as a result of the conditions. Read from the right and move to the left and then to the action. For instance, Married → Yes → then discount. The same goes for the student condition. Using the decision table we can ensure, to a good extent, that we do not skip any validation in a project.

	Rule 1	Rule 2
Condition		
Married	Yes	No
Student	Yes	No
Action		
Discount	Yes	No

FIGURE 64 **Test cases from the above decision tables**

(B) HOW DID YOU DEFINE SEVERITY RATINGS IN YOUR PROJECT?

Note: Severity ratings vary from organization to organization and project to project. But most organizations have four kinds of severity rating as shown.

There are four types of severity ratings as shown in the table:

Rating Severity	Description
1	Show Stoppers.
2	Application continues with severe defect.
3	Application continues with unexpected results.
4	Suggestions.

→ Changes from Organisation to organisation.
→ Changes from Projects to Projects.

FIGURE 65 **Severity rating in projects**

- Severity 1 (showstoppers): These kinds of defects do not allow the application to move ahead. So they are also called showstopper defects.
- Severity 2 (application continues with severe defects): Application continues working with these types of defects, but they can have high implications, later, which can be more difficult to remove.
- Severity 3 (application continues with unexpected results): In this scenario the application continues but with unexpected results.
- Severity 4 (suggestions): Defects with these severities are suggestions given by the customer to make the application better. These kinds of defects have the least priority and are considered at the end of the project or during the maintenance stage of the project.

Chapter 3

THE SOFTWARE PROCESS

(B) WHAT IS A SOFTWARE PROCESS?

A software process is a series of steps used to solve a problem. The following figure shows a pictorial view of how an organization has defined a way to solve risk problems. In the diagram we have shown two branches: one is

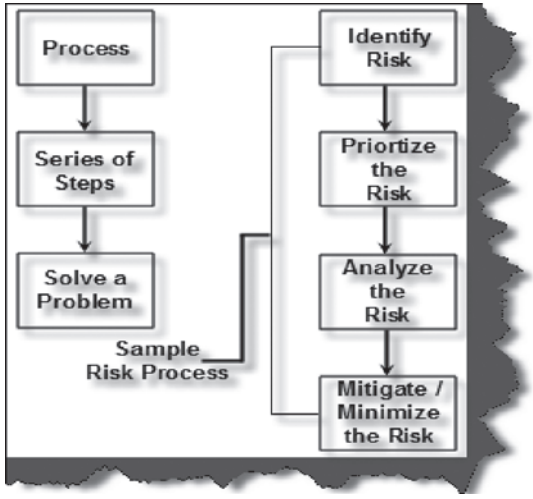


FIGURE 66 **Software process**

the process and the second branch shows a sample risk mitigation process for an organization. For instance, the risk mitigation process defines what step any department should follow to mitigate a risk. The process is as follows:

- Identify the risk of the project by discussion, proper requirement gathering, and forecasting.
- Once you have identified the risk prioritize which risk has the most impact and should be tackled on a priority basis.
- Analyze how the risk can be solved by proper impact analysis and planning.
- Finally, using the above analysis, we mitigate the risk.

(I) WHAT ARE THE DIFFERENT COST ELEMENTS INVOLVED IN IMPLEMENTING A PROCESS IN AN ORGANIZATION?

Below are some of the cost elements involved in the implementing process:

- Salary: This forms the major component of implementing any process, the salary of the employees. Normally while implementing a process in a company either organization can recruit full-time people or they can share resources part-time for implementing the process.
- Consultant: If the process is new it can also involve consultants which is again an added cost.
- Training Costs: Employees of the company may also have to undergo training in order to implement the new process.
- Tools: In order to implement the process an organization will also need to buy tools which again need to be budgeted for.

Note: Implementing a process is not an easy job in any organization. More than financial commitment, it requires commitment from people to follow the process.

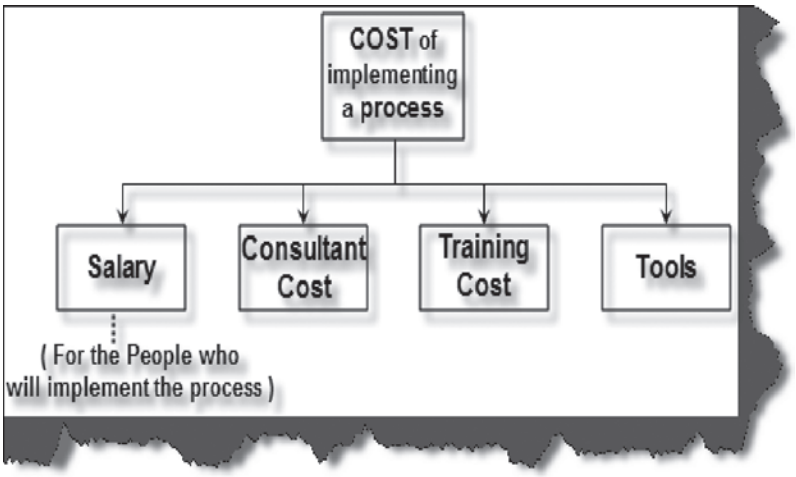


FIGURE 67 **Cost of implementing a process**

(B) WHAT IS A MODEL?

A model is nothing but best practices followed in an industry to solve issues and problems. Models are not made in a day but are finalized and realized by years of experience and continuous improvements.

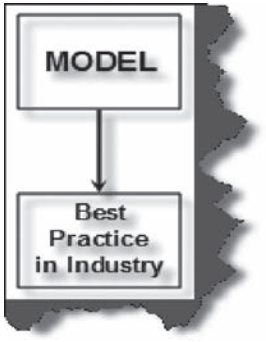


FIGURE 68 **Model**

Many companies reinvent the wheel rather than following time tested models in the industry.

(B) WHAT IS A MATURITY LEVEL?

A maturity level specifies the level of performance expected from an organization.

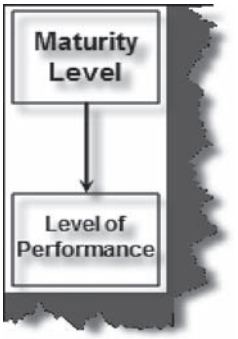


FIGURE 69 **Maturity level**

(B) CAN YOU EXPLAIN PROCESS AREAS IN CMMI?

A process area is the area of improvement defined by CMMI. Every maturity level consists of process areas. A process area is a group of practices or activities performed collectively to achieve a specific objective. For instance, you can see from the following figure we have process areas such as project planning, configuration management, and requirement gathering.

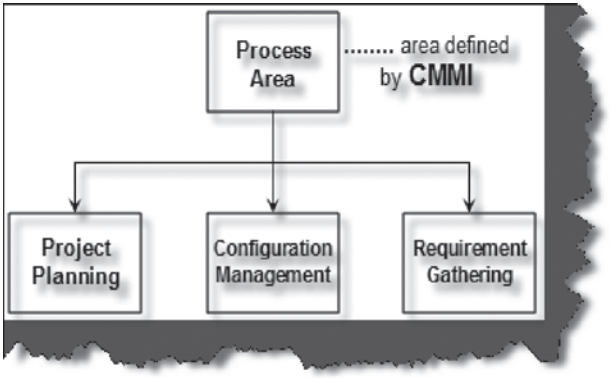


FIGURE 70 **Process areas in action**

(B) CAN YOU EXPLAIN TAILORING?

As the name suggests, tailoring is nothing but changing an action to achieve an objective according to conditions. Whenever tailoring is done there should be adequate reasons for it. Remember when a process is defined in an organization it should be followed properly. So even if tailoring is applied the process is not bypassed or omitted.

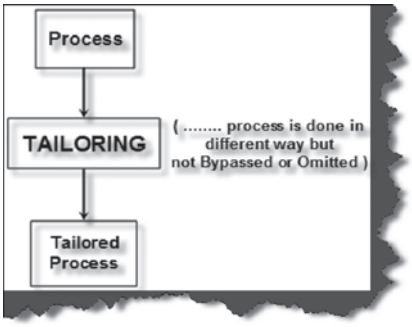


FIGURE 71 **Tailoring**

Let's try to understand this using a simple example. Let's say in a organization there is a process defined that every contract should have a hard copy signed. But there can be scenarios in the organization when the person is not present physically, so for those scenarios the contract should be signed through email. So in short, the process for signing a contract is not bypassed but the process approach is tailored.

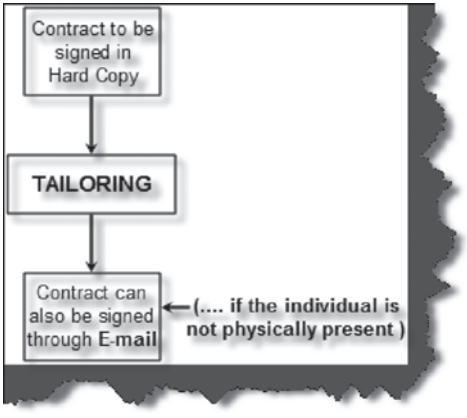


FIGURE 72 **Example of tailoring**

Chapter 4

CMMI

(B) WHAT IS CMMI AND WHAT'S THE ADVANTAGE OF IMPLEMENTING IT IN AN ORGANIZATION?

CMMI stands for Capability Maturity Model Integration. It is a process improvement approach that provides companies with the essential elements of an effective process. CMMI can serve as a good guide for process improvement across a project, organization, or division.

CMMI was formed by using multiple previous CMM processes. The following are the areas which CMMI addresses:

Systems engineering: This covers development of total systems. System engineers concentrate on converting customer needs to product solutions and supports them throughout the product lifecycle.

Software engineering: Software engineers concentrate on the application of systematic, disciplined, and quantifiable approaches to the development, operation, and maintenance of software.

Integrated Product and Process Development (IPPD): Integrated Product and Process Development (IPPD) is a systematic approach that achieves a timely collaboration of relevant stakeholders throughout the life of the product to better satisfy customer needs, expectations, and requirements. This section mostly concentrates on the integration part of the project for different processes. For instance, it's possible that your project is using services of some other third party component. In such situations the integration is a big task itself, and if approached in a systematic manner, can be handled with ease.

Software acquisition: Many times an organization has to acquire products from other organizations. Acquisition is itself a big step for any organization and if not handled in a proper manner means a disaster is sure to happen. The following figure shows the areas involved in CMMI.

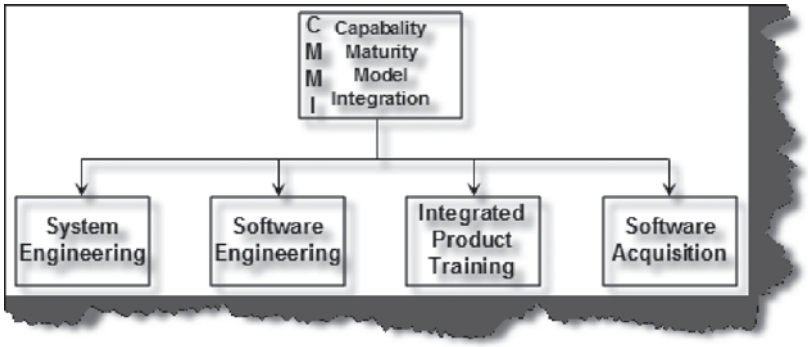


FIGURE 73 CMMI

(I) WHAT'S THE DIFFERENCE BETWEEN IMPLEMENTATION AND INSTITUTIONALIZATION?

Both of these concepts are important while implementing a process in any organization. Any new process implemented has to go through these two phases.

Implementation: It is just performing a task within a process area. A task is performed according to a process but actions performed to complete the process are not ingrained in the organization. That means the process involved is done according to the individual point of view. When an organization starts to implement any process it first starts at this phase, i.e., implementation, and then when this process looks good it is raised to the organization level so that it can be implemented across organizations.

Institutionalization: Institutionalization is the output of implementing the process again and again. The difference between implementation and institutionalization is in implementation if the person who implemented the process leaves the company the process is not followed, but if the process is institutionalized then even if the person leaves the organization, the process is still followed.

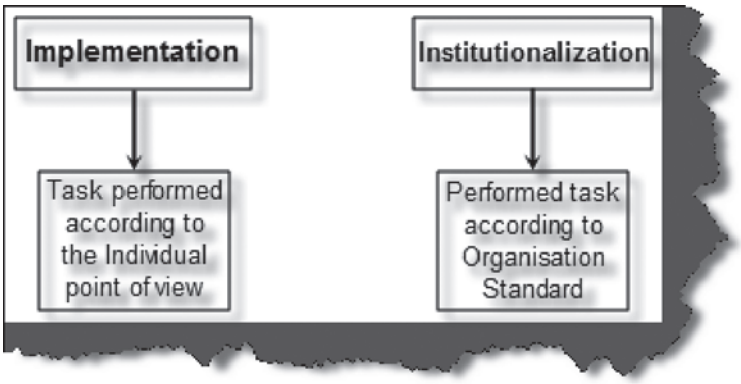


FIGURE: 74 **Implementation and institutionalization**

(I) WHAT ARE DIFFERENT MODELS IN CMMI?

OR

(I) CAN YOU EXPLAIN STAGED AND CONTINUOUS MODELS IN CMMI?

There are two models in CMMI. The first is "staged" in which the maturity level organizes the process areas. The second is "continuous" in which the capability level organizes the process area.

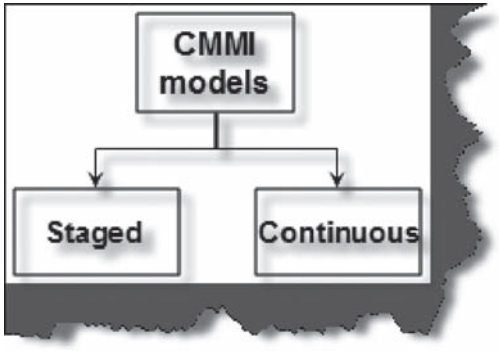


FIGURE 75 **CMMI models**

The following figure shows how process areas are grouped in both models.

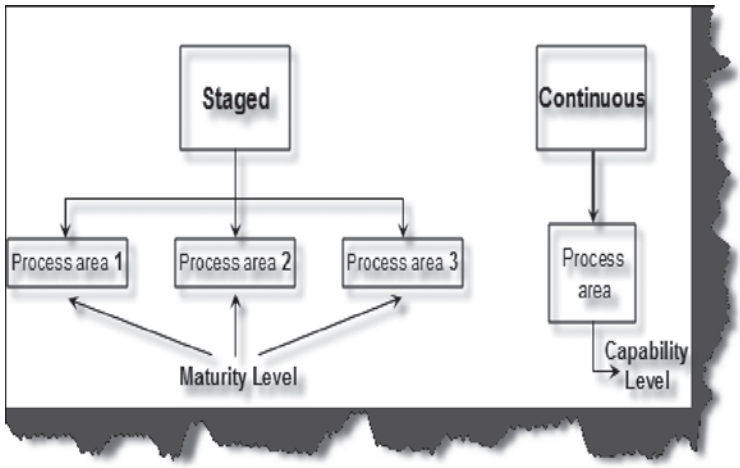


FIGURE 76 **Staged and continuous models**

Let's try to understand both the models in more detail. Before we move ahead let's discuss the basic structure of the CMMI process, goal, and practices. A process area, as said previously, is a group of practices or activities performed to achieve a specific objective. Every process area has specific as well as generic goals that should be satisfied to achieve that objective. To achieve those goals we need to follow certain practices. So again to achieve those specific goals we have specific practices and to achieve generic goals we have generic practices.

In one of our previous questions we talked about implementation and institutionalization. Implementation can be related to a specific practice while institutionalization can be related to generics practices. This is the common basic structure in both models: Process area → Specific/Generic goals → Specific/Generic practice.

Now let's try to understand model structures with both types of representations. In a staged representation, we revolve around the maturity level as shown in the following figure. All processes have to be at one maturity level, while in a continuous representation we try to achieve capability levels in those practices. The following diagram shows how continuous representation revolves around capability. Continuous representation is used when the

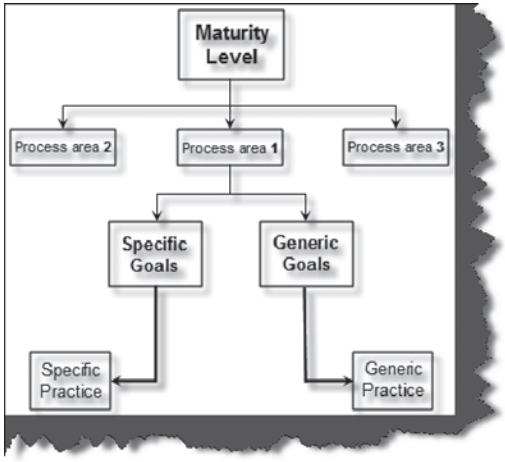


FIGURE 77 **Staged representation**

organization wants to mature and perform in one specific process area only. Let's say for instance in a non-IT organization we want to only improve the supplier agreement process. So that particular organization will only concentrate on the SAM and try to achieve a good capability level in that process area.

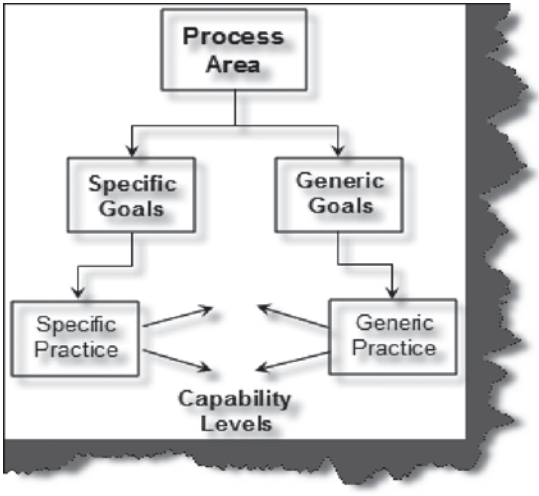


FIGURE 78 **Continuous representation**

(I) CAN YOU EXPLAIN THE DIFFERENT MATURITY LEVELS IN A STAGED REPRESENTATION?

There are five maturity levels in a staged representation as shown in the following figure.

Maturity Level 1 (Initial): In this level everything is adhoc. Development is completely chaotic with budget and schedules often exceeded. In this scenario we can never predict quality.

Maturity Level 2 (Managed): In the managed level basic project management is in place. But the basic project management and practices are followed only in the project level.

Maturity Level 3 (Defined): To reach this level the organization should have already achieved level 2. In the previous level the good practices and process were only done at the project level. But in this level all these good practices and processes are brought to the organization level. There are set and standard practices defined at the organization level which every project should follow. Maturity Level 3 moves ahead with defining a strong, meaningful, organizational approach to developing products. An important distinction between Maturity Levels 2 and 3 is that at Level 3, processes are described in more detail and more rigorously than at Level 2 and are at an organization level.

Maturity Level 4 (Quantitively measured): To start with, this level of organization should have already achieved Level 2 and Level 3. In this level, more statistics come into the picture. Organization controls the project by statistical and other quantitative techniques. Product quality, process performance, and service quality are understood in statistical terms and are managed throughout the life of the processes. Maturity Level 4 concentrates on using metrics to make decisions and to truly measure whether progress is happening and the product is becoming better. The main difference between Levels 3 and 4 are that at Level 3, processes are qualitatively predictable. At Level 4, processes are quantitatively predictable. Level 4 addresses causes of process variation and takes corrective action.

Maturity Level 5 (Optimized): The organization has achieved goals of maturity levels 2, 3, and 4. In this level, processes are continually improved based on an understanding of common causes of variation within the processes. This is like the final level; everyone on the team is a productive member, defects are minimized, and products are delivered on time and within the budget boundary.

The following figure shows, in detail, all the maturity levels in a pictorial fashion.

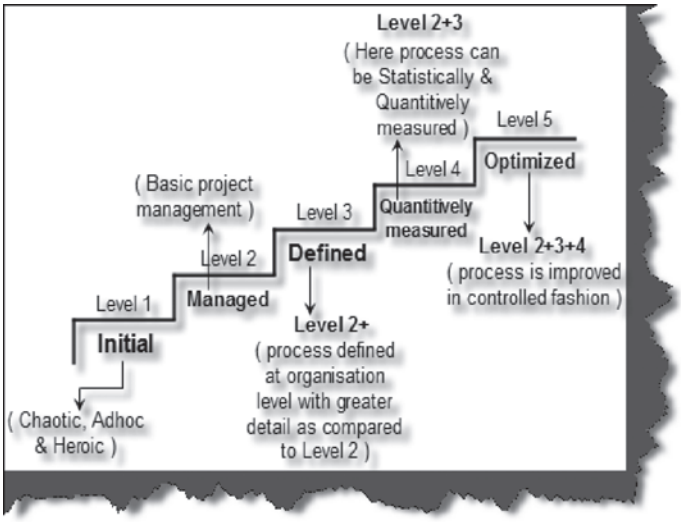


FIGURE 79 **Maturity level in staged model**

(I) CAN YOU EXPLAIN CAPABILITY LEVELS IN A CONTINUOUS REPRESENTATION?

The continuous model is the same as the staged model only that the arrangement is a bit different. The continuous representation/model concentrates on the action or task to be completed within a process area. It focuses on maturing the organizations ability to perform, control, and improve the performance in that specific performance area.

Capability Level 0: Incomplete

This level means that any generic or specific practice of capability level 1 is not performed.

Capability Level 1: Performed

The capability level 1 process is expected to perform all capability level 1 specific and generic practices for that process area. In this level performance

may not be stable and probably does not meet objectives such as quality, cost, and schedule, but still the task can be done.

Capability Level 2: Managed

Capability level 2 is a managed process planned properly, performed, monitored, and controlled to achieve a given purpose. Because the process is managed we achieve other objectives, such as cost, schedule, and quality. Because you are managing, certain metrics are consistently collected and applied to your management approach.

Capability Level 3: Defined

The defined process is a managed process that is tailored from an organization standard. Tailoring is done by justification and documentation guidelines. For instance your organization may have a standard that we should get an invoice from every supplier. But if the supplier is not able to supply the invoice then he should sign an agreement in place of the invoice. So here the invoice standard is not followed but the deviation is under control.

Capability Level 4: Quantitatively Managed

The quantitatively managed process is a defined process which is controlled through statistical and quantitative information. So from defect tracking to project schedules all are statistically tracked and measured for that process.

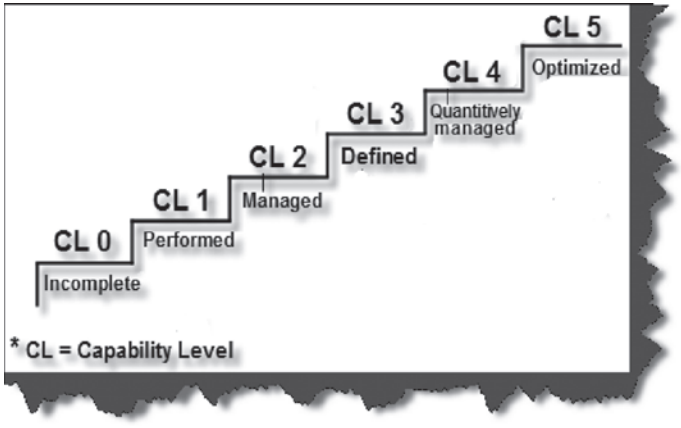


FIGURE 80 **Capability levels in a continuous model**

Capability Level 5: Optimizing

The optimizing process is a quantitatively managed process where we increase process performance through incremental and innovative improvements.

Continuous representation is the same as staged only that information is arranged in a different fashion. The biggest difference is one concentrates on a specific process while the other brings a group of processes to a certain maturity level.

(I) WHICH MODEL SHOULD WE USE AND UNDER WHAT SCENARIOS?

Staging defines an organization process implementation sequence. So staging is a sequence of targeted process areas that describe a path of process improvement the organization will take. For instance, you cannot do your project planning (Level 2) if you have not done requirements management (Level 2). While in the continuous model you select certain process areas even if they're linked with other process areas and mature there.

So when your organization should only concentrate on specific process areas you will likely go for the continuous model. But if you want your organization to have a specific plan and to achieve not only the specific process but also any interlinked process within that process area you should go for the continuous model.

(A) HOW MANY PROCESS AREAS ARE PRESENT IN CMMI AND WHAT CLASSIFICATION DO THEY FALL IN?

All 25 process areas in CMMI are classified into four major sections.

Process management

This process areas contain all project tasks related to defining, planning, executing, implementing, monitoring, controlling, measuring, and making better processes.

Project Management

Project management process areas cover the project management activities related to planning, monitoring, and controlling the project.

Engineering

Engineering process areas were written using general engineering terminology so that any technical discipline involved in the product development process (e.g., software engineering or mechanical engineering) can use them for process improvement.

Support

Support process areas address processes that are used in the context of performing other processes. In general, the support process areas address processes that are targeted toward the project and may address processes that apply more generally to the organization. For example, process and product quality assurance can be used with all the process areas to provide an objective evaluation of the processes and work products described in all the process areas.

The following diagram shows the classification and representation of the process areas.

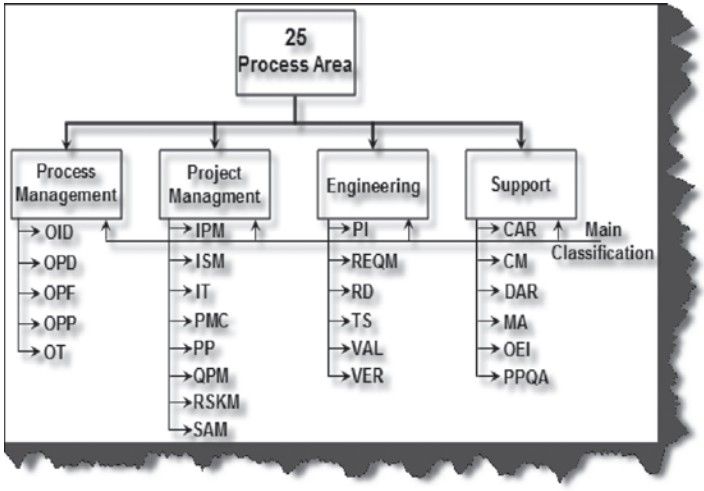


FIGURE 81 **The 25 Process areas**

The following table defines all the abbreviations of the process areas.

Abbreviation for 25 Process area : -			
Process Management		**Engineering**	
OID	Organisational Innovation & Deployment	PI	Product Integration
OPD	Organisational Process Definition	REQM	Requirements Management
OPF	Organisational Process Focus	RD	Requirements Development
OPP	Organisational Process Performance	TS	Technical Solution
OT	Organisational Training	VAL	Validation
		VER	Verification
Project Management			
IPM	Integrated Project Management	**Support**	
ISM	Integrated Supplier Management	CAR	Casual Analysis & Resolution
IT	Integrated Teaming	CM	Configuration Management
PMC	Project Monitoring & Control	DAR	Decision Analysis & Resolution
PP	Project Planning	MA	Measurement & Analysis
QPM	Quantitative Project Management	OEI	Organisational Environment for Integration
RSKM	Risk Management	PPQA	Process & Product Quality Assurance
SAM	Supplier Management Agreement		

FIGURE 82 **Abbreviations of all the process areas**

(B) CAN YOU DEFINE ALL THE LEVELS IN CMMI?

Level 1 and Level 2

These levels are the biggest steps for any organization because the organization moves from a immature position to a more mature organization. Level 1 is an adhoc process in which people have created a personal process to accomplish a certain task. With this approach there is a lot of redundant work and people do not share their information. This leads to heroes' in the project, so when people move out of the organization the knowledge also moves out, and the organization suffers.

In maturity level 2 individuals share their lessons and best practices, which leads to devising preliminary processes at the project and in some cases it also moves to the organization level. In level 2 we focus on project management

issues that affect day to day routines. It has seven process areas as shown in the figure below.

So in the short difference between level 1 and level 2 is related to immature and mature organizations.

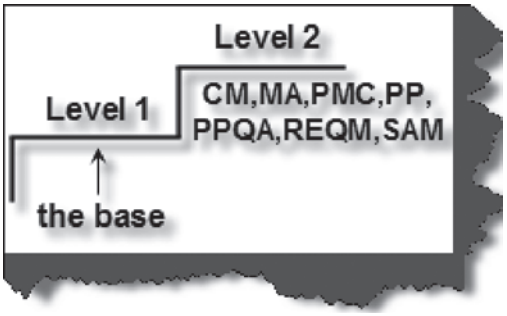


FIGURE 83 **From level 1 to Level 2**

Level 2 to Level 3

Now that in Level 2 good practices are observed at the project level, it is time to move these good practices to the organization level so that every one can benefit from the same. So the biggest difference between Level 2 and Level 3 is good practices from the projects that are bubbled up to organization level. The organization approach of doing business is documented. To perform Maturity level 3, first Maturity 2 must be achieved with the 14 processes as shown in the given figure.

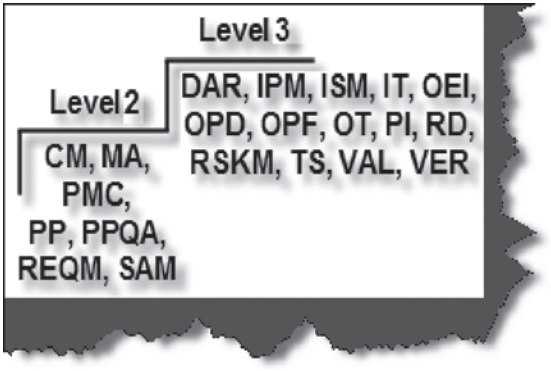


FIGURE 84 **Level 2 to Level 3**

Level 3 to Level 4

Maturity level 4 is all about numbers and statistics. All aspects of the project are managed by numbers. All decisions are made by numbers. Product quality and process are measured by numbers. So in Level 3 we say this is of good quality; in Level 4 we say this is of good quality because the defect ratio is less than 1 %. So there are two process areas in Level 4 as shown below. In order to move to Level 4, you should have achieved all the PA's of Level 3 and also the two process areas below.

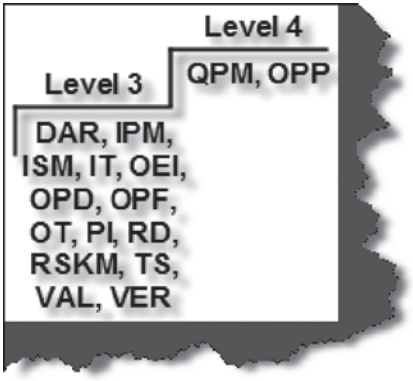


FIGURE 85 **Level 3 to Level 4**

Level 4 to Level 5

Level 5 is all about improvement as compared to Level 4. Level 5 concentrates on improving quality of organization process by identifying variation, by looking at root causes of the conditions and incorporating improvements for

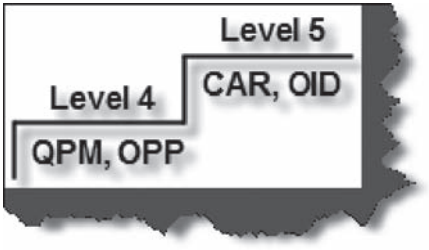


FIGURE 86 **Level 4 to Level 5**

improve process. Below are the two process areas in Level 5 as shown in figure below. In order to get level 5 all level 4 PA's should be satisfied. So the basic difference between level 4 and level 5 is in Level 4 we have already achieved a good level of quality, and in level 5 we are trying to improve the quality.

(I) WHAT DIFFERENT SOURCES ARE NEEDED TO VERIFY AUTHENTICITY FOR CMMI IMPLEMENTATION?

There are three different sources from which an appraiser can verify that an organization followed the process or not.

Instruments: An instrument is a survey or questionnaire provided to the organization, project, or individuals before starting the assessment so that beforehand the appraiser knows some basic details of the project.

Interview: An interview is a formal meeting between one or more members of the organization in which they are asked some questions and the appraiser makes some judgments based on those interviews. During the interview the member represents some process area or role which he performs. For instance, the appraiser may interview a tester or programmer asking him indirectly what metrics he has submitted to his project manager. By this the appraiser gets a fair idea of CMMI implementation in that organization.

Documents: A document is a written work or product which serves as evidence that a process is followed. It can be hard copy, Word document, email, or any type of written official proof.

The following figure is the pictorial view of the sources used to verify how compliant the organization is with CMMI.

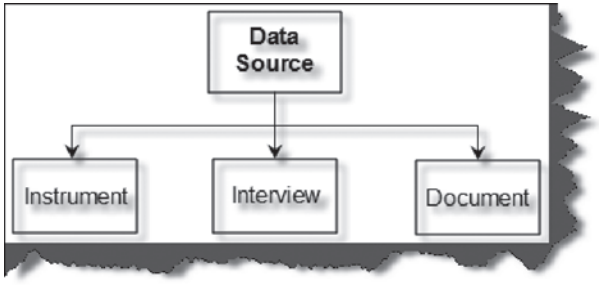


FIGURE 87 **Different data sources used for verification**

(I) CAN YOU EXPLAIN THE SCAMPI PROCESS?

OR

(I) HOW IS APPRAISAL DONE IN CMMI?

SCAMPI stands for Standard CMMI Appraisal Method for Process Improvement. SCAMPI is an assessment process used to get CMMI certified for an organization. There are three classes of CMMI appraisal methods: Class A, Class B, and Class C. Class A is the most aggressive, while Class B is less aggressive, and Class C is the least aggressive.

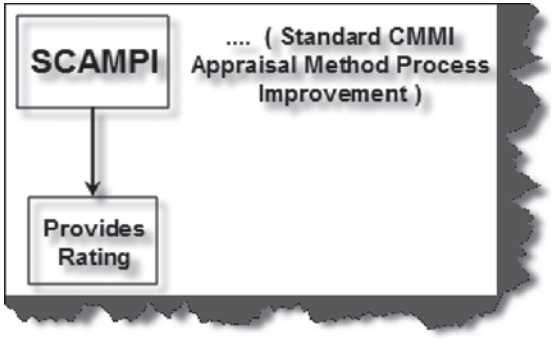


FIGURE 88 SCAMPI

Let's discuss these appraisal methods in more detail.

Class A: This is the only method that can provide a rating and get you a CMMI certificate. It requires all three sources of data instruments, interviews, and documents.

Class B: This class requires only two sources of data (interviews and either documents or instruments). But please note you do not get rated with Class B appraisals. Class B is just a warm-up to see if an organization is ready for Class A. With less verification the appraisal takes less time. In this class data sufficiency and draft presentations are optional.

Class C: This class requires only one source of data (interviews, instruments, or documents). Team consensus, validation, observation, data sufficiency, and draft presentation are optional.

The following table shows the characteristic features with proper comparison.

Characteristic	Class A	Class B	Class C
Amount of objective evidence gathered (relative)	High	Medium	Low
Rating generated	Yes	No	No
Resource needs (relative)	High	Medium	Low
Team size (relative)	Large	Medium	Small
Data sources (instruments, interview, & documents)	Requires all 3 Data sources	Requires 2 Data sources one must be Interview	Requires only 1 Data sources
Appraisal Team Leader requirement	Authorized Lead Appraiser	Authorized Lead Appraiser or person trained & experienced	Person trained & experienced

* **Source:** adapted from Appraisal Requirement for CMMI Version 1.1

FIGURE 89 **Comparison between Class A, B, and C**

(I) WHICH APPRAISAL METHOD CLASS IS BEST?

Normally, organizations use a mix of the classes to achieve process improvement. The following are some of the strategies which an organization uses:

First Strategy

Use Class B to initiate a process improvement plan. After that apply Class C to check readiness for Class B or Class A. The following diagram shows this strategy.

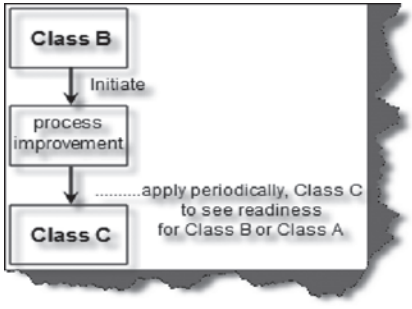


FIGURE 90 **Strategy one**

Second Strategy

Class C appraisal is used on a subset of an organization. From this we get an aggregation of weakness across the organization. From this we can prepare a process improvement plan. We can then apply a Class B appraisal to see if we are ready for Class A appraisal. The following diagram shows the strategy.

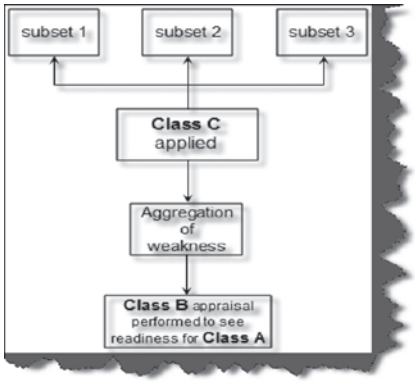


FIGURE 91 **Second strategy**

Third Strategy

Class A is used to initiate an organization level process. The process improvement plan is based on an identified weakness. Class B appraisal should be performed after six months to see the readiness for the second Class A appraisal rating. The following diagram shows this strategy.

FIGURE 92 **Third strategy**

(I) CAN YOU EXPLAIN THE IMPORTANCE OF PII IN SCAMPI?

Using PII (Practice Implementation Indicators) we find information about the organization. PII gives us a compliance matrix showing how practices are performed in an organization. PII basically consists of three types of information: direct work products, indirect work products, and affirmations. Direct work products and indirect work products come from documents while affirmations come from interviews. The following table shows sample PII information for the SAM process and for one of the key process areas.

SG 1: - Establish Supplier Agreement			
PII Type	Direct work products	Indirect work products	Affirmation
Organisation **Evidence**	signed supplier agreement copy found	supplier agreement document was used to pass invoices	supplier has to sign supplier agreement
Notes	supplier agreement found	invoices passed with supplier agreement	

FIGURE 93 **Sample PIID**

Once the PII documents are filed we can rate whether the organization is compliant or not. Below are the steps to be followed during the SCAMPI:

- Gather documentation.
- Conduct interviews.
- Discover and document strengths and weaknesses.
- Communicate/present findings.

(A) CAN YOU EXPLAIN IMPLEMENTATION OF CMMI IN ONE OF THE KEY PROCESS AREAS?

Note: This question will be asked to judge whether you have actually implemented CMMI in a proper fashion in your oganization. To answer this question, we will be using SAM as the process area. But you can answer with whatever process area you have implemented in your organization.

For the following SAM process there are the two SG1 and SG2 practices which need to be implemented to satisfy the process area. SAM helps us to define our agreement with the supplier while procuring products in the company. Let's see, in the next step, how we have mapped our existing process with the SAM practices defined in CMMI.

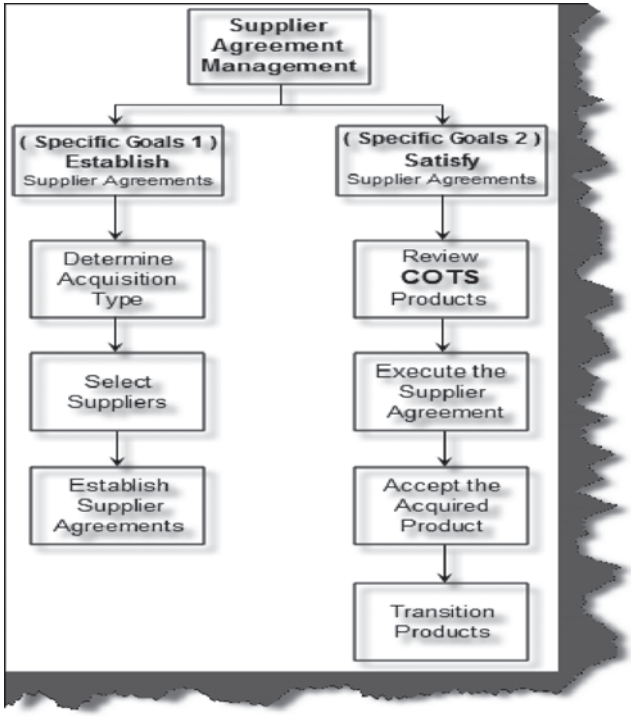


FIGURE 94 **SAM process area**

SAM is a process adopted by the company. If anyone wants to demand any product he has to first raise demand for the item by using the demand form which is defined by the company. Depending on demand the supervisor defines which acquisition type the demand is. For instance, is it a production acquisition type, office material acquisition type, or another type. Once the acquisition type is decided the organization places an advertisement in the newspaper to ask suppliers for quotes. Once all quotations are received depending on cost, quality, and other factors the final supplier is decided. The supplier is then called to the office and he has to sign an agreement with the organization for the delivery of the product. Once the agreement is signed the supplier sends a sample product which is analyzed by the organization practically. Finally, the product is accepted and the supplier is then asked to

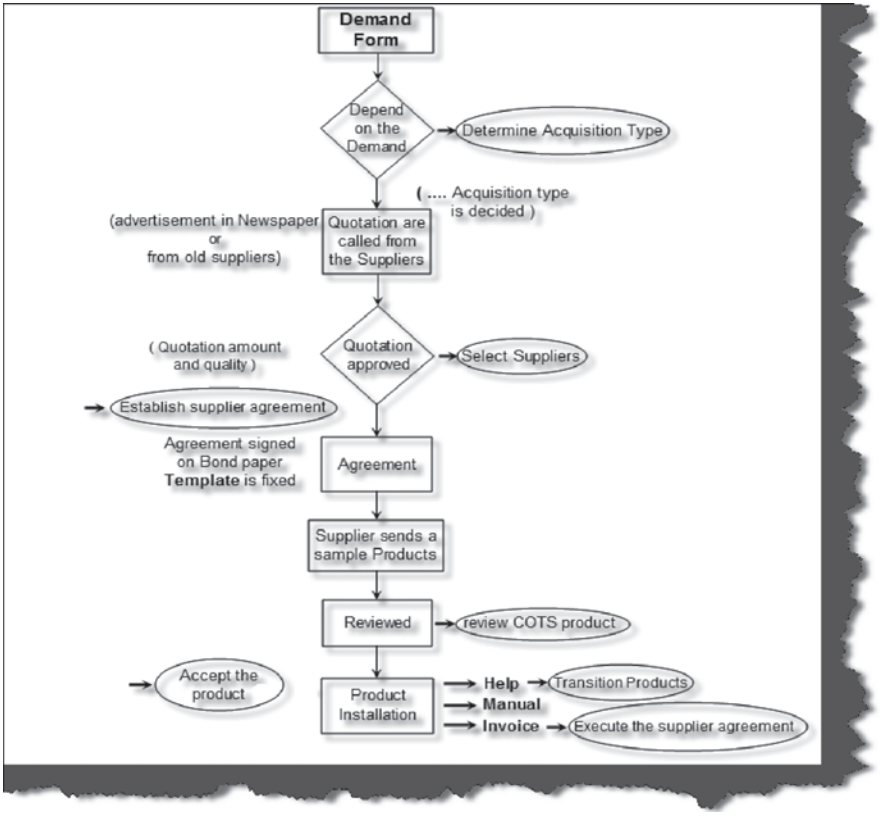


FIGURE 95 **SAM process area mapped**

send the complete delivery of all products. The product is accepted in the organization by issuing the supplier a proper invoice. The invoice document says that the product is accepted by the organization officially. When the product is installed in the organization then either someone from the supplier side comes for the demo or a help brochure is shipped with the product.

The above explanation is from the perspective of the how the organization manages its transactions with the supplier. Now let's try to map how the above process fits in the CMMI model. In the above diagram the circled descriptions are process areas of CMMI.

CMMI process	Organization process
Determine acquisition type	In the above process the demand form decides what the acquisition type of the product is.
Select suppliers	Looking at the quotation the supplier is reviewed and the selection is done.
Establish supplier agreements	In the above process we have a step when we sign an agreement with the supplier which establishes all the terms and conditions for the supplier agreement.
Review product	One of the steps of the process is that the supplier has to send a sample which is reviewed by the organization.
Execute supplier agreements	The supplier agreement is executed by accepting the invoice.
Accept acquired product	The invoice is the proof of acceptance of the product.
Transition products	In the above process the transition of the product either happens through help brochures or when the demo person visits.

(B) WHAT ARE ALL THE PROCESS AREAS AND GOALS AND PRACTICES?

OR

(A) CAN YOU EXPLAIN ALL THE PROCESS AREAS?

Note: No one is going to ask such a question, but they would like to know at least the purpose of each KPA. Second, they would like to know what you did to attain compatibility in these process areas. For instance, you say that you did an organizational process. They would like to know how you did it. You can justify it by saying that you made standard documents for coding standards which was then followed at the organization level for reference. Normally everyone follows a process; only they do not realize it. So try to map the KPA to the process that you followed.

Each process area is defined by a set of goals and practices. There are two categories of goals and practices: generic and specific. Generic goals and practices are a part of every process area. Specific goals and practices are specific to a given process area. A process area is satisfied when company processes cover all of the generic and specific goals and practices for that process area.

Generic goals and practices are a part of every process area. They include the following:

GG 1 Achieve Specific Goals
GP 1.1 Perform Base Practices
GG 2 Institutionalize a Managed Process
GP 2.1 Establish an Organizational Policy
GP 2.2 Plan the Process
GP 2.3 Provide Resources
GP 2.4 Assign Responsibility
GP 2.5 Train People
GP 2.6 Manage Configurations
GP 2.7 Identify and Involve Relevant Stakeholders
GP 2.8 Monitor and Control the Process
GP 2.9 Objectively Evaluate Adherence

GP 2.10 Review Status with Higher Level Management
GG 3 Institutionalize a Defined Process
GP 3.1 Establish a Defined Process
GP 3.2 Collect Improvement Information
GG 4 Institutionalize a Quantitatively Managed Process
GP 4.1 Establish Quantitative Objectives for the Process
GP 4.2 Stabilize Sub process Performance
GG 5 Institutionalize an Optimizing Process
GP 5.1 Ensure Continuous Process Improvement
GP 5.2 Correct Root Causes of Problems

Process Areas

The CMMI contains 25 key process areas indicating the aspects of product development that are to be covered by company processes.

Causal Analysis and Resolution (CAR)

A support process area at Maturity Level 5.

Purpose

The purpose of Causal Analysis and Resolution (CAR) is to identify causes of defects and other problems and take action to prevent them from occurring in the future.

Specific Practices by Goal

SG 1 Determine Causes of Defects
SP 1.1-1 Select Defect Data for Analysis
SP 1.2-1 Analyze Causes
SG 2 Address Causes of Defects
SP 2.1-1 Implement the Action Proposals
SP 2.2-1 Evaluate the Effect of Changes
SP 2.3-1 Record Data

Configuration Management (CM)

A support process area at Maturity Level 2.

Purpose

The purpose of Configuration Management (CM) is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

Specific Practices by Goal

SG 1	Establish Baselines
SP 1.1-1	Identify Configuration Items
SP 1.2-1	Establish a Configuration Management System
SP 1.3-1	Create or Release Baselines
SG 2	Track and Control Changes
SP 2.1-1	Track Change Requests
SP 2.2-1	Control Configuration Items
SG 3	Establish Integrity
SP 3.1-1	Establish Configuration Management Records
SP 3.2-1	Perform Configuration Audits

Decision Analysis and Resolution (DAR)

A support process area at Maturity Level 3.

Purpose

The purpose of Decision Analysis and Resolution (DAR) is to analyze possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria.

Specific Practices by Goal

SG 1	Evaluate Alternatives
SP 1.1-1	Establish Guidelines for Decision Analysis
SP 1.2-1	Establish Evaluation Criteria
SP 1.3-1	Identify Alternative Solutions
SP 1.4-1	Select Evaluation Methods
SP 1.5-1	Evaluate Alternatives
SP 1.6-1	Select Solutions

Integrated Project Management (IPM)

A Project Management process area at Maturity Level 3.

Purpose

The purpose of Integrated Project Management (IPM) is to establish and manage the project and the involvement of the relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes.

Specific Practices by Goal

SG 1	Use the Project's Defined Process
SP 1.1-1	Establish the Project's Defined Process
SP 1.2-1	Use Organizational Process Assets for Planning Project Activities
SP 1.3-1	Integrate Plans
SP 1.4-1	Manage the Project Using the Integrated Plans
SP 1.5-1	Contribute to the Organizational Process Assets
SG 2	Coordinate and Collaborate with Relevant Stakeholders
SP 2.1-1	Manage Stakeholder Involvement
SP 2.2-1	Manage Dependencies
SP 2.3-1	Resolve Coordination Issues
SG 3	Use the Project's Shared Vision for IPPD
SP 3.1-1	Define a Project's Shared Vision for IPPD
SP 3.2-1	Establish the Project's Shared Vision
SG 4	Organize Integrated Teams for IPPD
SP 4.1-1	Determine Integrated Team Structure for the Project
SP 4.2-1	Develop a Preliminary Distribution of Requirements to Integrated Teams
SP 4.3-1	Establish Integrated Teams

Integrated Supplier Management (ISM)

A project management process area at Maturity Level 3.

Purpose

The purpose of Integrated Supplier Management (ISM) is to proactively identify sources of products that may be used to satisfy the project's requirements and to manage selected suppliers while maintaining a cooperative project-supplier relationship.

Specific Practices by Goal

SG 1	Analyze and Select Sources of Products
SP 1.1-1	Analyze Potential Sources of Products
SP 1.2-1	Evaluate and Determine Sources of Products
SG 2	Coordinate Work with Suppliers
SP 2.1-1	Monitor Selected Supplier Processes
SP 2.2-1	Evaluate Selected Supplier Work Products
SP 2.3-1	Revise the Supplier Agreement or Relationship

Integrated Teaming (IT)

A Project Management process area at Maturity Level 3.

Purpose

The purpose of Integrated Teaming (IT) is to form and sustain an integrated team for the development of work products.

Specific Practices by Goal

SG 1	Establish Team Composition
SP 1.1-1	Identify Team Tasks
SP 1.2-1	Identify Needed Knowledge and Skills
SP 1.3-1	Assign Appropriate Team Members
SG 2	Govern Team Operation
SP 2.1-1	Establish a Shared Vision
SP 2.2-1	Establish a Team Charter
SP 2.3-1	Define Roles and Responsibilities
SP 2.4-1	Establish Operating Procedures
SP 2.5-1	Collaborate among Interfacing Teams

Measurement and Analysis (MA)

A support process area at Maturity Level 2.

Purpose

The purpose of Measurement and Analysis (MA) is to develop and sustain a measurement capability that is used to support management information needs.

Specific Practices by Goal

SG 1 Align Measurement and Analysis Activities
SP 1.1-1 Establish Measurement Objectives
SP 1.2-1 Specify Measures
SP 1.3-1 Specify Data Collection and Storage Procedures
SP 1.4-1 Specify Analysis Procedures
SG 2 Provide Measurement Results
SP 2.1-1 Collect Measurement Data
SP 2.2-1 Analyze Measurement Data
SP 2.3-1 Store Data and Results
SP 2.4-1 Communicate Results

Organizational Environment for Integration (OEI)

A support process area at Maturity Level 3.

Purpose

The purpose of Organizational Environment for Integration (OEI) is to provide an Integrated Product and Process Development (IPPD) infrastructure and manage people for integration.

Specific Practices by Goal

SG 1 Provide IPPD Infrastructure
SP 1.1-1 Establish the Organization's Shared Vision
SP 1.2-1 Establish an Integrated Work Environment
SP 1.3-1 Identify IPPD-Unique Skill Requirements
SG 2 Manage People for Integration
SP 2.1-1 Establish Leadership Mechanisms
SP 2.2-1 Establish Incentives for Integration
SP 2.3-1 Establish Mechanisms to Balance Team and Home Organization Responsibilities

Organizational Innovation and Deployment (OID)

A Process Management process area at Maturity Level 5.

Purpose

The purpose of Organizational Innovation and Deployment (OID) is to select and deploy incremental and innovative improvements that measurably improve the organization's processes and technologies. The improvements

support the organization's quality and process-performance objectives as derived from the organization's business objectives.

Specific Practices by Goal

SG 1	Select Improvements
SP 1.1-1	Collect and Analyze Improvement Proposals
SP 1.2-1	Identify and Analyze Innovations
SP 1.3-1	Pilot Improvements
SP 1.4-1	Select Improvements for Deployment
SG 2	Deploy Improvements
SP 2.1-1	Plan the Deployment Areas
SP 2.2-1	Manage the Deployment
SP 2.3-1	Measure Improvement Effects

Organizational Process Definition (OPD)

A process management process area at Maturity Level 3.

Purpose

The purpose of the Organizational Process Definition (OPD) is to establish and maintain a usable set of organizational process assets.

Specific Practices by Goal

SG 1	Establish Organizational Process Assets
SP 1.1-1	Establish Standard Processes
SP 1.2-1	Establish Life-Cycle Model Descriptions
SP 1.3-1	Establish Tailoring Criteria and Guidelines
SP 1.4-1	Establish the Organization's Measurement Repository
SP 1.5-1	Establish the Organization's Process Asset Library

Organizational Process Focus (OPF)

A process management process area at Maturity Level 3.

Purpose

The purpose of Organizational Process Focus (OPF) is to plan and implement organizational process improvement based on a thorough understanding of

the current strengths and weaknesses of the organization's processes and process assets.

Specific Practices by Goal

SG 1	Determine Process Improvement Opportunities
SP 1.1-1	Establish Organizational Process Needs
SP 1.2-1	Appraise the Organization's Processes
SP 1.3-1	Identify the Organization's Process Improvements
SG 2	Plan and Implement Process Improvement Activities
SP 2.1-1	Establish Process Action Plans
SP 2.2-1	Implement Process Action Plans
SP 2.3-1	Deploy Organizational Process Assets
SP 2.4-1	Incorporate Process-Related Experiences into the Organizational Process Assets

Organizational Process Performance (OPP)

A Process Management process area at Maturity Level 4.

Purpose

The purpose of Organizational Process Performance (OPP) is to establish and maintain a quantitative understanding of the performance of the organization's set of standard processes in support of quality and process-performance objectives, and to provide the process performance data, baselines, and models to quantitatively manage the organization's projects.

Specific Practices by Goal

SG 1	Establish Performance Baselines and Models
SP 1.1-1	Select Processes
SP 1.2-1	Establish Process Performance Measures
SP 1.3-1	Establish Quality and Process Performance Objectives
SP 1.4-1	Establish Process Performance Baselines
SP 1.5-1	Establish Process Performance Models

Organizational Training (OT)

A process management process area at Maturity Level 3.

Purpose

The purpose of Organizational Training (OT) is to develop the skills and knowledge of people so that they can perform their roles effectively and efficiently.

Specific Practices by Goal

SG 1	Establish an Organizational Training Capability
SP 1.1-1	Establish the Strategic Training Needs
SP 1.2-1	Determine Which Training Needs Are the Responsibility of the Organization
SP 1.3-1	Establish an Organizational Training Tactical Plan
SP 1.4-1	Establish Training Capability
SG 2	Provide Necessary Training
SP 2.1-1	Deliver Training
SP 2.2-1	Establish Training Records
SP 2.3-1	Assess Training Effectiveness

Product Integration (PI)

An engineering process area at Maturity Level 3.

Purpose

The purpose of Product Integration (PI) is to assemble the product from the product components, ensure that the product is integrated, functions properly, and delivers the product.

Specific Practices by Goal

SG 1	Prepare for Product Integration
SP 1.1-1	Determine Integration Sequence
SP 1.2-1	Establish the Product Integration Environment
SP 1.3-1	Establish Product Integration Procedures and Criteria
SG 2	Ensure Interface Compatibility
SP 2.1-1	Review Interface Descriptions for Completeness
SP 2.2-1	Manage Interfaces
SG 3	Assemble Product Components and Deliver the Product
SP 3.1-1	Confirm Readiness of Product Components for Integration

SP 3.2-1 Assemble Product Components
SP 3.3-1 Evaluate Assembled Product Components
SP 3.4-1 Package and Deliver the Product or Product Component

Project Monitoring and Control (PMC)

A project management process area at Maturity Level 2.

Purpose

The purpose of Project Monitoring and Control (PMC) is to provide an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan.

Specific Practices by Goals

SG 1 Monitor Project Against the Plan
SP 1.1-1 Monitor Project Planning Parameters
SP 1.2-1 Monitor Commitments
SP 1.3-1 Monitor Project Risks
SP 1.4-1 Monitor Data Management
SP 1.5-1 Monitor Stakeholder Involvement
SP 1.6-1 Conduct Progress Reviews
SP 1.7-1 Conduct Milestone Reviews
SG 2 Manage Corrective Action to Closure
SP 2.1-1 Analyze Issues
SP 2.2-1 Take Corrective Action
SP 2.3-1 Manage Corrective Action

Project Planning (PP)

A project management process area at Maturity Level 2.

Purpose

The purpose of Project Planning (PP) is to establish and maintain plans that define project activities.

Specific Practices by Goal

SG 1 Establish Estimates
SP 1.1-1 Estimate the Scope of the Project

SP 1.2-1 Establish Estimates of Work Product and Task Attributes
SP 1.3-1 Define Project Life Cycle
SP 1.4-1 Determine Estimates of Effort and Cost
SG 2 Develop a Project Plan
SP 2.1-1 Establish the Budget and Schedule
SP 2.2-1 Identify Project Risks
SP 2.3-1 Plan for Data Management
SP 2.4-1 Plan for Project Resources
SP 2.5-1 Plan for Needed Knowledge and Skills
SP 2.6-1 Plan Stakeholder Involvement
SP 2.7-1 Establish the Project Plan
SG 3 Obtain Commitment to the Plan
SP 3.1-1 Review Plans that Affect the Project
SP 3.2-1 Reconcile Work and Resource Levels
SP 3.3-1 Obtain Plan Commitment

Process and Product Quality Assurance (PPQA)

A support process area at Maturity Level 2.

Purpose

The purpose of Process and Product Quality Assurance (PPQA) is to provide staff and management with objective insight into processes and associated work products.

Specific Practices by Goal

SG 1 Objectively Evaluate Processes and Work Products
SP 1.1-1 Objectively Evaluate Processes
SP 1.2-1 Objectively Evaluate Work Products and Services
SG 2 Provide Objective Insight
SP 2.1-1 Communicate and Ensure Resolution of Noncompliance Issues
SP 2.2-1 Establish Records

Quantitative Project Management (QPM)

A Project Management process area at Maturity Level 4.

Purpose

The purpose of the Quantitative Project Management (QPM) process area is to quantitatively manage the project's defined process to achieve the project's established quality and process-performance objectives.

Specific Practices by Goal

SG 1	Quantitatively Manage the Project
SP 1.1-1	Establish the Project's Objectives
SP 1.2-1	Compose the Defined Processes
SP 1.3-1	Select the Sub processes that Will Be Statistically Managed
SP 1.4-1	Manage Project Performance
SG 2	Statistically Manage Sub-process Performance
SP 2.1-1	Select Measures and Analytic Techniques
SP 2.2-1	Apply Statistical Methods to Understand Variation
SP 2.3-1	Monitor Performance of the Selected Sub-processes
SP 2.4-1	Record Statistical Management Data

Requirements Development (RD)

An engineering process area at Maturity Level 3.

Purpose

The purpose of Requirements Development (RD) is to produce and analyze customer, product, and product-component requirements.

Specific Practices by Goal

SG 1	Develop Customer Requirements
SP 1.1-1	Collect Stakeholder Needs
SP 1.1-2	Elicit Needs
SP 1.2-1	Develop the Customer Requirements
SG 2	Develop Product Requirements
SP 2.1-1	Establish Product and Product-Component Requirements
SP 2.2-1	Allocate Product-Component Requirements
SP 2.3-1	Identify Interface Requirements
SG 3	Analyze and Validate Requirements

SP 3.1-1 Establish Operational Concepts and Scenarios
SP 3.2-1 Establish a Definition of Required Functionality
SP 3.3-1 Analyze Requirements
SP 3.4-3 Analyze Requirements to Achieve Balance
SP 3.5-1 Validate Requirements
SP 3.5-2 Validate Requirements with Comprehensive Methods

Requirements Management (REQM)

An engineering process area at Maturity Level 2.

Purpose

The purpose of Requirements Management (REQM) is to manage the requirements of the project's products and product components and to identify inconsistencies between those requirements and the project's plans and work products.

Specific Practices by Goal

SG 1 Manage Requirements
SP 1.1-1 Obtain an Understanding of Requirements
SP 1.2-2 Obtain Commitment to Requirements
SP 1.3-1 Manage Requirements Changes
SP 1.4-2 Maintain Bidirectional Traceability of Requirements
SP 1.5-1 Identify Inconsistencies between Project Work and Requirements

Risk Management (RSKM)

A project management process area at Maturity Level 3.

Purpose

The purpose of Risk Management (RSKM) is to identify potential problems before they occur so that risk-handling activities can be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives.

Specific Practices by Goal

SG 1 Prepare for Risk Management
SP 1.1-1 Determine Risk Sources and Categories

SP 1.2-1 Define Risk Parameters
SP 1.3-1 Establish a Risk Management Strategy
SG 2 Identify and Analyze Risks
SP 2.1-1 Identify Risks
SP 2.2-1 Evaluate, Categorize, and Prioritize Risks
SG 3 Mitigate Risks
SP 3.1-1 Develop Risk Mitigation Plans
SP 3.2-1 Implement Risk Mitigation Plans

Supplier Agreement Management (SAM)

A project management process area at Maturity Level 2.

Purpose

The purpose of the Supplier Agreement Management (SAM) is to manage the acquisition of products from suppliers for which there exists a formal agreement.

Specific Practices by Goal

SG 1 Establish Supplier Agreements
SP 1.1-1 Determine Acquisition Type
SP 1.2-1 Select Suppliers
SP 1.3-1 Establish Supplier Agreements
SG 2 Satisfy Supplier Agreements
SP 2.1-1 Review COTS Products
SP 2.2-1 Execute the Supplier Agreement
SP 2.3-1 Accept the Acquired Product
SP 2.4-1 Transition Products

Technical Solution (TS)

An engineering process area at Maturity Level 3.

Purpose

The purpose of the Technical Solution (TS) is to design, develop, and implement solutions to requirements. Solutions, designs, and implementations encompass products, product components, and product-related life-cycle processes either alone or in appropriate combinations.

Specific Practices by Goal

SG 1	Select Product-Component Solutions
SP 1.1-1	Develop Alternative Solutions and Selection Criteria
SP 1.1-2	Develop Detailed Alternative Solutions and Selection Criteria
SP 1.2-2	Evolve Operational Concepts and Scenarios
SP 1.3-1	Select Product-Component Solutions
SG 2	Develop the Design
SP 2.1-1	Design the Product or Product Component
SP 2.2-3	Establish a Technical Data Package
SP 2.3-1	Establish Interface Descriptions
SP 2.3-3	Design Interfaces Using Criteria
SP 2.4-3	Perform Make, Buy, or Reuse Analyses
SG 3	Implement the Product Design
SP 3.1-1	Implement the Design
SP 3.2-1	Develop Product Support

Documentation Validation (VAL)

An engineering process area at Maturity Level 3.

Purpose

The purpose of Validation (VAL) is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment.

Specific Practices by Goal

SG 1	Prepare for Validation
SP 1.1-1	Select Products for Validation
SP 1.2-2	Establish the Validation Environment
SP 1.3-3	Establish Validation Procedures and Criteria
SG 2	Validate Product or Product Components
SP 2.1-1	Perform Validation
SP 2.2-1	Analyze Validation Results

Verification (VER)

An engineering process area at Maturity Level 3.

Purpose

The purpose of Verification (VER) is to ensure that a selected work product meets their specified requirements.

Specific Practices by Goal

SG 1	Prepare for Verification
SP 1.1-1	Select Work Products for Verification
SP 1.2-2	Establish the Verification Environment
SP 1.3-3	Establish Verification Procedures and Criteria
SG 2	Perform Peer Reviews
SP 2.1-1	Prepare for Peer Reviews
SP 2.2-1	Conduct Peer Reviews
SP 2.3-2	Analyze Peer Review Data
SG 3	Verify Selected Work Products
SP 3.1-1	Perform Verification
SP 3.2-2	Analyze Verification Results and Identify Corrective Action.

Chapter 5

SIX SIGMA

(B) WHAT IS SIX SIGMA?

Six Sigma is a statistical measure of variation in a process. We say a process has achieved Six Sigma if the quality is 3.4 DPMO (Defect per Million Opportunities). It's a problem-solving methodology that can be applied to a process to eliminate the root cause of defects and costs associated with it.

FIGURE 96 Six Sigma

(I) CAN YOU EXPLAIN THE DIFFERENT METHODOLOGY FOR THE EXECUTION AND THE DESIGN PROCESS STAGES IN SIX SIGMA?

The main focus of Six Sigma is to reduce defects and variations in the processes. DMAIC and DMADV are the models used in most Six Sigma initiatives.

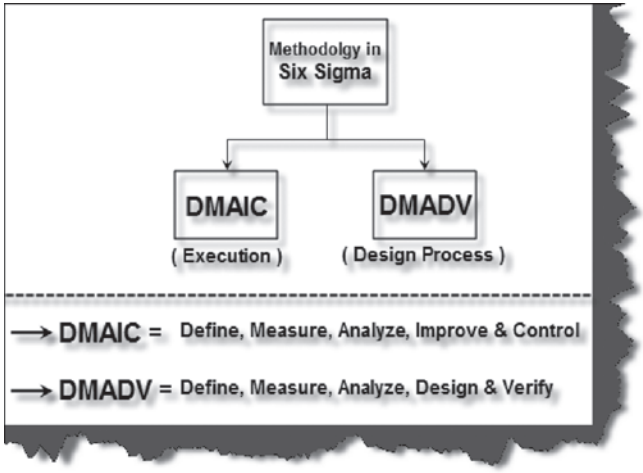


FIGURE 97 **Methodology in Six Sigma**

DMADV is the model for designing processes while DMAIC is used for improving the process.

The DMADV model includes the following five steps:

- Define: Determine the project goals and the requirements of customers (external and internal).
- Measure: Assess customer needs and specifications.
- Analyze: Examine process options to meet customer requirements.
- Design: Develop the process to meet the customer requirements.
- Verify: Check the design to ensure that it's meeting customer requirements

The DMAIC model includes the following five steps:

- Define the projects, goals, and deliverables to customers (internal and external). Describe and quantify both the defects and the expected improvements.
- Measure the current performance of the process. Validate data to make sure it is credible and set the baselines.

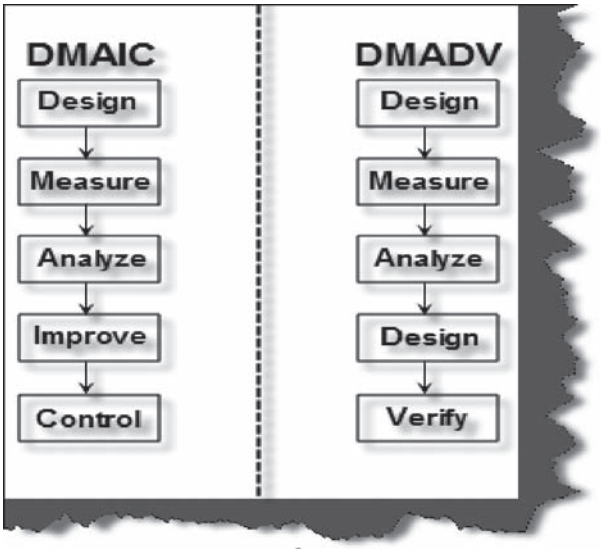


FIGURE 98 **DMAIC and DMADV**

- Analyze and determine the root cause(s) of the defects. Narrow the causal factors to the vital few.
- Improve the process to eliminate defects. Optimize the vital few and their interrelationships.
- Control the performance of the process. Lock down the gains.

(I) WHAT ARE EXECUTIVE LEADERS, CHAMPIONS, MASTER BLACK BELTS, GREEN BELTS, AND BLACK BELTS?

Six Sigma is not only about techniques, tools, and statistics, but also about people. In Six Sigma there are five key players:

- Executive leaders
- Champions
- Master black belts
- Black belts
- Green belts

Let's try to understand the role of the players step by step.

Executive leaders: They are the main people who actually decide that we need to do Six Sigma. They promote it throughout the organization and ensure commitment of the organization. Executive leaders are mainly either CEOs or from the board of directors. So, in short, they are the people who fund the Six Sigma initiative. They should believe that Six Sigma will improve the organization process and that they will succeed. They should ensure that resources get proper training on Six Sigma, understand how it will benefit the organization, and track the metrics.

Champions: Champions are normally senior managers of the company. These people promote Six Sigma mainly between the business users. The champion understands Six Sigma thoroughly, and serve as a coaches and mentors, select the project, decide objectives, dedicate resources to black belts, and remove obstacles which come across black belt players. Historically, champions always fight for a cause. In Six Sigma they fight to remove black belt hurdles.

Master black belts: This role requires the highest level of technical capability in Six Sigma. Normally organizations that are just starting up with Six Sigma will not have master black belts. So normally outsiders are recruited. The main role of the master black belt is to train, mentor, and guide. He helps the executive leaders in selecting candidates, finding the right project, teaching the basics, and training resources. They regularly meet with black belts and green belts training and mentoring them.

Black belts: Black belts lead a team on a selected project which has to be showcased for Six Sigma. They are mainly responsible for finding out variations and seeing how these variations can be minimized. Master black belts basically select a project and train resources, but black belts are the people who actually implement them. Black belts normally work in projects as team leaders or project managers. They are central to Six Sigma as they are actually implementing Six Sigma in the organization.

Green belts: Green belts assist black belts in their functional areas. They are mainly in projects and work part-time on Six Sigma implementation. They apply Six Sigma methodologies to solve problems and improve processes at the bottom level. They have just enough knowledge of Six Sigma and they help to define the base of Six Sigma implementation in the organization. They assist black belts in Six Sigma implementation.

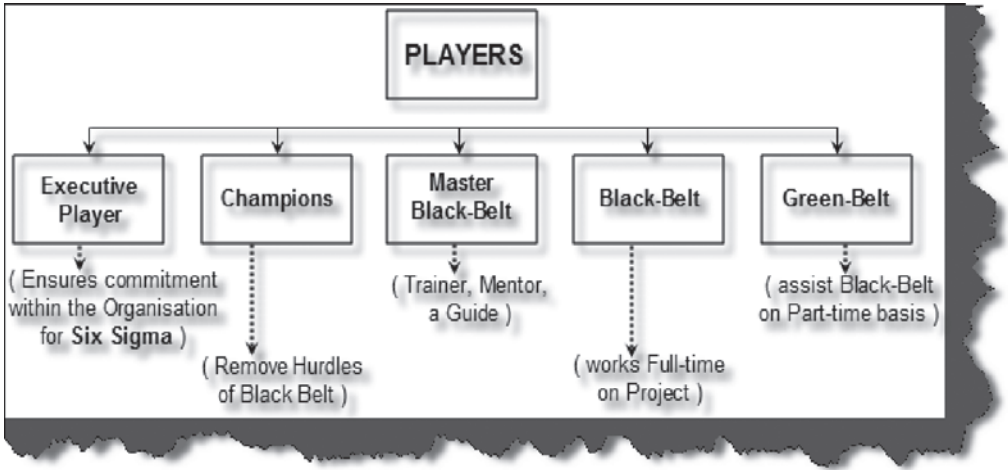


FIGURE 99 **Six Sigma key players**

(I) WHAT ARE THE DIFFERENT KINDS OF VARIATIONS USED IN SIX SIGMA?

Variation is the basis of Six Sigma. It defines how many changes are happening in the output of a process. So if a process is improved then this should reduce

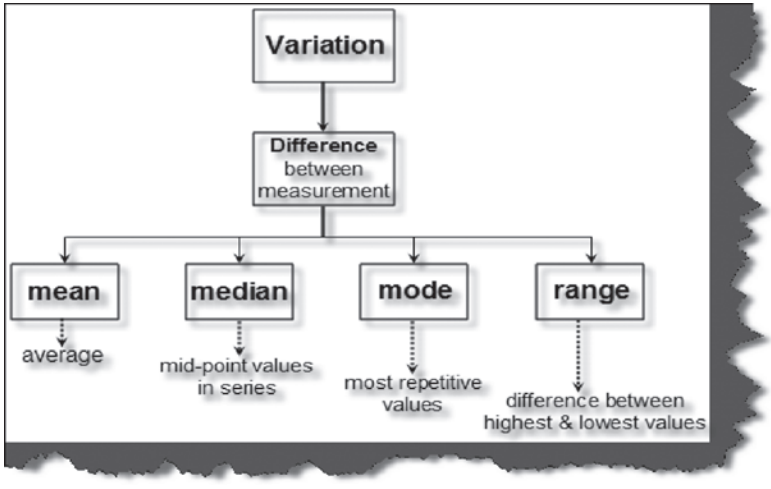


FIGURE 100 **Different variations in Six Sigma**

variations. In Six Sigma we identify variations in the process, control them, and reduce or eliminate defects. Now let's discuss how we can measure variations.

There are four basic ways of measuring variations: Mean, Median, Mode, and Range. Let's discuss each of these variations in more depth for better analysis.

Mean: In the mean measurement the variations are measured and compared using averaging techniques. For instance, you can see from the following figures which shows two weekly measures, how many computers are manufactured. We have tracked two weeks; one we have named Week 1 and the other Week 2. So to calculate variation using mean we calculate the mean of Week 1 and Week 2. You can see from the calculations in the following figure we have 5.083 for Week 1 and 2.85 for Week 2. So we have a variation of 2.23.

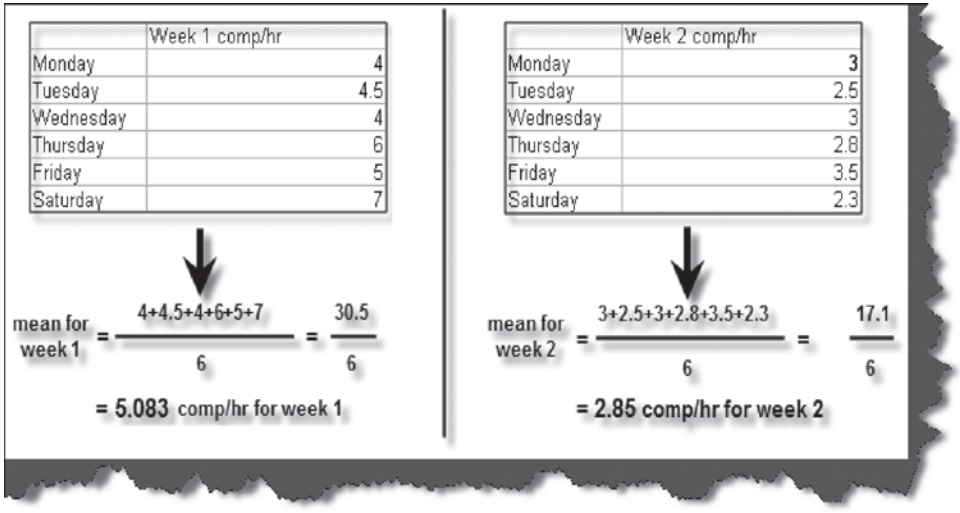


FIGURE 101 **Measuring variations using mean**

Median: Median value is a mid-point in our range of data. The mid-point can be found by finding the difference between the highest and lowest value and then dividing it by two and, finally, adding the lowest value to it. For instance, for the following figure in Week 1 we have 4 as the lowest value and 7 as the highest value. So first we subtract the lowest value from the highest value, i.e., 7 − 4. Then we divide it by two and add the lowest value. So for Week 1 the median is 5.5 and for Week 2 the median is 2.9. So the variation is 5.5-2.9.

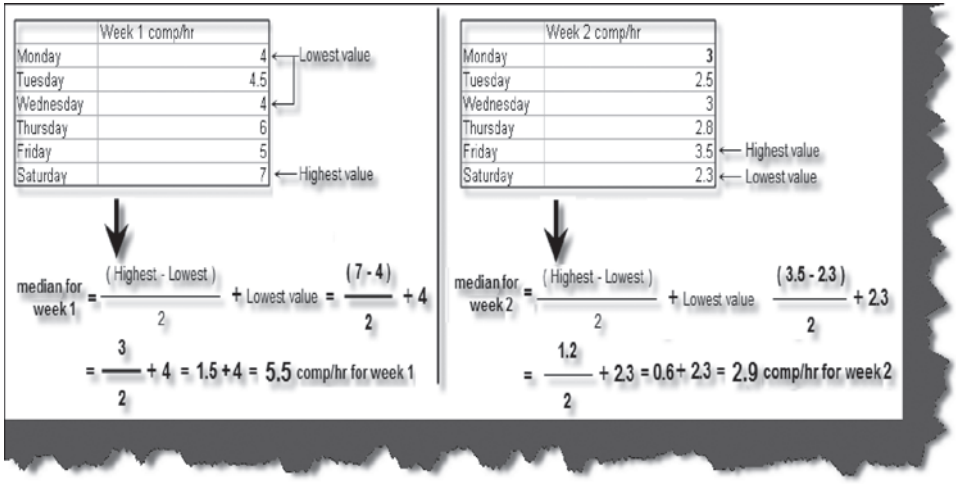


FIGURE 102 **Median for calculating variations**

Range: Range is nothing but the spread of values for a particular data range. In short, it is the difference between the highest and lowest values in a particular data range. For instance, you can see for the recorded computer data of Week 2 we have found the range of values by subtracting the highest value from the lowest.

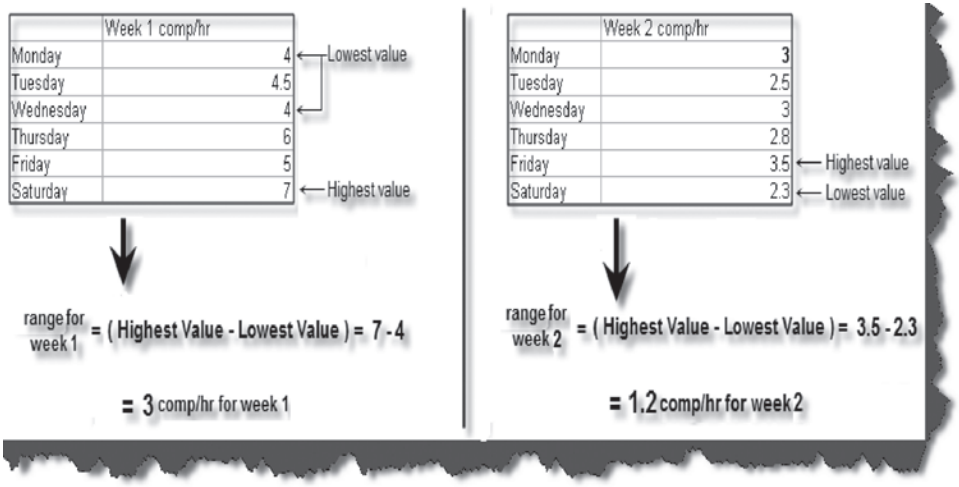


FIGURE 103 **Range for calculating variations**

Mode: Mode is nothing but the most frequently occurring values in a data range. For instance, in our computer manufacturing data, range 4 is the most occurring value in Week 1 and 3 is the most occurring value in Week 2. So the variation is 1 between these data ranges.

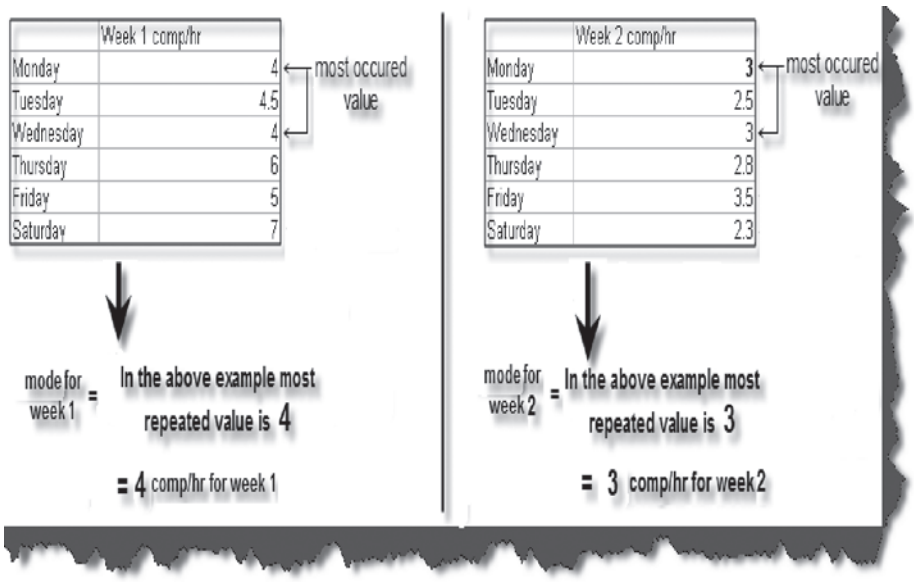


FIGURE 104 **Mode for calculating variations**

(A) CAN YOU EXPLAIN STANDARD DEVIATION?

The most accurate method of quantifying variation is by using standard deviation. It indicates the degree of variation in a set of measurements or a process by measuring the average spread of data around the mean. It's more complicated than the deviation process discussed in the previous question, but it does give accurate information.

Below is the formula for standard deviation. The "σ" symbol stands for standard deviation. X is the observed values; X (with the top bar) is the arithmetic mean; and n is the number of observations. The formula must look complicated but let's break-up into steps to understand it better.

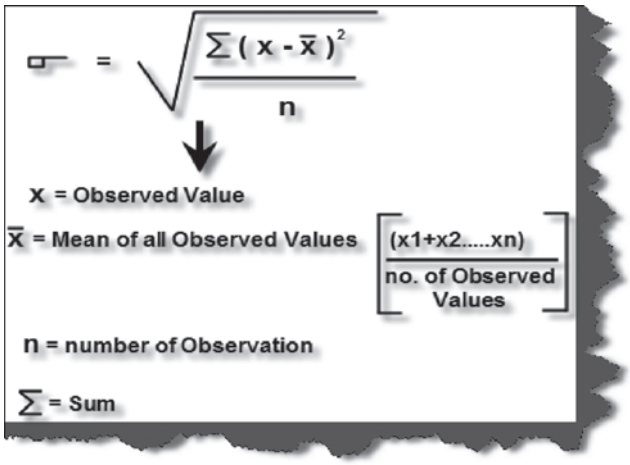


FIGURE 105 **Standard deviation formula**

The first step is to calculate the mean. This can be calculated by adding up all the observed values and dividing them by the number of observed values.

The second step is to subtract the average from each observation, square them, and then sum them. Because we square them we will not get negative

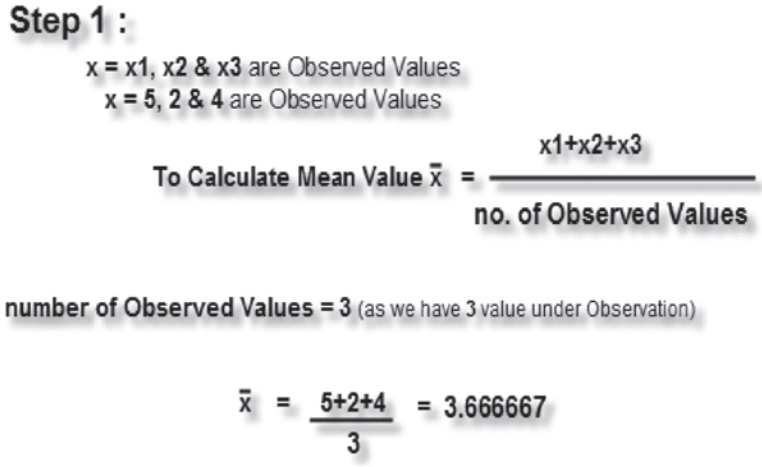


FIGURE 106 **Step 1: Standard deviation**

values. The following figure shows this very detailed manner.

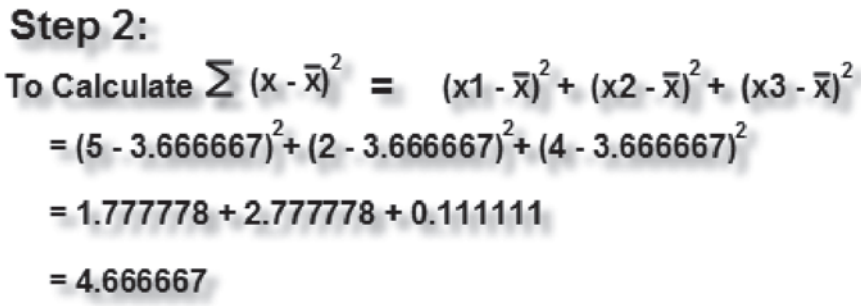


FIGURE 107 **Step 2: Standard deviation**

In the third step we divide the average by the number of observations as shown in the figure.

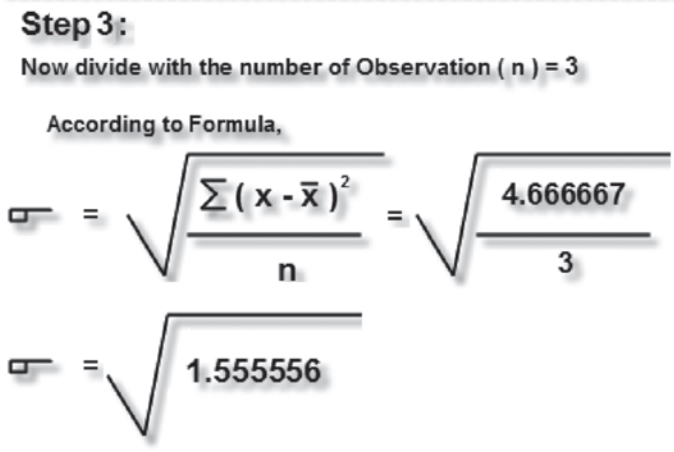


FIGURE 108 **Step 3: Standard deviation**

In the final step we take the square root which gives the standard deviation.

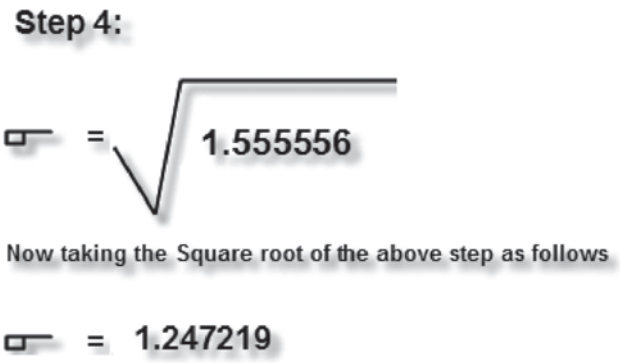


FIGURE 109 **Step 4: Standard deviation**

(B) CAN YOU EXPLAIN THE FISH BONE/ISHIKAWA DIAGRAM?

There are situations where we need to analyze what caused the failure or problem in a project. The fish bone or Ishikawa diagram is one important concept which can help you find the root cause of the problem. Fish bone was conceptualized by Ishikawa, so in honor of its inventor, this concept was named the Ishikawa diagram. Inputs to conduct a fish bone diagram come from discussion and brainstorming with people involved in the project. The following figure shows the structure of the Ishikawa diagram.

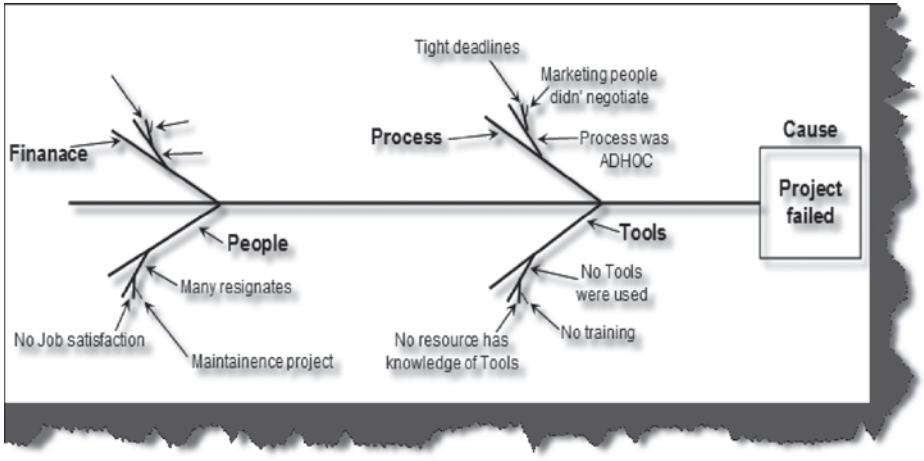


FIGURE 110 **Fish bone/Ishikawa diagram**

The main bone is the problem which we need to address to know what caused the failure. For instance, the following fish bone is constructed to find what caused the project failure. To know this cause we have taken four main bones as inputs: Finance, Process, People, and Tools. For instance, on the people front there are many resignations → this was caused because there was no job satisfaction → this was caused because the project was a maintenance project. In the same way causes are analyzed on the Tools front also. In Tools → No tools were used in the project → because no resource had enough knowledge of them → this happened because of a lack of planning. In the Process front the process was adhoc → this was because of tight deadlines → this was caused because marketing people over promised and did not negotiate properly with the end customer.

Now once the diagram is drawn the end bones of the fish bone signify the main cause of project failure. From the following diagram here's a list of causes:

- No training was provided for the resources regarding tools.
- Marketing people over promised the customer which lead to tight deadlines.
- Resources resigned because it's a maintenance project.

Chapter 6

METRICS

(B) WHAT IS MEANT BY MEASURES AND METRICS?

Measures are quantitatively unit defined elements, for instance, hours, km, etc. Measures are basically comprised of more than one measure. For instance, we can have metrics such as km/hr, m/s etc.

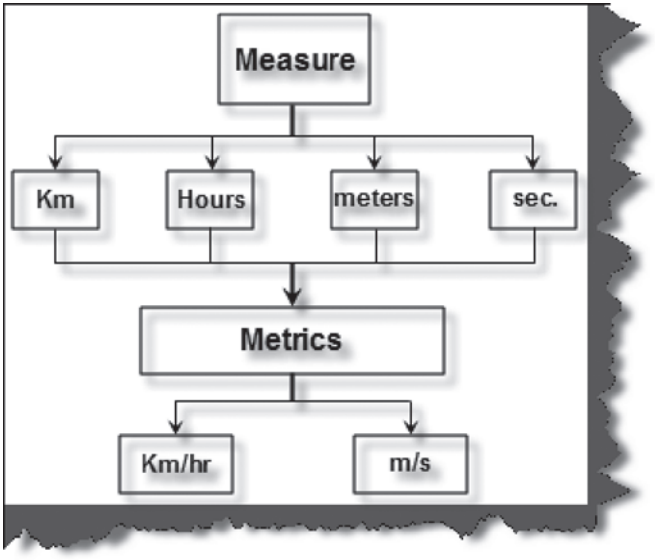


FIGURE 111 **Measure and metrics**

(I) CAN YOU EXPLAIN HOW THE NUMBER OF DEFECTS ARE MEASURED?

The number of defects is one of the measures used to measure test effectiveness. One of the side effects of the number of defects is that all bugs are not equal. So it becomes necessary to weight bugs according to there criticality level. If we are using the number of defects as the metric measurement the following are the issues:

- The number of bugs that originally existed significantly impacts the number of bugs discovered, which in turns gives a wrong measure of the software quality.
- All defects are not equal so defects should be numbered with a criticality level to get the right software quality measure.

The following are three simple tables which show the number of defects SDLC phase-wise, module-wise and developer-wise.

Phase	Number of Defects		
	High	Medium	Low
Requirement	10	6	20
Design	7	8	9
Execution	4	3	2
Production	10	12	6

FIGURE 112 **Number of defects phase-wise**

Modules	Number of Defects		
	High	Low	Medium
Cash Screen	7	5	4
Reports	10	12	8
Voucher Module	6	8	10
Login screen	12	3	4

FIGURE 113 **Number of defects module-wise**

Engineer	Number of Defects		
	High	Medium	Low
Vinod	15	9	4
Ravi	8	5	2
Ankit	6	3	1
Pradeep	11	7	6

FIGURE 114 **Number of defects**

(I) CAN YOU EXPLAIN HOW THE NUMBER OF PRODUCTION DEFECTS ARE MEASURED?

This is one of the most effective measures. The number of defects found in a production is recorded. The only issue with this measure is it can have latent and masked defects which can give us the wrong value regarding software quality.

(I) CAN YOU EXPLAIN DEFECT SEEDING?

Defect seeding is a technique that was developed to estimate the number of defects resident in a piece of software. It's an offline technique and should not be used by everyone. The process is the following: we inject the application

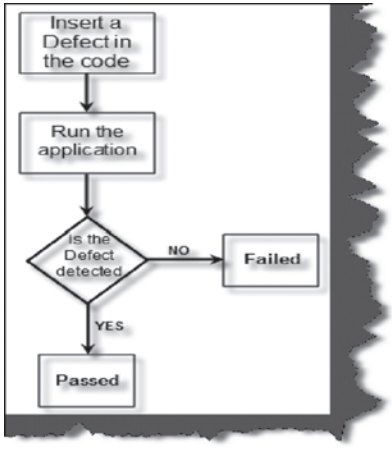


FIGURE 115 **Defect seeding**

with defects and then see if the defect is found or not. So, for instance, if we have injected 100 defects we try to get three values. First how many seeded defects were discovered, how many were not discovered, and how many new defects (unseeded) are discovered. By using defect seeding we can predict the number of defects remaining in the system.

Let's discuss the concept of defect seeding by doing some detailed calculations and also try to understand how we can predict the number of defects remaining in a system. The following is the calculation used:

1. First, calculate the seed ratio using the following formula, i.e., number of seed bugs found divided by the total number of seeded bugs.
2. After that we need to calculate the total number of defects by using the formula (number of defects divided by the seed ratio).
3. Finally, we can know the estimated defects by using the formula (total number of defects−the number of defect calculated by Step 3).

The following figure shows a sample with the step-by-step calculation. You can see that first we calculate the seed ratio, then the total number of defects, and finally, we get the estimated defects.

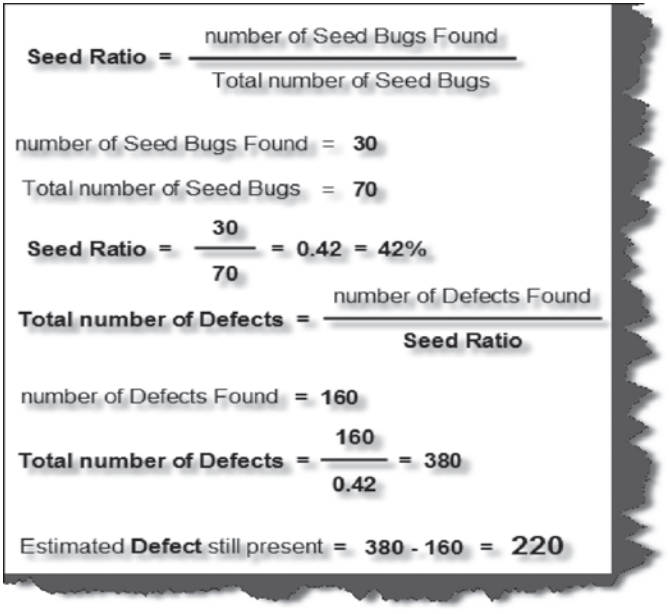


FIGURE 116 **Seed calculation**

(I) CAN YOU EXPLAIN DRE?

DRE (Defect Removal Efficiency) is a powerful metric used to measure test effectiveness. From this metric we come to know how many bugs we found from the set of bugs which we could have found. The following is the formula for calculating DRE. We need two inputs for calculating this metric: the number of bugs found during development and the number of defects detected at the end user.

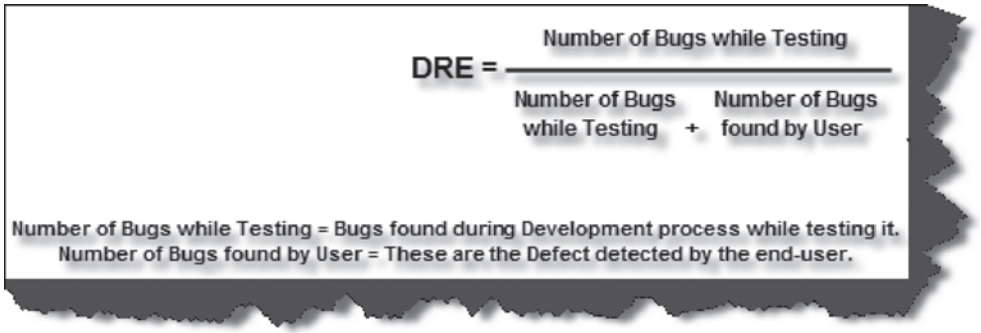


FIGURE 117 **DRE formula**

But the success of DRE depends on several factors. The following are some of them:

- Severity and distribution of bugs must be taken into account.
- Second, how do we confirm when the customer has found all the bugs. This is normally achieved by looking at the history of the customer.

(B) CAN YOU EXPLAIN UNIT AND SYSTEM TEST DRE?

DRE is also useful to measure the effectiveness of a particular test such as acceptance, unit, or system testing. The following figure shows defect numbers at various software cycle levels. The + indicates that defects are input at the phase and−indicates that these many defects were removed from that

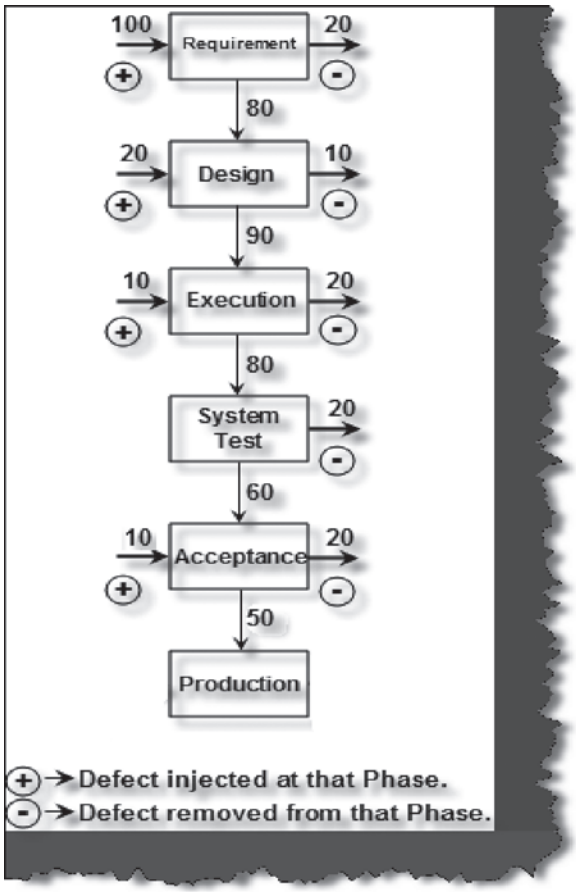


FIGURE 118 **Defect injected and removed per phase**

particular phase. For instance, in the requirement phase 100 defects were present, but 20 defects are removed from the requirement phase due to a code review. So if 20 defects are removed then 80 defects get carried to the new phase (design) and so on.

First, let's calculate simple DRE of the above diagram. DRE will be the total bugs found in testing divided by the total bugs found in testing plus the total bugs found by the user, that is, during acceptance testing. So the following diagram gives the DRE for the those values.

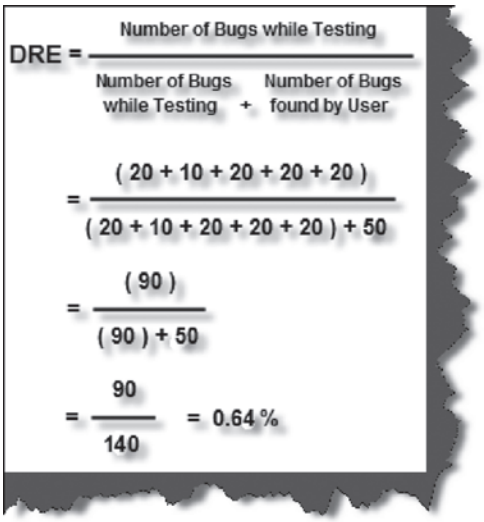


FIGURE 119 **DRE calculation**

Now let's calculate system DRE of the above given project. In order to calculate the system DRE we need to take the number of defects found during the system divided by the defects found during system testing plus the defects found during acceptance testing. The following figure shows the system DRE calculation step by step.

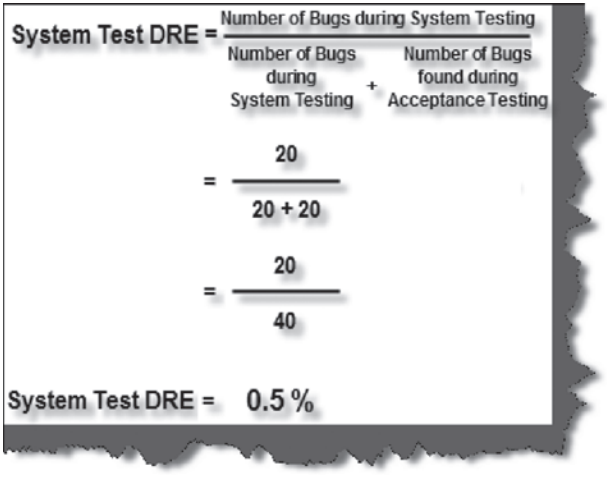


FIGURE 120 **System testing DRE calculation**

Unit testing DRE calculation is similar to system testing DRE. As you can see from the following figure it's nothing but the number of defects found during unit testing divided by the number of defects found during unit testing plus the number of defects found during system testing.

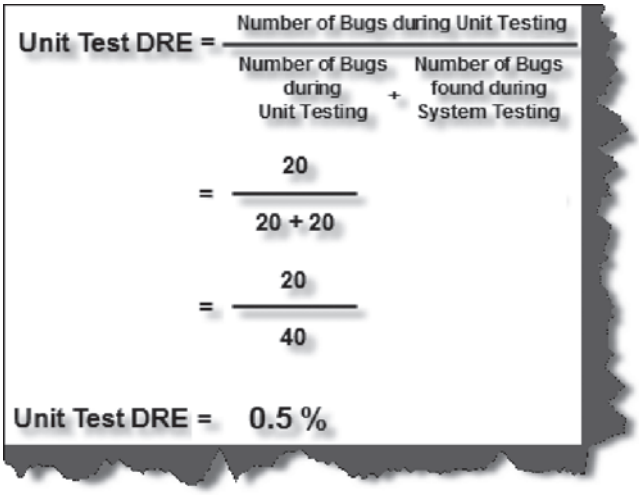


FIGURE 121 **Unit test DRE calculation**

One of the important factors to be noted while calculating unit testing DRE is that we need to exclude those defects which cannot be produced due to the limitations of unit testing. For instance, passing of data between components to each other. In unit testing, because we test it as a single unit, we can never reproduce defects which involve interaction. So such kinds of defects should be removed to get accurate test results.

(I) HOW DO YOU MEASURE TEST EFFECTIVENESS?

Test effectiveness is the measure of the bug-finding ability of our tests. In short, it measures how good the tests were. So effectiveness is the ratio of the measure of bugs found during testing to the total bugs found. Total bugs are the sum of new defects found by the user plus the bugs found in the test. The following figure explains the calculations in a pictorial format.

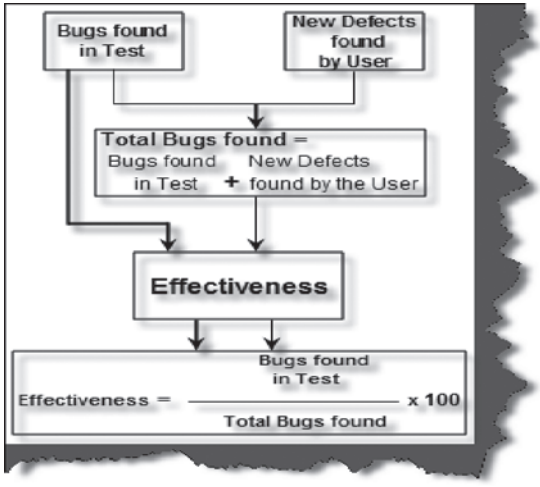


FIGURE 122 **Measure test effectiveness**

(B) CAN YOU EXPLAIN DEFECT AGE AND DEFECT SPOILAGE?

Defect age is also called a phase age or phage. One of the most important things to remember in testing is that the later we find a defect the more it costs to fix it. Defect age and defect spoilage metrics work with the same fundamental, i.e., how late you found the defect. So the first thing we need to define is what is the scale of the defect age according to phases. For instance, the following table defines the scale according to phases. So, for instance, requirement defects, if found in the design phase, have a scale of 1, and the same defect, if propagated until the production phase, goes up to a scale of 4.

Phase created	Requirement	Design	Execution	Testing	Production
Requirement	0	1	2	3	4
Design	0	0	1	2	3
Execution	0	0	0	1	2

FIGURE 123 **Scale of defect age**

Phase Created	Requirement	Design	Execution	Testing	Production	Total
Requirement	0	Def = 8 (1) Req Def = 4 4 x 1 = 4	Def = 10 (2) Req Def = 2 2 x 2 = 4	Def = 9 (3) Req Def = 0	-- (4)	$\frac{8}{27} = 0.29$
Design	0	0	Def = 4 (1) Des. Def = 5 5 x 1 = 5	Def = 2 (2) Des. Def = 3 3 x 2 = 6	Def = 0 (3) Des. Def = 1 1 x 3 = 3	$\frac{14}{6} = 2.33$
Execution	0	0	0	Def = 4 (1) Exec.Def= 2 2 x 1 = 2	Def = 0 (2) Exec.Def= 0	$\frac{2}{4} = 0.5$
Main Total	NA	NA	NA	NA	NA	$\frac{24}{37} = 0.64$

FIGURE124 **Defect spoilage**

Once the scale is decided now we can find the defect spoilage. Defect spoilage is defects from the previous phase multiplied by the scale. For instance, in the following figure we have found 8 defects in the design phase from which 4 defects are propagated from the requirement phase. So we multiply the 4 defects with the scale defined in the previous table, so we get the value of 4. In the same fashion we calculate for all the phases. The following is the spoilage formula. It's the ratio of the sum of defects passed from the previous phase multiplied by the discovered phase then finally divided by the total number of defects. For instance, the first row shows that total defects are 27 and the sum of passed on defects multiplied by their factor is 8 ($4 \times 1 = 4 + 2 \times 2 = 4$). In this way we calculate for all phases and finally the total. The optimal value is 1. A lower value of spoilage indicates a more effective defect discovery process.

$$\text{Spoilage} = \frac{\text{sum of number of Defects x Discovered Phage}}{\text{Total number of Defects}}$$

FIGURE 125 **Spoilage formula**

Chapter 7

AUTOMATED TESTING

(B) WHAT ARE GOOD CANDIDATES FOR AUTOMATION IN TESTING?

OR

(B) DOES AUTOMATION REPLACE MANUAL TESTING?

Automation is the integration of testing tools into the test environment in such a manner that the test execution, logging, and comparison of results are done with little human intervention. A testing tool is a software application which helps automate the testing process. But the testing tool is not the complete answer for automation. One of the huge mistakes done in testing automation is automating the wrong things during development. Many testers learn the hard way that everything cannot be automated. The best components to automate are repetitive tasks. So some companies first start with manual testing and then see which tests are the most repetitive ones and only those are then automated.

As a rule of thumb do not try to automate:

- Unstable software: If the software is still under development and undergoing many changes automation testing will not be that effective.
- Once in a blue moon test scripts: Do not automate test scripts which will be run once in a while.
- Code and document review: Do not try to automate code and document reviews; they will just cause trouble.

The following figure shows what should not be automated.

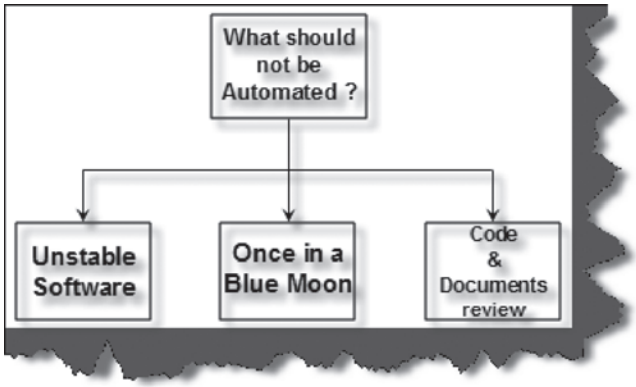


FIGURE 126 **What should not be automated**

All repetitive tasks which are frequently used should be automated. For instance, regression tests are prime candidates for automation because they're typically executed many times. Smoke, load, and performance tests are other examples of repetitive tasks that are suitable for automation. White box testing can also be automated using various unit testing tools. Code coverage can also be a good candidate for automation. The following figure shows, in general, the type of tests which can be automated.

(I) WHICH AUTOMATION TOOLS HAVE YOU WORKED WITH AND CAN YOU EXPLAIN THEM BRIEFLY?

Note: For this book we are using AutomatedQA as the tool for testing automation. So we will answer this question from the point of view of the AutomatedQA tool. You can install the AutomationQA tool and practice for yourself to see how it really works.

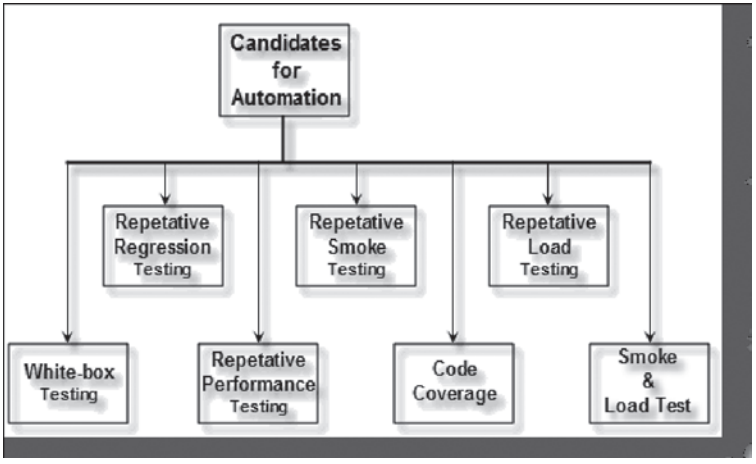


FIGURE 127 **Candidates for automation**

In this answer we will be testing a tool called "WindowsFileSearch." This tool offers the following functionality:

- This tool basically searches files by name and internal content of the file.
- It also has a wildcard search as well as an extension search which means we can search the file by extension, for instance, *.doc, *.exe, etc.

Note: To answer this answer in detail we have used the FileSearch application. You can experiment with any other application installed on your system such as a messenger or office application.

Let's go step by step to learn to use the AutomatedQA tool to automate our testing process. First, start the tool by clicking all programs → AutomatedQA → TestComplete 5. Once the tool is started you will get a screen as shown

here. We first need to create a new project by using the New Project menu as shown in the following figure.

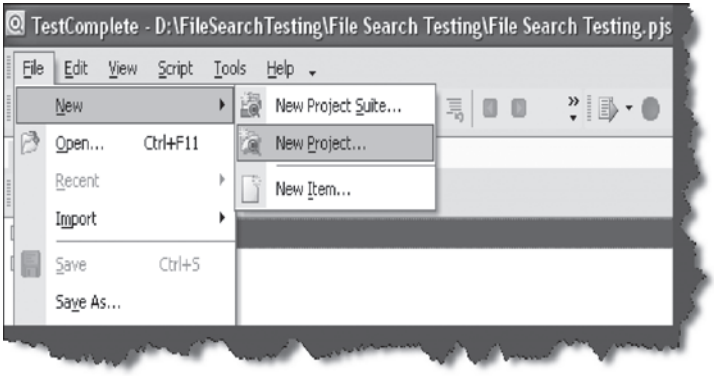


FIGURE 128 **Create a new project**

After clicking on the new project we will be prompted for what kind of testing we are looking at, i.e., load testing, general testing, etc. Currently, we will select only General-Purpose Test project. At this moment, you can also specify the project name, location, and the language for scripting (Select VBscript, currently).

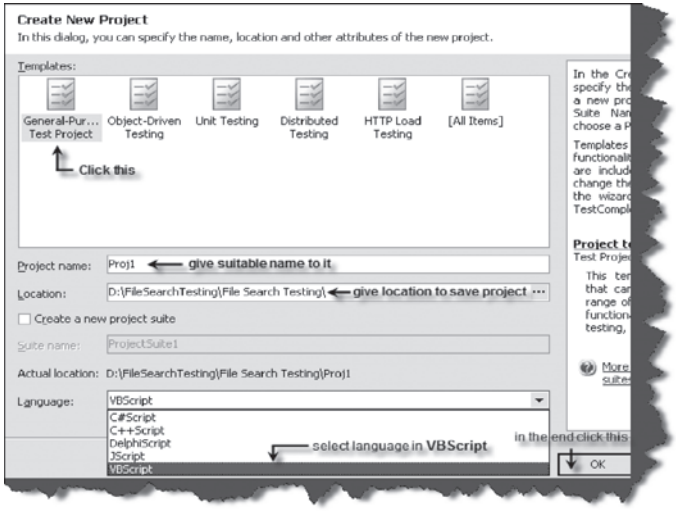


FIGURE 129 **Select the type of project**

Once the project name and path are given you will then be prompted with a screen as shown here. These are project items which we need to be included in your project depending on the testing type. Because currently we are doing a Windows application test we need to select the project items as shown in the figure. Please note events have to be selected compulsorily.

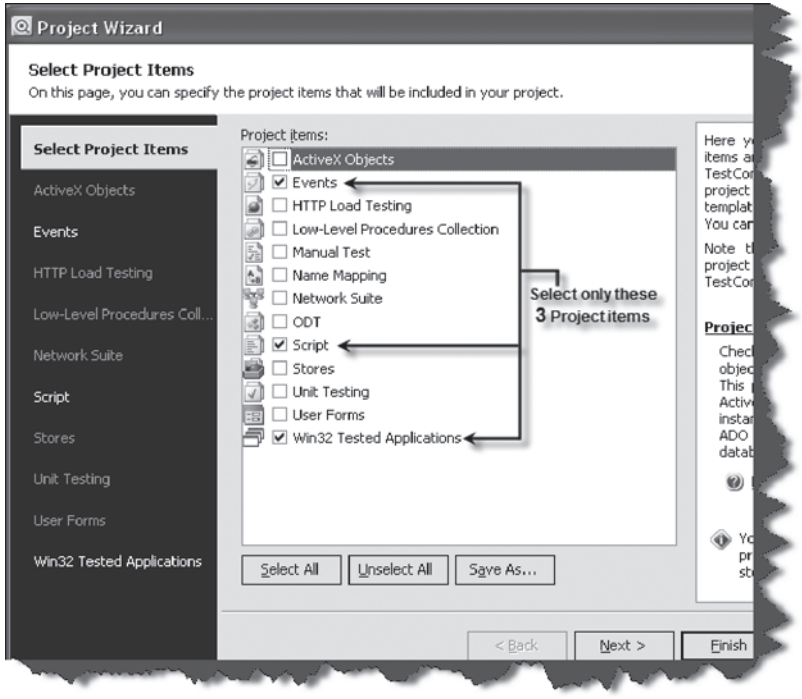


FIGURE 130 **Select project items**

Once you have clicked finished you will get the Test Complete Project Explorer as shown here. The Test Complete Project Explorer is divided into three main parts: Events, Scripts, and TestedApps. Script is where all the programming logic is present. In TestedApps we add the applications that we want to test. So let's first add the application in TestedApps.

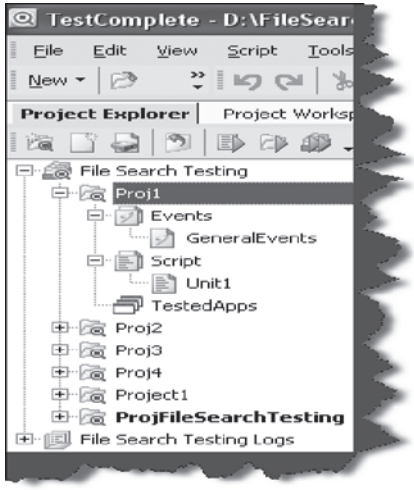


FIGURE 131 **Project explorer**

In order to add the application EXE in TestedApps we need to right click on the TestedApps folder and click on New Item.

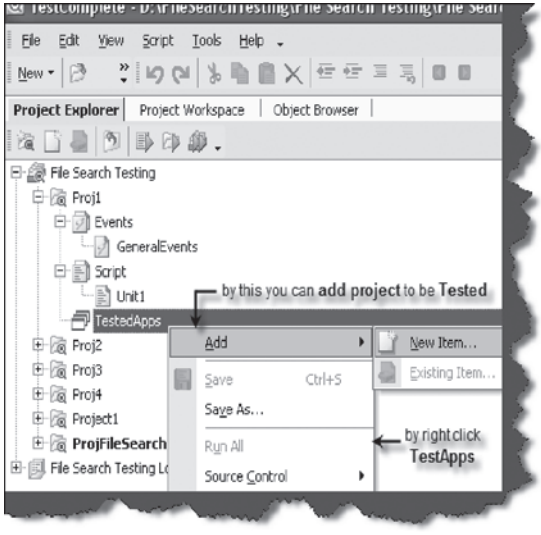


FIGURE 132 **Add new applications to the project**

You will then be prompted with a screen as shown here. Browse to your application EXE file and add it to the TestedApps folder.

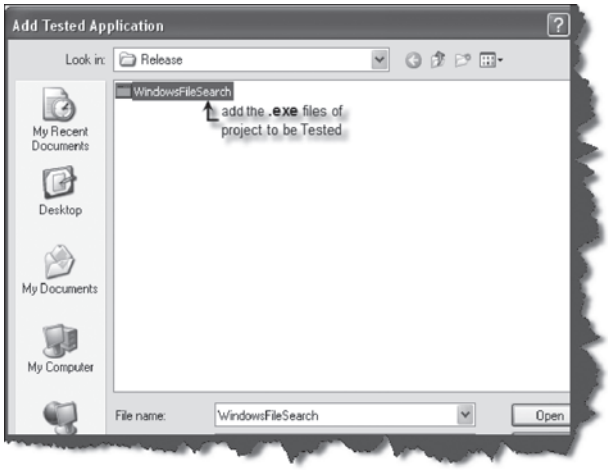


FIGURE 133 **Add the EXE to your TestedApps folder**

Currently, we have added the WindowsFileSearch application. Now that your application is added we need to start recording our test. In order to start recording click on the button shown in the figure or push SHIFT + F1.

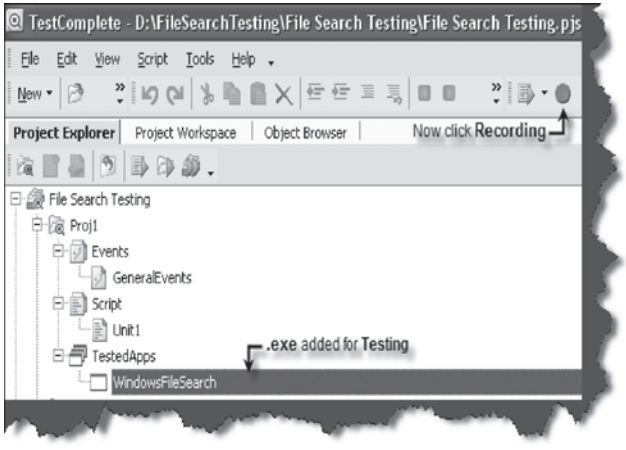


FIGURE 134 **EXE has been added successfully**

Once the recording toolbar is seen right click on the application added and run your test. In this scenario you can see the WindowsFileSearch application running. In this we have recorded a complete test in which we gave the folder name and keyword, and then tried to see if we were getting proper results. Your application being tested can be something different so your steps may vary.

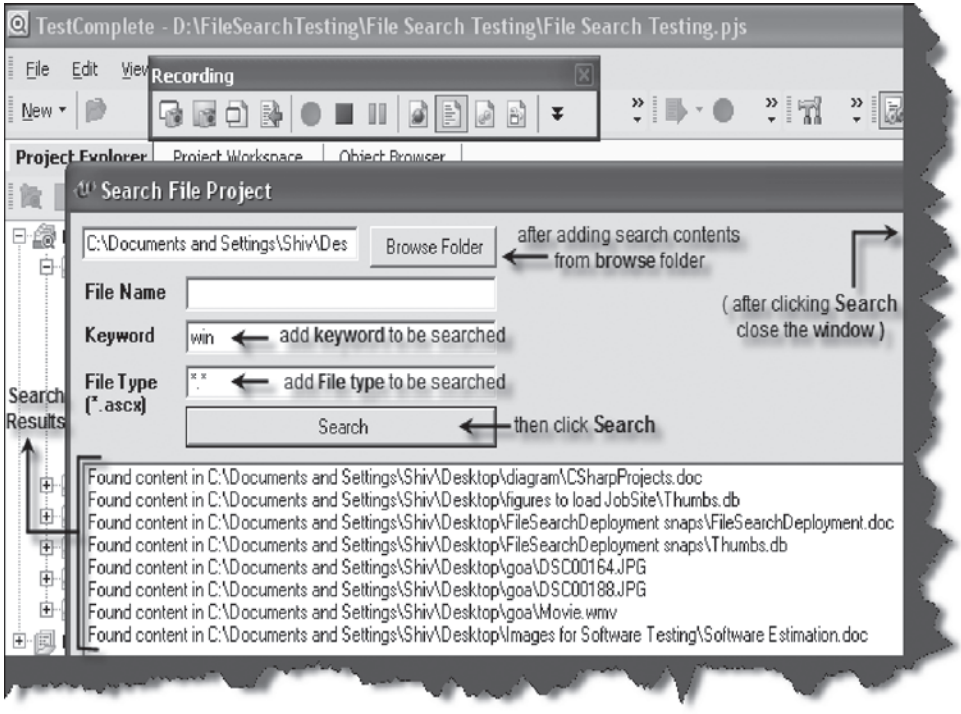


FIGURE 135 **Recording**

Once the test is complete you can stop the recording using the button on the recording toolbar. Once you stop, the recording tool will generate script of all your actions done as shown in the figure. You can view the programming script as shown here.

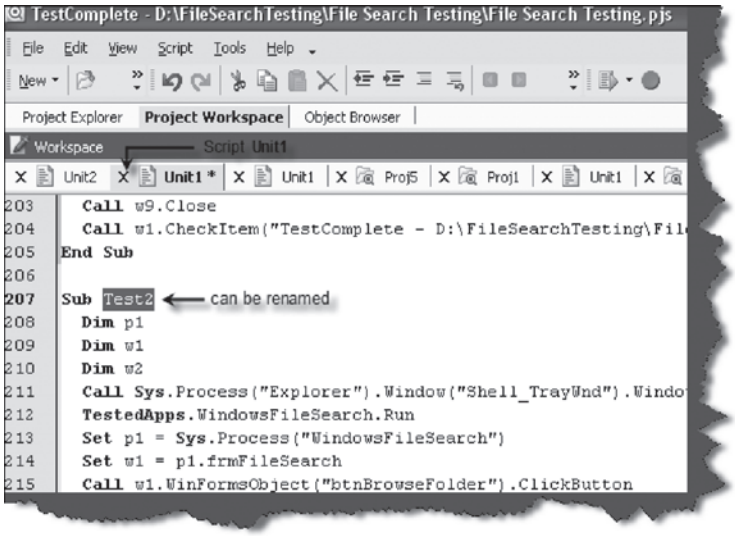


FIGURE 136 **Script generated for the recording**

Once the script is recorded you can run the script by right clicking and running it. Once you run it the script tool will playback all the test steps which you recorded.

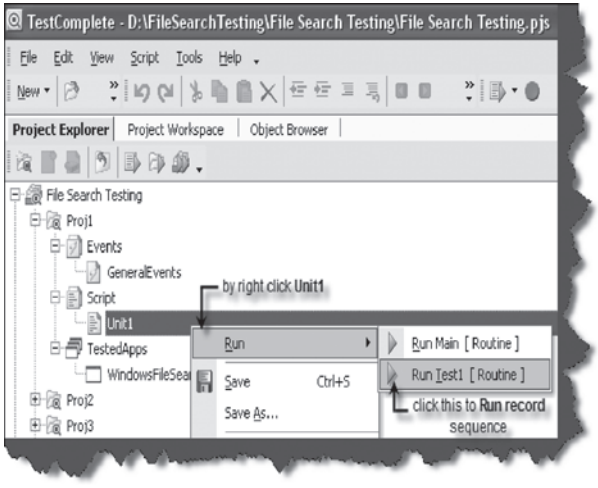


FIGURE 137 **Running the recorded test**

If everything goes right you can see the test log as shown here which signifies that your script has run successfully.

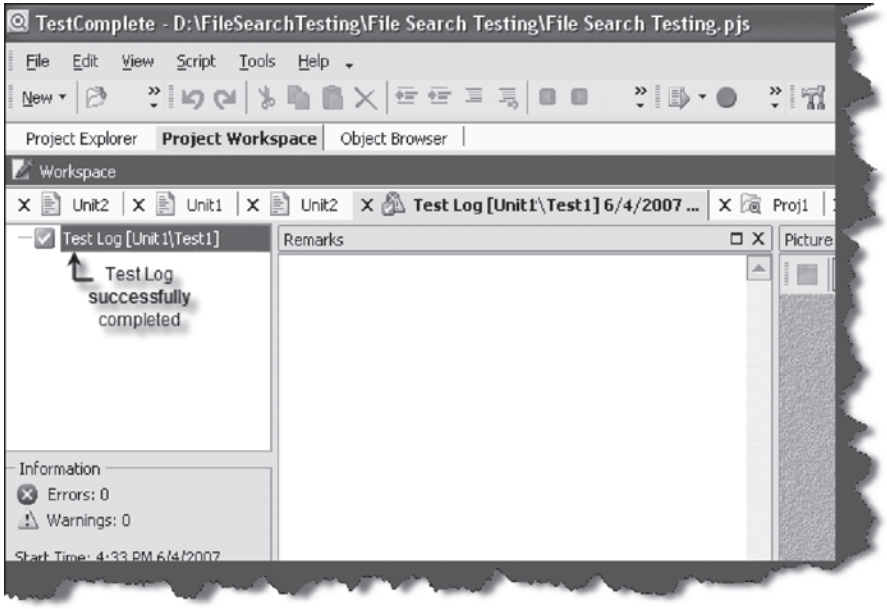


FIGURE 138 **Successful execution of the scripts**

(I) HOW DOES LOAD TESTING WORK FOR WEBSITES?

In order to understand this we need to first understand the concept of how websites work. Websites have software called a web server installed on the server. The user sends a request to the web server and receives a response. So, for instance, when you type http://www.questpond.com (that's my official website) the web server senses it and sends you the home page as a response. This happens each time you click on a link, do a submit, etc. So if we want to do load testing you need to just multiply these requests and responses "N" times. This is what an automation tool does. It first captures the request and response and then just multiplies it by "N" times and sends it to the web server, which results in load simulation.

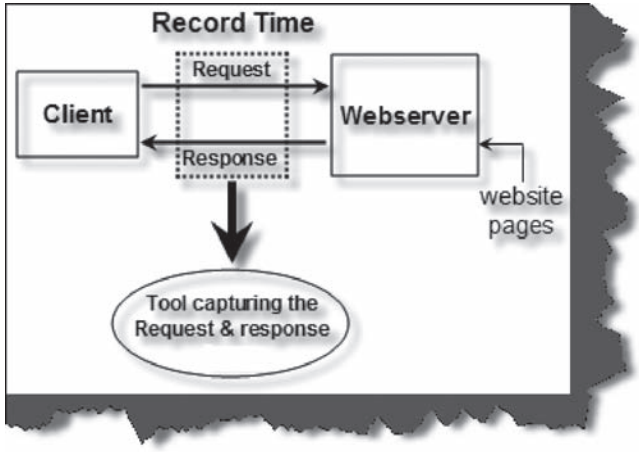


FIGURE 139 **Concept of load testing**

So once the tool captures the request and response, we just need to multiply the request and response with the virtual user. Virtual users are logical users which actually simulate the actual physical user by sending in the same request and response. If you want to do load testing with 10,000 users on an

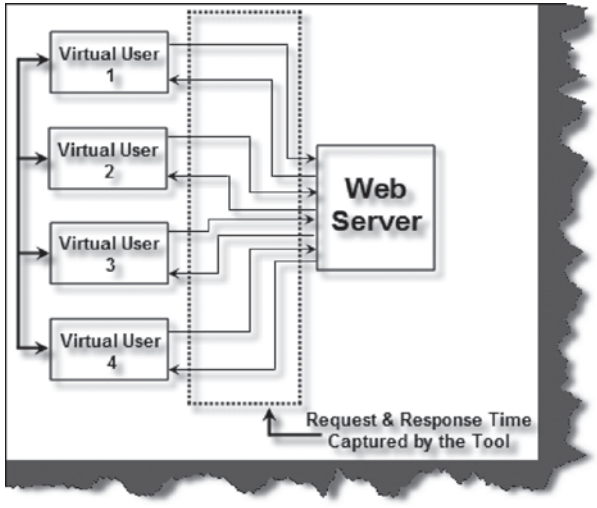


FIGURE 140 **Load testing simulation by virtual user**

application it's practically impossible. But by using the load testing tool you only need to create 1000 virtual users.

(A) CAN YOU GIVE AN EXAMPLE SHOWING LOAD TESTING FOR WEBSITES?

Note: As said previously we will be using the AutomatedQA tool for automation in this book. So let's try to answer this question from the same perspective. You can get the tool from the CD provided with the book.

The first step is to open a new project using TestComplete.

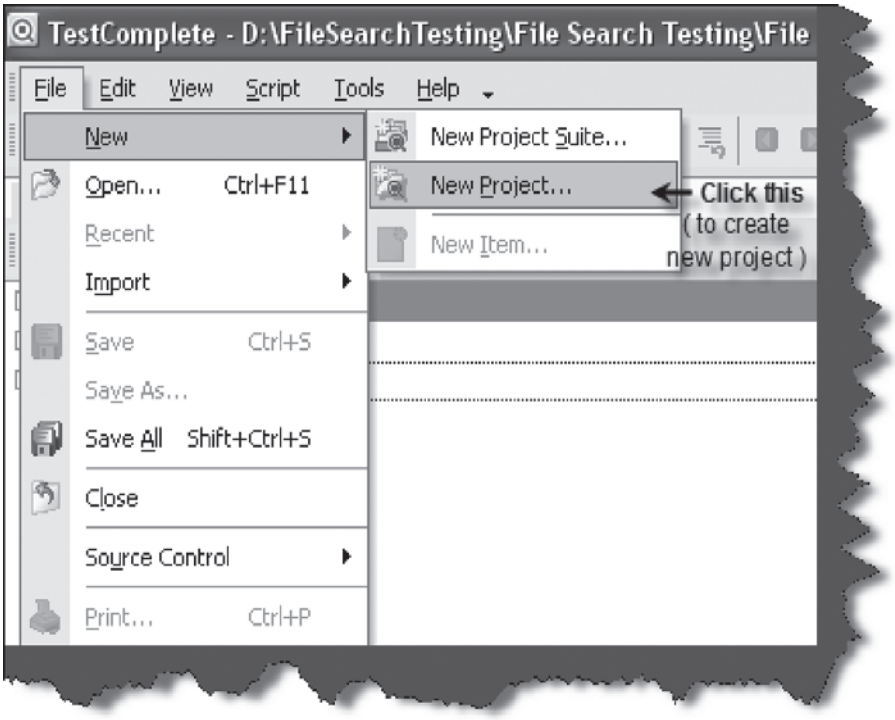


FIGURE 141 **Create a new project**

After that select HTTP Load Testing from the project types.

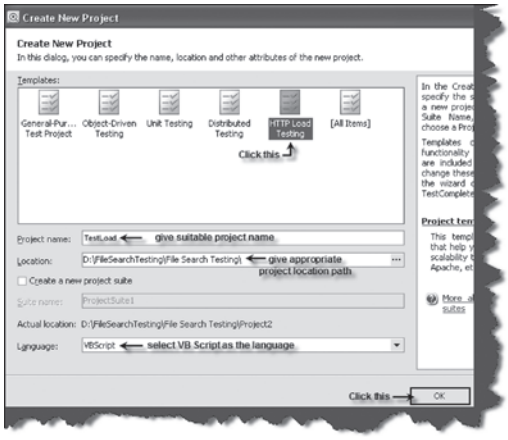


FIGURE 142 **Select HTTP load testing**

Once you click "OK" you will get different project items which you need for the project. For load testing only select three, i.e., Events, HTTP Load Testing, and Script as shown here.

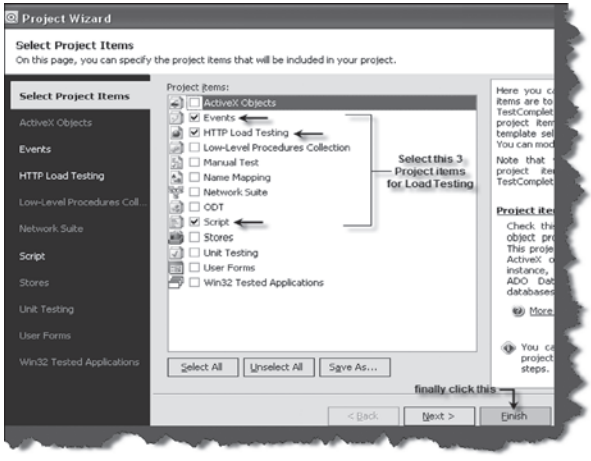


FIGURE 143 **Select the three items in load testing**

This project has the following items: Stations, Tasks, Tests, and Scripts. Stations basically define how many users the load testing will be performed for. Task has the request and response captured. Tests and Scripts have the Script which is generated when we record the automated test.

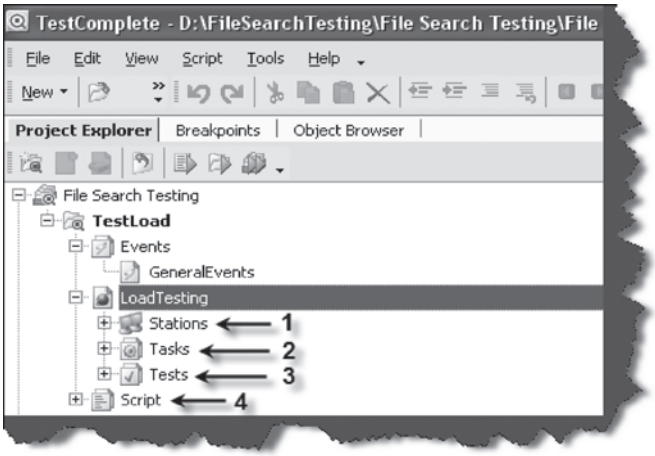


FIGURE 144 **Load testing explorer**

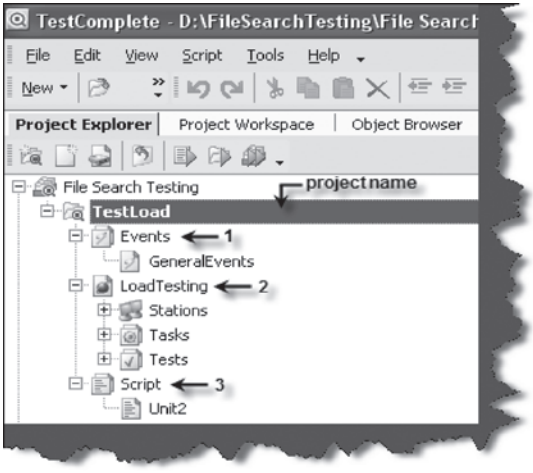


FIGURE 145 **Project items**

You need to specify the number of virtual users, tasks, and the browser type such as Internet Explorer, Opera, etc.

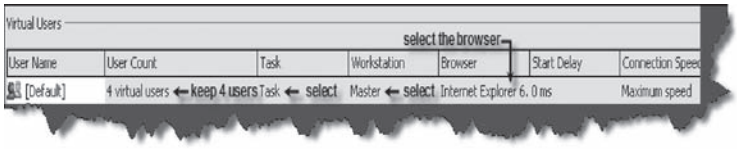


FIGURE 146 **Assign the number of virtual users and the browser**

As said previously the basic idea in load testing is the request and response which need to be recorded. That can be done by using the recording taskbar and clicking the icon shown.

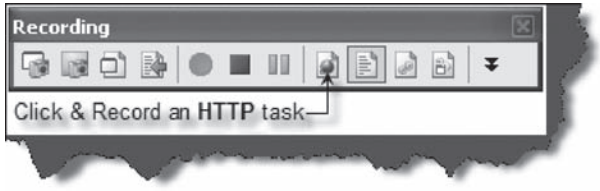


FIGURE 147 **Record HTTP task**

Once you click on the icon you need to enter the task name for it.

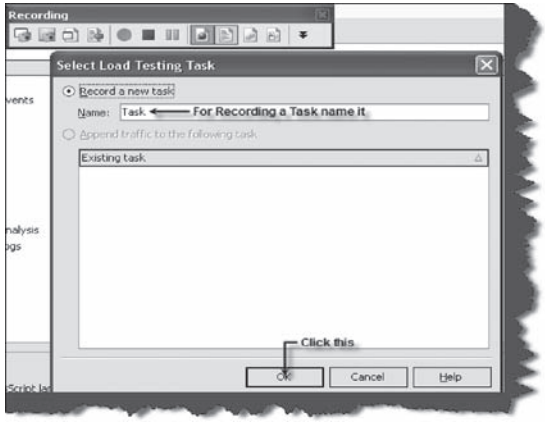


FIGURE 148 **Specify task name**

In order to record the request and response the tool changes the proxy setting of the browser. So you can see from the screen here just click yes and let the next screen change the proxy settings.

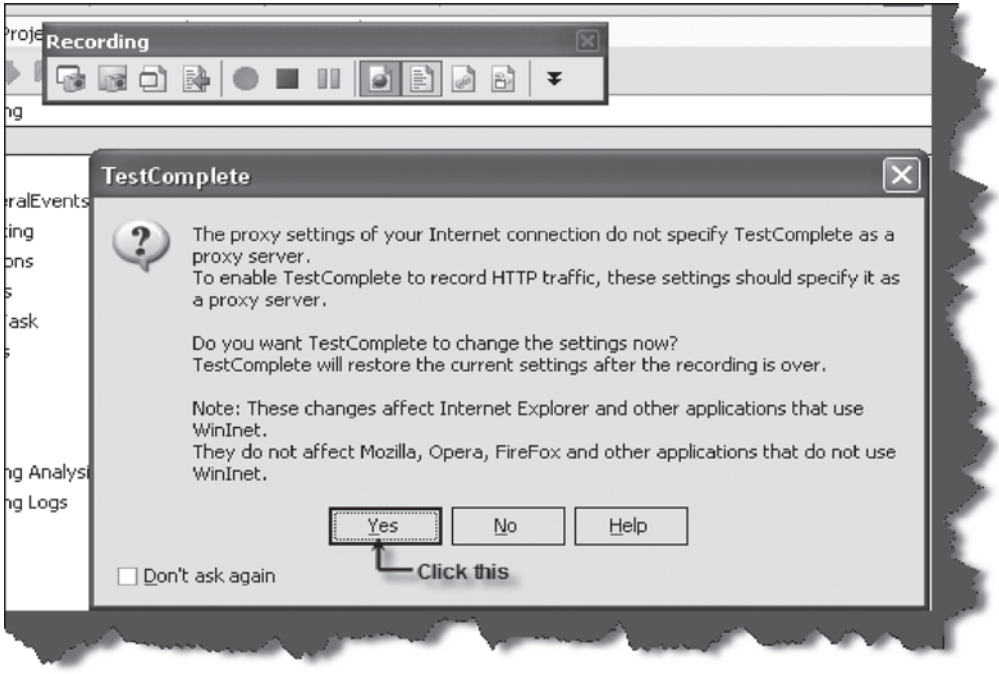


FIGURE 149 **Prompt to change proxy setting**

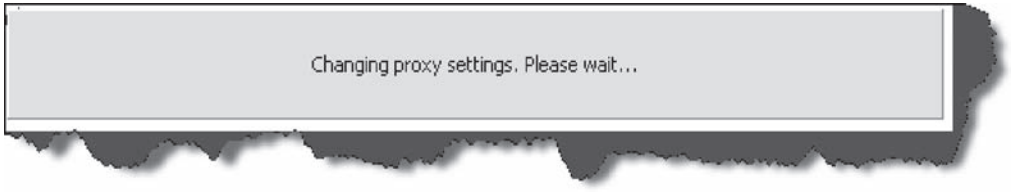


FIGURE 150 **Changing proxy settings**

Once the setting is changed you can then start your browser and make some requests and responses. Once that is done click on the stop button to stop the recording.

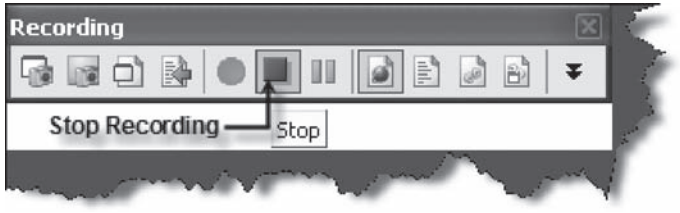


FIGURE 151 **Stop the task once done**

The tool actually generates a script for the task recorded. You can see the script and the code generated in the following figure. To view the code you can double click on the Test2 script (here we have named it Test2 script).

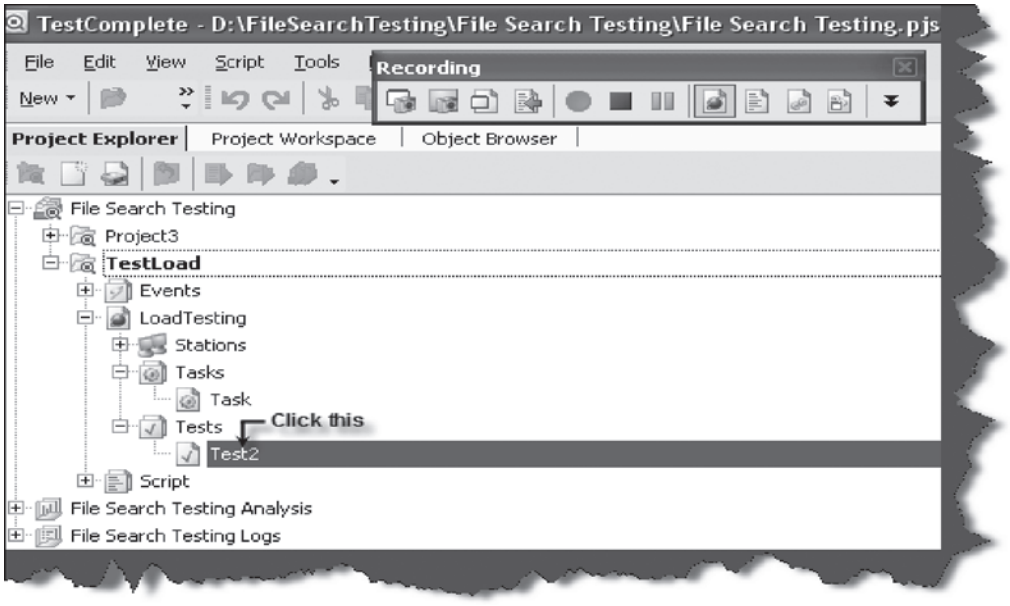


FIGURE 152 **Test2 created**

If you double click the test you can see the code.

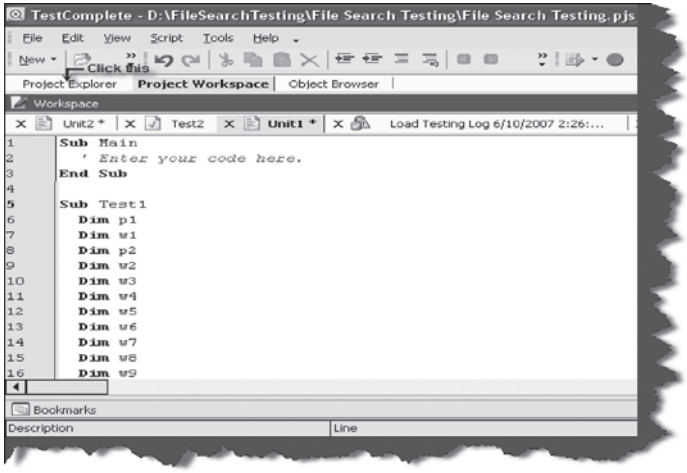


FIGURE 153 **Code generated for test**

Right click on the task and run it and you will see a summary report as shown in the figure.

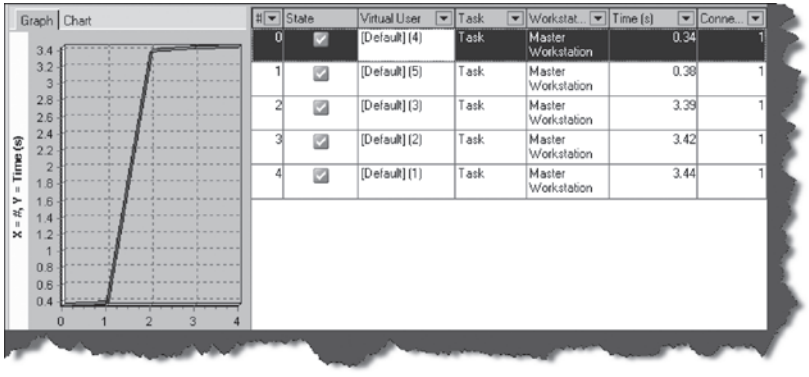


FIGURE 154 **Load test summary report**

(I) WHAT DOES THE LOAD TEST SUMMARY REPORT CONTAIN?

The figure above explains the answer.

(I) CAN YOU EXPLAIN DATA-DRIVEN TESTING?

Normally an application has to be tested with multiple sets of data. For instance, a simple login screen, depending on the user type, will give different rights. For example, if the user is an admin he will have full rights, while a user will have limited rights and support if he only has read-only support rights. In this scenario the testing steps are the same but with different user ids and passwords. In data-driven testing, inputs to the system are read from data files such as Excel, CSV (comma separated values), ODBC, etc. So the values are read from these sources and then test steps are executed by automated testing.

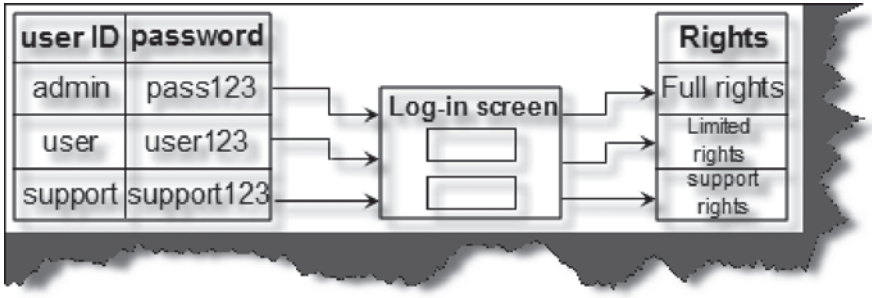


FIGURE 153 **Data-driven testing**

(I) CAN YOU EXPLAIN TABLE-DRIVEN TESTING?

OR

(I) HOW CAN YOU PERFORM DATA-DRIVEN TESTING USING AUTOMATED QA?

[This question is left to the user. Please install the tool and try for yourself.]

Chapter 8

TESTING ESTIMATION

(B) WHAT ARE THE DIFFERENT WAYS OF DOING BLACK BOX TESTING?

Note: Below we have listed the most used estimation methodologies in testing. As this is an interview question book we limit ourselves to TPA which is the most preferred estimation methodology for black box testing.

There are five methodologies most frequently used:

- Top down according to budget
- WBS (Work Breakdown Structure)
- Guess and gut feeling
- Early project data
- TPA (Test Point Analysis)

(B) CAN YOU EXPLAIN TPA ANALYSIS?

TPA is a technique used to estimate test efforts for black box testing. Inputs for TPA are the counts derived from function points (function points will be discussed in more detail in the next sections).

Below are the features of TPA:

- Used to estimate only black box testing.
- Require function points as inputs.

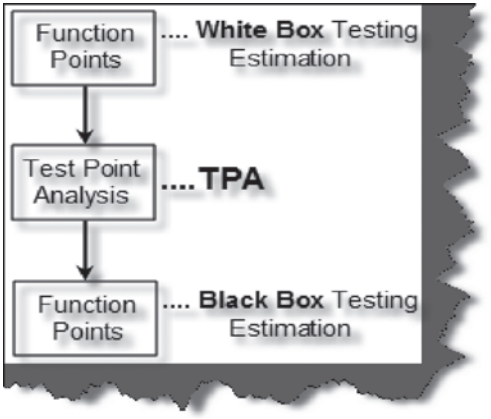


FIGURE 154 **Inputs for TPA come from function points**

Note: In the following section we will look into how to estimate function points.

(A) CAN YOU EXPLAIN FUNCTION POINTS?

Note: It's rare that someone will ask you to give the full definition of function points. They will rather ask about specific sections such as GSC, ILF, etc. The main interest of the interviewer will be how you use the function point value in TPA analysis. Function point analysis is mainly done by the development team so from a testing perspective you only need to get the function point value and then use TPA to get the black box testing estimates.

Note: This document contains material which has been extracted from the IFPUG Counting Practices Manual. It is reproduced in this document with the permission of IFPUG.

Function Point Analysis was developed first by Allan J. Albrecht in the mid-1970s. It was an attempt to overcome difficulties associated with lines of code as a measure of software size, and to assist in developing a mechanism to predict efforts associated with software development. The method was first published in 1979, then later in 1983. In 1984 Albrecht refined the method and since 1986, when the International Function Point User Group (IFPUG) was set up, several versions of the Function Point Counting Practices Manual have come out.

Note: The best way to understand any complicated system is to break the system down into smaller subsystems and try to understand those smaller sub-systems first. In a function point you break complicated systems into smaller systems and estimate those smaller pieces, then total up all the subsystem estimates to come up with a final estimate.

Basics of Function Points

The Following are some terms used in FPA: [Function Point analysis].

(B) CAN YOU EXPLAIN AN APPLICATION BOUNDARY?

Application Boundary

The first step in FPA is to define the boundary. There are two types of major boundaries:

- Internal Application Boundary
- External Application Boundary

We will give the features of external application boundaries and the internal application boundaries will be obvious.

The external application boundary can be identified using the following litmus test:

- Does it have or will it have any other interface to maintain its data, which was not developed by you?. Example: Your

Company is developing an "Accounts Application" and at the end of the accounting year, you have to report to the tax department. The tax department has its own website where companies can connect and report their tax transactions. Tax department applications have other maintenance and reporting screens developed by the tax software department. These maintenance screens are used internally by the tax department. So the tax online interface has other interfaces to maintain its data which is not within your scope, thus we can identify the tax website reporting as an external application.

- Does your program have to go through a third party API or layer? In order for your application to interact with the tax department application your code has to interact with the tax department API.
- The best litmus test is to ask yourself if you have full access to the system. If you have full rights to make changes then it is an internal application boundary, otherwise it is an external application boundary.

(B) CAN YOU EXPLAIN THE ELEMENTARY PROCESS?

OR

(B) CAN YOU EXPLAIN THE CONCEPT OF THE STATIC AND DYNAMIC ELEMENTARY PROCESSES?

The Elementary Processes

As said previously FPA is about breaking huge systems into smaller pieces and analyzing them. Software applications are a combination of elementary processes.

Note: An EP is the smallest unit of activity that is meaningful to a user. An EP must be self-contained and leave the application in a consistent state.

When elementary processes come together they form a software application.

Note: An elementary process is not necessarily completely independent. So, we can define elementary process as small units of self-contained functionality from a user's perspective.

Dynamic and static elementary processes

There are two types of elementary processes:

- Dynamic elementary Process.
- Static elementary Process.

The dynamic elementary process moves data from an internal application boundary to an external application boundary or vice-versa.

Examples of dynamic elementary processes include:

- Input data screen where a user inputs data into the application. Data moves from the input screen inside the application.
- Transactions exported in export files in XML or any other standard.
- Display reports which can come from an external application boundary and an internal application boundary.

Examples of static elementary processes include:

- Static elementary process which maintains the data of the application either inside the application boundary or in the external application boundary.

For instance, in a customer maintenance screen maintaining customer data is a static elementary process.

(I) CAN YOU EXPLAIN FTR, ILF, EIF, EI, EO, EQ, AND GSC?

Elements of Function Points

The following are the elements of FPA:

Internal Logical Files (ILFs)

The following are points to be noted for ILF:

- ILFs are logically related data from a user's point of view.
- They reside in the internal application boundary and are maintained through the elementary process of the application.
- ILFs can have a maintenance screen but not always.

Note: Do not make the mistake of mapping a one-to-one relationship between ILFs and the technical database design. This can make FPA go very wrong. The main difference between ILFs and a technical database is an ILF is a logical view and a database is a physical structure (technical design). Example: A supplier database design will have tables such as Supplier, Supplier Address, SupplierPhonenumbers, but from the ILF point of view you will only see the Supplier as logically they are all Supplier details.

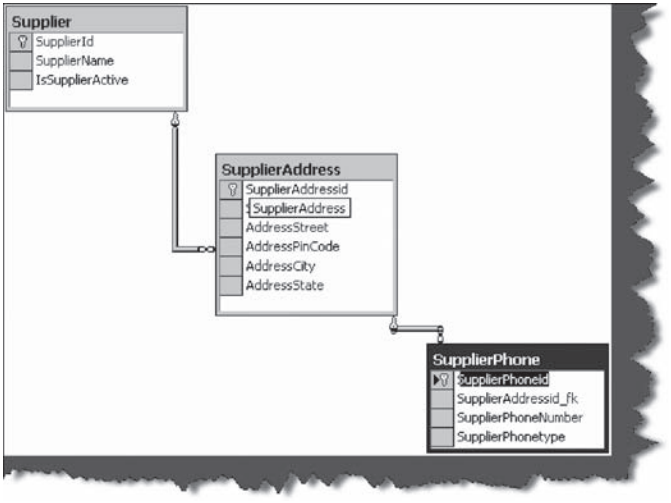


FIGURE 155 **ILF example**

External Interface Files (EIFs)

- These files are logically related data from the user point of view.
- EIFs reside in the external application boundary.
- EIFs are used only for reference purposes and are not maintained by internal applications.
- EIFs are maintained by external applications.

Record Element Type (RET)

The following points are to be noted for RETs:

- An RET is a sub-group element data of ILF or EIF.
- If there is no sub-group of ILF then count the ILF itself as one RET.
- A group of RETs within ILF are logically related. Most likely with a parent-child relationship. Example: A supplier has multiple addresses and every address can have multiple phone numbers (see the following figure which shows a database diagram). So, Supplier, SupplierAddress, and SupplierPhoneNumber are a RETs.

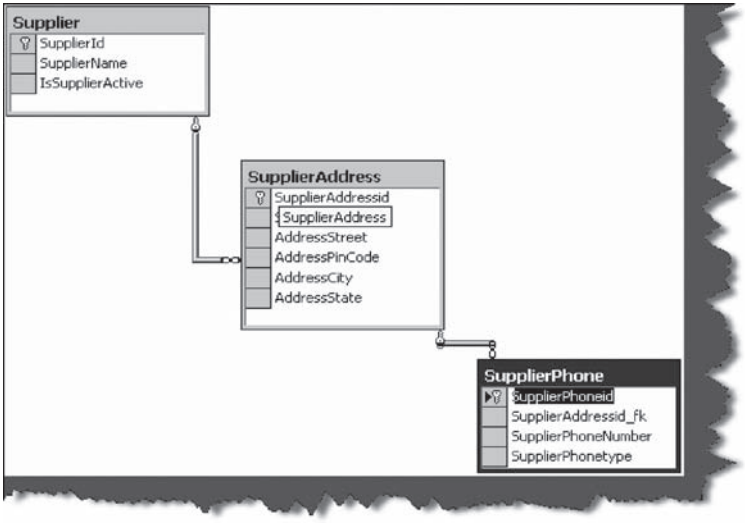


FIGURE 156 **RET**

Please note the whole database is one supplier ILF as all belong to one logical section. The RET quantifies the relationship complexity of ILF and EIF.

Data Element Types (DETs)

The following are the points to be noted for DETs counting:

- Each DET should be user recognizable. For example, in the previous figure we have kept the auto increment field (SupplierId) as the primary key. The SupplierId field from a user point of view never exists at all, it's only from a software designing aspect, so does not qualify as a DET.
- DETs should be a non-recursive fields in ILF. DETs should not repeat in the same ILF again, and should be counted only once.
- Count foreign keys as one DET. SupplierId does not qualify as a DET but its relationship in the SupplierAddress table is counted as a DET. So Supplierid_fk in the SupplierAddress table is counted as a DET. The same holds true for "Supplieraddressid_fk".

File Type References (FTRs)

The following points are to be noted for FTRs:

- An FTR is a file or data referenced by a transaction.
- An FTR should be an ILF or EIF. So count each ILF or EIF read during the process.
- If the EP is maintained as an ILF then count that as an FTR. So by default you will always have one FTR in any EP.

External Input (EI)

The following are points to be noted for EIs:

- EIs are dynamic elementary processes in which data is received from the external application boundary. Example: User interaction screens, when data comes from the User Interface to the Internal Application.

- EIs may maintain the ILF of the application, but it's not a compulsory rule.
- Example: A calculator application does not maintain any data, but still the screen of the calculator will be counted as EI.
- Most of the time user screens will be EI, but again it's not a hard and fast rule. Example: An import batch process running from the command line does not have a screen, but still should be counted as EI as it helps pass data from the external application boundary to the internal application boundary.

External Inquiry (EQ)

The following are points to be noted for EQs:

- An EQ is a dynamic elementary process in which result data is retrieved from one or more ILF or EIF. In this EP some input requests have to enter the application boundary. Output results exits the application boundary.
- EQ does not contain any derived data. Derived data means any complex calculated data. Derived data is not just mere retrieval data but are combined with additional formula to generate results. Derived data is not part of ILF or EIF, they are generated on the fly.
- EQ does not update any ILF or EIF.
- EQ activity should be meaningful from a user perspective.
- EP is self-contained and leaves the business in a consistent state.
- DET and processing logic is different from other EQs.
- Simple reports form good a base for EQs.

Note: There are no hard and fast rules that only simple reports are EQs. Simple view functionality can also be counted as an EQ.

External Output (EO)

The Following are points to be noted for EOs:

- EOs are dynamic elementary processes in which derived data crosses from the internal application boundary to the external application boundary.

- EO can update an ILF or EIF.
- The Process should be the smallest unit of activity that is meaningful to the end user in business.
- EP is self-contained and leaves the business in a consistent state.
- DET is different from other EOs. So this ensures that we do not count EOs twice.
- They have derived data or formulae calculated data.

The major difference between EO and EQ is that data passes across the application boundary.

Example: Exporting accounts transactions to some external file format such as XML or some other format, which later the external accounting software can import. The second important difference is that EQ has non-derived data and EO has derived data.

General System Characteristics (GSC) Section

This section is the most important section. All the previously discussed sections relate only to applications. But there are other things also to be considered while making software, such as are you going to make it an N-Tier application, what's the performance level the user is expecting, etc. These other factors are called GSCs. These are external factors which affect the software and the cost of the software. When you submit a function point to a client, he normally will skip everything and go to the GSC section first. The GSC gives us something called the VAFs (Value Added Factors).

There are 14 points associated with (VAFs) and the associated rating tables:

Data Communications

How many communication facilities are there to aid in the transfer or exchange of information with the application or system?

Rating	Description
0	Application uses pure batch processing or a stand-alone PC.
1	Application uses batch processing but has remote data entry or remote printing.
2	Application uses batch processing but has remote data entry and remote printing.
3	Application includes online data collection or TP (Teleprocessing) front-end to a batch process or query system.
4	Application is more than a front-end, but supports only one type of TP communications protocol.
5	Application is more than a front-end, and supports more than one type of TP communications protocol.

Table 5 Data communication

Distributed Data Processing

How are distributed data and processing functions handled?

Rating	Description
0	Application does not aid the transfer of data or processing functions between components of the system.
1	Application prepares data for end-user processing on another component of the system such as PC spreadsheets or PC DBMS.
2	Data is prepared for transfer, then is transferred and processed on another component of the system (not for end-user processing).
3	Distributed processing and data transfer are online and in one direction only.
4	Distributed processing and data transfer are online and in both directions.
5	Processing functions are dynamically performed on the most appropriate component of the system.

Table 6 Distributed data processing

Performance

Did the user require response time or throughput?

Rating	Description
0	No special performance requirements were stated by the user.
1	Performance and design requirements were stated and reviewed but no special actions were required.
2	Response time or throughput is critical during peak hours.No special design for CPU utilization was required. Processing deadline is for the next business day.
3	Response time or throughput is critical during all business hours. No special design for CPU utilization was required. Processing deadline requirements with interfacing systems are constraining.
4	In addition, stated user performance requirements are stringent enough to require performance analysis tasks in the design phase.
5	In addition, performance analysis tools were used in the design, development, and/or implementation phases to meet the stated user performance requirements.

Table 7 Performance

Heavily Used Configuration

How heavily used is the current hardware platform where the application will be executed?

Rating	Description
0	No explicit or implicit operational restrictions are included.
1	Operational restrictions do exist, but are less restrictive than a typical application. No special effort is needed to meet the restrictions.
2	Some security or timing considerations are included.
3	Specific processor requirement for a specific piece of the application is included.
4	Stated operation restrictions require special constraints on the application in the central processor or a dedicated processor.
5	In addition, there are special constraints on the application in the distributed components of the system.

Table 8 Heavily used configuration

Transaction Rate

How frequently are transactions executed; daily, weekly, monthly, etc.?

Rating	Description
0	No peak transaction period is anticipated.
1	Peak transaction period (e.g., monthly, quarterly, seasonally, annually) is anticipated.
2	Weekly peak transaction period is anticipated.
3	Daily peak transaction period is anticipated.
4	High transaction rate(s) stated by the user in the application requirements or service-level agreements are high enough to require performance analysis tasks in the design phase.
5	High transaction rate(s) stated by the user in the application requirements or service-level agreements are high enough to require performance analysis tasks and, in addition, require the use of performance analysis tools in the design, development, and/or installation phases.

Table 9 Transaction rate

Online Data Entry

What percentage of the information is entered online?

Rating	Description
0	All transactions are processed in batch mode.
1	1% to 7% of transactions are interactive data entry.
2	8% to 15% of transactions are interactive data entry.
3	16% to 23% of transactions are interactive data entry.
4	24% to 30% of transactions are interactive data entry.
5	More than 30% of transactions are interactive data entry.

Table 10 Online data entry

End-user Efficiency

Was the application designed for end-user efficiency? There are seven end-user efficiency factors which govern how this point is rated.

YES OR NO	End-user Efficiency Factor.
1	Navigational aids (e.g., function keys, jumps, dynamically generated menus).
2	Menus.
3	Online help and documents.
4	Automated cursor movement.
5	Scrolling.
6	Remote printing (via online transactions).
7	Preassigned function keys.
8	Batch jobs submitted from online transactions.
9	Cursor selection of screen data.
10	Heavy use of reverse video, highlighting, colors underlining, and other indicators.
11	Hard copy user documentation of online transactions.
12	Mouse interface.
13	Pop-up windows.
14	As few screens as possible to accomplish a business function.
15	Bilingual support (supports two languages; count as four items).
16	Multilingual support (supports more than two languages; count as six items).

Table 11 End-user efficiency factor

Rating	Description
0	None of the above.
1	One to three of the above.
2	Four to five of the above.
3	Six or more of the above, but there are no specific user requirements related to efficiency.
4	Six or more of the above and stated requirements for end-user efficiency are strong enough to require design tasks for human factors to be included (for example, minimize keystrokes, maximize defaults, use of templates).
5	Six or more of the above and stated requirements for end-user efficiency are strong enough to require use of special tools and processes to demonstrate that the objectives have been achieved.

Table 12 End-user efficiency

Online Update

How many ILFs are updated by online transactions?

Rating	Description
0	None of the above.
1	Online update of one to three control files is included. Volume of updating is slow and recovery is easy.
2	Online update of four or more control files is included. Volume of updating is low and recovery is easy.
3	Online update of major internal logical files is included.
4	In addition, protection against data lost is essential and has been specially designed and programmed in the system.
5	In addition, high volumes bring cost considerations into the recovery process. Highly automated recovery procedures with minimum operator intervention are included.

Table 13 Online update

Complex Processing

Does the application have extensive logical or mathematical processing?

YES OR NO	Complex Processing Factor
1	Sensitive control (for e.g., special audit processing) and/or application specific security processing.
2	Extensive logical processing.
3	Extensive mathematical processing.
4	Much exception processing results in incomplete transactions that must be processed again, for example, incomplete ATM transactions caused by TP interruption, missing data values, or failed edits.
5	Complex processing to handle multiple input/output possibilities, for example, multimedia, or device independence.

Table 14 Complex processing factor

Rating	Description
0	None of the above.
1	Any one of the above.
2	Any two of the above.
3	Any three of the above.
4	Any four of the above.
5	All five of the above

Table 15 Complex processing

Reusability

Was the application developed to meet one or many users needs?

Rating	Description
0	No reusable code.
1	Reusable code is used within the application.
2	Less than 10% of the application considers more than one user's needs.
3	Ten percent or more of the application considers more than one user's needs.
4	The application was specifically packaged and/or documented to ease re-use, and the application is customized by the user at a source-code level.
5	The application was specifically packaged and/or documented to ease re-use, and the application is customized for use by means of user parameter maintenance.

Table 16 Reusability

Installation Ease

How difficult is conversion and installation?

Rating	Description
0	No special considerations were stated by the user, and no special setup is required for installation.
1	No special considerations were stated by the user but special setup is required for installation.
2	Conversion and installation requirements were stated by the user and conversion and installation guides were provided and tested. The impact of conversion on the project is not considered to be important.
3	Conversion and installation requirements were stated by the user, and conversion and installation guides were provided and tested. The impact of conversion on the project is considered to be important.
4	In addition to 2 above, automated conversion and installation tools were provided and tested.
5	In addition to 3 above, automated conversion and installation tools were provided and tested.

Table 17 Installation ease

Operational Ease

How effective and/or automated are start-up, back-up, and recovery procedures?

Rating	Description
0	No special operational considerations other than the normal back-up procedures were stated by the user.
1–4	One, some, or all of the following items apply to the application. Select all that apply. Each item has a point value of one, except where noted otherwise. Effective start-up, back-up, and recovery processes were provided, but operator intervention is required. Effective start-up, back-up, and recovery processes were provided, and no operator intervention is required (count as two items). The application minimizes the need for tape mounts. The application minimizes the need for paper handling.

Continued

Rating	Description
5	The application is designed for unattended operation. Unattended operation means no operator intervention is required to operate the system other than to start-up or shut-down the application. Automatic error recovery is a feature of the application.

Table 18 Operational ease

Multiple Sites

Was the application specifically designed, developed, and supported to be installed at multiple sites for multiple organizations?

Description	Rating
0	User requirements do not require consider the needs of more than one user/installation site.
1	Needs of multiple sites were considered in the design, and the application is designed to operate only under identical hardware and software environments.
2	Needs of multiple sites were considered in the design, and the application is designed to operate only under similar hardware and/or software environments.
3	Needs of multiple sites were considered in the design, and the application is designed to operate under different hardware and/or software environments.
4	Documentation and support plans are provided and tested to support the application at multiple sites and the application is as described by 1 or 2.
5	Documentation and support plans are provided and tested to support the application at multiple sites and the application is as described by 3.

Table 19 Multiple sites

Facilitate Change

Was the application specifically designed, developed, and supported to facilitate change?

The following characteristics can apply to the application:

YES OR NO	Facilitates factors.
0	None of above.
1	Flexible query and report facility is provided that can handle simple requests; for example, and/or logic applied to only one internal logical file (counts as one item).
2	Flexible query and report facility is provided that can handle requests of average complexity, for example, and/or logic applied to more than one internal logical file (counts as two items).
3	Flexible query and report facility is provided that can handle complex requests, for example, and/or logic combinations on one or more internal logical files (counts as three items).
4	Business control data is kept in tables that are maintained by the user with online interactive processes, but changes take effect only on the next business day.
5	Business control data is kept in tables that are maintained by the user with online interactive processes and the changes take effect immediately (counts as two items)

Table 20 Facilitates change factors

Rating	Description
0	None of the above.
1	Any one of the above.
2	Any two of the above.
3	Any three of the above.
4	Any four of the above.
5	All five of the above

Table 21 Facilitate change

All of the above GSCs are rated from 0-5.Then VAFs are calculated from the equation below:

$$VAF = 0.65 + (\text{sum of all GSC factor})/100).$$

Note: GSC has not been widely accepted in the software industry. Many software companies use unadjusted function points rather than adjusted. ISO has also removed the GSC section from its books and only kept unadjusted function points as the base for measurement.

The following are the look-up tables which will be referred to during counting.

EI Rating Table

	Data Elements		
FTR	**1 to 4**	**5 to 15**	**Greater than 15**
Less than 2	3	3	4
Equal to 2	3	4	6
Greater than 2	4	4	6

Table 22 EI rating table

This table says that in any EI (External Input), if your DET count (Data Element) and FTR (File Type Reference) exceed these limits, then this should be the FP (Function Point). For example, if your DET exceeds >15 and the FTR is greater than 2, then the function point count is 6. The following tables also show the same things. These tables should be there before us when we are doing function point counting. The best way is to put these values in Excel

EO Rating Table

	Data Elements		
FTR	**1 to 5**	**6 to 19**	**Greater than 19**
Less than 2	4	4	5
2 or 3	4	5	7
Greater than 2	5	7	7

Table 23 EO rating table

with the formula so that you only have to put the quantity in the appropriate section and you get the final value.

EQ Rating Table			
	Data Elements		
FTR	**1 to 5**	**6 to 19**	**Greater than 19**
Less than 2	3	3	4
2 or 3	3	4	6
Greater than 2	4	6	6

Table 24 EQ rating table

ILF Rating Table			
	Data Elements		
RET	1 to 19	20 to 50	51 or more
1 RET	7	7	10
2 to 5	7	10	15
Greater than 6	10	15	15
EIF Rating Table			
RET	1 to 19	20 to 50	51 or more
1 RET	5	5	7
2 to 5	5	7	10
Greater than 6	7	10	10

Table 25 ILF rating table

Steps used to Count Function Points

This section will discuss the practical way of counting FPs to end up with the number of men/days on a project.

1. Count the ILF, EIF, EI, EQ, RET, DET, FTR (this is basically all sections discussed above): This whole FP count will be called the "unadjusted function point."

2. Then put rating values 0 to 5 for all 14 GSCs. Add the total of all 14 GSCs to set the total VAF. The formula for VAF = 0.65 + (sum of all GSC factors/100).
3. Finally, make the calculation of adjusted function points. Formula: Total function point = VAF * unadjusted function point.
4. Make an estimation of how many function points you will cover per day. This is also called the "performance factor."
5. On the basis of the performance factor, you can calculate men/days.

Let's try to implement these details in a sample customer project.

Sample Customer Project

We will be evaluating the customer GUI, so we will assume what the customer GUI is all about.

The following is the scope of the customer screen:

- The customer screen will be as shown here.
- After inputting the customer code and customer name, they will be verified with a credit card check.

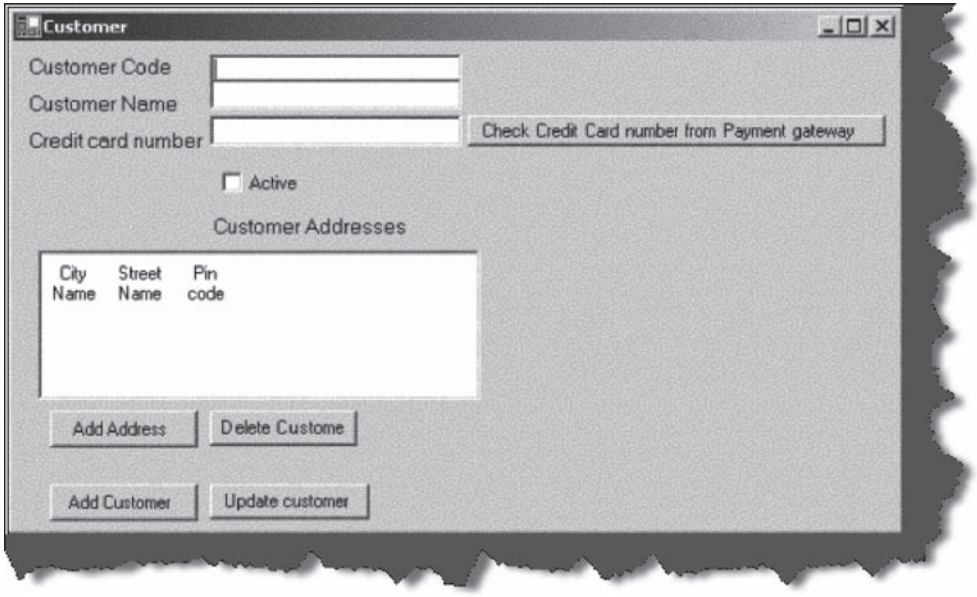


Figure157 Custom screen

- The credit card check is an external system.
- Every customer can have multiple addresses.
- The customer will have add and update functionality.

There is one ILF in the customer screen:

- The customer ILF.
- There is one EIF in the form.
- Credit card system.

The following are the ILF counting rules:

- ILF are logically related data from the user's point of view. Customers and customer addresses belong logically to the customer category.
- ILF reside in the internal application boundary and are maintained through the elementary process of the application. Customer resides inside the application boundary as we have full access over it.

The following table gives the appropriate ILFs:

ILF Customer		
Description	**Number of DETs**	**Number of RETs**
There are total 9 DETs, all add and update buttons, even the credit check button, the address list box, check box active, all text boxes. There is only one RET, the customer addresses.	9	1
So according to the ILF ranking table	**Total function**	7

Table 26 ILF for the customer

EIF lies outside the application boundary.

EI Credit Card Information		
	Number of DETs	**Number of RETs**
Description		
The credit card information referenced is an EIF. Note this file is only referenced for the credit card check. There's only one textbox credit card number and hence one DET is put in the side column. And RET is 0. Looking at the rating table the total FP is 5. So according to the above ranking table	1	1
	Total function	5

Table 27 EI for the customer

The following EIF rules were defined in the previous sections:

- It is a dynamic elementary process in which data is received from the external application boundary. Customer details are received from the external boundary, that is, the customer input screen.
- EI may maintain the ILF of the application, but it's not a compulsory rule. In this sample project the customer ILF is maintained. So there are two EI: one for add and one from update.

While counting EI I have seen many people multiply it by 3.That means we are going to do all CRUD functionality (ADD, UPDATE, and DELETE). Here the customer screen has add and update. We can say that 2 * 6; that = 12 FP for this EI customer. But later when someone refers to your FP sheet he will be completely lost.

EI Add Customer	Number of DETs	Number of FTRs
Description		
There are total 9 DETs, all add and update buttons, even the credit check button, the address list box, check box active, all text boxes.		
There are 3 FTRs, one is the address and the second is the credit card information, and the third is the customer itself.	9	3
So according to the above ranking table	**Total function**	6

Table 28 EI for the add customer

EI Update Customer		
Description	**Number of DET**	**Number of RET**
There are 9 total DETs, all add and update uttons, even the credit check button, the address list box, check box active, all text boxes.There are 3 FTRs, one is the address, the second is the credit card information, and the third is the customer itself.	9	3
So according to the above ranking table	**Total function**	6

Table 29 EI for the update customer

The following are rules to recognize EO:

- Data should cross application boundaries and should involve complex logic.

Credit card check processes can be complex as credit card API complexity is still not known. Credit card information crosses from the credit card system to the customer system.

EO Check Credit Card		
Description	**Number of DETs**	**Number of RETs**
One DET credit card number and one RET credit card itself. Note if there are no RET we use a default of one. Look for RET counting rules defined in previous sections.	1	1
So according to the above ranking table	**Total function**	4

Table 30 EO to check the credit card

The following are rules used to recognize EQ:

- EQ is a dynamic elementary process in which result data is retrieved from one or more ILFs or EIFs. For editing, the customer we will need to retrieve the customer details.
- In this EP some input requests have to enter the application boundary. The customer code is inputted from the same screen.
- Output results exit the application boundary. The customer details are displayed while the customer is editing the customer data.
- EQ does not contain any derived data. The customer data which is displayed does not contain any complex calculations.

EQ Display Customer Edit Information		
Description	**Number of DETs**	**Number of FTRs**
There are 5 DETs to be retrieved: customer code, customer name, credit card number, active, customer address. Only customer details and customer address will be referenced.	5	2
So according to the above ranking table	**Total function**	3

Table 31 EQ to display customer edit

So now let's add the total FPs from the previous tables:

Function Point	Section Name Counted
ILF customer	
EO credit card check system	4
EIF credit card information	5
EI customer (add and update)	12
EQ display customer edit information	3
Total unadjusted function points	31

Table 32 Total of all function points.

So the unadjusted FPs come to 31. Please note we refer to unadjusted function points as we have not accounted for other variance factors of the project (programmers leaving the job, languages, we, architecture, etc.).

In order to make it the adjusted function points, we have to calculate and tabulate the GSCs and end up with the VAFs.

GSCs	Value (0–5)
Data communications	1
Distributed data processing	1
Performance	4
Heavily used configuration	0
Transaction rate	1
Online data entry	0
End-user efficiency	4
Online update	0
Complex processing	0
Reusability	3
Installation ease	4
Operational ease	4
Multiple sites	0
Facilitate change	0
Total	**22**

Table 33 GSC

VAF = 0.65 + ((sum of all GSC factor)/100) = 0.65 + (22/100) = 0.87.

This factor affects the whole FP so be very careful with this factor. So now, calculating the

adjusted FPs = VAFs * total unadjusted. Now we know that the complete FPs for the customer GUI is 27 FPs. Now calculating the efficiency factor, we say that we will complete 3 FPs per day, that is, 9 working days. So, the whole customer GUI is of 9 working days (note: do not consider Saturday and Sunday as working days).

FPs = 0.87 * 31 = 26.97 = rounded to 27 FPs.

Considering the SDLC (System Development Life Cycle)

Before reading this section please refer to the different SDLC cycles in previous chapters.

Quotations are heavily affected by which software lifecycle you follow because deliverables change according to the SLDC model the project manager chooses for the project. Example: For the waterfall model we will have requirement documents, design documents, source code, and testing plans. But for prototyping models, in addition to the documents above, we will also need to deliver the rough prototype. For the build and fix model we will not deliver any of the documents and the only document delivered will be the source code. So according to the SDLC model deliverables change and hence the quotation. We will divide the estimation across requirement, design, implementation (coding), and testing. How the estimation divides across all deliverables is all up to the project manager and his plans.

Phase	Percentage distribution effort
Requirements	10% of total effort
Design Phase	20% of total effort
Coding	100% of total effort
Testing	10% of total effort

Table 34 Phase-wise distribution of effort

The above sample is 100% of the distribution of effort across various phases. But note that function points or any other estimation methodology only gives you the total execution estimation. So you can see in the above distribution we have given coding 100%. But as previously said it is up to the project manager to change according to scenarios. From the above function point estimation the estimation is 7 days. Let's try to divide it across all phases.

Phase	Percentage distribution effort	Distribution of men/ days acrossphases
Requirements	10% of total effort	0.9 days
Design Phase	20% of total effort	1.8 days
Coding	60% of total effort	7 days
Testing	10% of total effort	0.9 days
Total		**10.6 days**

Table 35 Phase-wise effort distribution of man days

The table shows the division of project men/days across the project. Now let's put down the final quotation. But first just a small comment about test cases.

The total number of Test Cases = (Function Points) raised to a power of 1.2.

(A) HOW CAN YOU ESTIMATE THE NUMBER OF ACCEPTANCE TEST CASES IN A PROJECT?

The number of acceptance test cases = 1.2 * Function Points.

20–25% of the total effort can be allocated to the testing phase. Test cases are non-deterministic. That means if the test passes it takes "X" amount of time and if it does not then to amend it takes "Y" amount of time.

Final Quotation

One programmer will work on the project for $1,000 a month. So his 10.6 days of salary comes to around $318.00. The following quotation format is a simple

format. Every company has its own quotation format. http://www.microsoft.com/mac/resources/templates.aspx?pid=templates has a good collection of decent templates.

XYZ SOFTWARE COMPANY				
To: TNC Limited, Western road 17, California. Quotation number: 90 Date: 1/1/2004 Customer ID: Z- 20090DATAENTRY				
Quantity	**Description**	**Discount**	**Taxable**	**Total**
1	Customer Project	0%	0%	$318.00
Quotation Valid for 100 days Goods delivery date within 25 days of half payment Quotation prepared by: XYZ estimation department Approved by: SPEG department XYZ				

Table 36 Final bill

CustomerSampleFP.xls is provided on the CD which has all the estimation details you need.

GSC Acceptance in Software industry

GSC factors have been always a controversial topic. Most software companies do not use GSC, rather they baseline UAFP or construct their own table depending on company project history. ISO has also adopted function points as units of measurement, but they also use UAFP rather than AFP. Let's do a small experiment to view the relationships between FP, AFP, GSC, and VAF. In this experiment we will assume UAFP = 120 and then lot graph with GSC in increments of five. So the formula is
VAF = 0.65 + (GS/100).

Here's the table with the values in the formula plotted.

FP	GSC
78	0
84	5
90	10
96	15
102	20
108	25
114	30
120	35
126	40
132	45
138	50
144	55
150	60
156	65
162	70

Table 37 GSC acceptance

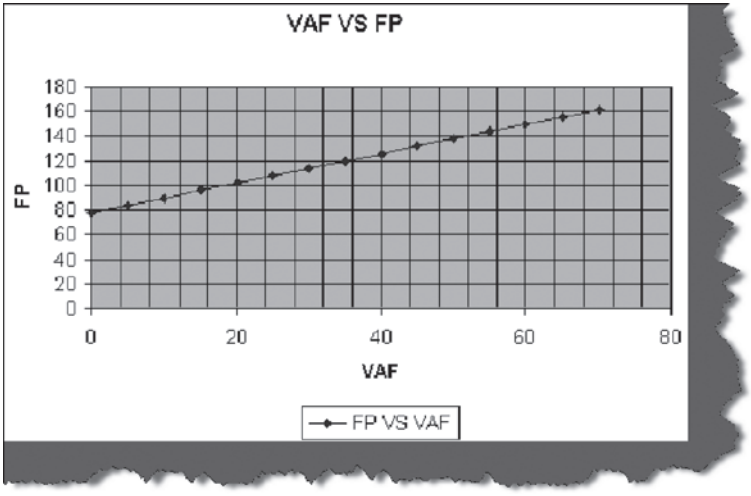


FIGURE 158 **FP versus VAF**

The following are the observations from the table and plot:

- The graph is linear. It also captures that the nature of complexity is linear.
- If the GSC value is zero then the VAF is 0.65. So the graph starts from UAFP * 0.65.GSC = 35 AFP = UAFP. So the VAF = 1.
- When GSC < 35 then AFP > UAFP. That means complexity decreases.
- When GSC > 35 then AFP > UAFP. That means complexity increases.

Readers must be wondering why 0.65? There are 14 GSC factors from zero to five. So the maximum value of VAF = 0.65 + (70/100) = 1.35. So that VAF does not have any affect, i.e., UAFP = FP, the VAF should be one. The VAF will be one when the GSC is 35, i.e., half of 70. So, in order to complete value "1", value "0.65" is taken. Note that the value is 0.35 when the GSC is 35, to complete the one factor, "0.65" is required.

But the following is the main problem related to the GSCs. The GSCs are applied throughout FPs even when some GSCs do not apply to whole function points. Here's the example to demonstrate the GSC problem.

Let's take the 11th GSC factor "installation ease." The project is of 100 UAFP and there is no consideration of the installation done previously by the client so the 11th factor is zero.

GSC with installation easewith ZERO

GSC	Value (0–5)
Data communications	1
Distributed data processing	1
Performance	4
Heavily used configuration	0
Transaction rate	1
Online data entry	0
End-user efficiency	4
Online update	0
Complex processing	0

continued

GSC	Value (0–5)
Reusability	3
Installation ease	0
Operational ease	4
Multiple sites	0
Facilitate change	0
Total	**18**

Table 39 GSC with installation ease zero

VAF = 0.65 + (18/100) = 0.83. So the FPs = 100 * 0.83 = 83 function points. But later the client demanded a full-blown installation for the project with auto updating when the new version is released. So we change the installation ease to 5.

GSC with installation easewith 5	
GSC	**Value (0–5)**
Data communications	1
Distributed data processing	1
Performance	4
Heavily used configuration	0
Transaction rate	1
Online data entry	0
End-user efficiency	4
Online update	0
Complex processing	0
Reusability	3
Installation ease	5
Operational ease	4
Multiple sites	0
Facilitate change	0
Total	**23**

Table 39 GSC with installation ease 5

So VAFs = 0.65 + (23/100) = 0.88 so the FPs = 100 * 0.88 = 88. The difference is only 5 FPs which in no way is a proper effort estimate. You cannot make an auto update for a software version in 5 function points. Just think about downloading the new version, deleting the old version, updating any databases, structure changes, etc. So that's the reason GSCs are not accepted in the software industry. It is best to baseline your UAFPs.

Enhancement Function Points

Major software projects fail not because of programmers or project managers, but due to changing needs of customers. Function point groups have come out with a methodology called "Enhancement Function Points."

The formula is as follows:

Formulae of EFP (Enhanced Function Points) = (ADD + CHGA) * VAFA + (DELFP) * VAFB

ADD: This is where new function points added. This value is achieved by counting all new EPs (elementary processes) given in a change request.

CHGA: Function points which are affected due to CR. This value is achieved by counting all DET, FTR, ILF, EI, EO, and EQ which are affected. Do not count elements that are not affected.

VAFA: This is a VAF which occurs because of CR. The example previously given was the desktop application that was changed to a web application so the GSC factor is affected.

DELFP: When CR is used for removing some functionality this value is counted. It's rare that the customer removes functionalities, but if they ever do the estimator has to take note of it by counting the deleted elementary processes.

VAFB: Again removal affects value added factors.

Once we are through with calculating enhanced function points, it is time to count the total function points of the application. The formula is as follows:

Total Function points = [UFPB + ADD + CHGA]−[CHGB−DELFP]

UFPB: Function points previously counted before enhancement.

ADD: Newlyadded functionality which leads to new function points after enhancements.

CHGA: Changed function points counted after enhancements.

CHGB: Changed function points before enhancements.

DELFP: Deleted function points.

(A) CAN YOU EXPLAIN HOW TPA WORKS?

There are three main elements which determine estimates for black box testing: size, test strategy, and productivity. Using all three elements we can determine the estimate for black box testing for a given project. Let's take a look at these elements.

Size: The most important aspect of estimating is definitely the size of the project. The size of a project is mainly defined by the number of function points. But a function point fails or pays the least attention to the following factors:

- **Complexity:** Complexity defines how many conditions exist in function points identified during a project. More conditions means more test cases which means more testing estimates. For instance, the following is an application which takes the customer name from the end user. If the customer name is greater than 20 characters then the application should give an error. So for this case there will be one test case. But let's say the end user also puts one more condition that if the user inputs any invalid character then the application should give an error. Because there is one more extra condition in the project the complexity has increased, which also means that we need to test two cases. The following illustrates this figure.

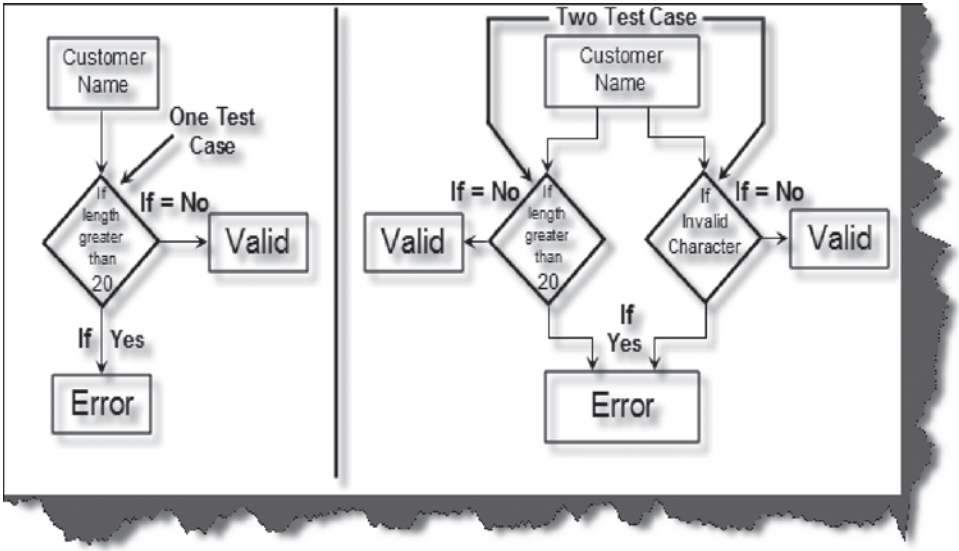


FIGURE 159 **Complexity**

- **Interfacing:** How much does one function affect the other part of the system? If a function is modified then accordingly the other systems have to be tested as one function always impacts another.
- **Uniformity:** How reusable is the application? It is important to consider how many similar structured functions exist in the system. It is important to consider the extent to which the system allows testing with slight modifications.

Test strategy: Every project has certain requirements. The importance of all these requirements also affects testing estimates. Any requirement importance is from two perspectives: one is the user importance and the other is the user usage. Depending on these two characteristics a requirement rating can be generated and a strategy can be chalked out accordingly, which also means that estimates vary accordingly.

Productivity: This is one more important aspect to be considered while estimating black box testing. Productivity depends on many aspects. For

instance, if your project has new testers your estimates shoot up because you will need to train the new testers in terms of project and domain knowledge. Productivity has two important aspects: environment and productivity figures. Environmental factors define how much the environment affects a project estimate. Environmental factors include aspects such as tools, test environments, availability of testware, etc. While the productivity figures depend on knowledge, how many senior people are on the team, etc.

The following diagram shows the different elements that constitute TPA analysis as discussed.

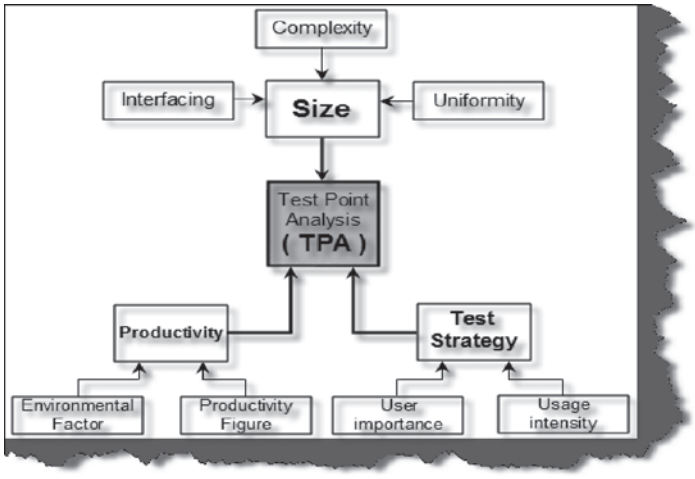


FIGURE 160 **TPA parameters**

(A) HOW DO YOU CREATE AN ESTIMATE FOR BLACK BOX TESTING?

Note: On the CD we have provided an Excel file called "FunctionPoints (Accounting Application)", which is used in this example to make TPA calculation easier. We have also provided an explanation of how to use the Excel spread sheet. The entire image snapshot which you will see in this answer is taken from the "FunctionPoints file."

In order to really answer this question let's do one complete estimation practically for a sample project. The following is a simple accounting application developed for http://www.questpond.com to track its sales. The first screen is a voucher entry screen. It's a normal simple voucher entry screen with extra functionality to print the voucher. The second screen is a master screen for adding accounting codes.

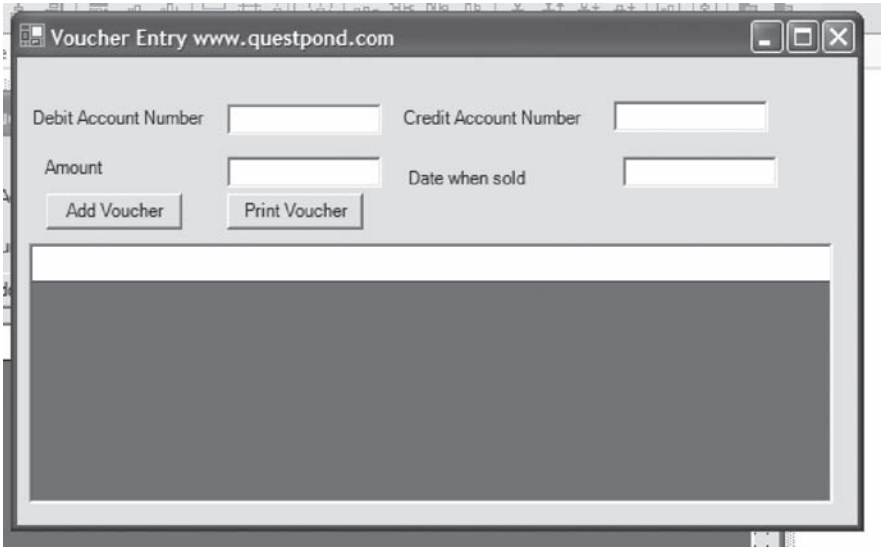


FIGURE 161 **Accounting application**

The following are point requirements gathered from the end customer:

(1) The account code entered in the voucher entry screen should be a valid account code from the defined chart of accounts given by the customer.
(2) The user should be able to add, delete, and modify the account code from the chart of the account master (this is what the second screen defines).
(3) The user will not be able to delete the chart of account codes if he has already entered transactions for in vouchers.
(4) The chart of account code master will consist of account codes and descriptions of the account code.
(5) The account code cannot be greater than 10.

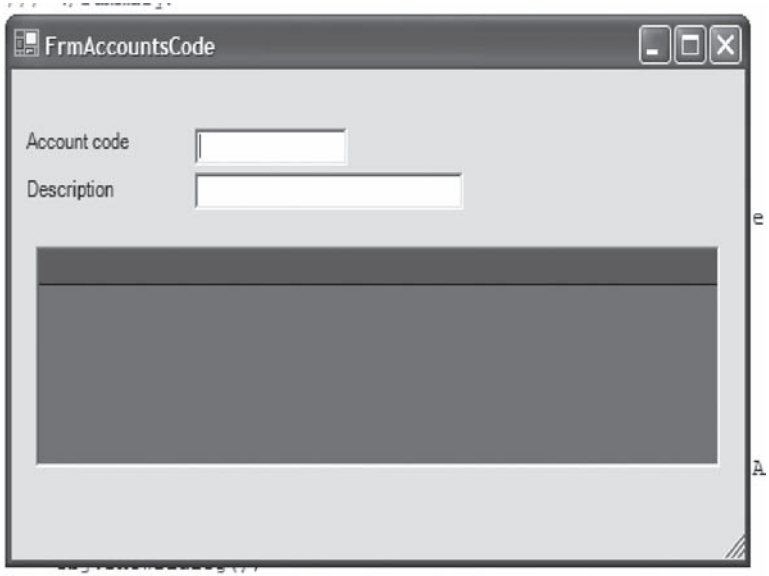


FIGURE 162 **Account code description**

(6) The voucher data entry screen consists of the debit account code, credit account code, date of transaction, and amount.
(7) Once the user enters voucher data he should be able to print it in the future at any time.
(8) The debit and credit account are compulsory.
(9) The amount value should not be negative.
(10) After pressing the submit button the value should be seen in the grid.
(11) The amount is compulsory and should be more than zero.
(12) The debit and credit account should be equal in value.
(13) Only numeric and non-negative values are allowed in the amount field.
(14) Two types of entries are allowed: sales and commissions.
(15) Date, amount, and voucher number are compulsory.
(16) The voucher number should be in chronological order and the system should auto increment the voucher number with every voucher added.
(17) No entries are allowed for previous months.

(18) Users should be able to access data from separate geographical locations. For instance, if one user is working in India and the other in China, then both users should be able to access each other's data through their respective location.

Now that we have all the requirements let's try to estimate how we can use TPA to do get the actual men days needed to complete a project. The following figure shows our road map and how we will achieve using TPA. There are in all ten steps needed to achieve our goal.

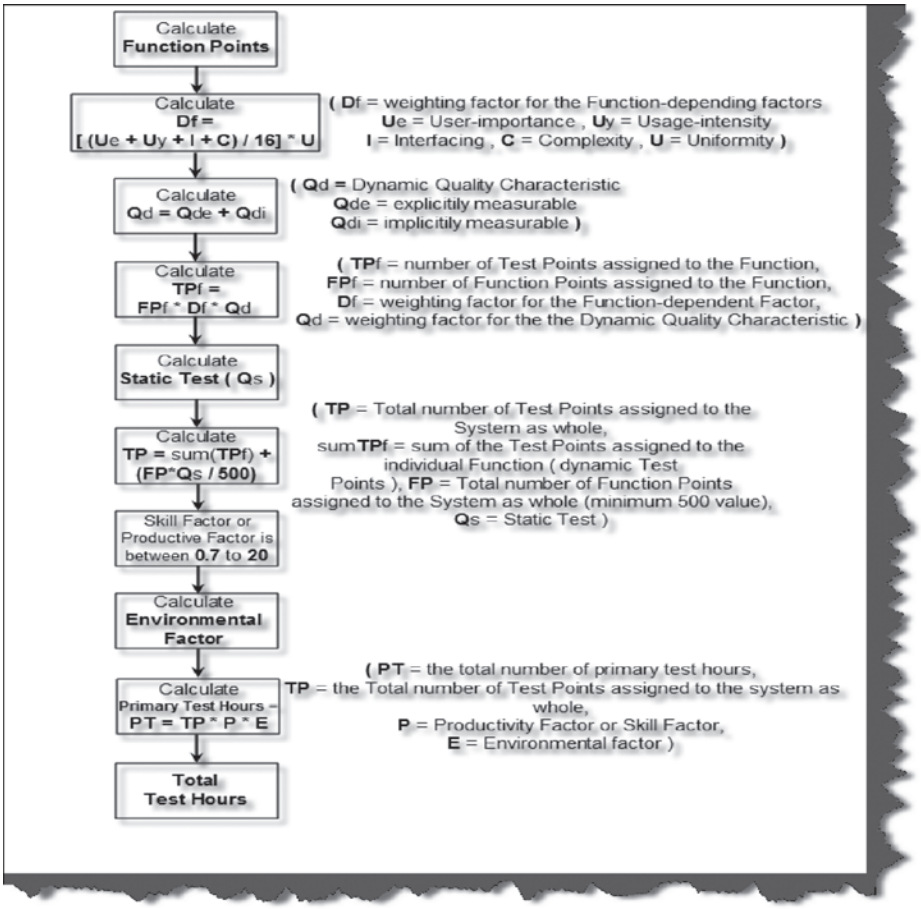


FIGURE 163 **TPA steps.**

Step 1: Calculate function points

> **Note:** You will understand this section if you have not read the function points explanation given previously.

EI Calculation

The following are the EI entries for the accounting application. Currently, we have two screens: one is the master screen and one is the voucher transaction screen. In the description we have also described which DETs we have considered. For the add voucher screen we have 7 DETs (note the buttons are also counted as DETs) and for the account code master we have 4 DETs.

Functionality	DET	FTR	Value	Description
Add voucher	7	1	3	DET :- Debit account code , Credit Account code , Amount , Date , Add voucher button , Print voucher button and display grid
Add account code	4	1	3	DET:- Account code , Add button , unselect all button and Grid

FIGURE 164 **EI for the accounting application**

EIF

There are no EIFs in the system because we do not communicate with any external application.

Functionality	DET	RET	Value	Description
NA	NA	NA	NA	NA

FIGURE 165 **EIF for the accounting application**

EO

EOs are nothing but complex reports. In our system we have three complex reports: trial balance, profit and loss, and balance sheet. By default we have assumed 20 fields which makes it a complex report (when we do estimations sometimes assumptions are okay).

Functionality	DET	FTR	Value	Description
Report Trial Balance	20	1	5	Assumed maximum 20 fields
Profit and Loss	20	1	5	Assumed maximum 20 fields
Balance sheet	20	1	5	Assumed maximum 20 fields

FIGURE 166 **EO for the accounting application**

EQ

EQs are nothing but simple output sent from the inside of the application to the external world. For instance, a simple report is a typical type of EQ. In our current accounting application we have one simple form that is the print voucher. We have assumed 20 DETs so that we can move ahead with the calculation.

Functionality	DET	FTR	Value	Description
Print voucher	20	1	4	Assumed 20 DET's

FIGURE 167 **EQ for the accounting application**

GSC Calculation

As said in the FPA tutorial previously given the GSC factor defines the other factors of the projects which the FP counting does not accommodate. For the accounting application we have kept all the GSC factors as 1 except for data communications and performance. We have kept communication as 2 because, one the requirement point is that we need application data to be accessed from multiple centers which increases the data communication complexity and also because the requirement of the end customer is that performance should be mediumly good. The following figure shows the GSC entries.

GSC Attribute	Definitions	Value
Data communications:	How many communication facilities are there to aid in the transfer or exchange of information with the application or system?	2
Distributed data processing	How are distributed data and processing functions handled?	0
Performance	Did the user require response time or throughput?	2
Heavily used configuration	How heavily used is the current hardware platform where the application will be executed?	1
Transaction rate	How frequently are transactions executed; daily, weekly, monthly, etc.?	1
On-Line data entry	What percentage of the information is entered On-Line?	1
End-user efficiency	Was the application designed for end-user efficiency?	1
On-Line update	How many ILF's are updated by On-Line transaction?	1
Complex processing	Does the application have extensive logical or mathematical processing?	1
Reusability	Was the application developed to meet one or many user's needs?	1
Installation ease	How difficult is conversion and installation?	1
Operational ease	How effective and/or automated are start-up, back up, and recovery procedures?	1
Multiple sites	Was the application specifically designed, developed, and supported to be installed at multiple sites for multiple organizations?	1
Facilitate change	Was the application specifically designed, developed, and supported to facilitate change?	1
GSC		**0.8**

FIGURE 168 **GSC factors for our accounting application**

Total Calculation

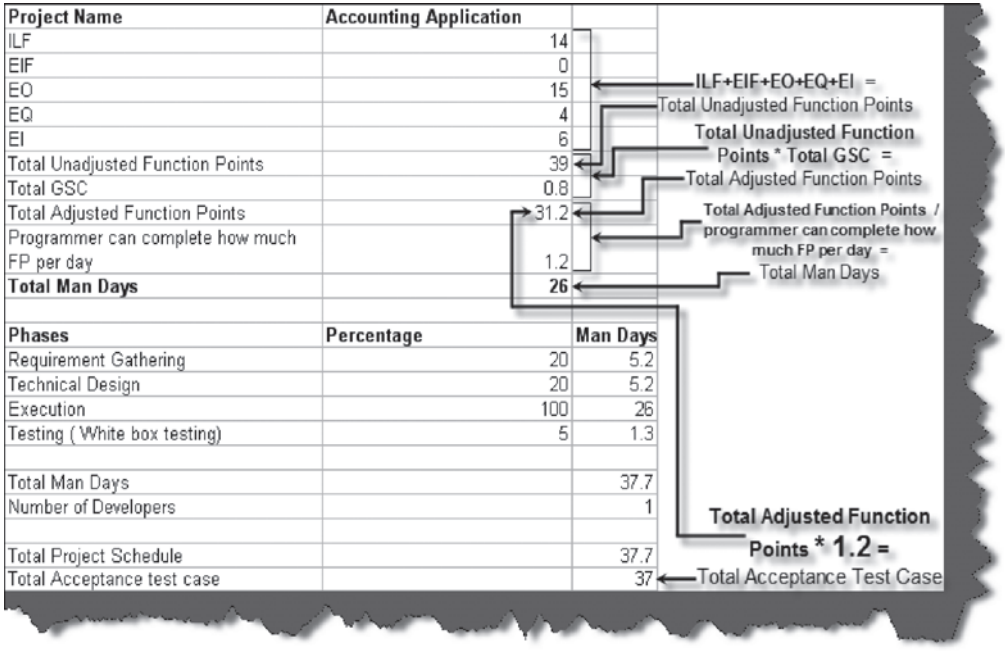
Now that we have filled in all the details we need to calculate the total man days. The following figure explains how the calculations are done. The first five rows, i.e., ILF, EIF, EO, EQ, and EI, are nothing but the total of the individual entries. A total unadjusted function point is the total of ILF + EIF + EO + EQ + EI. We get the total adjusted function which is nothing but the total un-adjusted function points multiplied by the GSC factors. Depending on the organizations baseline we define how many FPs can be completed by a programmer in one day. For instance, for the following accounting application we have 1.2 FPs per day. Depending on the FPs per day we get the total man days. Once we have the total man days we distribute these values across the phases. We have just found the total execution time. So we have assigned the total man days to the execution phase. From the execution phase and man days we distribute 20 percent to the requirement phase, 20 percent to technical design, and 5 percent to testing.

(A) HOW DO YOU ESTIMATE WHITE BOX TESTING?

The testing estimates derived from function points are actually the estimates for white box testing. So in the following figure the man days are actually the estimates for white box testing of the project. It does not take into account black box testing estimation.

(A) IS THERE A WAY TO ESTIMATE ACCEPTANCE TEST CASES IN A SYSTEM?

Total acceptance test cases = total adjusted function points multiplied by 1.2:
The total estimate for this project is 37.7 man days.



Project Name	Accounting Application	
ILF	14	
EIF	0	
EO	15	
EQ	4	
EI	6	
Total Unadjusted Function Points	39	
Total GSC	0.8	
Total Adjusted Function Points	31.2	
Programmer can complete how much FP per day	1.2	
Total Man Days	**26**	
Phases	**Percentage**	**Man Days**
Requirement Gathering	20	5.2
Technical Design	20	5.2
Execution	100	26
Testing (White box testing)	5	1.3
Total Man Days		37.7
Number of Developers		1
Total Project Schedule		37.7
Total Acceptance test case		37

FIGURE 169 **Total estimation of the accounting application**

Now that we have completed the function point analysis for this project let's move on to the second step needed to calculate black box testing using TPA.

Step 2: Calculate Df (Function-dependant factors)

Df is defined for each function point. So all the function point descriptions as well as values are taken and the Dfs are calculated for, each of them. You can see from the figure how every function point factor is taken, and how the Df is calculated.

Df = ((Ue + Uy + I + C) / 16) * U

function\factors	TPf	FPf	Ue	Uy	I	C	U	Df
Voucher data	14.84	7	12	12	2	3	1	1.81
chart of accounts data	5.12	7	3	2	2	3	1	0.63
Report trail balance	4.75	5	3	2	2	6	1	0.81
Report profit and loss	4.75	5	3	2	2	6	1	0.81
Report balance sheet	4.75	5	3	2	2	6	1	0.81
Print voucher	9.36	4	12	12	2	6	1	2.00
add Voucher	8.34	3	12	12	2	12	1	2.38
Add account code	3.29	3	6	2	4	3	1	0.94

FIGURE 170 **Df calculated**

But we have still not seen how Df will be calculated. Df is calculated using four inputs: user importance, usage intensity, interfacing, and complexity. The following figure shows the different inputs in a pictorial manner. All four factors are rated as low, normal, and high and assigned to each function are factors derived from the function points. Let's take a look at these factors.

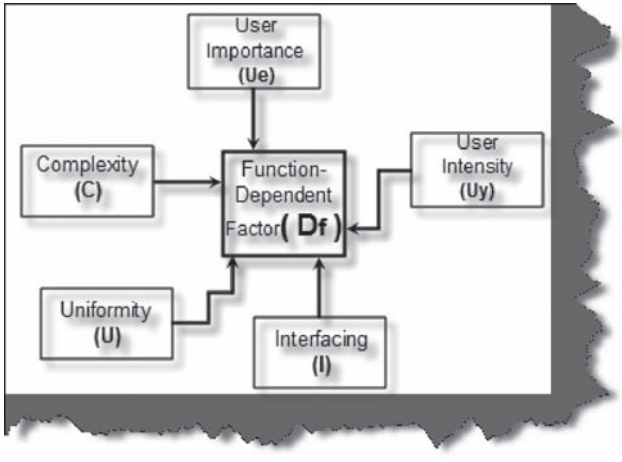
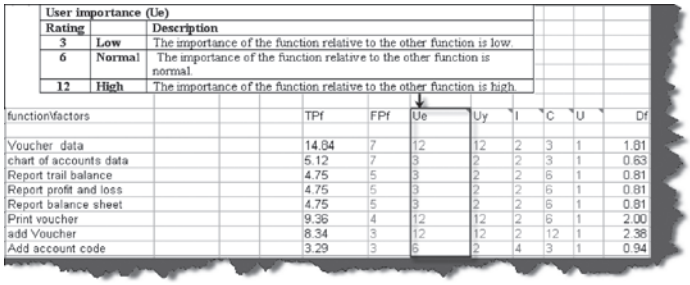


FIGURE 171 **Factors on which Dfs depend**

User importance (Ue): How important is this function factor to the user compared to other function factors? The following figure shows how they are rated. Voucher data, print voucher, and add voucher are rated with high user importance. Without these the user cannot work at all. Reports have been rated low because they do not really stop the user from working. The chart of accounts master is rated low because the master data is something which is added at one time and can also be added from the back end.

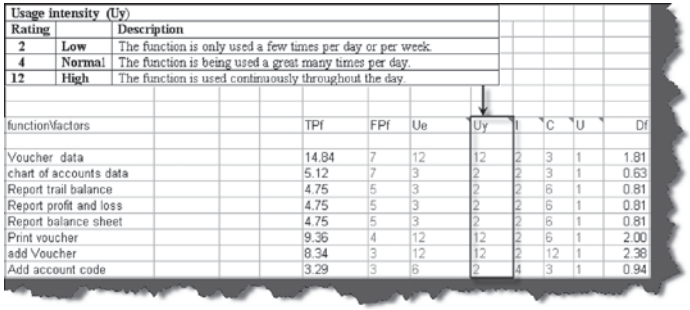


User importance (Ue)		
Rating		Description
3	Low	The importance of the function relative to the other function is low.
6	Normal	The importance of the functon relative to the other function is normal.
12	High	The importance of the function relative to the other function is high.

function\factors	TPf	FPf	Ue	Uy	I	C	U	Df
Voucher data	14.84	7	12	12	2	3	1	1.81
chart of accounts data	5.12	7	3	2	2	3	1	0.63
Report trail balance	4.75	5	3	2	2	6	1	0.81
Report profit and loss	4.75	5	3	2	2	6	1	0.81
Report balance sheet	4.75	5	3	2	2	6	1	0.81
Print voucher	9.36	4	12	12	2	6	1	2.00
add Voucher	8.34	3	12	12	2	12	1	2.38
Add account code	3.29	3	6	2	4	3	1	0.94

FIGURE 172 **User importance**

Usage intensity (Uy): This factor tells how many users use the application and how often. The following figure shows how we have assigned the values to each function factor. Add voucher, Print Voucher, and voucher data are the most used function factors. So they are rated high. All other function factors are rated as low.



Usage intensity (Uy)		
Rating		Description
2	Low	The function is only used a few times per day or per week.
4	Normal	The function is being used a great many times per day.
12	High	The function is used continuously throughout the day.

function\factors	TPf	FPf	Ue	Uy	I	C	U	Df
Voucher data	14.84	7	12	12	2	3	1	1.81
chart of accounts data	5.12	7	3	2	2	3	1	0.63
Report trail balance	4.75	5	3	2	2	6	1	0.81
Report profit and loss	4.75	5	3	2	2	6	1	0.81
Report balance sheet	4.75	5	3	2	2	6	1	0.81
Print voucher	9.36	4	12	12	2	6	1	2.00
add Voucher	8.34	3	12	12	2	12	1	2.38
Add account code	3.29	3	6	2	4	3	1	0.94

Figure 173 Usage intensity

Interfacing (I): This factor defines how much impact this function factor has on other parts of the system. But how do we now find the impact? In TPA, the concept of LDS is used to determine the interfacing rating. LDS stands for Logical Data Source. In our project we have two logical data sources: one is voucher data and the other is account code data (i.e., chart of accounts data). The following are the important points to be noted which determine the interfacing:

- We need to consider only functions which modify LDS. If a function is not modifying LDS then its rating is Low by default.
- To define LDS we need to define how many LDSs are affected by the function and how many other functions access the LDS. Other functions only need to access the function; even if they do not modify it.

The following is the table which defines the complexity level according to the number of LDSs and functions impacting on LDS.

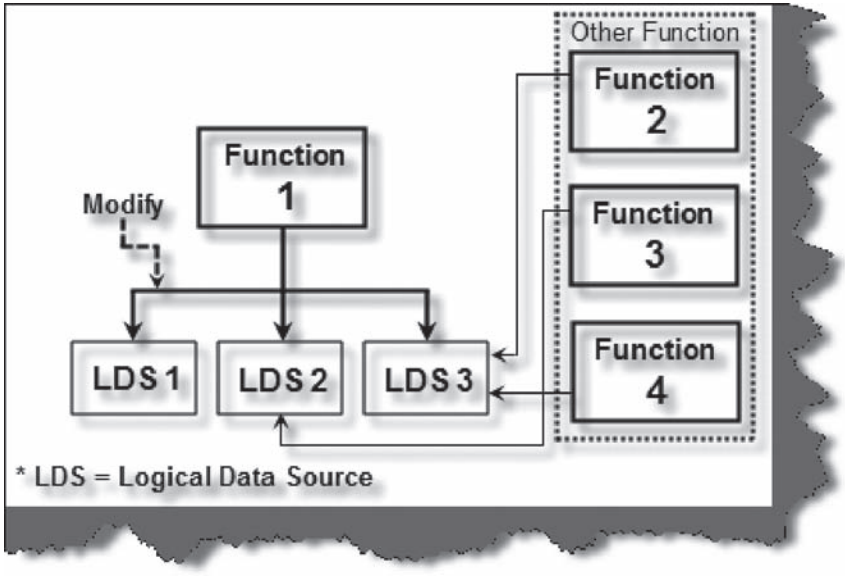


FIGURE 174 **LDS and the function concept**

	Functions →		
LDS ↓	1	2 to 5	greater than 5
1	L	L	A
2 to 5	L	A	H
greater than 5	A	H	H

(* L = Low, A = Average, H = High)

FIGURE 175 **LDS ratings**

So now depending on the two points defined above let's try to find out the interfacing value for our accounting project. As said previously we have two functions which modify LDS in our project: one is the add voucher function which affects the voucher data and the add account code which affects the chart of accounts code (i.e., the accounts code master). The add voucher function primarily affects voucher data LDFs. But other functions such as reports and print also use the LDS. So in total there are five functions and one LDS. Now looking at the number of LDSs and the number of functions the impact complexity factor is Low.

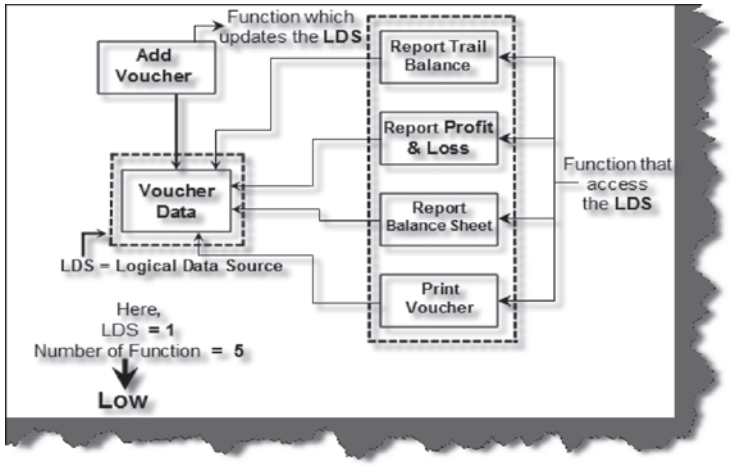


FIGURE 176 **Add voucher data**

The other function which modifies is the Add account code function. The LDS affected is the chart of account code and the function which affects it is the Add account code function. There are other functions that indirectly affect this function, too. For instance, Report which needs to access account code, Print voucher which uses the account code to print account description and also the Add voucher function which uses the chart of accounts code LDS to verify if the account code is correct. So we can see the look-up table and the impact complexity factor is Average.

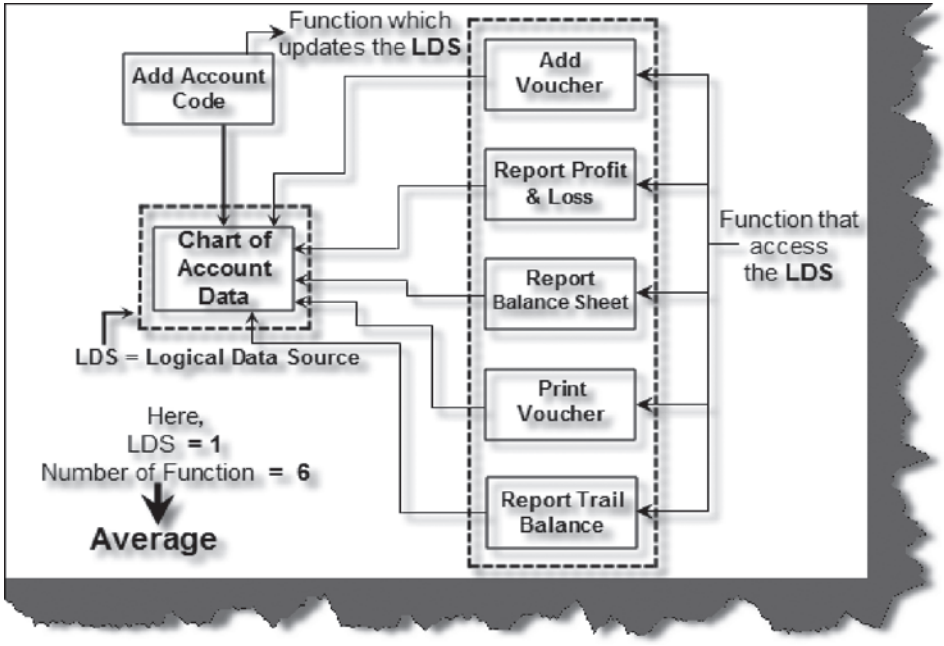
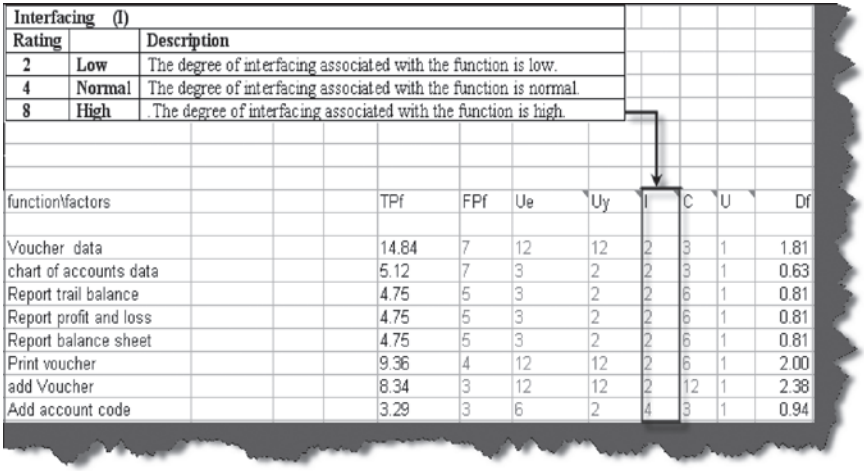


FIGURE 177 **Add account code LDS and functions**

The other function factors do not modify any data so we give them a Low rating. The following is the interfacing complexity factors assigned.

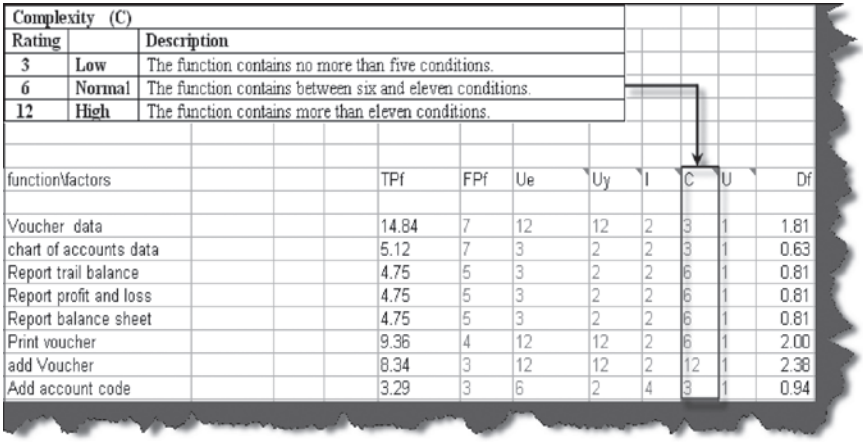


Interfacing (I)		
Rating		Description
2	Low	The degree of interfacing associated with the function is low.
4	Normal	The degree of interfacing associated with the function is normal.
8	High	. The degree of interfacing associated with the function is high.

function\factors	TPf	FPf	Ue	Uy	I	C	U	Df
Voucher data	14.84	7	12	12	2	3	1	1.81
chart of accounts data	5.12	7	3	2	2	3	1	0.63
Report trail balance	4.75	5	3	2	2	6	1	0.81
Report profit and loss	4.75	5	3	2	2	6	1	0.81
Report balance sheet	4.75	5	3	2	2	6	1	0.81
Print voucher	9.36	4	12	12	2	6	1	2.00
add Voucher	8.34	3	12	12	2	12	1	2.38
Add account code	3.29	3	6	2	4	3	1	0.94

FIGURE 178 **Interfacing**

Complexity (C): This factor defines how complex the algorithm for the particular function factor is. Add voucher is the most complex function in the project and it can have more than 11 conditions so we have rated the complexity factor the highest. Reports are mildly complex and can be rated as average in complexity. So as discussed we have assigned values accordingly as shown in the figure.



Complexity (C)		
Rating		Description
3	Low	The function contains no more than five conditions.
6	Normal	The function contains between six and eleven conditions.
12	High	The function contains more than eleven conditions.

function\factors	TPf	FPf	Ue	Uy	I	C	U	Df
Voucher data	14.84	7	12	12	2	3	1	1.81
chart of accounts data	5.12	7	3	2	2	3	1	0.63
Report trail balance	4.75	5	3	2	2	6	1	0.81
Report profit and loss	4.75	5	3	2	2	6	1	0.81
Report balance sheet	4.75	5	3	2	2	6	1	0.81
Print voucher	9.36	4	12	12	2	6	1	2.00
add Voucher	8.34	3	12	12	2	12	1	2.38
Add account code	3.29	3	6	2	4	3	1	0.94

FIGURE 179 **Complexity**

Uniformity (U): This factor defines how reusable a system is. For instance, if a test case written for one function can be applied again then it affects the testing estimates accordingly. Currently, for this project, we have taken a uniformity factor of 1. So, for example, if the customer had a requirement to also update the accounts code then we could have used two functions, Add voucher and Update voucher.

Uniformity (U)	
Rating	**Description**
0.6	In the case of a second occurrence of a virtually unique function :in such cases, the test specifications can be largely reused
0.6	In the case of a clone function: the test specifications can be reused for clone functions.
0.6	In the case of a dummy function (provided that reusable test specifications have already been drawn up for the dummy).
1	Otherwise Uniformity factor is 1

function\factors	TPf	FPf	Ue	Uy	I	C	U	Df
Voucher data	14.84	7	12	12	2	3	1	1.81
chart of accounts data	5.12	7	3	2	2	3	1	0.63
Report trail balance	4.75	5	3	2	2	6	1	0.81
Report profit and loss	4.75	5	3	2	2	6	1	0.81
Report balance sheet	4.75	5	3	2	2	6	1	0.81
Print voucher	9.36	4	12	12	2	6	1	2.00
add Voucher	8.34	3	12	12	2	12	1	2.38
Add account code	3.29	3	6	2	4	3	1	0.94

FIGURE 180 **Uniformity**

One we have all the five factors we apply the following formula to calculate Df for all the function factors:

$$Df = [(Ue + Uy + I + C)/16] * U$$

Step 3: Calculate Qd

The third step is to calculate Qd. Qd, i.e, dynamic quality characteristics, have two parts: explicit characteristics (Qde) and implicit characteristics (Qdi). Qde has five important characteristics: Functionality, Security, Suitability, Performance, and Portability. The following diagram shows how we rate those ratings. Qdi defines the implicit characteristic part of the Qd. These are not standard and vary from project to project. For instance, we have identified for this accounting application four characteristics: user friendly, efficiency, performance, and maintainability. From these four characteristics we assign

each 0.02 value. We can see from the following figure for user friendliness we have assigned 0.02 value. In the Qde part we have given functionality normal importance and performance as relatively unimportant but we do need to account for them. Once we have Qde and Qdi then Qd = Qde + Qdi. For this sample you can see that the total value of Qd is 1.17 (which is obtained from 1.15 + 0.02).

Qd is calculated using the rating multiplied by the value. The following table shows the rating and the actual value. So the 1.15 has come from the following formula:

$$((5 * 0.75) + (3 * 0.05) + (4 * 0.10) + (3 * 0.10) + (3 * .10)) / 4$$

Characteristics\Rating	0	3	4	5	6
functionality	(Weighting 0.75)				
security	(Weighting 0.05)				
Usability	(Weighting 0.10)				
Efficiency	(Weighting 0.10)				

FIGURE 181 **Qd ratings**

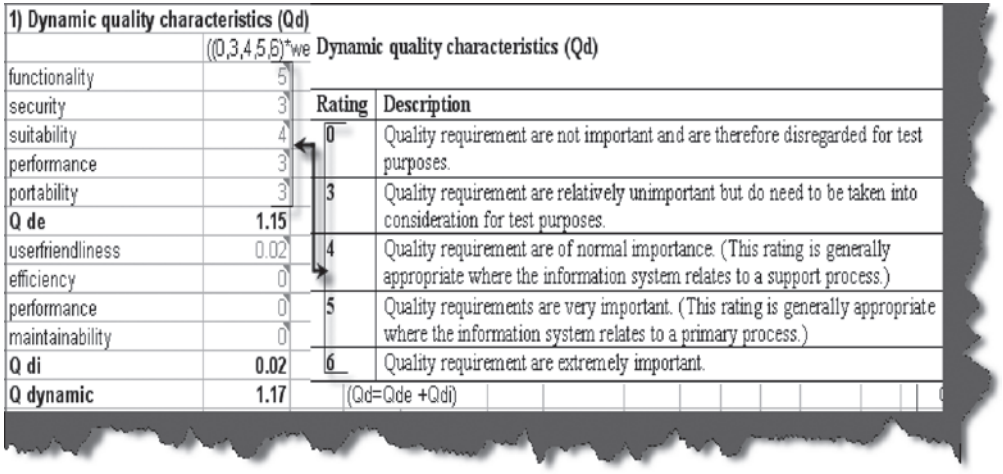


FIGURE 182 **Calculation of Qd (dynamic characteristics)**

Step 4: Calculate TPf for each function

In this step we calculate TPf (number of test points assigned to each function). This is done by using three data values (FPf, Df, and Qd). The following is the formula:

$$TPf = FPf * Df * Qd$$

Because we are using the Excel worksheet these calculations are done automatically. The following figure shows how the TPf calculations are done.

functionality	5	(weight factor 0,75)							
security	3	(weight factor 0,05)							
suitability	4	(weight factor 0,10)							
performance	3	(weight factor 0,05)							
portability	3	(weight factor 0,05)							
Q de	**1.15**			explicitly measurable					
userfriendliness	0.02	(weight factor 0,02)							
efficiency	0	(weight factor 0,02)							
performance	0	(weight factor 0,02)							
maintainability	0	(weight factor 0,02)							
Q di	**0.02**			implicitly measurable					
Q dynamic	**1.17**	(Qd=Qde +Qdi)							
2) Function dependent variables (Df) and test points (TPf)									
Df=((Ue+Uy+I+C)/16)*U									
TPf=FPf*Df*Qd									
function\factors			TPf	FPf	Ue	Uy	I	C	U	Df
Voucher data			14.84	7	12	12	2	3	1	1.81
chart of accounts data			5.12	7	3	2	2	3	1	0.63
Report trail balance			4.75	5	3	2	2	6	1	0.81
Report profit and loss			4.75	5	3	2	2	6	1	0.81
Report balance sheet			4.75	5	3	2	2	6	1	0.81
Print voucher			9.36	4	12	12	2	6	1	2.00
add Voucher			8.34	3	12	12	2	12	1	2.38
Add account code			3.29	3	6	2	4	3	1	0.94

TPf = FPf * Df * Qd

FIGURE 183 **Calculation of TPf**

Step 5: Calculate static test points Qs

In this step we take into account the static quality characteristic of the project. This is done by defining a checklist of properties and then assigning a value of 16 to those properties. For this project we have only considered easy-to-use as a criteria and hence assigned 16 to it.

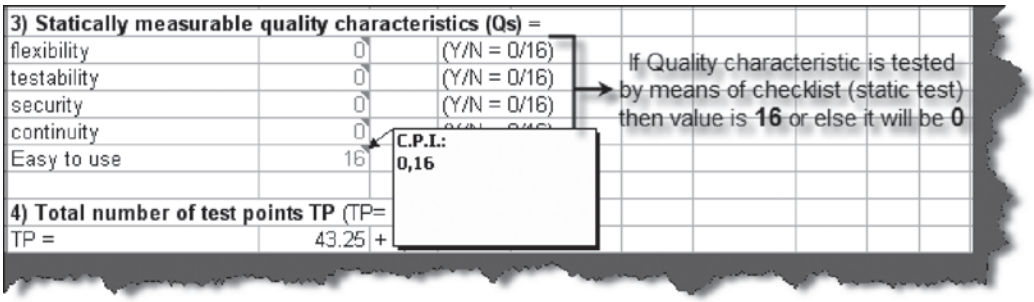


FIGURE 184 **Qs calculation**

Step 6: Calculate total number of test points

Now that we have TPfs for all function factors, FPs and Qs (static test point data), it's time to calculate the Tp (Total number of test points). The formula is as follows:

Tp = sum(TPf) + (FP*Qs/500)

For the accounting system total Tp = 71.21 (use a calculator if needed). The following figure shows how the total Tp is derived.

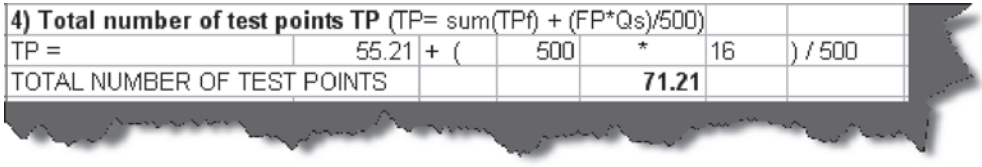


FIGURE 185 **Total number of test points**

Step 7: Calculate Productivity/Skill factors

Productivity/skill factors show the number of test hours needed per test points. It's a measure of experience, knowledge, and expertise and a team's ability to perform. Productivity factors vary from project to project and also organization to organization. For instance, if we have a project team with many seniors then productivity increases. But if we have a new testing team productivity decreases. The higher the productivity factor the higher the number of test hours required.

For this project we have good resources with great ability. So we have entered a value of 1.50 which means we have high productivity.

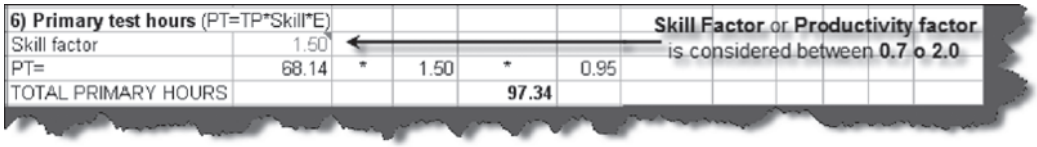


FIGURE 186 **Productivity factor/Skill factor**

Step 8: Calculate environmental Factor (E)

The number of test hours for each test point is influenced not only by skills but also by the environment in which those resources work. The following figure shows the different environmental factors. You can also see the table ratings for each environmental factor.

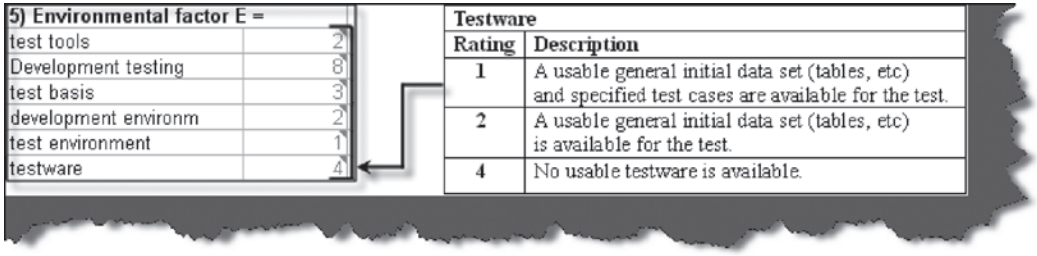


FIGURE 187 **Testware**

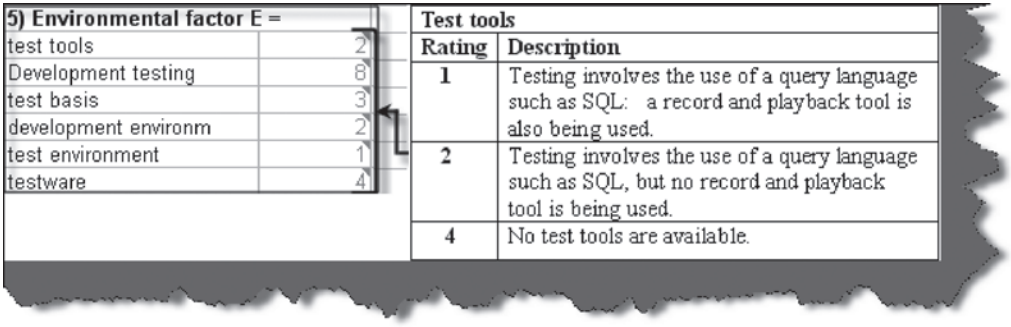
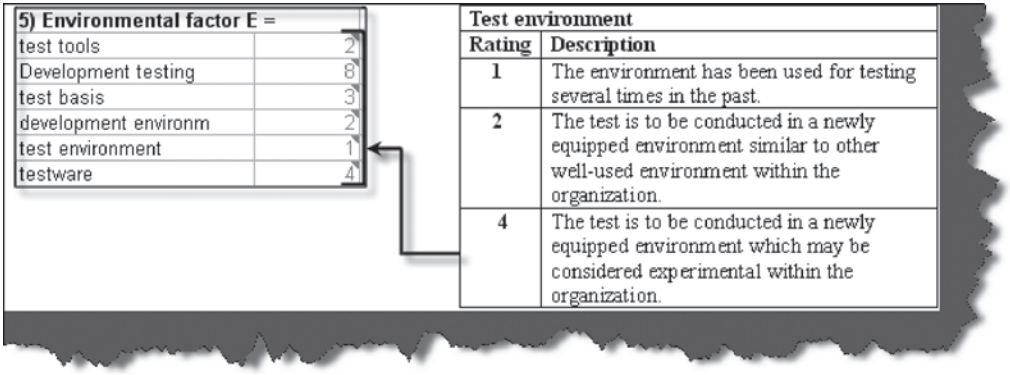


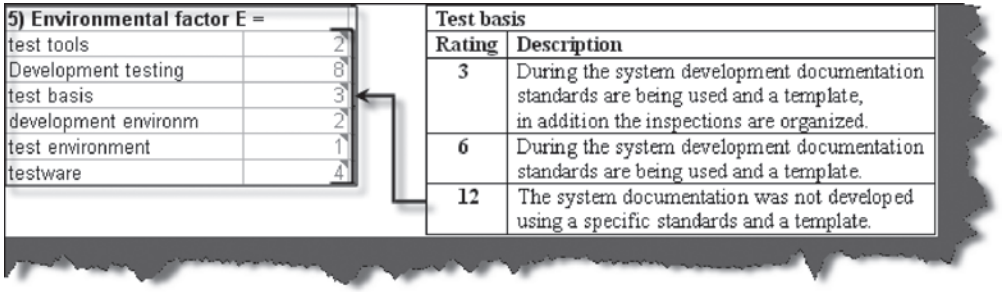
FIGURE 188 **Test tools**



5) Environmental factor E =	
test tools	2
Development testing	8
test basis	3
development environm	2
test environment	1
testware	4

Test environment	
Rating	**Description**
1	The environment has been used for testing several times in the past.
2	The test is to be conducted in a newly equipped environment similar to other well-used environment within the organization.
4	The test is to be conducted in a newly equipped environment which may be considered experimental within the organization.

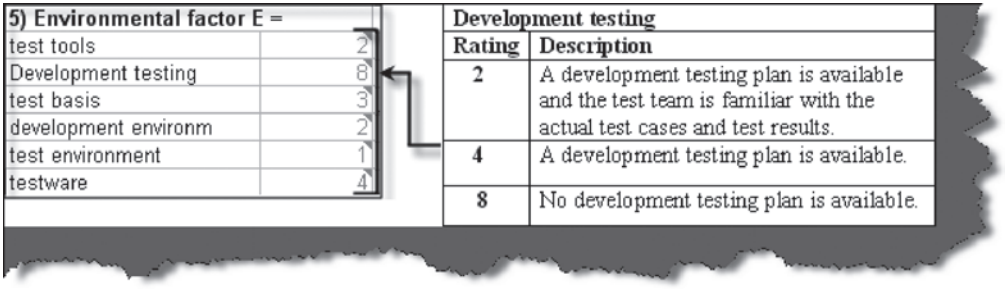
FIGURE 189 **Test environment**



5) Environmental factor E =	
test tools	2
Development testing	8
test basis	3
development environm	2
test environment	1
testware	4

Test basis	
Rating	**Description**
3	During the system development documentation standards are being used and a template, in addition the inspections are organized.
6	During the system development documentation standards are being used and a template.
12	The system documentation was not developed using a specific standards and a template.

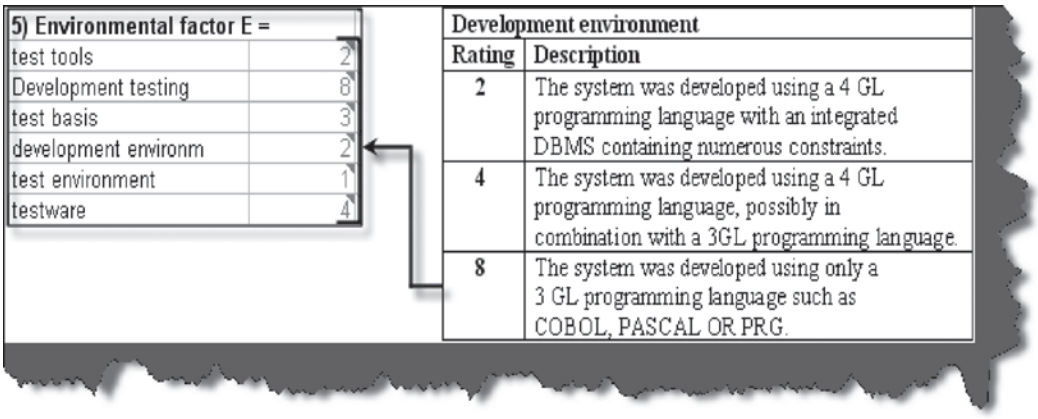
FIGURE 190 **Test basis**



5) Environmental factor E =	
test tools	2
Development testing	8
test basis	3
development environm	2
test environment	1
testware	4

Development testing	
Rating	**Description**
2	A development testing plan is available and the test team is familiar with the actual test cases and test results.
4	A development testing plan is available.
8	No development testing plan is available.

FIGURE 191 **Development testing**



5) Environmental factor E =	
test tools	2
Development testing	8
test basis	3
development environm	2
test environment	1
testware	4

Development environment	
Rating	Description
2	The system was developed using a 4 GL programming language with an integrated DBMS containing numerous constraints.
4	The system was developed using a 4 GL programming language, possibly in combination with a 3GL programming language.
8	The system was developed using only a 3 GL programming language such as COBOL, PASCAL OR PRG.

FIGURE 192 **Development environment**

Step 9: Calculate primary test hours (PT)

Primary test hours are the product of test points, skill factors, and environmental factors. The following formula shows the concept in more detail:

$$\text{Primary test hours} = \text{TP} * \text{Skill factor} * \text{E}$$

For the accounting application the total primary test hours is 101.73 as shown in the figure.

6) Primary test hours (PT=TP*Skill*E)					
Skill factor	1.50				
PT=	71.21	*	1.50	*	0.95
TOTAL PRIMARY HOURS				**101.73**	

FIGURE 193 **Primary test hours**

Step 10: Calculate total hours

Every process involves planning and management activities. We also need to take into account these activities. Planning and management is affected by two important concepts. Team size and management tools. So below are the rating sheet for team size and management tools. These values are summed and the percentage of this value is then multiplied with the primary test hours.

7) Total number of test hours		
Team size	3	
Planning and control tools	8	
	11	%
TOTAL HOURS		

Team size	
Rating	**Description**
3	The team consists of no more than four people.
6	The team consists of between five and ten people.
12	The team consists of more than ten people.

FIGURE 194 **Number of test hours**

7) Total number of test hours		
Team size	3	
Planning and control tools	8	
	11	%
TOTAL HOURS		

Planning and control tools	
Rating	**Description**
2	Both an automated time registration system and an automated defect tracking system (including CM) are available.
4	Either an automated time registration system or an automated defect tracking system (including CM) arte available.
8	No automated (management) systems are available.

FIGURE 195 **Planning and control tools**

Finally, we distribute this number across the phases. So the total black box testing estimate for this project in man hours is 101.73 man hours, a 13-man day approximately.

8) Distribution over phases				Incl man.overhead			Excl man.overhead		
preparation	10	%		11.29	hour		10.17	hour	
specification	40	%		45.17	hour		40.69	hour	
execution	45	%		50.81	hour		45.78	hour	
completion	5	%		5.65	hour		5.09	hour	

FIGURE 196 **Distribution over phases**

Appendix A

About the CD-ROM

- Included on the CD-ROM are files related to topics about software testing
- See the "README" files for any specific information/system requirements related to each file folder, but most files will run on Windows XP or higher

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