EFFECTIVE HYBRID REVIEW PROCESS (EHRP)

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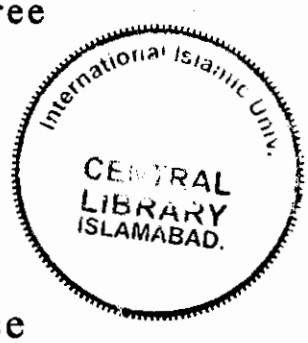

Department of Computer Science
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DEPARTMENT OF COMPUTER SCIENCE

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FINAL APPROVAL

It is certified that we have read this project report titled 'Effective Hybrid Review Process (EHRP)' submitted by Miss Sumaira Nazir (100-FAS/MSSE/F05) and Nargis Fatima (101-FAS/MSSE/F05). It is our judgment that this report is sufficient standard to warrant its acceptance by International Islamic University, Islamabad for the MS degree in Software Engineering.

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THESIS IN BRIEF

THESIS TITLE:	Effective Hybrid Review Process
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DECLARATION

We hereby declare that this material has not been copied out from any source. No portion of the work presented in this thesis has been submitted in support of any other degree of qualification to this or any other university or institute of learning.

Sumaira Nazir

Nargis Fatima

Dedicated to

our loving parents,

precious gift of Allah, for their love, understanding and support

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ABSTRACT

Quality is an essential factor for software and there are number of means to verify it throughout the software development. Software review is an effective and best practice to verify the software quality and minimize the rework cost overhead. In software review processes the review procedure, team structure and meetings are key elements and centre point of discussion since large era. To leverage off the review process rigidness and load from the reviewers, an effective and efficient review process has been proposed, which overcomes the obstacles facing the current review processes, due to their rigid and time consuming nature. The proposed review process is an attempt to minimize the inflexible requirements of the review meetings. Keeping in mind the importance of the reviewers' precious time and experience, the proposed review process has introduced twofold review activity, an effectual meeting procedure and course of actions for future improvements. The process is evaluated through comparative analysis with other review processes. An experiment has also been performed to assess the effectiveness and efficiency of the proposed review process and has provided effective results.

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CHAPTER 1

INTRODUCTION

This Chapter briefly introduces the background theory of software reviews and describes the research question of the thesis. It has following sections.

- **1.1.** ***'Introduction'***: This section briefly describes the computer software and relation of reviews with the computer software.
- **1.2.** ***'History':*** This section describes the background and the origination of software review processes.
- **1.3.** ***'Purpose of study':*** This section illustrates the aim of the research.
- **1.4.** ***'Problem Domain':*** This section explains the research area focused by the thesis.
- **1.5.** ***'Research Problem':*** This section describes the research questions which are analyzed and depicted from the literature.
- **1.6.** ***'Research Method':*** This section briefly explains the method of research followed to depict and reach the research problem.
- **1.7.** ***'Main Contribution':*** This section mentions the contribution provided by performing the research in the domain of the software review processes.
- **1.8.** ***'Evaluation':*** This section describes the way in which the research of the software review processes is assessed.
- **1.9.** ***'Scope':*** This section describes the scope of the thesis.
- **1.10.** ***'Assumptions and Limitations':*** This section describes the assumptions and limitation of the research performed.
- **1.11.** ***'Description of terms':*** This section provides the definition of most of the important terms used in the thesis which help in better understanding of the research objective.
- **1.12.** ***'Organization of the study':*** This section provides the outline of the thesis in which the thesis is organized.

1.1. INTRODUCTION

The fast and enormous growth of computer has made software development more and more challenging. Software is playing very significant role in every field of life from smaller systems to larger ones i.e. automobiles to cellular phones to air traffic control to disease diagnostic systems etc. Unfortunately instead of the best development techniques the defects cannot be avoided completely during the building of the software because the software development is the human-based activity. These defects lead to the poor quality software.

The defect is *"an instance in which a request is not satisfied"* (Fagan, 1976). The defects can also be defined as the diversions from the required quality attributes therefore they must be detected and resolved from the software before it is handed over to the customer (Laitenberger et al., 2002).

Further more the demands from software are increasing day by day, such as it must be of low cost with higher and good response time as well as of promising quality (Wallin & Land, 2000). This high demand of software needs a good review process. The development continued to look for a better review process, which can improve the quality of the software.

Software review is the visual examination of the software artifact (requirement artifact, design artifact, source code artifact etc). Review processes are the cost effective method to eliminate the defects from the software engineering process by the detection and elimination of defects (Wong, 2003). Review process is absolutely necessary for the development as it reduces development time and improves the quality of software (Freedman, D.P, & Weinberg, G.M., 1990). Testing is not comparable with reviews because it does not address the quality issues, which are possible with any review process. In fact reviews help in an efficient and fast testing of the product so it is important to

conduct review process in a manner in which all work products should be reviewed. "*In essence review process provides milestones with teeth*" (James, 1988). The main purpose of the reviews is to assess whether the project could progress to the next phase in the manageable way.

1.2. History

Software review process was firstly introduced by Michael Fagan (1976) at IBM. Fagan's work provides the basis for all the future work done in the field of software review processes. After Fagan's review process the research regarding software reviews was performed in two subfields which are as follows (Aurum et al., 2001).

- Structure of the review processes, explored and suggested by the number of researchers like Parnas and Weiss (Active design review process), Bisant and Lyle (Two person inspection process), Knight and Myers (Phased inspection process), Votta (Votta's inspection process), Gilb and Graham (Gilb and Graham inspection process) etc.
- Supporting techniques and tools of the review processes like reading techniques and tool support etc.

1.3. Purpose Of Study

Increasing demands of software is a source of promotion for the development process to assure the quality software. Review process further ensures the quality product (Boehm, 2006). To achieve the quality oriented goals presently a various review processes are in practice. Each review process has its own merits and demerits (Laura, 2001). There is a genuine requirement of an efficient review process, which is capable of enhancing the software quality in the better with minimum limitations.

The aim of the research is to study the difference between present software review processes, their advantages and disadvantages. The goal is to devise an effective software review process, which assures software quality. Such review process can be utilized for greater benefit at any phase of software development life cycle from requirement through development.

1.4. Problem Domain

Software review process is a process of checking artifacts produced during the software development life cycle to detect the defects (Marri, 2001).

The fundamental elements of the software review process are: purpose/goal, procedure, roles and artifacts. The purpose and the roles of the review process can be implicit or explicit. The procedure includes all the activities of the review process. (Kroyer, 2007).

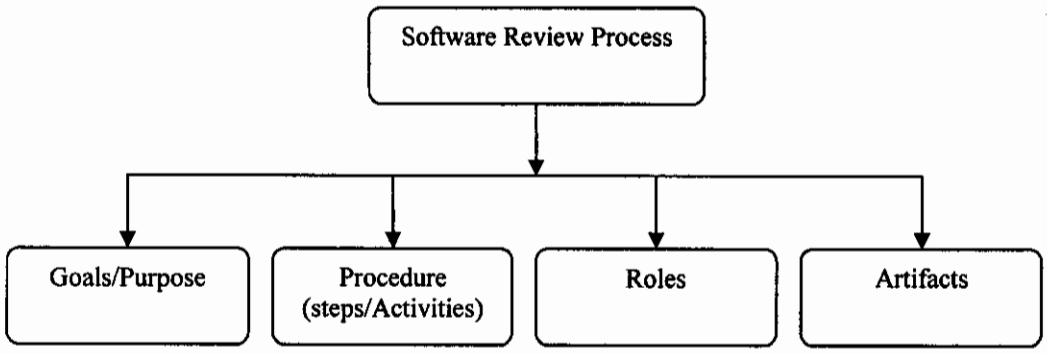

Figure 1.1. Elements of Software Review Process

Every review process has well defined:

- Goal: Purpose of the review.

- Roles: People involved in conducting the review.
- Process: Activities/Steps followed to conduct the review.
- Artifact: Work product that is to be reviewed.

Reviewing the artifacts plays a vital role in ensuring the quality of the software (Schaefer, 2001). Software quality refers to the conformance of the functional and nonfunctional requirements defined by the stakeholders of the software. It can be measured by number of bugs, defects rate (No. of defects/size unit), reliability and the degree to which the product is compliant with the requirements (Melo et al., 2001). Thus it is of vital importance to conduct the software review for improving the software quality.

As the software reviews are very important and best practice to enhance the quality of software. Therefore it is of utmost importance to design a review process which can be effective within an acceptable cost. An effective software review process should address the relationship between the variables for example people skill, their training, activities involved in the process and tool support etc (Mishra & Mishra, 2007). The quality of software increases by using effective software review process. Therefore it must be understood that what effectiveness is and what counts as an effectiveness of a software review processes? What are the factors that have impact on the effectiveness of software review processes? Answers to these questions are discussed below.

1.4.1. EFFECTIVENESS

Effectiveness of software review process refers to the percentage of defects identified in a review process. It also refers to as total number of defects found (Thelin et al., 2001). Effectiveness factors which affect the effectiveness of software review processes found in literature are as follows.

1.4.1.1. Software Review Procedure

Software review procedure defined as an involved activities, stages or phases which are required to run the process (Marri, 2001), (Aurum et al., 2001), (Kroyer, 2007). The sequence and arrangement of these phases have impact on the review process. Different researchers have introduced different activities or phases in different review processes which are explained in detail in chapter 2.

1.4.1.2. Team Structure

Team structure refers to the composition of team i.e. the members who participate in a review process. Team structure can be clearly defined through sub factors i.e. number of reviewers selected to compose a team, description of roles with associated responsibilities and individual expertise level. All these sub factors of team structure have impact on team structure which in turn contributes to the effectiveness of the review process. The sub factors are defined below.

- **Team Size**

  Team size refers to number of human beings involved in a team.Team members involved in a review process drives the process (Laitenberger et al., 2002). Success and failure of the review process depends upon the involved members. Results of the review process depend on the review team members (Porter & Johnson, 1997). Different researchers have tried to find out the effective team size, it is described in detail in chapter 3.

- **Roles**

  Roles are another most important influencing factor of the team structure. Roles are referred to as titles associated with team members with specified responsibilities. They can be explicit or implicit (Kroyer, 2007). They are

described in detail in chapter 3 with respect to the view point of different researchers.

- **Individual Expertise**

Individual expertise refers to the capability and expertise level of the individuals. Individual expertise can be defined in terms of technical skills, domain knowledge and experience.

Technical skill is the knowledge of different defect categories and capability to find true defects. Reviewers' capabilities have great impact on the review process (Biffl, 2000).

Domain knowledge refers to the reviewers' knowledge related to the field. For example the software engineer has the domain knowledge of the software development. He/She better knows how to design effective quality software as compared to programmer or a manger. So software engineer is domain expert of software development field. Similarly for the flow of the library system the librarian is the domain expert.

Experience is the collective knowledge which increases with time. It is not necessary that a person have knowledge and experience at the same time, one can be professional in programming but he/she can have no experience. But if one has experience he/she obviously must have knowledge. Experience cannot increase artificially or immediately.

According to Sauer et al. (2000) individual expertise is very important influencing factor of review process. Knight and Myers (1993) emphasized that experience can effect the rate of defect detection. According to Aurum et al. (2001) reviewers

involved in the review process must be selected on the basis of their experience and expertise level.

1.4.1.3. Defect Detection Techniques

Defect detection techniques are defined as the steps which guide the reviewers to get good understanding of artifact for detection of defects. Defect detection techniques help and guide the reviewers to easily find out the defects from the artifact (Laitenberger & DeBoud, 2000). Using defect detection technique is an important activity for individual defect detection (Basili, 1997). Defect detection techniques can be systematic for example perspective base readings and can be non systematic for example adhoc or checklist base.

Adhoc Reading as name shows are adhoc in nature i.e. no technical support is provided to reviewers to review with the aim of finding defects. It is just a thorough reading of artifact using own experience (Aurum et al., 2001). It does not need training.

Checklist reading technique is formal than adhoc reading. Checklist normally consists of questions or marked option with the issues written in checklist (Aurum et al., 2001). It provide general framework to the reviewer.

Scenario based defect detection technique is systematic with well defined responsibilities for the reviewers (Porter & Votta, 1994), (Porter et al., 1995). In scenario based defect detection, set of scenarios are created for system usage to cover all defect categories. Different set of questions are created for almost each defect category, and then the scenarios are created to answer the question (Aurum et al., 2001).

Perspective base reading is an enhancement of scenario based reading. In it different set of questions are created for each scenario. Reviewers while reviewing the artifact from a particular view point and create a physical model. This physical model can be then

analyzed by answering the questions. The scenarios are created on the basis of the stakeholders' perspective so it is called perspective base reading (Aurum et al., 2001).

1.4.1.4. Review Rate

Review rate refers to the speed at which the review process progress. Some researchers believed that slow rate can be effective (Russel, 1991), (Gilb & Graham, 1993), (Aurum et al., 2001). Gilb and Graham (1993) suggested that review speed should be 150 lines per hour. Laitenberger and DeBoud (1997) suggested 200-300 lines within 2 hours. Review rate can affect the review process effectiveness. If review rate is fast then the quality of review will be lower and if the review rate is slow then it can waste the time of reviewers. Review rate effect the review process normally in situations where group based defect detection is done.

1.4.1.5. Advanced Preparation

Purpose of the advanced preparation is to understand the artifact individually to easily detect the defects. It is also an important factor that has impact on the review process. Many review processes having group based defect detection favors the advance preparation with understanding purpose. In this case the reviewers efficiently prepare themselves before attending the group meeting for defect detection. These results in time save and better outcome. If the process emphasize on individual defect detection and group base collection then there is dual purpose of advanced preparation i.e. understanding and defect detection. According to Laitenberger et al. (2002) if reviewer has large time for preparation they can effectively contribute to the effectiveness of the review process by understanding the artifact and keenly finding defects.

1.4.1.6. Interaction Mode

Interaction mode refers to the way in which the review team members interact with each other. The mode of interaction can be synchronous or asynchronous.
In Synchronous mode of interaction the review team members interact with each other in impersonal face to face meeting while in asynchronous mode of interaction the review team members does not interact with each other impersonally. They use some other means of interaction e.g. telephone, online tools etc (Mishra & Mishra, 2007).

Different researchers have suggested different mode of interaction for review processes. They greatly impact on the effectiveness of the review processes. The interaction modes are discussed in detail in chapter 3.

1.5. Research Problem

Software reviews detect defects and purifies the software engineering process (Freedman & Weinberg, 1990). Reviews can play vital role in ensuring the quality of software. They should be performed on all the artifacts produced during the life cycle of software development (James, 1988). Multiple software review processes exists to detect defects early in the software development. Many of them face problems in fast software development world because of their simplicity, complexity, rigidity, time consumption and team structure (Laura, 2001).

Team structure plays a crucial role to avoid defects. The effective review team can increase the defect detection rate. Inclusion of the experts in the review team increases the efficiency of the review process as compared to large review team without expert personals (Marri, 2001). Selecting the right reviewers to perform the defect detection task is very important for the review process to be successful (Wong, 2003).

To devise a review process it is vital to understand deeply the existing review processes and problems associated with them and the factors affecting them like team structure and meeting procedure i.e. Which combination of team affects their efficiency? What are the combinations of teams in the existing review processes? What are the consequences of frequently held meetings for the review of one artifact? What problems occur in the meeting-less review processes? This understanding enables what should be the team structure and meeting procedure of the review process.

Based on the above-mentioned problems the research questions of the thesis are:

- Does the review procedure affect the effectiveness of the review process?
- Does the review procedure affect the efficiency of the review process?
- Does the review team structure affect the effectiveness of the review process?
- Can the synchronous review meetings for the critical defect discussion, replace the synchronous review meeting for defect detection and discussion of all the detected defects?

1.6. Research Method

Different methods could be followed to get to the objectives of this thesis, but only one can be used because of time constraint. The literature survey approach has been followed for the deduction and induction from the literature.

At first the intended area of research was identified then the abstract level of literature survey was performed for information gathering about the problem domain. The collected data was refined to reach to the problem. After defining the problem the detailed literature survey has been performed to deeply understand the existing review processes, their merits and demerits. Based on analysis of the studied literature of the existing review processes the evaluation criterions has been set to critically analyze these processes and issues associated with them.

Further searches have been performed and the papers were thoroughly studied in depth to get to the problems with respect to the defined evaluation criterion. Based on the facts and the figures of the problems associated with the review processes obtained from the literature a new review process "Effective Hybrid Review Process (EHRP)" has been proposed.

Comparative evaluation has been performed to analyze the proposed review process. The experimental evaluation is also done to know the efficiency and the effectiveness of the proposed review process.

1.7. Main Contributions

On the basis of the literature survey and evaluation of the existing review process since 1976, our contribution is to introduce an Effective hybrid review process, which assures quality from different angle perspectives i.e. team structure, meeting and review procedure.

Devised review process has removed some of the issues related to the meeting and review procedures held for review process and the review team structure that conduct the review. The study has proposed a review procedure in which the main focus is towards saving the time and minimizing the load from the reviewers.

The research focuses towards finding the ways to increase the focus of reviewers on most important critical defects. The process has decreased the load from the reviewers by dividing the review activity in to two phases i.e. pre-review (pre-initiation phase) and individual review (evaluation phase). The load from the reviewers is also reduced by an effective review meeting procedure i.e. meeting held only for critical defects discussion, with those reviewers who have concerned with the critical defects' identification or called by the leader and the author. All reviewers are not necessarily required to attend the

review meeting. It is analyzed through the experiment that the involved domain expert in a review team is very effective in finding critical defects.

Another important contribution of the research is the introduction of the ways to gather the precious experience of expert reviewers for future improvements, through postmortem asking. The research contributed to provide benefits for entities at three sides, the author community by their job satisfaction by providing them feedback related to their work, the reviewers community by leveraging off their load and thirdly most important to customer community whose requirement will be fulfilled effectively.

1.8. Evaluation

Effective Hybrid Review Process (EHRP) is evaluated with the comparison between the existing and the devised review process. Research questions are answered on the basis of the findings. As the objectives of the research is to study the differences between the currently used review processes, their merits and demerits based on the study the review process will be devised against the problems analyzed in the existing review processes regarding the team structure, meeting and review procedure parameters.

The devised review process is also experimentally evaluated for the fulfillment of the research questions mentioned under research problem. The main reason of the evaluation using the experiment is to analyze the effectiveness and efficiency of the review process.

1.9. Scope

There is the dire need of an effective and efficient review process having minimum issues and problems. The aim of the study is to devise a review process with reduced issues and problems which are present in the existing review processes. To achieve the goal of the study the knowledge related to the software reviews was gathered through the literature

survey. Based on that knowledge each review process was explored for its virtues and issues. Mainly the scope was to explore effectiveness factor of the review processes. The impact of these factors on the effectiveness and efficiency of the review process was also examined. Based on the virtues and issues of the review processes and impact of effectiveness factor a new review process is proposed.

1.10. Assumptions And Limitations

The proposed review process can be used to review any type of artifact (specification, design, code etc.) at any stage of software development. It requires at least five members in a review team. One author, one leader, one linguistic expert and two reviewers. The leader must be defect analyst and should have review experience. Out of two reviewers one must be domain expert. The number of reviewers depends upon the company policy and size of artifact. Large as well as small companies can effectively use the proposed review process.

Due to the time and resource limitations all the effectiveness factors were not explored. The tool for the proposed process was out of scope to develop in such limited time and resources. Similarly due to resource limitation the experimental evaluation for the proposed review process was done manually. The review process has proposed the effective postmortem phase at the end of the review process. It is at initial level and need to be improved.

1.11. Description Of Terms

Different terms used in the previous and next sections need to be defined clearly to understand the objective of the thesis. This section briefly describes different terms used in this thesis.

- **Quality**

  Quality is the software characteristic that stands on its ability to satisfy given needs for example conformance to specification (Fitzpatrick et al., 2003).

- **Artifact**

  It refers to any work product that is produced during software developmental cycle for example requirement specification, source code, and design etc (Pressman, 2002).

- **SRS**

  SRS stands for software requirement specification. It is "*a specification for particular software product, program or set of program that does certain things*" (IEEE Std., 1984).

- **Validation**

  Validation refers to determining whether the right product is being developed, that is the requirements reflect the user needs. The software should do what the user really requires (Sommerville, 2000).

- **Verification**

  Verification refers to determining whether the product is being made correctly, that is the requirements are being implemented correctly. The software should confirm the specifications (Sommerville, 2000).

- **Static Verification**

  Static verification is concerned with analysis of the static system representation to discover issues and problems (Sommerville, 2000).

- **Dynamic Verification**

  Dynamic verification is concerned with exercising and observing product behaviour. The system is executed with test data and its operational behaviour is observed (Sommerville, 2000).

- **Defect**

  Defect is undesired consequences of software development process (Wohlin et al., 2000b).

- **Review process effectiveness**

  It refers to how large number of defects can be detected during review (Gilb & Graham, 1993), (Thelin et al., 2003).

- **Review process efficiency**

  It is defined as the total number of defects detected per hour during review (Humphrey, 1995), (Thelin et al., 2003).

- **Review Process Structure / Procedure**

  It refers to how review process is organized, what activities involved in it and how they are conducted (Wong, 2003).

1.12. Organization Of Study

The remainder of the thesis is organized as follows

- **Chapter 2 : Literature Survey**

  This chapter describes the existing work that has been done on the software review processes since 1976 to 2007. The literature survey of the existing work helps in getting the knowledge and performing the research. It also helps in analyzing the research questions.

- **Chapter 3 : Comparative Analysis of Review Processes (1976-2007)**

  This chapter provides the detail comparative analysis that has been performed on the software review processes based on effectiveness factors.

- **Chapter 4 : Conceptual Framework**

  This chapter provides the detailed description of the proposed review process based on the problems identified in the existing software review processes. The process is proposed for reviewing the artifacts. The chapter ends up with the comparative evaluation of the proposed process.

- **Chapter 5 : Experimental Evaluation**

  This chapter presents the detail of the experiment performed to evaluate the efficiency and effectiveness of the proposed review process. The chapter also states the data analysis of the experiment.

- **Chapter 6 : Conclusion and Future Work**

  This chapter provides the conclusion of the research thesis and the summery of the experimental findings with the opportunities to work in future.

CHAPTER 2

LITERATURE SURVEY

This chapter provides the detailed overview of the review processes. It has following sections.

- **2.1.** ***'Introduction'***: This section gives general description and basic overview of review processes and their relationships with software quality.
- **2.2.** ***'Advantages of Software Review processes':*** This section highlights the importance and advantages of software review processes.
- **2.3.** ***'Issues of Software Review processes':*** The issues and challenges of the software review processes are discussed in this section.
- **2.4.** ***'Existing Software Review Processes':*** This section introduces and compares the existing review processes. Each review process is described in detail with respect to phases, teams, merits and demerits to get the better understanding and knowledge of existing work.

2.1. Introduction

Basic goal of software development is to develop a quality system that satisfies explicit and implicit needs of user (Mishra & Mishra, 2007). Therefore various artifacts associated with the software development require continual insight and modification throughout the development cycle to fulfill the needs of users (Basili et al., 1996). This can be achieved with effective review process as the goal of a review process is to improve the software quality by providing timely feedback to the author.

Software reviews are effective way to statistically analyze and verify the artifacts (Req., design and code etc.). This static verification can be applied through out the developmental phases while the dynamic verification needs an executable program (Sommerville, 2000). Software reviews at one hand save the cost and on the other hand they reduce the time for dynamic verification and improve quality of software. Effective reviews enhance the quality of the software.

2.2. Advantages of Software Reviews Process

Software review processes are the best practices to enhance the quality of software. Large number of advantages found in literature related to the software review processes.

Mainly the software reviews provide an efficient means to accomplish quality software by applying them to any artifact produced during software development (Aurum et al., 2001). They can be applied to any artifact at any stage of development to locate defects directly as compared to testing which require execution to find any defects. With logical and technical problems the reviews also find the ways how to reduce the complexity and do improvements (Berztiss, 2000). Software review processes facilitate in project tracking, providing educational benefits as well as knowledge sharing (James, 1988), (Gilb & Graham, 1993), (Weigers, 2001), (Weigers & Moore, 2002), (Briand et al., 2004). They can identify quality issues which are impossible with testing (James, 1988),

(Phongpaibul, 2005), (Mishra & Mishra, 2007). The table 2.1 below summarizes the benefits of the software review processes.

Table 2.1 Advantages of Software Review Processes

Advantages	References
Verify and accomplish quality in software.	(Gilb & Graham, 1993), (Weigers, 2001), (Sauer et al., 2000)
Can be applied to any artifact produced during development of software at any stage of software development.	(Aurum et al., 2001), (Berztiss, 2000)
Reduce the defect fixing cost as well as delay in the development by detecting defect early in the development phases.	(Mishra & Mishra, 2007)
Help in tracking the project.	(James, 1988)
Make maintainability of software easier.	(James, 1988)
Address those quality issues which are impossible with testing.	(James, 1988), (Phongpaibul, 2005), (Mishra & Mishra, 2007)
Efficient way to provide feedback to author.	(James, 1988)
Improve the team communication.	(Gilb & Graham, 1993),(Weigers, 2001), (Briand et al., 2004)
Software reviews provide good mentoring.	(Weigers et al., 2002)
Provide educational benefits and means for knowledge sharing.	(Gilb & Graham, 1993), (Briand et al., 2004), (Weigers, 2001).
Increase familiarity and improves the general understanding of the system and artifact which is also very helpful for defect detection.	(Berztiss, 2000), (James, 1988)
Locate defects early and directly as compared to testing. In testing when test give failure result a large effort required to locate the defected area.	(Berztiss, 2000), (Gilb & Graham, 1993)
Not only look for actual defects but also checks for the improvements in style and complexity reduction	(Berztiss, 2000)

The most important payback of the software review processes is that they reduce the rework cost by early defect detection because as software development phases progress the amount of rework and its cost increases. For example if development cost at requirement stage is 6%, then the rework cost at this stage is 1%, but if the defects

identified in later phases i.e. in preliminary design or detail design phases, then rework cost at these phases will be 4% and 8% respectively. Author of the artifact have to perform more rework if the defects are not identified in the early phases of development and the cost of rework almost doubles in the later phases of development, so the use of the review process can reduce the rework and cost of rework by detecting defect at initial phases (Basili et al., 1996), (Boehm, 1987). Amount and cost of rework during software development cycle is shown below.

Table 2.2 Cost of Rework during Software Development

Development phases	Production Cost (%)	Rework Cost (%)	Total Cost (%)
Requirement	6	1	7
Preliminary Design	12	4	16
Detail Design	16	8	24
Coding & Unit Testing	12	12	24
Integration & System Testing	10	19	29

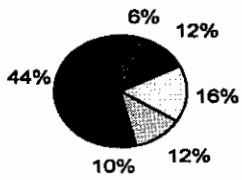

Figure 2.1. (a) Amount of Rework and Development Cost during Software Development

Figure 2.1. (b) Rework Cost that can be Reduced by Software Reviews

Figure 2.1(b) shows that the 44% of rework can be reduced by detecting and correcting defects at initial phases of the development by performing reviews.

2.3. Issues of Software Review Process

There are large numbers of advantages of software review processes but certain issues are also associated with them. The issues are summarized in the table 2.3.

Issues	Reference
Selection of right reviewers.	(Wong, 2003)
Time and resource limitations.	(Wong, 2003), (Johnson & Tjahjono, 1998)
Lack of guidance for choosing the process.	(Johnson,1994), (Berztiss, 2000)
Labor intensive nature.	(Johnson & Tjahjono, 1998).
Trustworthiness of a reviewer in a review process.	(Berztiss, 2000)
Individual behavior during review meeting.	(Weigers et al., 2002)
Person having leader/moderator role often dominate and turns the meeting into presentation instead of encouraging open questioning.	(Weigers et al., 2002), (Johnson, 1994), (Berztiss, 2000)
Coordination of schedule and location.	(Weigers et al., 2002)
Busy developers regard review as waste of time.	(Weigers et al., 2002)
In sufficient preparation result low quality review, when one or two reviewer inadequately prepares.	(Johnson, 1994), (Berztiss, 2000)
Incorrect review rate i.e. if the reviewers perform review too slowly the review time will be wasted, and too fast review decreases the quality of the review.	(Johnson, 1994), (Berztiss, 2000)
Must be cost effective.	(Johnson & Tjahjono, 1998) (Laitenberger et al., 2002)
Should be effective and efficient.	(Johnson & Tjahjono, 1998), (Schaperd, 2001)
Review metrics collection and efficient usage in future.	(Shirey, 1992)

Most important issue which must be resolved is the selection of right reviewers for review process (Wong, 2003). Reviewers act as an input in the software review process, so if the input will be effective only then ultimately the output will be effective. Other issues with the software review processes are the time and resource constraints, sometimes companies or organization does not have so much resources to employee review process in their company or organization and sometimes the reviewers have time limitations to participate in a review process (Wong, 2003), (Johnson & Tjahjono., 1998).

As the behavior of individuals involve in review process effects the reviews (Weigers et al., 2002), the group reviews have many issues associated with them like insufficient preparation, incorrect review rate, coordination of schedule and location (Johnson, 1994), (Berztiss, 2000). When more than one reviewers reviews the artifact at the same time and same location it often happens that one or two reviewers does not properly prepare before the group review as the skills and efficiencies of different individuals vary, so if some reviewers does not properly prepare before participating in a group review they might result in low quality reviews and the wastage of the time of other members. Some time in group review it also happens that the leader dominates and turns the review into presentation. Every one wants to have an efficient and effective review process free of such issues.

2.4. Existing Work

The importance and benefits of software review processes are well known. Many software review processes exists with their variations. These variations are especially based on the number of phases, team composition, mode of interaction and purpose of interaction etc. For example Fagan (1976) suggested five phases for review process (overview, preparation, meeting, rework and follow-up), Parnas and Weiss (1985) suggested four phases (overview, review, meeting, rework), and Formal technical asynchronous review method presented by Johnson in 1994 suggested seven phases

(setup, orientation, private review, public review, consolidation, group review and conclusion) (Johnson, 1994), (Johnson & Tjahjono, 1998) etc.
Review processes also vary with respect to team composition, some review processes have favored the small group composition while others have favored the large team composition.

Another reason of review process variation is the interaction mode, some review processes have introduced synchronous interaction mode i.e. the team members interact with each other in a face to face meeting for example Weigers review process (Weigers, 2001), Fagan's review process, Active design review process, Structured review process, Phased inspection process (Knight & Myers, 1993), Two person inspection process, Active review for intermediate design etc (Clements, 2000).

Some review processes have eliminated the synchronous mode of interaction to some extent and emphasized on asynchronous review interaction mode with a little introduction of synchronous interaction modes for finding unique defect's list by removing false positive (false positive are defect which are seemed to be defects but are not actually true defects) and discussion for example, Simplified software review process, Votta's review process (Votta, 1993). Formal technical asynchronous review method have introduced both synchronous as well as asynchronous mode of interaction but the synchronous mode of interaction is optional like proposed in Reengineered inspection process (Sauer et al., 2000) and Light weight review process (Muller, 2007) etc.

In this section existing review processes and their background is described on the basis of their goals, roles, activities involved, artifacts, team structure as well as their merits and demerits. This can provide the concept and background idea of each review process.

2.4.1. FAGAN'S REVIEW PROCESS

Fagan's Inspection is a review process originally proposed by Michael Fagan in 1976 (Fagan, 1976), (Doolan, 1992). From his name and the formality of process it was generally named as Fagan's inspection. According to Fagan the inspection process is used for two main purposes. Firstly "*to find and fix all defects in the product*". Secondly "*to find and fix defects in the development process that causes product defects*" (Fagan, 1976), (Phongpaibul, 2005). The inspection process introduced by Fagan consists of five phases and five members with associated defined roles.

2.4.1.1. Phases of Fagan's Review Process

Phases of the Fagan review process are overview, preparation, meeting, rework and follow-up. The phases are described below.

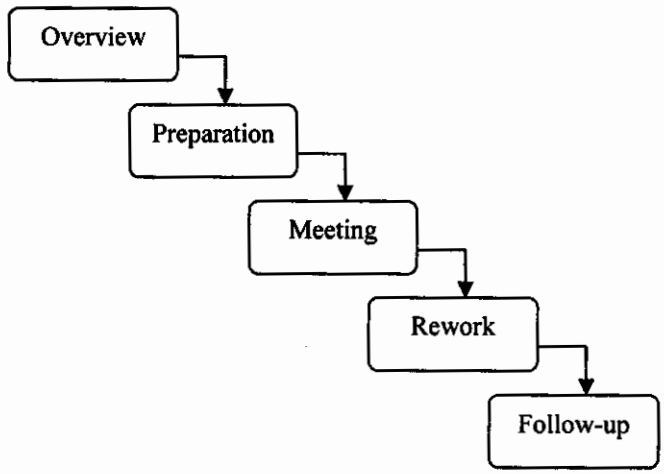

Figure 2.2. Phases of Fagan's Review Process

- **Overview**

  In this phase the introductory meeting is held between the team members. All the team members have to attend the meeting. The purpose of the review process is defined in this meeting. Role assignment to all the members takes place. Overview of the artifact (specification, design, code etc.) which is to be reviewed is given to all members as well as that artifact is also distributed to them (Sommerville, 2000). The overview meeting is of short duration almost 20-30 minutes.

- **Preparation**

  This is the second phase of Fagan's review process. Basic purpose of this phase is to understand the artifact given for review. Each review member individually gives thorough reading to the artifact. At this phase the meeting can also be held but for short duration to remove further ambiguities from understanding perspective. Reviewers at this phase can also identify potential defects, which they want to mention in the review meeting. In short the reviewers understand the artifact and get prepared for the review session. (Porter & Johnson, 1997)

- **Meeting**

  In this phase the whole team attends the meeting. The contents of the artifact (specification, design, code etc.) are read by the reader. Team members mutually find out defects and their severity. At the end of the meeting the report in which defects are documented is submitted to author (Wong, 2003).

- **Rework**

  In this phase the defects identified by team members during the meeting are corrected by author.

- **Follow-up**

  In this phase the moderator assures that the defects are fixed by author.

2.4.1.2. Team Roles of Fagan's Review Process

Roles in this review process are:

- **Moderator**

  The responsibility of the moderator is the organization of review process (Doolan, 1992). Review process planning, team selection, review meeting management and distribution of artifacts are the duties of moderator. In short the management is the responsibility of the moderator.

- **Author**

  Author is basically the producer of artifact (Aurum et al., 2001). He/She answers the questions asked by the reviewers concerning the artifact under review. He/She receives the defect report from moderator to perform necessary changes.

- **Reader**

  Reader reads the artifact line by line which is to be reviewed during the meeting. He/She not only read the artifact but also paraphrases it.

- **Recorder**

  Recorder records the defects which are identified by the reviewers in the meeting.

- **Reviewer**

  All the reviewers must have to attend the meeting and their responsibility is to find defects from the artifacts which are to be reviewed.

Table 2.4: Team Roles of Fagan's Review Process

PHASES	TEAM ROLES				
	Moderator	Author	Reader	Recorder	Reviewer
Overview	✓	✓	✓	✓	✓
Preparation	✓	✓	✓	✓	✓
Meeting	✓	✓	✓	✓	✓
Rework		✓			
Follow-up	✓				

2.4.1.3. Merits and Demerits of Fagan's Review Process

Merits of Fagan's review process are as follows:

- Improve quality by preventing defects (Fagan, 1976), (Grunbacher et al., 2003).
- High defect detection rate almost 80% (Phongpaibul, 2005).
- Effective Verification Process.
- Good for promoting and enhancing team work (Doolan, 1992).
- Provide good platform for employee training related to standards.

Demerits of Fagan's review process are as follows:

- Information collected from process cannot be efficiently used for improvement (Shiery, 1992), (Aurum et al., 2001).
- Difficult to incorporate even in a large company (Aurum et al., 2001), (Grady & Slack, 1994).
- Labor Intensive and rigorous process (Mishra & Mishra, 2007).

- Coordination of schedule and location is difficult (Johnson, 1994).
- All reviewers have to meet at same time and same location (Votta, 1993).

2.4.2. ACTIVE DESIGN REVIEW PROCESS

The Active design review process was introduced by Parnas and Weiss in 1985. Parnas and Weiss (1985) have simplified the Fagan's review process by reducing the number of reviewers and by cracking the large review meeting to smaller ones. Parnas and Weiss has increased the objective of preparation from understanding to defect detection and modified the purpose of the meeting from defect detection to defect discussion (Johnson , 1994). Main objective of this review process is to increase focus of reviewers on artifacts which are to be reviewed. In this review process the reviewers have to answer the given question. The questions are designed such that they need thorough reading of artifact. Active design review process is basically used to review the design document for the purpose of the enhancement of the quality of design (Clements, 2000).

Active design review process has tried to solve the existing problems such as each reviewer has different skill and specialty and combined meeting can waste the time of reviewers.

2.4.2.1. Phases of Active Design Review Process

Phases involved in Active design review process are overview, review, meeting and rework. The phases are described below.

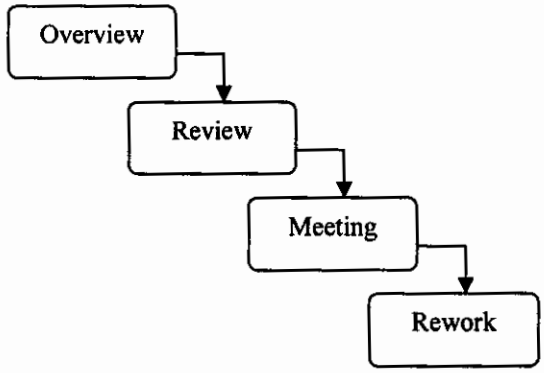

Figure 2.3: Phases of Active Design Review Process

- **Overview**

  Overview phase includes the preparation of the design. Review team members are selected based on their experience and specialties (Parnas & Weiss, 1985). In this phase reviewers understand the artifact to remove confusions.

- **Review**

  In the review phase each reviewer reviews his part and answers the given question.

- **Meeting**

  The short meeting held between reviewer and author for discussion. This meeting creates an environment for informal communication. Reviewer and author can discuss freely and easily with each other without hesitation.

- **Rework**

  During this phase the authors collects the identified defects from all the reviewers and perform necessary rework.

2.4.2.2. Team Roles of Active Design Review Process

Team of active design review process comprises of author and the reviewers. Parnas and Weiss have avoided definite roles' definition. Only two roles are defined by them.

- **Author**

  Author is responsible for the preparation of design document, selection of reviewers based on their experience, designing of questionnaire with respect to design document.

- **Reviewer**

  Reviewers review the design document and attend meeting with author to answer the given questions.

Table 2.5 Team Roles of Active Design Review Process

PHASES	TEAM ROLES	
	Author	Reviewer
Overview	✓	✓
Review		✓
Meeting	✓	✓
Rework	✓	

2.4.2.3. Merits and Demerits of Active Design Review Process

Merits of active design review process are as follows:

- Incorporate the double objectives of individual evaluation i.e. comprehension and defect detection (Johnson & Tjahjono, 1997)
- Small meeting (Parnas & Weiss, 1985).

- Reviewers can individually interact with author which can provide environment of relax communication (Aurum et al., 2001).
- Enhance focus of reviewers on artifact and defect detection by eliminating group meeting (Mishra & Mishra, 2007).
- Reviewers individually review the artifact.
- Errors are classified as inconsistency, inefficiency for review guidance.
- Save time of the technical persons as the reviewers individually meets the author.
- Involve domain experts.

Demerits of active design review process are as follows:

- Multiple sessions of meetings (Mishra & Mishra, 2007).
- Does not support remote reviewers because they have to meet the author physically after preparation and defect detection.
- Synchronous mode of meeting.
- Scope is only limited to design document.
- Process improvement issues.
- A huge burden for the author as he/she has to meet all the reviewers individually.

2.4.3. STRUCTURED WALKTHROUGH

Structured walkthrough review process is presented by Edward Yourdan in 1989 (Yourdan, 1989). Objective of this process is similar to those of Fagan review process, but it is less formal and less rigorous.

2.4.3.1. Phases of Structured Walkthrough

Phases of the structured walkthrough are:

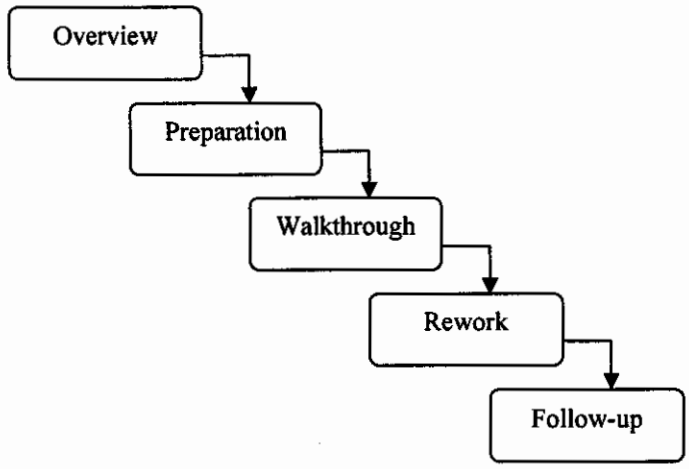

Figure 2.4. Phases of Structured Walkthrough

- **Overview**

  In the overview phase the producer supplies the artifact to the coordinator and he/she distributes it to all reviewers. Coordinator also sets the date and plan for the meeting during this phase.

- **Preparation**

  Every participant reviews the artifact individually for understating. It is basically a pre-meeting phase before the walkthrough meeting. In it reviewers are satisfied about their confusions regarding the artifact to be reviewed.

- **Walkthrough**

  In this phase the presenter introduces the artifact to all the members. Reviewers put the comments on the artifact and can ask for the clarification from the producer. In the meeting no time is spent for taking the corrective measures. Meeting spans over 30 to 60 minutes. At the end of the artifact review the voting is held to find the status of the artifact. Then the coordinator prepares the

summary report and the list of the comments which is distributed to all the participants.

- **Rework**

  In this phase the producer do the necessary changes based on the comments of the participants.

- **Follow-up**

  During the follow-up phase the coordinator verifies the changes made to the artifact.

2.4.3.2. Team Roles of Structured Walkthrough

The roles defined by the presenter of the process are coordinator, author and reviewer.

- **Coordinator**

  Coordinator does the planning and the organization of the review process and he/she takes the role of the moderator during the meeting.

- **Producer**

  Producer is responsible to prepare the artifact that is to be reviewed.

- **Reviewer**

  The reviewers' task is to find the defects from the artifact.

PHASES	TEAM ROLES		
	Coordinator	Producer	Reviewer
Overview	✓	✓	
Preparation	✓	✓	✓
Walkthrough	✓	✓	✓
Rework		✓	
Follow-up	✓		

2.4.3.3. Merits and Demerits of Structured Walkthrough

Merits of structured walkthrough are as follows:

- Less rigorous and less formal (Yourdan, 1989).
- Improve quality by preventing defects early in the development.
- Good for promoting and enhancing team work.

Demerits of structured walkthrough are as follows:

- Information collected from process cannot be efficiently used for improving purposes.
- All reviewers have to meet at same time and location.
- Follows structured meeting based process.
- Process is dominated by moderator (Johnson, 1994).
- Insufficient preparation problem.
- Incorrect review rate problem.
- Interpersonal problems/personality conflicts and ego involvement.
- Keeping the records of the process is also a problem.
- Don't involve the domain experts.
- Original cause of the defects cannot be found out.
- Availability of the reviewers for the meeting is a problem.
- Less focused.

2.4.4. TWO-PERSON INSPECTION PROCESS

This process was suggested by Bisant and Lyle in 1989. It is very useful for the evaluation of less experienced programmers' productivity. It includes all phase of Fagan's review process but the roles are reduced to two only i.e. author and a reviewer. This review process consists of single meeting between author and reviewer. Bisant and Lyle have conducted experiment with this process and they found it very much useful for program quality and productivity. It is usefull in small organizations because of less resource consumption (Bisant & Lyle, 1989), (Aurum et al., 2001).

2.4.4.1. Phases of Two-Person Inspection Process

The two-person inspection process has following phases.

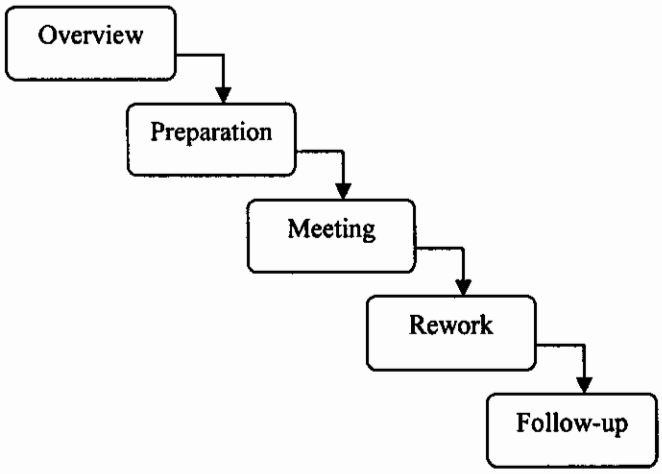

Figure 2.5. Phases of Two-Person Inspection Process

- **Overview**

  In this phase the selection of reviewer takes place. Short meeting is held between the author and the reviewer and the artifact to be reviewed is presented to the reviewers. Objective of the process defined in this meeting.

- **Preparation**

  Purpose of this phase is personal understanding of the artifact to be reviewed. Reviewer thoroughly read the material.

- **Meeting**

  In this phase the single session is held between reviewer and author for identification of defects.

- **Rework**

  In this phase the defects identified by reviewer during the meeting are corrected by author.

- **Follow-up**

  In this phase the author makes sure that the defects are fixed.

2.4.4.2. Team Roles of Two-Person Inspection Process

Two-person inspection process has two roles i.e. Author and Reviewer.

- **Author**

  Author prepares the artifact, answers the questions asked by the reviewers concerning the artifact under review and performs the necessary changes in the artifact.

- **Reviewer**

  All the reviewers have to find defects from the artifact which is to be reviewed.

PHASES	TEAM ROLES	
	Author	Reviewer
Overview	✓	✓
Preparation	✓	✓
Meeting	✓	✓
Rework	✓	
Follow-up	✓	

2.4.4.3. Merits and Demerits of Two-Person Inspection Process

Merits of Two-person inspection process are as follows:

- Reduce meeting cost as number of members is reduced to two (Aurum et al., 2001).
- Require fewer resources (Bisant & Lyle, 1989).
- Improve the less experienced programmer performance.
- Short duration meeting.
- Enhance focus of reviewers on artifact and defect detection by eliminating group meeting.

Demerits of Two-person inspection process as follows:

- Author have high work load.
- Review quality will be low as single reviewer.
- Single reviewer has to review the artifact from different angles for each type of defects.
- Information collected from process cannot be efficiently used for improvement purposes (Shiery, 1992), (Aurum et al., 2001).
- The original cause of the defects can not be found out.
- This process is applicable only in small organizations.
- Defect detection only takes place in the meeting.

2.4.5. HUMPHREY'S REVIEW PROCESS

This process is proposed by Humphrey in 1989. Humphrey's review process has introduced a phase called as analysis in which the producer analyzes the defects detected by reviewers (Humphrey, 1989).

2.4.5.1. Phases of Humphrey's Review Process

Humphrey's review has following phases.

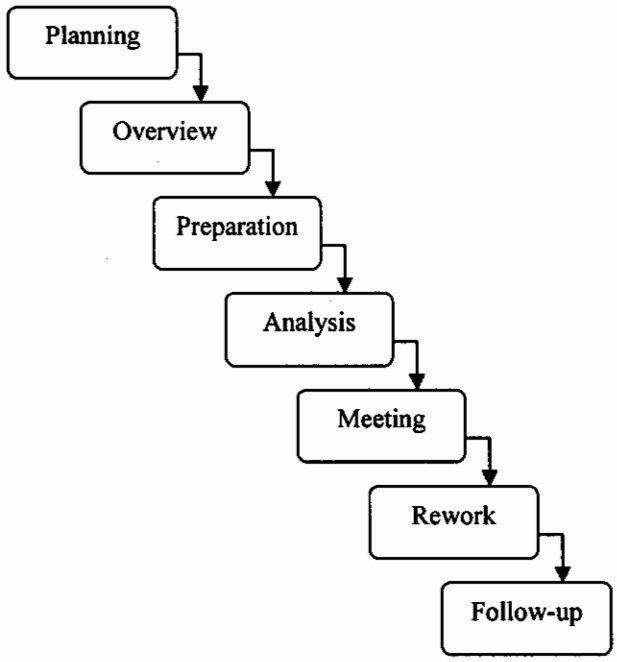

Figure 2.6. Phases of Humphrey's Review Process

- **Planning**

  During this phase review plan is created and selection of team members takes place.

- **Overview**

  During this phase the artifact is presented to the reviewers for basic understanding and it is also distributed. All the members are informed about the meeting date, time and place.

- **Preparation**

  During this phase reviewers not only read the artifact for understanding but also detect the defects individually.

- **Analysis**

  During this phase producer analyzes the defects detected by reviewers individually. He/She removes the duplication of defects and find out the unique defect list.

- **Meeting**

  Meeting is held at this phase. In the meeting producer describes each defect and each reviewer who has detected the defects clarifies its meaning. The main purpose of the meeting is to find the unique defect lists.

- **Rework**

  At this phase the necessary changes are made by the producer on the basis of identified defects.

- **Follow-up**

  At this phase the moderator verifies that necessary changes are made properly.

2.4.5.2. Team Roles of Humphrey's Review Process

Following roles are involved in the Humphrey's review process.

- **Moderator**

  The moderator is responsible for the management of the review meeting, review team selection, distribution of material to reviewer and monitoring the follow up and Rework phases.

- **Producer**

  Responsibility of the producer is to find unique defect list, to read each defect during review meeting for its clarification by reviewer, to present artifact to the reviewers.

- **Reviewer**

  Reviewers review the artifact for the purpose of finding defects in the artifact.

Table 2.8: Team roles in Humphrey's review process

PHASES	TEAM ROLES		
	Moderator	Producer	Reviewer
Planning	✓	✓	
Overview	✓	✓	✓
Preparation			✓
Analysis		✓	
Meeting	✓	✓	✓
Rework		✓	
Follow up	✓		

2.4.5.3. Merits and Demerits of Humphrey's Review Process

Humphrey's review process has following merits.

- Preparation goal is enhanced i.e. understanding with defect detection (Humphrey, 1989).
- Individual Defect detection.

Humphrey inspection process has following demerits.

- Large meeting for defect collection.

- Rigorous and require large effort.
- Domain experts are not involved.
- Original cause of the defects cannot be found out.
- Availability of the reviewers for the meeting is a problem.
- Every reviewer has to be present in the meeting even if he/she has no conflict.

2.4.6. N-FOLD INSPECTION PROCESS

N-fold inspection process was presented by Martin and Tsai in 1990 (Martin & Tsai, 1990). This process is used to review the requirement document for mission critical software. Single large review team is replicated to small N sub-teams. Each N sub-team reviews the same requirement document in parallel. Basic concept of this process is that two or more teams can detect more defects than a single review team. There is a single moderator who manages N sub-teams co-ordination. Each sub-team independently and individually detects the defects in artifact. Moderator then collects the defects from all sub-teams and finds the unique defect list. This process involves large human resource so it is an expensive process.

2.4.6.1. Phases of N-Fold Inspection Process

N-Fold Inspection has following phases

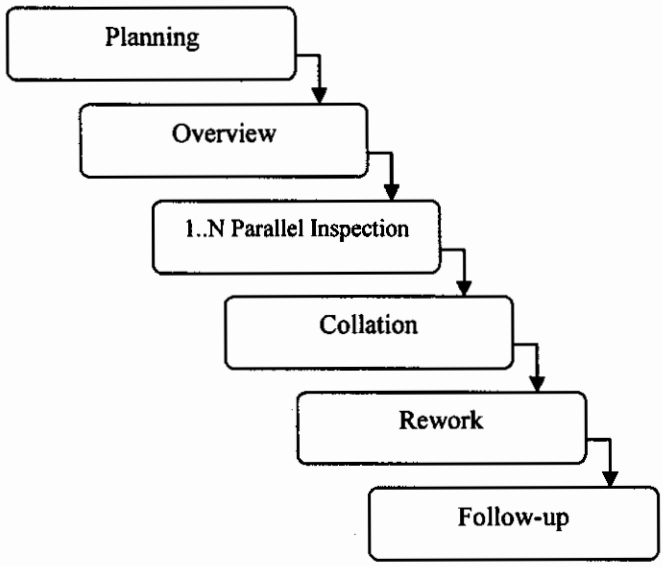

Figure 2.7. Phases of N-fold Inspection Process

- **Planning**

  This phase consists of planning for inspection process and selection of team members.

- **Overview**

  In this phase a little meeting held between the members. Document to be reviewed is presented to reviewers and is distributed to the reviewers.

- **1...N Parallel Inspection**

  In this phase the N sub-teams independently, individually and in parallel review the document. Reviewers individually check the artifact for defects. All sub-teams hold their inspection meetings but there is a single moderator for all team.

- **Collation**

  In this phase the moderator collects the defects details from N sub-teams and checks for the consistency and uniqueness of defects.

- **Rework**

  Once the moderator logged the unique defects, he/she sends the defects report to the author for necessary rework. Author again read the document and made necessary changes.

- **Follow-up**

  Moderator at this phase verifies the correctness and completeness of necessary changes.

2.4.6.2. Team Roles of N-Fold Inspection Process

Following roles are involved in the process.

- **Moderator**

  Moderator is responsible for making a plan, review team selection, distribution of material to reviewers, collection of defects finding unique defect list and sending defect detail report to author.

- **Author**

  Author performs the necessary rework based on defect detection by N sub-teams.

- **Reviewer**

  Reviewers review the document and find defects. They work in 1…N independent teams.

PHASES	TEAM ROLES		
	Moderator	Author	Reviewer
Planning	✓		
Overview	✓	✓	✓
1...N parallel Inspection			✓
Collation	✓		
Rework		✓	
Follow up	✓		

2.4.6.3. Merits and Demerits of N-Fold Inspection Process

Merits of N-Fold inspection are as follows.

- High defect detection rate, as large number of reviewers read the same document.
- Minimum possibility that defects are left behind as multiple eyes sees the same artifact.
- Good quality review.

Demerits of N-Fold inspection are as follows.

- Multiple small meetings increase cost and decreases effectiveness (Porter & Johnson, 1997).
- Very costly as requires large human resource (Martin & Tsai, 1990).
- Co-ordination difficulties.
- Overlapping of Defect.
- Large effort is required for removing the overlapped defects.

- Moderator's workload increases as he/she has to co-ordinate 1-N teams.
- Defect detection is done in the meeting, it doesn't involve individual defect detection.
- Reviewers don't have discussion with the author about the defects.
- Domain experts are not involved.
- Original cause of the defects cannot be found.
- Availability of the reviewers for the meeting is a problem

2.4.7. PHASED INSPECTION PROCESS

Phased Inspection Process was presented by Knight and Myers in 1993. It is based on the combination of Active design reviews process and N-fold inspection process but this process is most rigorous than N-fold and Active design reviews process. Phased inspection process is a series of small individual inspection phases. Each phase fulfills its desirable property to progress to the next phase. Reviewer also use checklist in this process (Kinght & Myers, 1993)

2.4.7.1. Phases of Phased Inspection Process

Phased inspection process has the following phases.

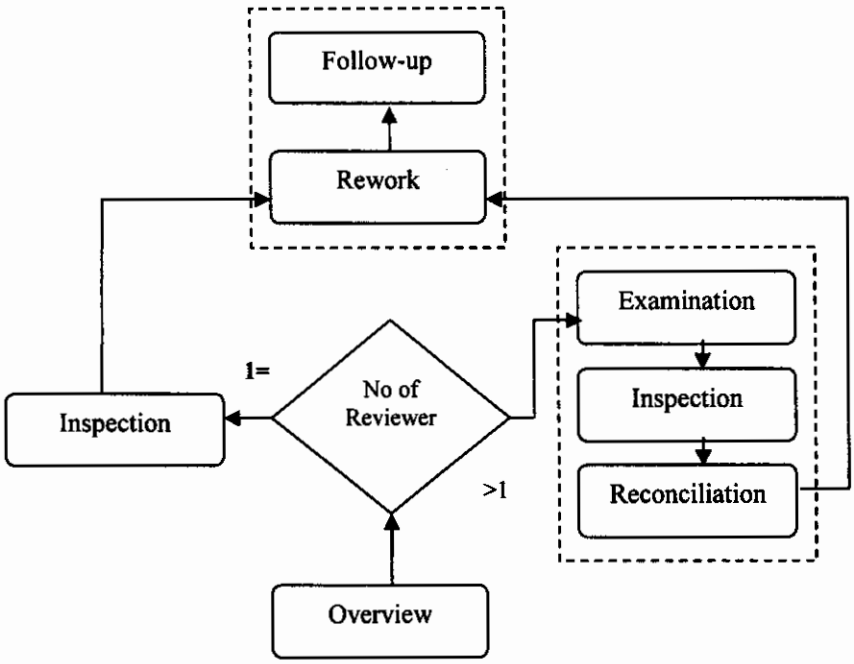

Figure 2.8. Phases of Phased Inspection Process

- **Overview**

  In this phase the material is presented to the reviewers. In case of the single reviewer the material is given to that single reviewer for inspection while in multi reviewers case the next phase is examination.

- **Examination**

  This phase occurs during the multi-inspector situation. In this phase the material to be reviewed is distributed to all the reviewers.

- **Inspection**

  During this phase the reviewers individually checks for the correctness and completeness of the artifact. In case of single reviewer identified defects are given

to author without occurring reconciliation phase while in case of multi reviewers the inspection phase is followed by reconciliation phase.

- **Reconciliation**

  This phase occurs during the multi-inspector situation. In this phase meeting is held between the team members to find consistent and unique defects.

- **Rework**

  Author receives the defects details and again read the document and made necessary changes.

- **Follow-up**

  Author verifies the fixation of defects.

2.4.7.2. Team Roles of Phased Inspection Process

In this process team roles are not identified unlike other processes. According to defined task in phased inspection it seems that two roles are involved in this process i.e. author and reviewer.

- **Author**

  Author presents and distributes the artifact to the reviewers. Other task of the author is to perform the rework.

- **Reviewer**

  Reviewers review the artifact and find defects. Reviewers can be single or multiple.

PHASES	TEAM ROLES	
	Author	Reviewer
Overview	✓	✓
Examination	✓	✓
Inspection		✓
Reconciliation	✓	✓
Rework	✓	
Follow-up	✓	

2.4.7.3. Merits and Demerits of Phased Inspection Process

Merits of Phased inspection process are as follows:

- Focus on quality attributes of software such as reusability, maintainability etc.
- Individual defect detection.

Demerits of Phased inspection process are as follows:

- Defect collection takes place in meeting.
- Require multiple sittings which is costly and ineffective (Porter & Johnson, 1997).
- Cause the project delay.
- Duty distribution problem as roles are not explicitly defined.
- Reviewers' availability for the meetings is a problem.
- Domain experts are not involved.

- Original cause of the defects cannot be found.

2.4.8. GILB AND GRAHAM INSPECTION PROCESS

The Gilb and Graham inspection was introduced by Gilb and Graham in 1993. This is an explicate version of Fagan's review process. The Gilb and Graham (1993) have enhanced the Fagan's review process by introducing other phases called entry and brainstorming. Entry phase starts the process by checking the status of the artifact that whether it is ready for review. Brainstorming phase comes after the meeting phase. Main purpose of this phase is to find the root cause of defects detected in meeting. Gilb and Graham inspection process not only find the defects but also focuses on the root cause of the defects to take the preventive measures. This can be very helpful to enhance and improve the development process for future projects.

2.4.8.1. Phases of Gilb and Graham Inspection Process

The phases of the Gilb and Graham inspection process are:

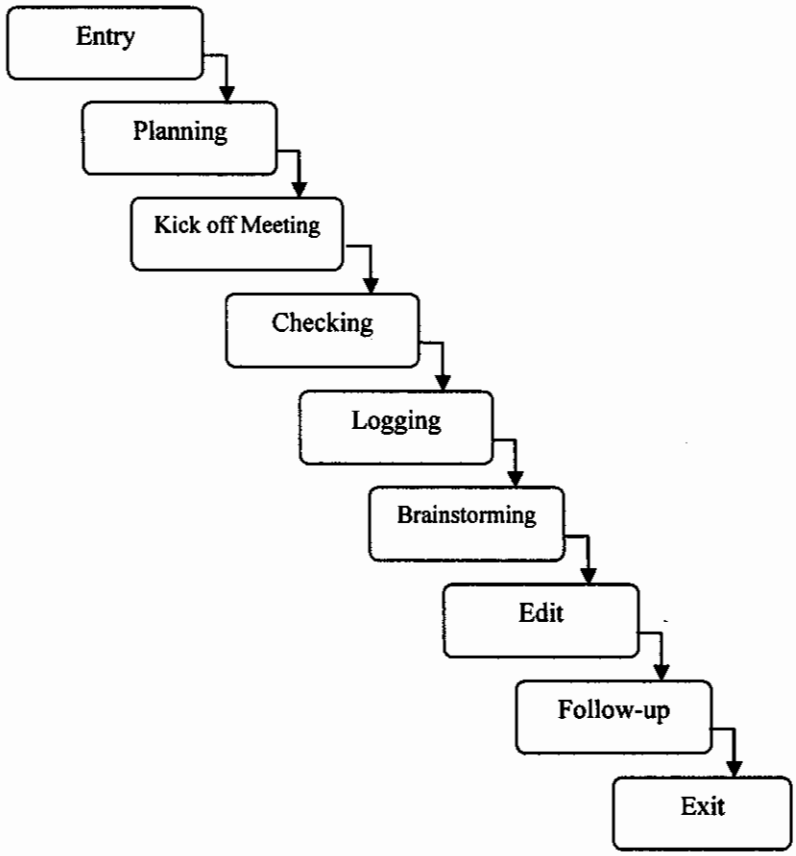

Figure 2.9. Phases of Gilb and Graham Inspection Process

- **Entry**

  This phase is basically for checking the status of the artifact which is to be reviewed. Artifact is checked that whether it is ready for review or not.

- **Planning**

  This phase consists of the planning for inspection process, selection of members etc.

- **Kick off Meeting**

  This phase is like the overview phase of the Fagan's review process. Small meeting is held between the members. They get the overview of the artifact which is to be reviewed. Review material is also distributed in this phase.

- **Checking**

  In this phase the reviewers individually checks the artifact for defects. This phase is like a preparation phase of Fagan's review process but added another objective that is defect detection.

- **Logging**

  In the Logging phase all the members meet and the meeting time is 2 hours. Leader assigns the role of the scribe to one of the checker. Scribe records the defects detected during the checking phase by the reviewers individually. Checkers at this phase are not supposed to perform discussion, as it kills the time of team members and diverts attention from actual purpose.

- **Brainstorming**

  During this phase the members find the root cause of the identified defects for the purpose of the improvement of the process and to avoid them in future. This meeting should not be more than 30 minutes.

- **Edit**

  This phase is like the rework phase in the previous processes. In this phase the author gets the detailed documented defects and issues to correct the defects and settle the issues. The author do the defect fixation.

- **Follow-up**

  Leader at this phase makes sure that defects are corrected by the author.

- **Exit**

  In this phase the artifact is finally approved. Leader checks the exit criteria and if the criterion is met he/she exits the inspection process.

2.4.8.2. Team Roles of Gilb and Graham Inspection Process

Following roles are involved in the process.

- **Leader**

  Leader is responsible for the selection of team, preparation of inspection plan, team leading, assurance of the artifact correctness and monitoring of edit, follow-up and exit phases.

- **Author**

  Author not only attends the meeting but also performs a review as a checker. He/She also receives the details of defects to perform necessary changes.

- **Checker**

  Checker checks the artifact for the issues and defects.

- **Scribe**

  Scribe is not a separate entity. He/She is selected by the team leader from the team of checker only within the meeting. The job of the scribe is to log all the defects detected by the checkers.

PHASES	TEAM ROLES			
	Leader	Author	Checker	Scribe
Entry	✓			Scribe is not a separate entity during the logging phase one of the checker made a scribe by the team leader to log the defects the defects found during meeting
Planning	✓			
Kick off meeting	✓	✓	✓	
Checking	✓	✓	✓	
Logging	✓	✓	✓	
Brainstorming	✓	✓	✓	
Edit		✓		
Follow up	✓			
Exit	✓			

2.4.8.2. Merits and Demerits of Gilb and Graham Inspection Process

Merits of Gilb and Graham inspection process are stated below.

- Brainstorming meeting at the end can be useful for prevention of defects and further improvements.
- Individual checking of defects.

Demerits of Gilb and Graham Inspection Process are stated below.

- Rigorous process (Aurum et al., 2001).
- All reviewers have to meet at same time and same location.

- Follows strictly structured meeting based process (Mishra & Mishra, 2007), (IEEE Std. 1997).
- The reviewers' availability for the meeting is a problem.
- Domain experts are not involved.
- Interpersonal communication increases.
- Defect Collection takes place in well disciplined meeting.

2.4.9. VOTTA'S INSPECTION PROCESS

Votta was the first critic of review meeting. In 1993 he conducted experiments to differentiate between effectiveness of meeting-based and meeting-less review processes. The experiments were performed with two groups. Group1 perform review in which the members meet in a meeting to find the defects while Group2 follow review process in which the members individually detect the defects during preparation phase and collect them in meeting. Votta analyzed from the experiments that the group which followed meeting-less procedure was effective in finding defects than the group who followed meeting based process (Votta, 1993).

2.4.9.1. Votta's View Point with respect to Meeting

Well disciplined meetings can delay the project. It only consumes extra time and resources. Normally the moderator or the person who is talkative and dominant by nature dominates the meeting. Meeting can waste time of technical persons because at a time only two people can communicate in a meeting. According to Votta the review process meeting can be important and successful in removing false positives.

2.4.9.2. Votta's Suggestions with respect to Meeting

Votta argued that meetings are resource consuming but they are important with respect to finding false positive defects. He argued that it is not worth to remove meeting as a whole

but some aspects of meeting should be removed which are really time consuming and effects the individual skills. Votta suggested three types of meetings.

- **Managed Meetings**

  These are well organized meetings with clear agenda, objectives and well defined roles. Moderator should lead the meeting and is responsible for all its management.

- **Deposition**

  These are the meetings in which only three roles are involved i.e. author, moderator and reviewers. In this meeting the reviewers' findings and comments are collected. Author and moderator have the responsibility of collection.

- **Correspondence**

  It includes interaction through different types of communication channels i.e. through paper, mail etc.

2.4.9.3. Phases of Votta's Inspection Process

Votta's inspection process has the following phases.

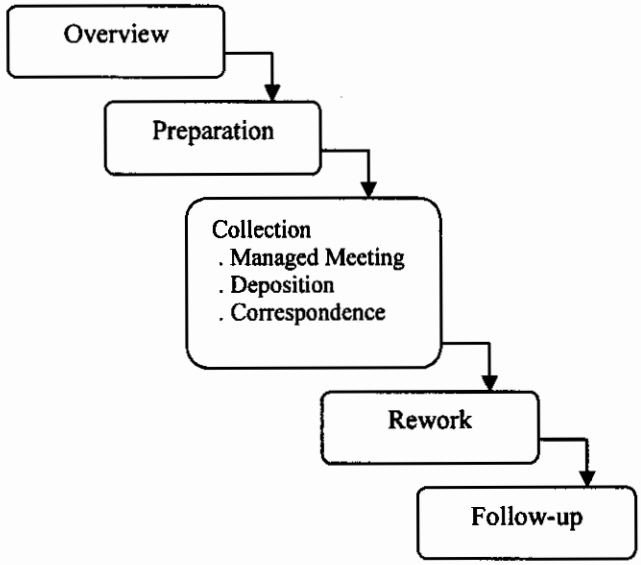

Figure 2.10. Phases of Votta's Inspection Process

- **Overview**

  In this phase the selection of the team members and the distribution of the artifact to the selected team members are done.

- **Preparation**

  Reviewers perform individual defect detection in the preparation phase.

- **Collection**

  In the collection phase the team members remove the false positive defects and find the unique defect list. Three ways are suggested by Votta's for the collection of defects i.e. managed meetings, depositions and correspondence.

- **Rework**

  In the rework phase author performs the necessary changes on the basis of the identified defects.

- **Follow-up**

  In the follow-up phase the moderator is responsible for the verification of changes made by the author in the case of managed meeting and deposition.

2.4.9.4. Team Roles of Votta's Inspection Process

Team roles of Votta's inspection process are:

- **Author**

  Author prepares the artifact and performs necessary changes based on the identified defects.

- **Moderator**

  The responsibility of the moderator is the organization of the review process i.e. selection of reviewers, creation of detailed defect report and management of meeting.

- **Reviewer**

  Reviewers review the artifact to find the defects.

PHASES	TEAM ROLES		
	Author	Moderator	Reviewer
Overview	✓	✓	
Preparation	✓	✓	✓
Collection			
-Managed	✓	✓	✓
-Deposition	✓	✓	✓
-Correspondence	✓		✓
Rework	✓		
Follow-up		✓	

2.4.9.5. Merits and Demerits of Votta's Inspection Process

Merits of Votta's inspection process are as follows.

- Individual defect checking.
- Resolved reviewers' availability problem in case of interaction through papers or mail.
- Reviewers have more focus on the artifact to be reviewed.

Demerits of Votta's Inspection process are as follows.

- Verification procedures are lacking in case of correspondance.
- Large team size (Mishra & Mishra, 2007).
- Does not involve domain experts.
- Root cause analysis procedures are lacking.

2.4.10. FORMAL TECHNICAL ASYNCHRONOUS REVIEW METHOD (FTARM)

Formal technical review method was suggested by Johnson (Johnson, 1994). He has modified the existing Fagan's review process by removing large review meetings. This is

computer based review process in which reviewers are not required to attend face to face meetings unless all the problems are solved. Meeting at the end of the process can be held if there are some issues which could only be resolved by face to face communication. Reviewers get the artifact to be reviewed online and they individually detect the defects and sends there comments online. All the reviewers can see others comments.

2.4.10.1. Phases of Formal Technical Asynchronous Review Method

Formal technical asynchronous review method has seven well defined phases.

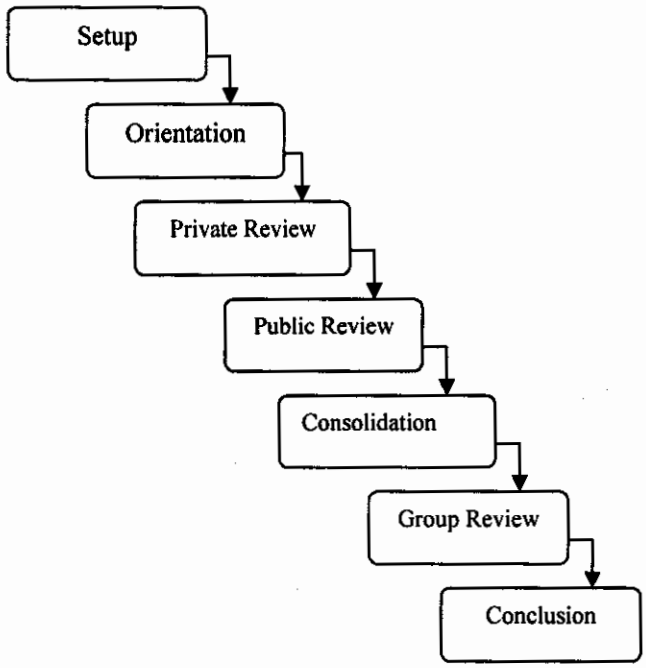

Figure 2.11. Phases of Formal Technical Asynchronous Review Method

- **Setup**

  Formal technical review asynchronous method starts with this phase. In it team selection, preparation of artifact takes place. Artifact to be reviewed is transformed into hyper text form.

- **Orientation**

  Orientation phase is like overview phase of Fagan's review process but it also involves preparation of artifact for understanding. All the reviewers get the artifact to be reviewed. The rigidness of overview phase depends upon the type of artifact under review. The interaction takes place through e-mail as well as face to face meeting if required depending upon the artifact under review.

- **Private Review**

  In this phase the reviewers individually reviews the artifact and adds their identified issues and comments on the document. The whole team can view each others comments but issues don't have public access at this phase.

- **Public Review**

  In this phase all review team members can have public access to issues and defects identified by all the reviewers. Asynchronous voting takes place for defects. Reviewer can have three level voting criterion on the basis of which they can vote. The levels are confirm, disconfirm or neutral.

- **Consolidation**

  In the consolidation phase the moderator summarizes the results and reports to the author. The details of issue like resolved, unresolved or degree of agreement are mentioned in that report. Result report created by moderator is more comprehensive as compared to other traditional review processes. Moderator can stop the review process if there are no unresolved defects and issues.

- **Group Review**

  If there are issues which are neither resolved in private review nor in public review then the group of reviewers review the artifact in a face to face meeting which is held between reviewers. In group meeting the moderator describe the unresolved issues only. After group discussions the reviewers may vote for them or the moderator himself take decisions.

- **Conclusion**

  The final phase is a conclusion in which the moderator produces final review report.

2.4.10.2. Team Roles of Formal Technical Asynchronous Review Method

The team roles of Formal technical asynchronous review method are as follows.

- **Moderator**

  Moderator plans the review process, selects the team members and produce summary report at the end.

- **Producer**

  Producer prepares the artifact for review and performs rework.

- **Reviewer**

  Reviewers individually review the artifact and find defects and add the comments directly to the given artifact. They also vote for comments as confirm, disconfirm or neutral.

PHASES	TEAM ROLES		
	Moderator	Producer	Reviewer
Setup	✓	✓	
Orientation	✓	✓	✓
Private Review	✓	✓	✓
Public Review	✓	✓	✓
Consolidation	✓	✓	✓
Group Review	✓	✓	✓
Conclusion	✓		

2.4.10.3. Merits and Demerits of Formal Technical Asynchronous Review Method

Merits of Formal technical asynchronous review method are summarized below:

- Not strictly meeting based (Johnson, 1994).
- Individual defect detection (Johnson & Tjahjono, 1998).
- Less interpersonal problem (Johnson, 1994).
- No moderator domination.
- No problem due to insufficient preparation of team members.
- Issues are also resolved as detected.
- Computer based so there are no record keeping problems.
- No incorrect review rate problem.

Demerits of Formal technical asynchronous review method are summarized below:

- No procedures for roots cause analysis for the defects.
- Coordination problem.
- Voting is performed for the unresolved issues.

2.4.11. ACTIVE REVIEW FOR INTERMEDIATE DESIGN (ARID)

Active review for intermediate design (ARID) was proposed by Clements in 2000 (Clements, 2000). This review process was modified form of Active design review process. The Active review for intermediate design is a review process used to review the design when it is developed and before its release. The main focus of the process is to examine that whether the design is well reviewed for the use of developer or not. Active review for intermediate design is scenario based review process which involves all stakeholders for review. Active review for intermediate design is an important review process for successful use of design.

2.4.11.1. Phases of Active Review for Intermediate Design

The Active review for intermediate design review process has the following phases.

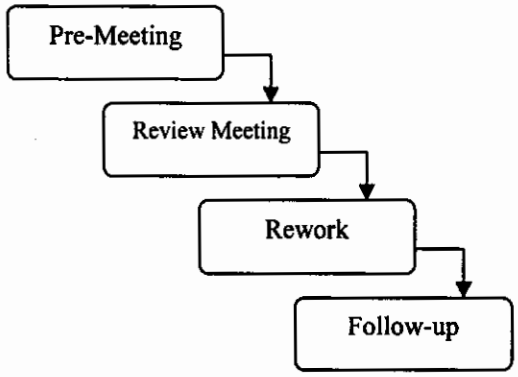

Figure 2.12. Phases of Active Review for Intermediate Design

- **Pre-Meeting**

  In this phase the reviewers are identified. Design presentation and seed scenarios are prepared. The preparations are done for the meeting.

- **Review Meeting**

  Active review for intermediate design method is presented to all the participants. The design is also presented to the participants. Brainstorming is done and the scenarios are prioritized. Then all the reviewers perform the review. Conclusions are described to all the participants.

- **Rework**

  The lead desidner will do the defect fixation.

- **Follow-up**

  In follow-up phase the verification by the lead designer is done, it is checked whether the required changes have been made or not.

2.4.11.2. Team Roles of Active Review for Intermediate Design

The Active review for intermediate design has the following team roles defined in the process.

- **Lead Designer**

  The responsibility of lead designer is to present the artifact during the review meeting. He/she is basically the spokes person. Lead designer receives the results of the review process.

- **Facilitator**

  Facilitator helps the lead designer to prepare for and to run the review meeting.

- **Reviewer**

  Reviewers are the software engineers who will use that design and they detect the defects from the design.

- **Scribe**

  Responsibility of the scribe is to get the inputs from the reviewers and the results of the meeting and then document them.

PHASES	TEAM ROLES			
	Lead Designer	Facilitator	Reviewers	Scribe
Pre-Meeting	✓	✓		
Review Meeting	✓	✓	✓	✓
Rework	✓			
Follow-up	✓			

2.4.11.3. Merits and Demerits of Active Review for Intermediate Design

Merits of Active review for intermediate design are summarized below:

- Consider domain experts (Clements, 2000).
- Early identification of the places where the design is not suitable.
- Open communication.

Demerits of Active review for intermediate design are summarized below:

- Used for design artifacts only.
- Group based defect detection.
- Incorrect review rate (Johnson, 1994).
- Rigorous and labor Intensive Process.

- All reviewers have to meet at same time and same location.
- Follows strictly structured meeting based process.
- Delay in the product occurs.
- Voting of the scenarios takes place.
- Detect fewer faults left portions of the design artifact.
- No way for finding root cause of the detected defects.
- Availability of the reviewers for the meeting is a problem.

2.4.12. REENGINEERED INSPECTION PROCESS

Reengineered inspection process was suggested by Sauer et al. (2000). Main objective of this process is to reduce the cost and time resources. This process is modified form of Fagan's review process. This process has eliminated preparation and meeting phase and introduced the other three phases named as discovery, collection, and discrimination.

2.4.12.1. Phases of Reengineered Inspection Process

Reengineered inspection process has the following phases.

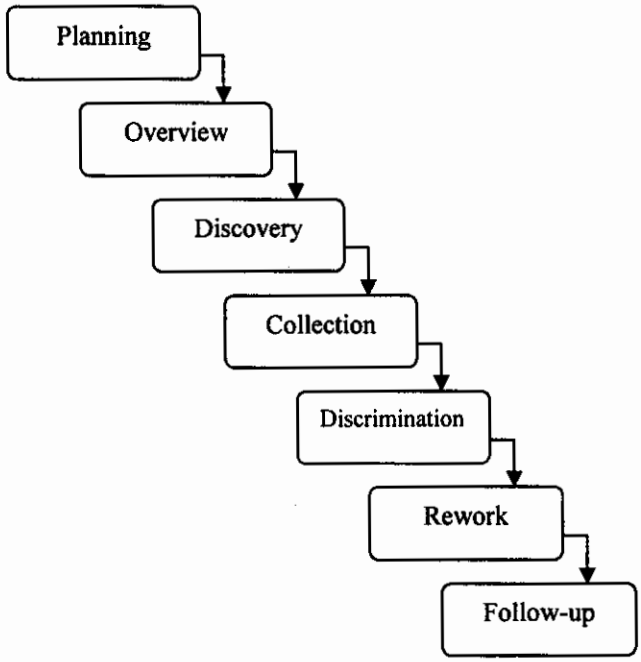

Figure 2.13. Phases of Reengineered Inspection Process

- **Planning**

  This phase consists of planning for inspection, team member selection and role assignment etc.

- **Overview**

  In the overview phase all the members get overview of the artifact which is to be reviewed. The artifact is also distributed to them in this phase.

- **Discovery**

  This phase is like preparation phase. The purpose of this phase is not only the individual understanding of the artifacts but also to find the defects individually from the artifact.

- **Collection**

  In this phase the defects which are identified by individual reviewers during the discovery phase are collected. A single person can perform the collection process it may be author or moderator.

- **Discrimination**

  Basic purpose of this phase is to find the unique defect list. This is the meeting phase in which a meeting is held. It is not compulsory for all reviewers to attend the meeting. The meeting can be held between single reviewer and an author. This can be very helpful in a situation where reviewers' time availability matters. The discrimination phase is optional and can be passed over to reduce cost, save time and reduce interpersonal communication. In this case all the defects which are collected submitted directly to author for necessary changes.

- **Rework**

  Author receives the defect list and performs rework to fix the identified defects.

- **Follow-up**

  Moderator at this phase verifies that author has made the required changes.

2.4.12.2. Team Roles of Reengineered Inspection Process

The team roles of the Reengineered inspection process are:

- **Moderator**

  Moderator is involved in planning and overview phase to perform management related work like inspection planning, selection of reviewers. He/She also monitors the follow-up phase and may involve in finding unique defect list.

- **Author**

  Author performs rework and may involve in finding unique defect list.

- **Reviewer**

  Reviewers review the artifact individually to understand and find the defects. They can attend meeting to discus detected defects.

PHASES	TEAM ROLES		
	Moderator	Author	Reviewer
Planning	✓	✓	
Overview	✓	✓	✓
Discovery			✓
Collection	Moderator or reviewer at a time collect the defects		
Discrimination	✓	✓	Some of the reviewers are involved and some are not.
Rework		✓	
Follow up	✓		

2.4.12.3. Merits and Demerits of Reengineered Inspection Process

Merits of Reengineered inspection process are stated below:

- Individual defect detection.
- Improve quality by detecting defects early in the development.
- Resolved incorrect review rate problem by individual defect detection.

Demerits of Reengineered inspection process are stated below:

- Availability of the reviewers for the meeting is a problem.
- Multiple meetings are costly.
- If the discrimination meeting is skipped then the author work load increases to remove the false positive defects.

2.4.13. WEIGERS INSPECTION PROCESS

Weigers inspection processes was given by Weigers in 2001 (Weigers, 2001). It is based on the conception of Fagan's review process and Gilb and Graham inspection process. All phases are identical to Fagan's review process except planning and casual analysis, which are based on the conception of Gilb and Graham inspection process. The overview phase is optional in this review process.

2.4.13.1. Phases of Weigers Inspection Process

The phases of the Weigers inspection process are:

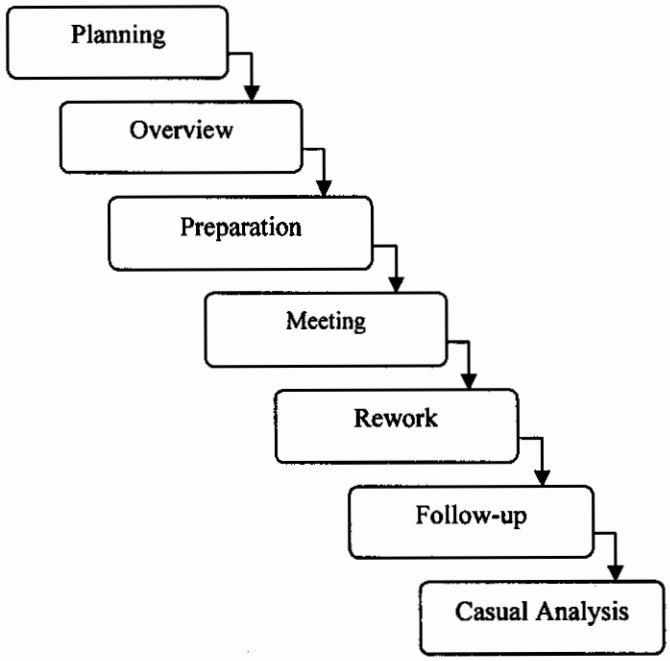

Figure 2.14. Phases of Weigers Inspection Process

- **Planning**

  This phase consists of the activities such as inspection planning, description of inspection goal as well as the team member selection.

- **Overview**

  This phase is optional. During this phase an introductory small meeting held between the team members. All team members have to attend the meeting. Overview of the artifact (specification, design, code etc.) which is to be reviewed is given to all the members and the artifact is also distributed to them.

- **Preparation**

  Basic purpose of this phase is to understand the artifact given for review. Each review member individually gives thorough reading to the artifact. Reviewers understand the artifact and get prepared for the review session.

- **Meeting**

  All the reviewers must have to attend the meeting. Reader presents the artifact (Req. design, code etc.). Reviewers find out defects and give their comments.

- **Rework**

  In this phase the defects identified by reviewers are addressed by author.

- **Follow-up**

  In this phase the author and moderator verifies the defect fixation.

- **Casual Analysis**

  This phase is like brainstorming phase of Gilb and Graham inspection process. The objective of this phase is to avoid defects occurring again by finding the root causes of the defects.

2.4.13.2. Team Roles of Weigers Inspection Process

Team roles in Weigers inspection process are:

- **Moderator**

  Responsibility of the moderator is the planning of the inspection process, team selection, inspection meeting management, distribution of artifacts and to monitor the rework and follow up phases of the process.

- **Author**

  Author is basically the producer of the artifact (Aurum et al., 2001). He/She answers the questions which are asked by the reviewers concerning the artifact under review. He/She receives the defect report from the moderator to perform necessary changes.

- **Reader**

  Reader reads the artifact under review line by line and paraphrases it.

- **Reviewer**

  Reviewers review the artifact and identify the defects in the meeting and give their comments.

PHASES	TEAM ROLES			
	Moderator	Author	Reader	Reviewer
Planning	✓	✓		
Overview	✓	✓	✓	✓
Preparation	✓	✓	✓	✓
Meeting	✓	✓	✓	✓
Rework		✓		
Follow-up	✓	✓		
Casual Analysis	✓	✓	✓	✓

2.4.13.3. Merits and Demerits of Weigers Inspection Process

Merits of Weigers inspection process are summarized below:

- Improve quality by preventing defects.
- Effective Verification Process.
- Good for promoting and enhancing team work.
- Provide good platform for employees training related to standards.

Demerits of Weigers inspection process are summarized below:

- Rigorous and labor intensive process.
- All reviewers have to meet at same time and same location.
- Follows strictly structured meeting based process.
- Process is dominated by moderator.
- Insufficient preparation problem.
- Incorrect review rate problem due to group based defects detection.
- Interpersonal problems/personality conflicts and ego involvement.
- Domain experts are not involved.
- Availability of the reviewers for the meeting is a problem.
- Less focused.

2.4.14. STRUCTURED REVIEW PROCESS

Structured review process was proposed by Laura in 2001. This review process is based on two hypothesis i.e. review process face problems due to their simplicity, complexity, rigidity, time requirement and individuals involved in existing review process can create complexity (Laura, 2001). This process is checklist based and it consists of very small team of three members i.e. one author and two reviewers. Purpose of this review process is only to detect the defects, it doesn't provide the solutions to reduce the number of detected defects .Roles are not explicitly specified in the process. The process is formal but members can communicate informally.

2.4.14.1. Phases of Structured Review Process

The Structured review process has the following phases.

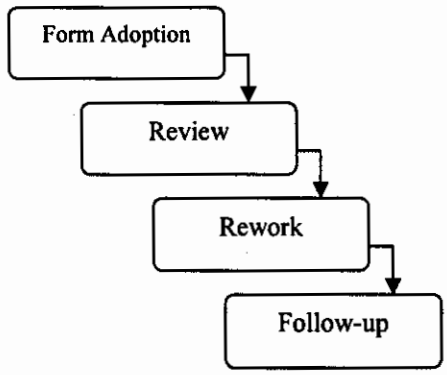

Figure 2.15. Phases of Structured Review Process

- **Form Adoption**

  This phase involves the collection of question based checklists to trigger the reviewers mind.

- **Review**

  In this phase the review meeting is held for the purpose of finding defects.

- **Rework**

  In this phase the author performs the changes to remove the defects which are identified in review meeting.

- **Follow-up**

  In this phase the verification takes place that all defects have been resolved.

2.4.14.2. Team Roles of Structured Review Process

Team roles of structured review process are as defined below.

- **Author**

  Author is responsible to create and distribute the checklists. He has to perform the rework.

- **Reviewer**

  Reviewers are responsible to review the artifact based on the given checklists to find the defects.

PHASES	TEAM ROLES	
	Author	Reviewer
Form Adoption	✓	✓
Review	✓	✓
Rework	✓	
Follow-up	✓	

2.4.14.3. Merits and Demerits of Structured Review Process

Merits of Structure review process are stated below:

- Less costly (Laura, 2001).
- Simple process.
- Applicable to all the artifacts throughout the development cycle.

Demerits of Structure review process are stated below:

- Very informal role specification.

- Group based defect detection.
- All reviewers have to meet at same time and same location.
- Domain experts are not involved.
- No way to analyze the root cause of detected defects.
- Availability of the reviewers for the meeting is a problem.
- Less focused.

2.4.15. LIGHT WEIGHT POSTMORTEM REVIEW PROCESS

Dingsoyr et al. (2001) proposed Light weight postmortem review process. This review process is applicable for collecting the experiences of the finished projects or when a phase is completed (Dingsoyr et al., 2002). It involves three to ten participants in the review meeting. This review process defines the new views of the known issues and also identifies the unknown issues.

2.4.15.1. Phases of Light Weight Postmortem Review Process

The Light weight postmortem review process has the following phases.

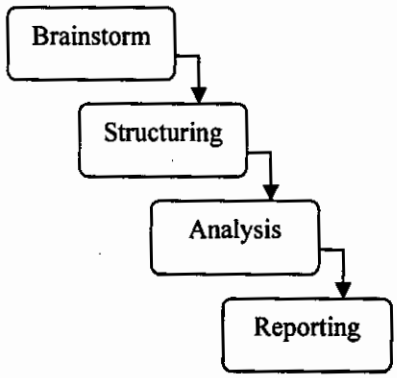

Figure 2.16. Phases of Light Weight Postmortem Review Process

- **Brainstorming**

  In the brainstorming phase all the participants are given the post-it notes and have to write one topic in few minutes about the issue which they find more important. Then each participant has to attach one of his note on the board and have to explain that why this issue is special.

- **Structuring**

  In the structuring phase the groups of the related post-it notes are formed and these groups are given some names. These groups are prioritized and the most prioritized topics are analyzed first.

- **Analysis**

  In the analysis phase Fish bone or Ishikawa diagram is used to find the cause of the important issues.

- **Reporting**

  In the reporting phase the results of the meeting are documented.

2.4.15.2. Team Roles of Light Weight Postmortem Review Process

The Light weight postmortem review process has the following team roles. The roles of the moderator and the secretary can rotate.

- **Moderator**

  Moderator is responsible to decide and announce the date of the meeting. He/She is also responsible to manage the discussions.

- **Secretary**

  Secretary is responsible to document the results of the meeting. He/She can also use any equipment for this purpose if possible.

- **Project Participants**

  Project participants share their experiences to improve the future projects.

PHASES	TEAM ROLES		
	Moderator	Secretary	Project Participants
Brainstorming	✓		✓
Structuring	✓		✓
Analysis	✓		✓
Reporting		✓	

2.4.15.3. Merits and Demerits of Light Weight Postmortem Review Process

Merits of Light weight postmortem review process are summarized below:

- This process is very much helpful to learn from the own experiences of the company.
- The preventive measures could be taken based on the captured information from the old experiences to get the greater benefits.
- Helpful to improve the quality of the products (Aurum et al., 2001)
- It is efficient, short and simple review process.
- This process is very important and useful to establish the knowledge base.
- Find the root cause analysis of the defects.

Demerits of Light weight postmortem review process are summarized below:

- It is an informal process.

- Reviewers' time availability problem for meeting.

2.4.16. VALUE BASE REVIEW PROCESS

Boehm and Lee (2005) have proposed Value base review process. This process is based on the priority and criticality of the artifact. Basis of this review process is the hypothesis that the focused reviews are better than unfocused reviews. Basic idea is that less cost is required if the review activities are focused on the artifact with higher priority and higher criticality at each higher priority level. According to Boehm and Lee low priority and low criticality artifacts are optional to review.

In the Value base review process the stakeholders of the project together select the artifact which is to be reviewed based on the priority of artifact. The priority of artifact is defined by all stakeholders mutually. Authors have defined three levels of priority i.e. high (H), medium (M), low (L). The artifacts with higher priority will be reviewed first. Authors have also defined the three criticality levels i.e. high (H), medium (M) and low (L). The high critical artifacts at each priority level reviewed first and the review of the other artifacts is based on time availability of the reviewers. Boehm and Lee have also given the effectiveness metric to select the artifact for review. Optionality of the artifact to be reviewed is dependent on that metric.

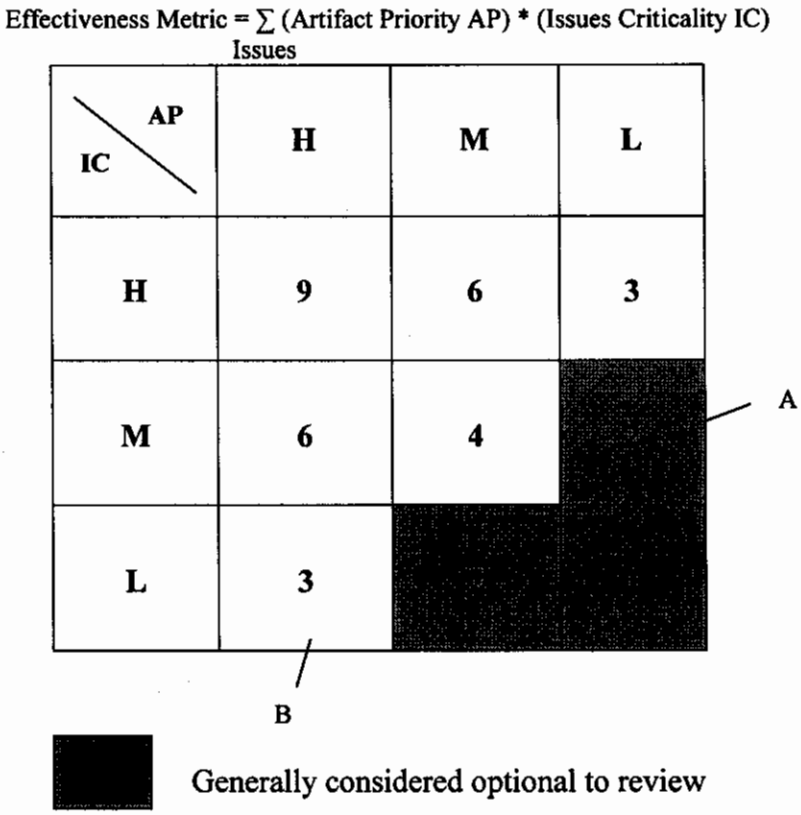

Figure 2.17. Review Effectiveness Metric; Issues Metric and Optionally Guidelines

2.4.16.1. Phases of Value Base Review Process

The review process does not have the explicitly defined phases it only provides the way to select the artifact for review to complete the review within time frame.

2.4.16.2. Team Roles of Value Base Review Process

Like phases team roles are also not defined but Boehm and Lee has suggested including all the stake holders in the review process for reviewing the artifact.

2.4.16.3. Merits and Demerits of Value Base Review Process

The main advantage of this review process is that it is cost effective. The main problem associated with the process is that it focuses on priority of the artifact as compared to criticality. The effective metric given above shows that the artifact marked as A has weighted sum of 2 having low (L) priority level and medium (M) criticality level is optional to review while artifact marked as B has weighted sum of 3 having high (H) priority level and Low (L) criticality level is considered to review first. This shows that the Value base review process is mainly focuses on the priority of the artifact, if the artifact is of higher priority it is considered to be reviewed ignoring the criticality of artifact. The criticality is that of equal importance to the priority because if here are two artifact having low and medium criticality. The artifact with medium criticality should be reviewed first but this is not the case in Value base review process.

2.4.17. OVER-THE-SHOULDER REVIEW PROCESS

Over-The-Shoulder review process is simple and informal review process. It is used to review the code. Reviewers perform review at the author's computer. Author starts the process by presenting code on his computer. Reviewer while reviewing the code if sees something missing he/she tell to the author. Author then performs on the spot changes in the code if the changes are minor. If the changes are major and reviewer does not have to involve, the author perform changes offline. This review process can work over the large distance but this can be problematic because of meeting time management and communication through telephone (Cohen, 2006).

2.4.17.1. Phases of Over-The-Shoulder Review Process

Phases of this process are:

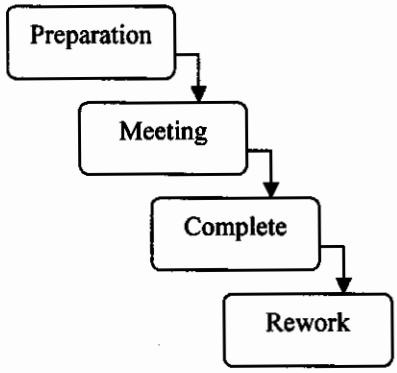

Figure 2.18. Phases of Over-The-Shoulder Review Process

- **Preparation**

  In preparation phase the author selects reviewers to review the code and sets the time of meeting with the reviewers.

- **Meeting**

  In the meeting phase the author presents the code to the reviewers. Reviewers while reviewing can ask questions from author and note down the defects.

- **Complete**

  In the complete phase the code is checked for version control.

- **Rework**

  In this phase developer fixes the identified defects with the help of the reviewers.

2.4.17.2. Team Roles of Over-The-Shoulder Review Process

Team roles of Over-The-Shoulder review process are:

- **Author**

  Author performs the preparation for the review. Selects the reviewers and schedules the time and location with them. Present the code to reviewers in the meeting.

- **Reviewer**

  Reviewers can be one or many. They review the code on the author's computer and note down the defects and help the author in on the spot fixation of the defects

PHASES	TEAM ROLES	
	Author	Reviewer
Preparation	✓	
Meeting	✓	✓
Complete	✓	
Rework	✓	✓

2.4.17.3. Merits and Demerits of Over-The-Shoulder Review Process

Merits of Over-The-Shoulder review process are:

- Execution is simple.
- No training required (Cohen, 2006).
- Implementation is easy and fast to complete.
- This review can also work on long distances using phone and desktop sharing.
- Provide good platform for learning through people interaction.

Demerits of Over-The-Shoulder review process are as follows:

- No way for the verification that the defects are fixed (Cohen, 2006).
- Files to review can easily be skipped and missed.
- No method for process improvement and measurement.
- Less time available for reviewers to review because the author is controlling the speed of the review, therefore the reviewer does not get a chance to do the good job.

2.4.18. EMAIL PASS-AROUND REVIEW PROCESS

Email pass-around review process is also an informal review process for code review. Email pass-around review process is light weight code review process (Cohen, 2006). In this process the author send the files through email to the reviewers. Reviewers collect the files from mail and review them. After reviewing the files they discus it with author again through e-mail and suggest changes after asking questions and discussions with author.

2.4.18.1. Phases of Email Pass-Around Review Process

Phases involved in Email pass-around review process are:

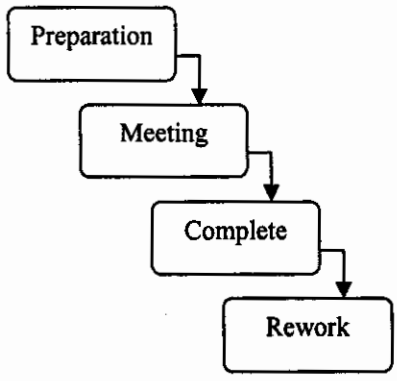

Figure 2.19. Phases of Email Pass-Around Review Process

- **Preparation**

  In preparation phase the author selects the reviewers, prepares the code which is to be reviewed and send it to the selected reviewers.

- **Meeting**

  In this phase the reviewers individually review the code and identify defects and problematic areas. They ask questions from author and perform discussions with them until the defects are resolved or ignored.

- **Complete**

  In this phase the author checks the changes in the version control.

- **Rework**

  In this phase author performs the changes to correct the code.

2.4.18.2. Team Roles of Email Pass-Around Review Process

Team roles of Over-The-Shoulder review process are as follows.

- **Author**

  Author performs the preparation of artifact and corrects the identified defects. To answer the questions of the reviewers is also the responsibility of the author.

- **Reviewer**

  Reviewers individually review the code and perform discussions with author and suggest the changes.

Table 2.20. Team Roles of Email Pass-Around Review Process

PHASES	TEAM ROLES	
	Author	Reviewer
Preparation	✓	
Meeting		✓
Complete	✓	
Rework	✓	

2.4.18.3. Merits and Demerits of Email Pass-Around Review Process

Merits of Email pass-around review process are stated below:

- Involve the remote reviewers.
- Involve many reviewers without interruption to other reviewers.

Demerits of Email pass-around review process are stated below:

- No verification procedure of defect fixation. (Cohen, 2006)
- The author can not know that whether the reviewers have checked the mail or they have deleted it without checking.
- No documentation and record keeping procedure for future projects.
- Process improvement procedures are lacking.

2.4.19. PAIR PROGRAMMING REVIEW PROCESS

Pair programming review process is basically a development process with incorporated continuous code review. In this process two people work at a single station (Cohen, 2006). One of them is writing the code and the other one review it continuously. If the reviewer identifies any defect the developer will make the change at the spot.

❖ **Overview**

In this phase the leader gives overview of the document and distributes it to the review participants for advance preparation.

❖ **Preparation**

In this state the participants read the document for general understanding.

❖ **Meeting**

The members meet at this phase to collectively find defects and issues in the document

❖ **Rework**

Author perform rework at this phase based on identified defects

- **Authorization**

In the authorization phase the artifact is reviewed and authorized by the operational manager. After that the artifact is changed only when change request comes. The sub-phase called follow-up comes under authorization phase.

❖ **Follow-up**

In the follow-up phase operational manage verifies that the changes have been made by the author. Then he/she authorize the document.

2.4.20.2. Team Roles of Light Weight Review Process

Light weight review process has defined three types of reviews for the same artifact. Roles are well defined only in the second type of review i.e. final review which brings the artifact to the concept phase, the roles in this review are producer, consumer, independent reviewer and context guardian. Operational manager is involved in authorize phase while many participants are involved in first review i.e. consultation and review. In the first type of review the roles are not specified. The description of roles is given below.

- **Producer**

  Producer organizes the artifact which is to be reviewed.

- **Consumer**

  Consumer reviews the document along with the reviewers. He/She use what is described in the artifact.

- **Context Guardian**

  Context Guardian is basically the architect who is responsible for the overall design.

- **Independent Reviewer**

  Independent reviewers are not involved in the project directly they only detect the blind spots.

- **Operational Manager**

  The responsibility of the operational manager is to verify that the changes have been made.

Table 2.2: Team Roles of Light Weight Review Process

PHASES	TEAM ROLES				
	Producer	Consumer	Context Guardian	Independent reviewer	Operational Manager
Overview	✓	✓	✓	✓	✓
Preparation		✓	✓	✓	
Meeting	✓	✓	✓	✓	✓
Rework			✓		
Follow-up					✓

2.4.20.3. Merits and Demerits of Light Weight Review Process

Merits of Light weight review process are stated below:

- Multiple reviews verify the quality of document (Muller, 2007).

Demerits of Light Weight Review Process are stated below:

- Final review is group based.
- Reviewers' time availability problems.
- Schedule and location conflicts.
- Informal not good for critical projects.
- Draft phase review consumes lots of time.

2.4.21. SIMPLIFIED SOFTWARE REVIEW PROCESS

D. Mishra and A. Mishra (2007) proposed Simplified software review Process. They suggested that defect detection process should take place in preparation phase or individual checking phase but there should be a small meeting for discussion purpose only to find original defect. Author emphasizes on the small meeting that should be held at the end of the Simplified software review process on the basis.

2.4.21.1. Phases of Simplified Software Review Process

The Simplified software review process has following phases.

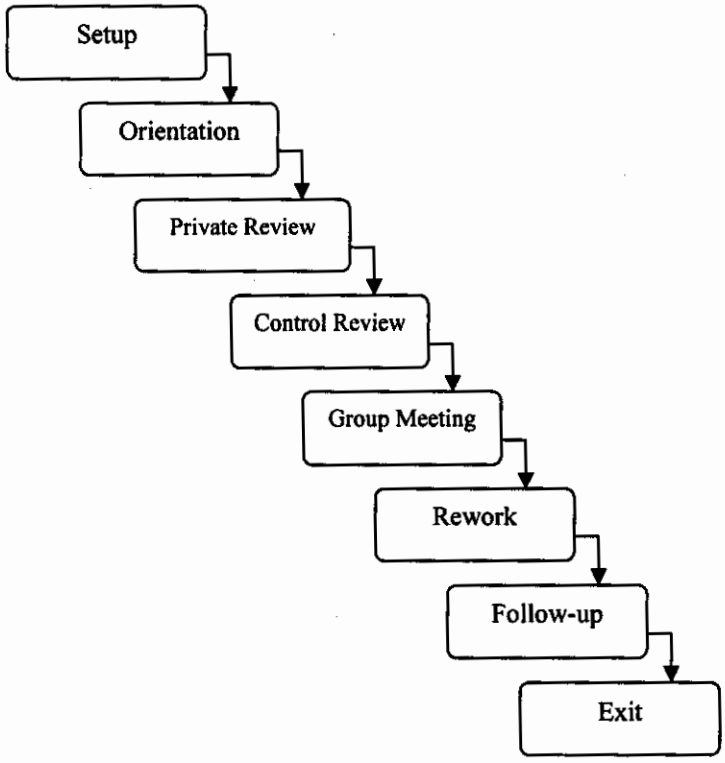

Figure 2.21. Phases of Simplified Software Review Process

- **Setup**

  Setup phase of Simplified software review process is like the entry phase of Gilb and Graham inspection process. In this phase the artifact is checked for the entry criterion and the leader select the members of the review process and prepare the review plan. Artifact to be reviewed is loaded on the web based tool and every participant is informed about the artifact.

- **Orientation**

  This phase is just like the overview phase of the Two-person inspection process. In this phase all the participants individually review the artifact.

- **Private Review**

  In this phase the reviewers individually prepare the artifact, find the issues and inform the author by entering the comments on the web based tool. Reviewers take the help of the checklists. There are different types of checklists for different types of artifacts. After writing the comments the reviewers send the mail so that author could know that the reviews have been completed.

- **Control Review**

  In the control review phase the author checks his/her mail and read comments of all the reviewers about the artifact which is under review. He/She puts his/her opinion about the submitted comments. The opinion submitted by author has three levels agree, disagree and discuss.

- **Group Meeting**

  Author has sent his opinion to all the participants. They have to meet in the review meeting for the discussions of detected defects. In the meeting the reviewers can see the comments of the other reviewers. The discussions in the meeting are only for disagreed and the discussed category defects. Agreed defects are also discussed but in very small detail. Discussed category defects are discussed for the solution. Disagreed defects are discussed for explaining the reason of disagreement. Meeting is helpful to find the false positive and the original defects.

- **Rework**

  In this phase based on identified defects the author made the changes.

- **Follow-up**

  In this phase the software quality engineer monitors that whether all the defects are corrected or not.

- **Exit**

  In this phase the artifact is checked for the exit criterion.

2.4.21.2. Team Roles of Simplified Software Review Process

Following team roles are included in Simplified software review process.

- **Leader**

  Leader prepares the review plan, select team members, inform software quality engineer about members of team and attend meeting for discussion.

- **Author**

  Author informs software quality engineer that artifact is ready for review, perform rework, read comments during control review and reply to them and attend meeting for defect discussion.

- **Software Quality Engineer (SQE)**

  Software quality engineer sends email to all the participants. He/She tells the team about date and time of the review. He/She monitors the changes that have to be made.

- **Reviewer**

  Reviewers review the given artifact, write the comments and send them to the author. They have to attend the meeting to discuss the defects.

PHASES	TEAM ROLES			
	Leader	Author	SQE	Reviewer
Setup	✓	✓	✓	
Orientation	✓	✓	✓	✓
Private Review				✓
Control Review		✓		
Meeting	✓	✓	✓	✓
Rework		✓		
Follow-up			✓	
Exit			✓	

2.4.21.3. Merits and Demerits of Simplified Software Review Process

Merits of Simplified software review process are as follows:

- Defects are detected individually in private review phase.
- Author confidentially answers the question to the reviewers as he/she analyzed the comments of the reviewers.
- Reviewers do not have to meet in a meeting for most of the time (Mishra & Mishra, 2007).

- Reviewers review only part of the product as document is divided in to small part for review purpose.
- Reviewing the small part of artifact ensure that nothing left behind for review.
- During private checking one reviewer cannot see the comments posted by other reviewers.

Demerits of Simplified software review process are as follows:

- Coordination problem.
- Information overload.
- Every reviewer has to attend the meeting held at the end for finding unique defect list.
- Comments marked as discus will be reviewed again in meeting for two minutes. If one reviewer has detected defects which are marked as agreed by the author then this meeting will be assumed to wastage of the time of reviewers.

CHAPTER 3

COMPARATIVE ANALYSIS OF REVIEW PROCESSES (1976-2007)

This chapter provides the detailed overview of the review processes domain. It has following sections.

- **3.1.** ***'Introduction'***: This section describes the hierarchal tree of the review processes since 1976 to 2007.
- **3.2.** ***'Analysis Methodology'***: This section describes the methodologies which are used to analyze the review processes.
- **3.3.** ***'Analysis based on Time Chart':*** In this section the review processes are discussed, when and by whom they were introduced. This section helps to get the overview of the review processes since 1976 to 2007 in a single glance.
- **3.4.** ***'Analysis based on effectiveness factors':*** This section discuses the analysis of review processes based on effectiveness factors. The view points of different researchers are explored with respect to effectiveness factors.

3.1. INTRODUCTION

Review process is an effective mean of static analysis. Numbers of review processes are proposed by different researcher since 19th century. The hierarchical division of the review processes is shown in figure 3.1. (Johnson & Tjahjono, 1998).

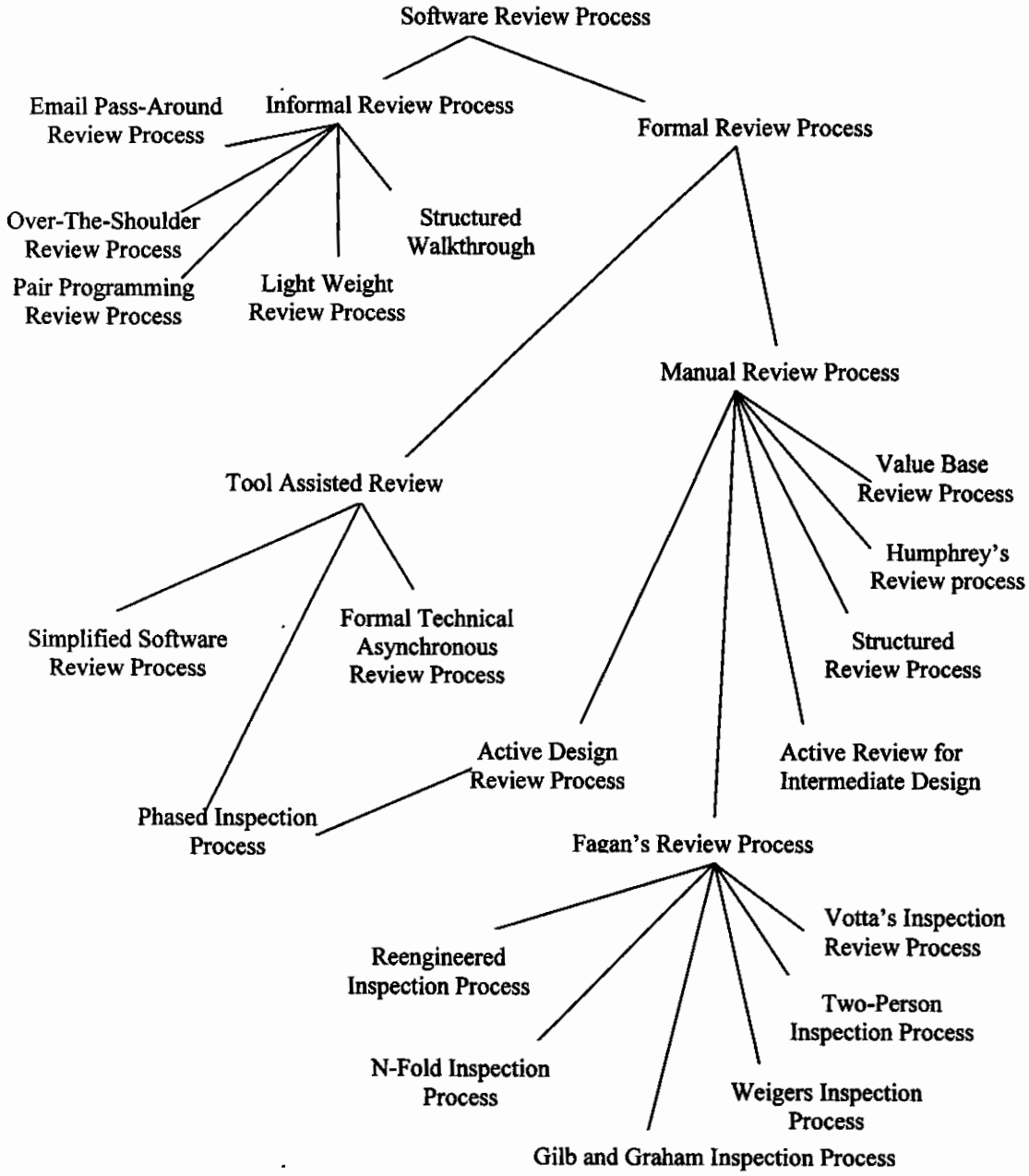

Figure 3.1. Hierarchical model of review processes

Review processes differ in various aspects. Most common differentiation is found in the procedure of review process (process phases), interaction mode (meeting criterion), team composition and artifacts etc. This Chapter describes the comparative analysis of the existing review processes.

3.2. Analysis Methodology

The goal of research is to provide an effective review process based on the existing studies, experiments and evaluations. This research has tried to solve many problems related to the current review processes. The initial method of analysis is based on the organization of existing review process. All review processes are analyzed and presented with the help of time chart. It shows very clearly the time of the review process presentation along with the information of the presenter of the processes. This covers the time period of almost 30 years. The major benefit of such analysis is that one can get a clear look on review processes since 1976 to 2007 in a single glance.

Further more the review processes are analyzed based on effectiveness factors. Reason of analyzing on the basis of effectiveness factor is that, before proposing a new process it is of utmost importance to know what counts for the effectiveness of review processes so that the process can give effective results. Factors on which the review processes are analyzed are basic review procedure, interaction mode and team size.

Analysis on the basis of review procedure shows and compares the activities involved in each review process i.e. planning, reviewing and reporting etc. The interaction mode analysis based on prior studies shows that which review process have used which interaction mode. The advantages as well as disadvantages of using the specific interaction mode are described in detail, which helps in selection of the best mode. The analysis based on team size is very important as they are the people who together run the process. If they are effective the process will also be effective. In this analysis all review

processes are analyzed based on team size and suggestion provided by different researchers for team size are discussed. At the end of each analysis category the summary table is provided for understanding in one glance.

The purpose of such comparative analysis is to develop a general understanding of ideas provided by different researcher since 1976 with respect to the effectiveness of review process as well as the virtues and issues of each idea.

3.3. Analysis via Time Chart

The first review process was introduced by Fagan in 1976 (Fagan, 1976) and largely used ever since with modification. Main focus of the Fagan's review process was on the review meeting with sufficient preparation of reviewers with respect to the artifact, which is to be reviewed in a meeting. Fagan's review process consists of five phases with five well defined roles. After Fagan's review process many questions arise related to the phases, their purpose, need of roles assignment with associated responsibilities etc. Based on these questions number of review processes were introduced.

The first process after Fagan's review process was Active design review process, introduced by Parnas and Weiss (Parnas & Weiss, 1985). In their process they reduced the number of reviewers participating in a meeting and eliminated the role assignment. Bisant and Lyle (1989) had introduced Two-person inspection process especially for small companies. They had tried to reduce the large consumption of resources i.e. the reviewers so they suggested, two members to participate in a review i.e. author and reviewer. In the same year Humphrey had introduced new phase analysis in Fagan's review process, the purpose of this phase was only the collection of defects identified individually in preparation phase. He shifted the goal of preparation from basic understanding to the defect detection (Humphrey, 1989).

Martin and Tsai in 1990 proposed effective review process for requirement phase of the critical projects. Main theme of the review process was to have N-sub teams, all the teams review the same requirement document. Their basic idea was that many small teams can detect more defects as compare to single team (Martin & Tsai, 1990). In 1993 the Phased inspection process was proposed by Knight and Myers (Knight et al., 1993). This review process was especially for code review. Gilb and Graham had also introduced their review process in 1993 (Gilb & Graham, 1993). They have proposed another phase called brainstorming to find root cause of detected defects. Another modification done by them was the introduction of entry phase at the start of the process to check the worth of the artifact to be reviewed. In the same year the criticism on review processes started with respect to review meetings then Votta had proposed meeting less review process to reduce the meeting overhead cost (Votta, 1993). Johnson proposed offline individual defect detection (Johnson 1994).

Sauer et al. proposed Reengineered review process with phases like discovery for individual defect detection, collection for defect collection and discrimination for finding unique true defects list (Sauer et al., 2000). In 2000 Clements based on Active design review process proposed another review process for design artifact (Clements, 2000).This process was well discipline meeting based. In this review process scenario based review technique was suggested to evaluate the design. Weigers (2001) proposed review process which was just like Fagan's review process except planning and casual analysis phase which was introduced by Weigers in his process.

Laura in 2001 suggested Structured review process. Main aim of this review process was to reduce the interpersonal communication overhead. So he reduced the number of reviewer and avoids role assignment to create the comfortable environment for reviews (Laura, 2001). Dingsoyr et al. introduce Postmortem review process for improvement purposes (Dingsoyr et al., 2002). Boehm & Lee introduced a good practice to review the artifact and suggest value base review process. They emphasized on the priority and

criticality of the artifact and suggested the artifacts having high priority define by stakeholders should be reviewed first. After considering the priority the high critical artifact should be considered for review (Boehm & Lee, 2005).

In 2007 two review processes were presented. Mishra & Mishra proposed Simplified software review process (Mishra & Mishra, 2007). It was based on Formal technical asynchrous review process. The other process presented in 2007 was Light weight review process. It was proposed by Muller for reviewing the requirement document (Muller, 2007)

Review Process	Author	Change	Year
Fagan's Review Process	Fagan	Major	1976
Active Design Review Process (ADR)	Parnas & Weiss	Major	1985
Structured Walkthrough	Yourdan	Minor	1989
Two- Person Inspection Process	Bisant & Lyle	Minor	1989
Humphrey's Review Process	Humphrey	Major	1989
N-fold Inspection Process	Martin & Tsai	Minor	1990
Phased Inspection Process	Knight & Myers	Minor	1993
Gilb and Graham Inspection Process	Gilb & Graham	Major	1993
Votta's Inspection Process	Votta	Major	1993
Formal Technical Asynchronous Review Method (FTARM)	Jhonson	Major	1994
Reengineered Inspection Process	Sauer et al.	Minor	2000
Active Review for Intermediate Design (ARID)	Clements	Minor	2000
Weigers Inspection Process	Weigers	Minor	2001
Structured Review Process	Laura	Minor	2001
Light Weight Postmortem Review	Dingsoyr et al.	Minor	2002
Value Base Review Process	Boehm & Lee	Minor	2005
Email Pass-Around Review Process	Cohen	Minor	2006
Over-The-Shoulder Review Process	Cohen	Minor	2006
Pair Programming Review Process	Cohen	Minor	2006
Light weight Review Process	Muller	Minor	2007
Simplified Software Review Process	Mishra & Mishra	Minor	2007

3.4. Analysis Based On Effectiveness Factors

Overview of the effectiveness factors of the review processes is defined in detail in chapter 2. In this section the existing review processes are comparatively analyzed on the

basis of the effectiveness factors. It is out of scope of the thesis to incorporate all the effectiveness factors.

3.4.1. SOFTWARE REVIEW PROCEDURE

Software review procedure is defined as an involved activities stages or phases which are required to run the process (Marri, 2001), (Aurum et al., 2001), (Kroyer, 2007). Through literature survey it is analyzed that basically all review processes broadly consists of three major phases i.e. initiation phase, evaluation phase and closing phase.

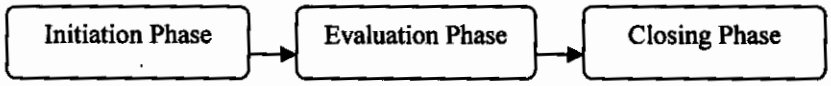

Figure 3.2. Major Phases of software review procedure

These three phases have sub-phases which are defined differently in different review processes. Some have defined the phases to greater extent while other has defined it to smaller extent. The contents as well as the names of the sub-phases vary. In this section all the review processes are analyzed based on their major phases, sub-phases and activities involved in them.

3.4.1.1. Initiation Phase

The basics purpose of the initiation phase is to do the necessary preparation of the review process. It includes number of activities.

- **General activities involved in Initiation Phase**

  The general activities involved in the initiation phase are:

- ❖ Preparation of the artifact for review.
- ❖ Selection of review team members.
- ❖ Distribution of artifact for review.
- ❖ Review planning.
- ❖ Presentation of artifact for review.
- ❖ Checking artifact for entry criteria.
- ❖ Informing the time, date and place for review meeting to the reviewers.

Different review processes have incorporated some or all of the above activities in a single sub-phase for example Fagan's review process (Fagan, 1976), Active design reviews process (Parnas & Weiss, 1985), Two person inspection process (Bisant & Lyle, 1989) , Phased inspection process (Kinight & Myers, 1993) and Light weight review process (Muller, 2007), while other processes have divided these activities into two or three sub-phases for example Humphrey's review process (Humphrey, 1989), N-fold inspection process (Martin & Tsai, 1990), Gilb and Graham inspection Process (Gilb & Graham, 1993), Formal technical asynchronous review method (Johnson, 1994), Reengineered inspection process (Saur et al., 2000) and Simplified software review process (Mishra & Mishra, 2007) etc..

- **Variation of Sub-phases in Initiation Phase**

The sub-phases are described differently in different review processes. This section briefly describes the sub-phases with their major objective and purpose.

- ❖ **Entry**

The purpose of this phase is to check the entry criteria of artifact which is to be reviewed. This phase is defined only in Gilb and Graham inspection process as a sub-phase of initiation phase (Gilb & Graham, 1993).

❖ **Planning**

The purpose of this sub-phase is organization of review process. It includes artifact's preparation for review, selection of team members, time, date and location planning for review. This phase exists in Humphrey's review process (Humphrey, 1989), N-fold inspection process (Martin & Tasi, 1990), Gilb and Graham inspection process (Gilb & Graham, 1993), Reengineered inspection process (Sauer et al., 2000) and Weigers inspection process (Weigers, 2001).

❖ **Overview**

If the review process has only the overview sub-phase in the initiation phase then the purposes of this sub-phase are artifact's preparation for review, selection of team members who will perform the review, planning of date, time and place for review meeting, distribution and presentation of artifact to the reviewers if the process has single overview phase. Otherwise the purpose of overview phase is only the distribution of the artifact to be reviewed and its presentation for general understanding. The main objective is to make artifact easy to review.

This phase can include small meeting (Fagan, 1976). Sometimes this meeting consumes extra effort and increase review process time. That is why overview sub-phase is not supported in some review processes but many review processes have incorporated it with different purpose. Because according to them it is valuable for effective review as it brings the entire review team member to the point where they review the artifact. For example the overview phase in Fagan's review process, Active design review process, Structured walkthroughs, Two person inspection process, Phased inspection process, Active review for intermediate design, and Light weight review process have the same purpose mentioned above.

In Humphrey's review process, N-fold inspection process, Reengineered inspection process and Weigers inspection process the purpose of overview sub-phase is distribution and presentation of the artifact to the reviewers and to inform them about the meeting time, date and place. Some process either had not used this phase or they had not found any effectiveness of performing this meeting (Bourgeois, 1996), (Knight & Myers, 1993). It is concluded that if the artifact is complex, of large system or the team members are inexperienced only then this meeting should be held otherwise overview meeting should not be incorporated.

- **Kick off**

The purpose of this phase is more or like overview sub-phase that is distribution and presentation of the artifact to the reviewers. The reviewers also get informed about the date, time and place for the meeting. This sub-phase is defined in Gilb and Graham. They suggested to use it when desired but not necessary for every review cycle (Gilb & Graham, 1993).

- **Setup**

This sub-phase is incorporated in review processes which have introduced the idea of smaller or meeting less review processes. For example Formal technical asynchronous review methods and simplified software review process. The goal of this phase is the selection of team member, loading of artifact on web based tool and notification to the reviewers about distribution.

- **Orientation Phase**

In this sub-phase the reviewers get the artifact which is to be reviewed. They prepare for individual review by getting overview of the artifact. Formal

technical asynchronous review method (Johnson, 1994) and Simplified software review processes (Mishra & Mishra, 2007) have incorporated this phase. Usually this phase is not meeting based but it depends again on the complexity of artifact.

❖ **Pre-Meeting**

This phase is defined only in the review process called as Active review for intermediate design which incorporated all the activities defined in initiation phase (Clements, 2000). This phase is just like an overview phase.

3.4.1.2. Evaluation Phase

Evaluation phase is the second major phase of software review procedure and it is considered as the central part of the review process. The purpose of this phase is detection of defects to make the artifact defect free.

- **General activities involved in Evaluation Phase**

The general activities involved in the evaluation phase are as follows.

- ❖ Individual preparation of the artifact.
- ❖ Individual defect detection.
- ❖ Group defect detection.
- ❖ Collection of detected defects.
- ❖ Creation of unique defect list.
- ❖ Removal of false positive defects to find true defects.
- ❖ Finding root cause of the detected defects.
- ❖ Creation of detailed defect report.

Generally the evaluation phase consists of individual or group based defect detection. Fagan's review process, N-fold inspection process, Structured walkthrough, Active review for intermediate design, Weigers inspection process, Structured review process, Value base review process, Over-the-shoulder review process, Pair programming review process have group based defect detection arrangements. Active design review process, Humphrey's review process, Phased inspection process, Gilb and Graham inspection process, Formal technical asynchronous review method, Reengineered inspection process, Email pass-around review process and Simplified software review process are based on individual defect detection.

After defect detection the next step is the collection of the detected defects. Collection process normally takes place after individual checking where the defects are identified by the reviewers individually collected in a meeting to remove false positive and finding unique defect list. In case of Active design review process the reviewers individually detect the defects and discus them individually with author in a meeting.

- **Variation of Sub-phases in Evaluation Phase**

Different review processes have defined different ways to detect defects from artifacts. In fact many variations in the processes are based on this phase. The evaluation phase is the central the central point of discussion in the context of review process i.e. how to arrange the sub-phases of defect detection phase to increase the defect detection rate. Different processes use different ways to find the defects and they introduce different sub-phases. To reduce the complexity of description of the sub-phases of evaluation phase they are broadly categorized as individual evaluation and group evaluation

❖ **Individual Evaluation**

Individual evaluation refers to the evaluation of the artifact by a single person. Different review processes have defined different purpose of individual evaluation as well as differently named sub-phases. Some researchers have suggested preparation phase for artifact understanding and they argue it by providing its benefits. According to Bisant and Lyle the preparation for basic understanding is good for education and knowledge gain (Bisant & Lyle, 1989). Similarly according to Ackerman et al. (1989) the preparation phase helps in the thorough understanding of artifact under review. Fagan has also favored the same idea (Fagan, 1976).

Many researchers do not favored individual evaluation for preparation purpose. They had proposed individual evaluation phase for defect detection purpose. For example Parna and Weiss had proposed Review phase for individual defect detection (Parnas & Weiss, 1985). Similarly Humphrey, Votta, Gilb and Graham, Johnson, D. Mishra and A. Mishra had proposed preparation, checking and private review phases for individual defect detection purpose.

Knight and Myer (1993) had proposed multiple small inspection for detecting different type of defects which involve single or multiple reviewers but Votta and Porter (1997) argued against it. According to them the multiple small reviews does not show any effectiveness in defect detection in fact they are costly. Laura in Structured review process (Laura, 2001) and Clements in Active review for intermediate design (Clements, 2000) had not supported individual defect detection. Many researchers have favored the individual defect detection (Porter et al., 1995), (Basli et al., 1996), (Basili, 1997).

❖ **Group Evaluation**

After individual evaluation the next step is group evaluation or review meeting. Different researchers have proposed different purpose of review meeting in their processes. It can be

- Defect detection
- Defect collection
- Defect discrimination

If the purpose of the review meeting is defect detection then defect collection and discrimination automatically takes place in the same meeting. Otherwise if the processes have proposed individual defect detection then the review meeting can have the collection (for collecting the defects detected by individual reviewers) or discrimination purpose (For removing the false positive and finding unique defect lists).

Many researchers have suggested defect detection as a procedure in which multiple individuals sit together to find the defects. For example in Fagan's review process, Structured walkthroughs, Two-person inspection process, Weigers inspection process process , Active review for intermediate design, Structured review process the review meeting held for the purpose of defect detection.

Parnas and Wiess suggested that the review meeting should be held for discussion of defects only. In phased inspection the review meeting is utilized for both collection and discrimination of defects. For this purpose they have proposed the reconciliation phase. Similarly in process proposed by Gilb and Graham the logging phase is proposed for collection of defect and removing

false positive to find the unique and consistent defect list. Logging phase is well disciplined meeting based (Gilb & Graham, 1993).

Martin and Tsai (1990) have supported multiple small review meeting for defect detection and collection of defect. In Humphrey's and Sauer's review process the meeting held for discrimination purpose. In Humphrey's review process collection takes place in analysis phase by moderator (Humphrey, 1989) and in Sauer's review process collection of defects is done in collection phase. The discrimination of defects is optional in Sauer's review process (Sauer et al., 2000). Johnson has suggested group review phase in which reviewers meet face to face to discus unresolved issues (Johnson, 1994). D. Mishra and A. Mishra have also the same idea (Mishra & Mishra, 2007).

3.4.1.3. Closing Phase

The last major phase in review procedure is closing phase where review process completion activities take place. In this phase little variation occurs between different processes.

- **General activities involved in Closing Phase**

  The general activities involved in the closing phase are as follows.

  - ❖ Defect fixation of identified defects.
  - ❖ Verification of fixed defects.
  - ❖ Checking of exit criteria to close the process.

- **Variation of the Sub-phases in Closing Phase**

  Sub-phases of closing phase are stated verily in different review processes. This section briefly describes these sub-phases with their major objective and purpose.

❖ **Rework**

During the rework sub-phase, author has to perform necessary changes based on identified defects. Almost all the review processes have this sub-phase except Gilb and Graham inspection process. They have defined edit phase in place of rework but it has the same purpose as of rework.

❖ **Follow-up**

The purpose of follow-up sub-phase is to verify that the changes have been made by author. Normally the moderator has the responsibility of verification. This sub-phase is also incorporated in almost all review processes except Formal technical asynchronous review method and Active review for intermediate design. They have combined the rework and follow-up phases in to a single phase named as conclusion.

❖ **Exit**

Gilb and Graham inspection process and Simplified software review process have defined this sub-phase to check the exist criteria of the process (Gilb & Graham, 1993), (Mishra & Mishra, 2007). Artifact is finally approved in this phase. If the exit criteria are met then the leader closes the review process.

Review Process	Initiation Phases	Evaluation phases	Closing Phases
Fagan's Review Process	Overview➢	Preparation➢ Meeting➢	Re-work➢Follow-up
Active Design Review Process	Overview➢	Review➢ Meeting➢	Re-work
Structured Walkthrough	Overview➢	Preparation➢Walkthrough➢	Re-work➢Follow-up
Two-person Inspection Process	Overview➢	Preparation➢ Meeting➢	Re-work➢Follow-up
Humphrey's Review Process	Planning➢Overview➢	Preparation➢Analysis➢ Meeting➢	Re-work➢Follow-up
N-Fold Inspection Process	Planning➢Overview➢	1...N Parallel Review➢ Collation➢	Re-work➢Follow-up
Phased Inspection Process	Overview➢	Inspection Examination➢ Inspection➢ Reconciliation➢	Re-work➢Follow-up
Gilb & Graham Inspection Process	Entry➢Planning➢ Kick off➢	Checking➢Logging➢ Brainstorming➢	Re-work➢Follow-up
Votta's Inspection Process	Overview➢	Preparation➢ Collection➢	Re-work➢Follow-up
Formal Technical Asynchronous Review Method	Setup➢Orientation➢	Private Review➢Public Review➢ Consolidation phase➢ Group Review➢	Conclusion
Reengineered Inspection Process	Planning➢Overview➢	Discovery➢Collection➢Discrimination➢	Re-work➢Follow-up
Active Review for Intermediate Design	Pre-Meeting➢	Review Meeting➢	Conclusion
Weigers Inspection Process	Planning➢Overview➢	Preparation➢ Meeting ➢	Re-work➢Follow-up➢ Casual Analysis
Structured Review Process	Form Adoption➢	Review Meeting➢	Re-work➢Follow-up
Light Weight Postmortem Review Process	----------	Brainstorming➢Structuring➢Analysis➢	Reporting
*Value Base Review Process	----------	----------	----------
Over-The-Shoulder Review process		Preparation➢Meeting➢	Complete➢Re-work
Email Pass-Around Review Process		Preparation➢Meeting➢	Complete➢Re-work
*Pair Programming Review Process	----------	----------	----------
Light weight Review Process	Overview➢	Review (Group/Individual) ➢	Re-work
Simplified Software Review Process	Setup➢Orientation➢	Private Review➢Control Review➢ Meeting➢	Re-work➢Follow-up➢ Exit

* VBRP and Pair programming review processes do not have well defined phases.

3.4.2. INTERACTION MODE

Interaction mode as discussed in chapter 1 refers to the synchronous and asynchronous meeting. Number of researches has been performed on the review meeting effectiveness. Different views exists in the literature regarding meetings in a review process i.e. whether they are good and effective or just wastage of reviewers time and loss of defects. Some researchers have favored the review meetings and discus their benefits (Fagan, 1976), (Gilb & Graham, 1993), (Mishra & Mishra, 2007) and (Martin & Tasi, 1990). while many researchers have suggested reducing their complexity or totally eliminating them (Parnas & Weiss, 1985), (Votta, 1993), and (Johnson, 1994). This section discusses the view points of researchers regarding the review meetings and also analyzes the interaction mode suggested by different researcher in their review processes.

Fagan focused and emphasized on the well disciplined meeting based review process. According to him the review meeting should involves an effective technique i.e. paraphrasing, which provides means of in depth analysis of artifact during the meeting. He also believes that meeting has synergy effect which helps in defect detection (Fagan, 1976). In Fagan's review process the purpose of meeting is defect detection. The researchers have shifted the defect detection to preparation phase. It has increased the goal of preparation phase from basic understanding of artifact to the detection of defects.

Just after the Fagan's review process, the question arises regarding review meeting effectiveness. Numbers of contradictory findings are present in literature regarding the review meeting. Review meetings criticism and questions are normally based on two facts. Firstly it delay the project and secondly many empirical studies shows that most of the defects are detected during individual checking and only the small number of defects are left behind.

Parnas and Weiss criticized and questioned the meeting based approach of the Fagan's review process. They believed that meeting can be the cause of the wastage of time for

developers and it diverts the focus of reviewers from defect detection task (Parnas & Weiss, 1985). They argued that the meetings only consumes the developers time, increases cost and has minimal effect in defect detection task. According to them meetings are unnecessary, instead they suggested multiple small individual synchronous reviews meeting with author. According to Humphrey (1989) reviewers individually detect the large number of defects. He believed that meetings only delay the project. He suggested that individual defect detection should be done in a preparation phase and only true defects should be detected in review meeting.

Bisant and Lyle believed that large number of team members increase the meeting complexity and cost so they suggested to reduce the members to only two to save the time and cost (Bisant & Lyle, 1989). Martin and Tsai emphasized on multiple small parallel review meetings for reviewing the same artifact. According to them single large review meeting is ineffective as compare to multiple small meetings (Martin & Tsai, 1990). Knight and Myers also suggested individual defect detection and utilization of meeting for collection of defects. They also had suggested multiple inspections (Knight & Myers, 1993). But the multiple sittings are not effective according to Porter and Votta, they argued it on the basis of their experimental results (Porter and Votta, 1997). Gilb and Graham also had the same view point as of Knight and Myers with respect to defects detection but they strictly emphasized on the detailed well discipline meeting for collection of defects and removing false positive (Gilb & Graham, 1993).

The ideas discussed above about the meetings are with the perspective of different researchers, which revolve around the synchronous mode of reviewers' interaction. The first critic of the synchronous mode of the meeting was Votta. He performed different experiments to assess the meeting effectiveness. He argued that strict and scheduled meetings can delay the developments and increase the review meeting time (Votta, 1993), (Johnson & Tjahjono, 1998), (Mishra & Mishra, 2007). He did not find synergy effect in meeting (Votta, 1993), (Porter & Johnson, 1997). According to him only two members

can successfully interact in a meeting at a time, other members waste their and others time. Votta also found that during individual checking majority of defects can be detected almost 90% (Votta, 1993), (McCarthy et al., 1996), (Johnson, 1994). Votta suggested review process without meeting. According to him only 10% defects can be detected in a review meeting. This argument is totally against the Fagan's review process in which he said that meeting is very important and the majority of defects found during meeting.

Porter and Johnson (1997) suggested that individual checking can detect more defects as compared to group base checking, but can increase the defect duplication cost. Porter and Johnson greatly emphasized on meeting less review process. According to them the meeting less review processes are effective than meeting base review processes. Bianchi et al., through their experiment on real (who attend physical meeting for defect detection) VS nominal teams (who detect defects individually) argued that null meeting improvement can be a reason to drop the teams meetings. According to them team meetings have negative effect on defect detection. They also investigate that team meetings does not show any presence of synergy effect (Bianchi et al., 2001).

Instead of large negative view points of researchers with respect to review team meeting one cannot forget the benefits and core importance of synchronous meeting. Sauer et al.(2000) believed that synchronous review meetings are important for defect collection and defect discrimination. According to them false positive defects can be a big problem because they can further increase the cost so they should be discussed and removed in a face to face meeting (Grunbacher et al., 2003). Votta, Porter and Jhonson also supported the Sauer's idea regarding false positive defects (Votta, 1993), (Porter & Johnson, 1997).

Defect detection is shifted to preparation phase in most of the review processes. It does not mean that synchronous meetings should be eliminated completely, as they are very successful in collection and discrimination of defects (Sauer et al., 2000).

It is concluded that meetings are important and essential part of the review processes. Defect collection meetings are more beneficial as the defects which are critical, ambiguous and need clarification must be discussed in face to face meeting. It helps to remove the false positives. So it seems that the cost of meetings depends on their purpose, member strength, formality and time availability of reviewers. Meetings are costly when they are complex when their purpose is defect detection, very formal, and need to be rescheduled again and again because of unavailability of reviewers. But they are less costly and effective when the purpose is general discussion regarding defect clarification and removing false positive, less formal, less complex, and independent of availability of all reviewers at same time and place.

Meeting approach of Formal technical review method (Johnson, 1994) and Simplified software review process (Mishra & Mishra, 2007) seems to be good but need to be improved. Formal technical asynchronous review method has opened the meeting as an optional. Formal technical asynchronous review method and Simplified software review process have emphasized the presence of all reviewers in a meeting, which depends upon the availability of reviewers to attend the meeting. It may results in the wastage of time for such reviewers who have no conflict with author. So the meeting criteria should be such that it should be independent of reviewers' availability and does not become a reason of wastage of reviewers' time.

Review Processes	Meeting Held	Sittings	Meeting Purpose	Meeting Type
Fagan's Review Process	Yes	Single	Defect Detection	Sync
Active Design Review Process	Yes	Multiple	Discussion of all Defects	Sync
Structured Walkthrough	Yes	Single	Defect Detection	Sync
Two-person Inspection Process	Yes	Single	Defect Detection	Sync
Humphrey's Review Process	Yes	Multiple	Finding Unique Defect List	Sync
N-Fold Inspection Process	Yes	Multiple	Defect Detection	Sync
Phased Inspection Process	Yes	Multiple	Defect Collection	Sync /Async
Gilb & Graham Inspection Process	Yes	Single	Defect Collection, Remove false positive	Sync
Votta's Inspection Process	Optional	Single	Defect Collection	Async
Formal Technical Asynchronous Review Method	Optional	No	Discussion of all defects, Remove false positive	Sync /Async
Reengineered Inspection Process	Optional	Single	Defect Discrimination	Sync
Active Review for Intermediate Design	Yes	Single	Defect Detection	Sync
Weigers Inspection Process	Yes	Single	Defect Detection	Sync
Structured Review Process	Yes	Single	Defect Detection	Sync
Light Weight Postmortem Review Process	Yes	Single	Experience Sharing	Sync
Value Base Review Process	Yes	Multiple	Defect Detection	Sync
Over-The-Shoulder Review process	Yes	Multiple	Defect Detection	Sync
Email Pass-Around Review Process	No	No	-	Async
Pair Programming Review Process	Yes	Multiple	Defect Detection and Correction	Sync
Light Weight Review Process	Yes	Single	Defect Detection	Sync /Async
Simplified Software Review Process	Yes	Single	Discussion of all defects, Remove False Positive	Sync/Async

3.4.3. TEAM STRUCTURE

Team structure can be clearly defined on the basis of number of reviewers, description of roles with associated responsibilities and individual expertise level. All these factors contribute to the effectiveness of the review process.

3.4.3.1. Team Size

Team size is one of the review processes influencing factor (Aurum et al., 2001). Every software review process involves a team which works together to find defects from the

artifacts. In some cases the team members initially do the individual defect detection then group defect detection in a meeting. In other cases they directly detect the defects in a meeting or just work offline without any impersonal physical interaction. Team work has lots of benefits like quality of product improves as it is reviewed by different members having different experience (Laitenberger & DeBoud, 1997).

Few researchers have worked to estimate the team size effect on the review Process. According to Fagan the most optimal team size is three to five members (Fagan, 1976), (Doolan, 1992). Bisant and Lyle have suggested Two-person team size, according to them individuals can improve their skills and can actively participate. Working in small teams helps in increased productivity level of less experienced programmers. They reasoned for suggesting two persons team size, that if the team size is large most dominant and experienced persons can actively participate and the less experienced members hesitate to give their suggestions, this suppresses their ability (Bisant & Lyle, 1989).

Martin & Tsai suggested multiple teams to review the same artifact, according to them a single team is ineffective as compared to multiple small teams. They argued that the multiple small teams performed parallel and independent reviews of same artifact which reduces the possibility of missing defects (Martin & Tsai, 1990). Weller like Fagan believed that there should be four members in a review team (Weller, 1993). Madachy et al. and Bourgeois suggested to have 3 to 5 people in a review team (Madachy et al., 1993), (Bourgeois, 1996).

According to Wheeler et al., the effective team size should consist of four to five members. This team size agreed with Fagan and Weller (Wheeler et al., 1996). Most important work done in this context was by McCarty, Porter and Votta on effective team size (McCarthy et al., 1996). They conduct experiments to analyze review process influencing factor like team size. As a result of their experiment they found that two or

more than two persons team is most effective than a single person. However they did not find any difference in effectiveness of two, three or four person's team. According to them these team sizes equally benefit the review process but they also suggested that as team size has large effect on review process with respect to meeting arrangements i.e. time, schedule and place planning, management for distribution of artifacts defect detection, defect collection etc.

Large team size can delay the development because of delay in review process arrangements and review results gathering. Owens suggested five to six persons in a review team because according to him multiple people reviewing the product can be more effective and beneficial (Owens, 1997). It is that believed that large number of people is not more effective because all of them are never efficient at the same time. Laitenberger et al. (2002) had the same idea as of Porter & Votta (1997) that two reviewers can be more effective than single one, they suggested team size of two people as suggested by Bisant and Lyle (1989). Laitenberger et al. also believed that large team size is better because large number of people can detect large number of defects (Laitenberger et al., 2002).

Wohlin et al. (2000b) analyzed that effectiveness of review process with different team sizes. According to their findings three persons team increases effectiveness higher than 50%, and this percentage gradually increase with the increase in number of reviewer i.e. higher than 70% for four reviewers and almost 81 % for five and 86% for six reviewers. But they also found that effectiveness reduces as number of reviewers increase from six to seven so they suggested that six reviewers can effectively contribute in a review process.

It is concluded from the literature that different researcher have different view points with respect to team size but most of the experimental results shows that large team can cause extra overhead cost as compare to smaller one's. So with respect to experimental results

its better to have five to six persons in a review team. Team size suggested by researchers in different review processes is analyzed in a Table 3.3 given below.

Researchers	Team members	Reference
Michael Fagan	3-5	(Fagan, 1976)
Bisant and Lyle	2	(Bisant & Lyle, 1989)
Martin and Tsai	Multiple small teams	(Martin & Tsai, 1990)
Weller	4	(Weller, 1993)
Madachy et al.	3-5	(Madachy, 1993)
Bourgeois	3-5	(Bourgeois, 1996)
Wheeler et al.	4-5	(Wheeler et al., 1996)
McCarthy et al.	>2	(McCarthy et al., 1996)
Owens	5-6	(Owens, 1997)
Wohlin et al.	5-6	(Wohlin et al., 2000b)

3.4.3.2. Roles Description

Roles are associated with the members involved in a review process. These roles differ in different review processes. For example some review processes have defined the most general roles such as moderator having the responsibility of review process management for example in Fagan review process (Fagan, 1976), Humphrey review process (Humphrey, 1993) and N-fold Inspection (Martin and Tasi, 1990). Other processes defined the role of leader for example in Simplified software review process and Gilb and Graham process (Mishra & Mishra, 2007), (Gilb & Graham, 1993) or coordinator (like in structured walkthrough) in place of moderator. They have somehow same responsibility like that of moderator.

Author role is defined in almost all review processes whose responsibility is artifact preparation for review, to resolve ambiguities if any related to the artifact under review and to fix the identified defects. Author is also referred to as producer in some review

processes. Another most important role is reviewers without this role the review process is impossible to run. The responsibility of the reviewers is to find defects from the artifact. Number of reviewers varies in different review processes. Reviewers some time are also called checkers like in Gilb and Graham inspection process (Gilb & Graham, 1993).

Another important role is reader some time called presenter defined by Fagan and Weigers only in their review processes (Fagan, 1976), (Weigers, 2001). If the process is meeting based the reader presents and paraphrases the artifact under review. Recorder role also called as scribe has the responsibility to record the defects which are identified in review meeting. Fagan and Weigers have introduced the role of recorder in their processes while Gilb and Graham have introduced the role of sribe for defect recording purpose (Fagan, 1976), (Gilb & Graham, 1993), (Weigers, 2001).

Different researchers have different view points with respect to the role's responsibilities. For example according to Russell (1991) the author should not participate and act as a silent person while Gilb and Graham have totally opposite idea about author. According to them the author should have to actively participate in a review process and should have to find defects (Gilb & Graham, 1993). There is not huge disagreement with respect to the roles. The Table 3.5 shows the defined roles with respect to different existing review process.

Review Process	Leader	Moderator	Coordinator	Secretary	Operational Manger	Producer	Presenter	Author	Lead Designer	Context Guardian	Reader	SQE	Reviewer	Checker	Recorder	Scribe	Facilitator	Consumer	Project Participants
Fagan's Review Process		•						•			•		•		•				
Active Design Review Process								•					•						
Structured Walkthrough			•			•							•						
Two-person Inspection Process								•					•						
Humphrey's Review Process		•				•							•						
N-Fold Inspection Process		•						•					•						
Phased Inspection Process							•						•						
Gilb & Graham Inspection Process	•							•						•		•			
Votta's Inspection Process		•						•					•						
Formal Technical Asynchronous Review Method		•				•							•						
Active Review for Intermediate Design									•				•			•	•		
Reengineered Inspection Process		•						•					•						
Weigers Inspection Process		•						•			•		•						
Structured Review Process								•						•					
Light Weight Postmortem Review Process		•		•															•
Value Base Review Process								•					•						•
Over-The-Shoulder Review process								•					•						
Email Pass-Around Review Process								•					•						
Pair Programming Review Process								•					•						
Light Weight Review Process					•	•				•			•					•	
Simplified Software Review Process	•							•				•	•						

3.4.3.3. Individual Expertise Level

It refers to individual capability and expertise level of the reviewers. Individual reviewer's expertise level can have greater impact on the review process. According to some researchers the individual expertise level is very important in increasing the effectiveness of review process. "*The expertise is key driver in a review performance*" (Sauer et al., 2000). According to Knight and Myers the experiences of the reviewers have effects on defect detection (Knight & Myers, 1993). Individual expertise consists of technical skill, domain knowledge and experience.

Few existing review processes have considered individual expertise while team selection. For example Active design review process (Parnas & Weiss, 1985), Active review for intermediate design (Clements, 2000) etc. The Table 3.5 has given below shows the processes which consider the expertise level of the team members while team selection and which does not consider.

Review Processes	Individual expertise Consideration
Fagan's Review Process	No
Active Design Review Process	Yes
Structured Walkthrough	No
Two-person Inspection Process	No
Humphrey's Review Process	No
N-Fold Inspection Process	No
Phased Inspection Process	No
Gilb & Graham Inspection Process	No
Votta's Inspection Process	No
FTARM	Yes
ARID	Yes
Reengineered Inspection Process	No
Weigers Inspection Process	No
Structured Review Process	No
Light Weight Postmortem Review Process	Yes
VBRP	Yes
Over-The-Shoulder Review process	No
Email Pass-Around Review Process	No
Pair Programming Review Process	No
Light Weight Review Process	Yes
Simplified Software Review Process	Yes

CHAPTER 4

CONCEPTUAL FRAMEWORK

This Chapter gives the detailed description of the proposed review process. It has following sections.

- **4.1.** ***'Introduction'***: This section briefly states the introduction of the chapter.
- **4.2.** ***'Proposed Review Process'***: This section describes the whole process in term of activities, purpose of activities team roles and their responsibilities. It also states the merits, demerits and the tool support of the review process.
- **4.3.** ***'Comparative Evaluation of Proposed Process'***: This section gives the comparative evaluation of the proposed review process on the basis of the effectiveness factors of existing review processes.

4.1. Introduction

It is well understood that software development has associated risks and uncertainties. During software development different artifacts are created. These artifacts serve as the basis for subsequent artifact in software development phases. As the creation of artifact is human activity so the artifact can have associated defects which can be missed by author. These defects must be removed to prevent them from passing to subsequent artifacts. For this purpose software reviews are used because they filter out the defects from artifact.

This chapter describes the proposed review process. The detail description of process is provided in terms of phases involved in it, the selection criterion of team members, roles associated with them and the mode and purpose of interaction and tool support.

In last section the comparative analysis of the proposed review process is done with existing review process.

4.2. Proposed Review Process

Proposed review process is especially designed to address the problems exists in current review processes. Proposed process has incorporated all the three major phases which are present in existing review processes i.e. initiation phase, evaluation phase and closing phase. Besides all these three phases the proposed review process has introduced another phase i.e. pre-initiation phase.

The proposed review process has introduced an efficient way to conduct review meeting which saves the reviewers' precious time. Proposed suggestion of the meeting decreases the load of the reviewers and handles the time availability problems of the reviewers.

Most important improvement suggested in this process is the postmortem asking about future improvements.

4.2.1. PHASES OF PROPOSED REVIEW PROCESS

Proposed review process consists of four major Phases pre-initiation phase, initiation phase, evaluation phase and closing phase. Each major phase has some associated sub-phases.

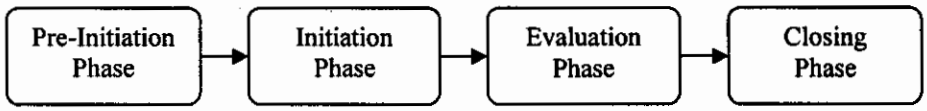

Figure 4.1. Block Diagram of Proposed Review Process

In this section the review process is described on the basis of major phases, sub-phases and activities involved in them. The figure 4.2 gives the detailed overview of the process.

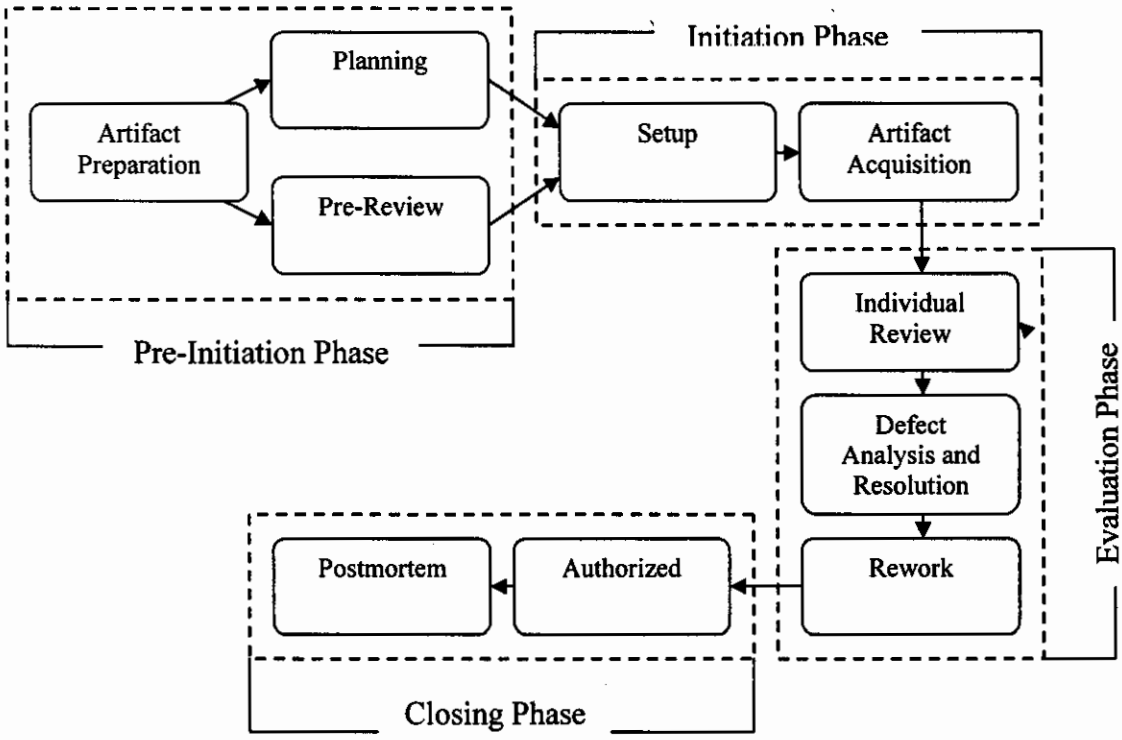

Figure 4.2. Model of Proposed Review Process

4.2.1.1. Pre-Initiation Phase

The purpose of this phase is preparation of artifact, planning the review activities and creating the artifact free of syntax, spelling and grammatical defects.

The pre-initiation phase has three sub-phases i.e. artifact preparation, pre-review and planning. The two sub-phases of the pre-initiation phase i.e. pre-review and planning runs in parallel. Main purpose of the pre-initiation phase is to leverage off the load of reviewers. In this phase pre-review of the artifact is done by the linguistic expert for finding and correcting the less critical defects related to syntax, grammar, spelling mistake and formatting style before distributing the artifact for review. This is one of the new features in proposed review process. The advantage of pre-review phase is that it saves the reviewers' time and reduces cost and time of the review process.

- **Artifact Preparation**

  The purpose artifact preparation is to perform the necessary preparation to make the artifact available to review. In this phase the author modified the artifact into review able form. He/She checks the format of the artifact and prepares the artifact i.e. if tool is to be use on review process the artifact will be converted to the format that is supported by the tool etc.

  In this phase author based on the artifact decides the linguistic expert and sends/provides the artifact to linguistic expert. Author also provides the defect report form to the linguistic expert to identified defects and the correction made to the artifact based on these defects.

- **Pre-review**

  In this phase the linguistic expert review the artifact for less critical defects for example mistakes of grammar, spelling, formatting style and syntax etc.

  Reason of performing pre-review before initiation phase is that there are general defects which do not need an expert reviewer, they should be found before passing the artifact for review. When author writes an artifact he/she might be in hurry create syntax, grammatical and spelling mistakes, these can be fixed in this phase at the spot by the linguistic expert.

- **Planning**

  The planning phase run in parallel with pre-review phase as the linguistic expert is not involved in planning phase.

  In this phase planning of the reviewers is done and it is planned that how many reviewers are needed to run the review process successfully (The number of

reviewers depends upon the complexity of the artifact). Leader selects the reviewers to review the artifact. There must be at least one domain expert among the reviewers (the number of domain experts depends upon the company budget and policy). Another purpose of this phase includes the planning of time for the completion of the review procedure. Leader with the help of author plans the division of artifact among the reviewers based on their expertise.

4.2.1.2. Initiation Phase

In the initiation phase the artifact is divided and distributed to the reviewers for review. Reviewers are notified about the artifact by the leader and he/she also gets the acknowledgement about receiving the artifact by the reviewers. The initiation phase has following sub-phases.

- **Setup**

  In the setup phase the leader divide the artifact into the parts according to the plan and distribute the whole artifact to all the reviewers with the specified allocated part. The whole artifact is distributed for the understanding purpose. Distribution of the artifact could be manual or with the tool depending upon the company policy. Reviewers also notified about the allocation and distribution of the artifact with the specified feedback time limit.

- **Artifact Acquisition**

  In this phase the reviewers acquire the artifact which is to be reviewed with their defined parts and specified time to give the feedback. The reviewers send the reverse notification about receiving the artifact to the leader.

4.2.1.3. Evaluation Phase

The purpose of the evaluation phase is to make artifact defect free. In the evaluation phase the artifact is individually reviewed for finding the defects. The defects are analyzed and are tried to be resolved using certain strategies. The sub-phases of the evaluation phase are as follows.

- **Individual Review**

  In this phase the reviewers individually review the artifact. Keeping in mind the benefits of individual evaluation and drawbacks of well discipline formal meetings this phase is proposed for defect detection.

  After reviewing the specified part of the artifact the reviewers give their feedback to the leader within the allocated time limit. In the feedback the reviewers sends the identified defect with the comments about the defects and the possible solutions.

- **Defect Analysis and Resolution**

  After getting the feedback from the reviewers the leader and author see the identified defects, analyze them and categorize them as less critical and critical defects. Based on the defects analysis they decide the ways towards the defect removal. If there are any defects which are accepted and need no discussion or meeting these are fixed without meeting and discussion.

  If the defects belong to the less critical defect category i.e. misconceptions or ambiguity they will be discussed with them individually in a synchronous (face to face interaction) or asynchronous (through telephone or e-mail) way.

If the defects belong to the critical defect category or the reviewers have the conflict between them. They will be discussed in the face to face meeting. The meeting doesn't require the presence of all the reviewers. Only those reviewers are compulsory to attend the meeting who have identified the defect, have conflicts or called by leader to attend the meeting.

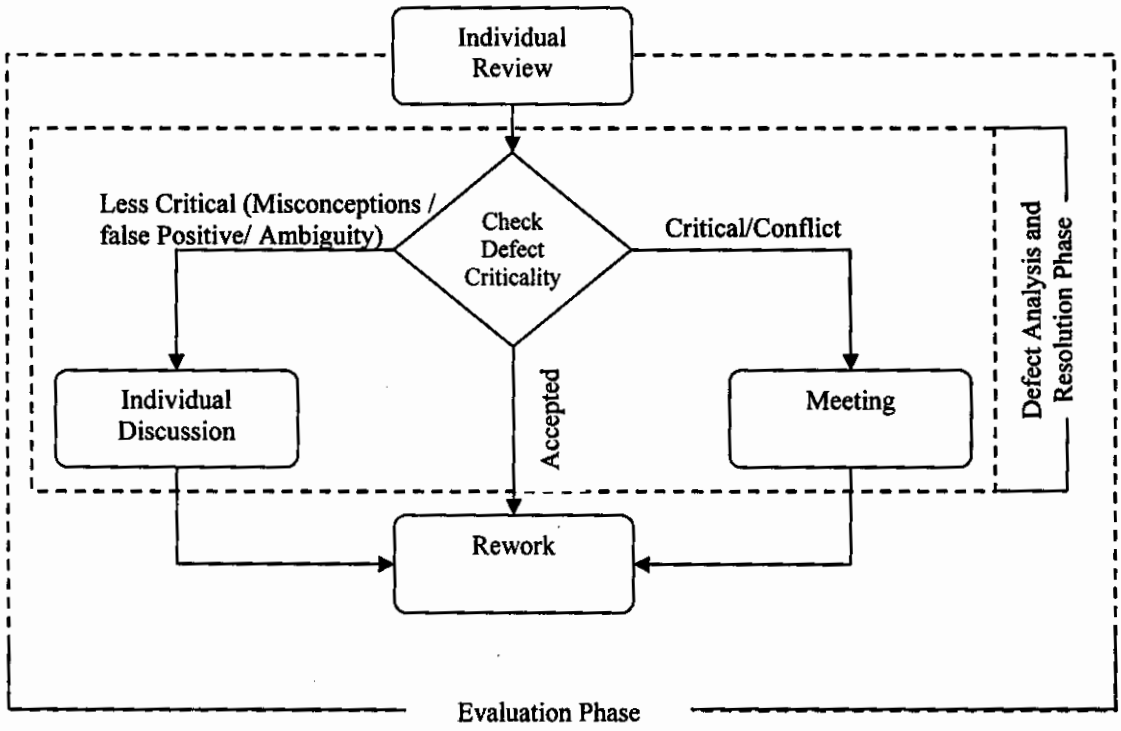

Figure 4.3. Logical Model of Defect Analysis and Resolution Phase

- **Rework**

In this phase the author based on identified defects, issues, recommendations, the results of the meeting and discussion if held fix the defects of the artifact. After defect fixation the artifact is send to the leader for authorization.

4.2.1.4. Closing Phase

The closing phase initiate when all defects and issues are resolved and based on it the rework is performed by the author. In the closing phase it is verified by the leader that whether all the identified defects are fixed by the author. The most important activity performed in this phase is the postmortem of the process and the artifact reviewed. The sub-phases involved in the closing phase are as follows.

- **Authorized**

  In this phase the leader verifies that all the changes have been made by author based on identified defects.

- **Postmortem**

  In this phase two types of the postmortems are performed i.e. postmortem of the review process followed and the postmortem of the artifact. In the postmortem of the review process the suggestion about the improvement of the review process are taken from the reviewers for improving the process. It also includes the analysis of the resources used during review process and the outcome of the review process.

  In the postmortem of the artifact the experiences of the reviewers are shared about the issues and defects identified and their solutions. The root causes of the defects are also identified and the suggestions to avoid similar type of defects in future projects are also discussed. This helps when the same type of the artifact comes under review in future.

  Postmortem phase can be conducted in different ways. It may be a synchronous meeting of short duration, offline interviews or survey questioners etc.

4.2.2. TEAM ROLES OF PROPOSED REVIEW PROCESS

Roles involved in the of the proposed review process are as follows.

4.2.2.1. Author

Main responsibility of the author is to prepare the artifact for review. Author helps the leader in the planning of the division and allocation of the artifact to the reviewers. Author does the rework and makes the changes in the artifact based on the identified defects, issues and the solution to those defects and issues. Author also participates in the discussions and meeting if held and required. Author also actively participates in artifact and review process postmortem for future improvements.

4.2.2.2 . Leader

Leader must be the defect analyst and the review expert plans and manages the review process and its recourses. Leader with the help of author does the division and allocation of the artifact to the reviewers. Leader also performs the authentication of all the changes made by the author. During the defect analysis phase the leader analyzes the defect and decide them as critical and less critical with the help of author. Based on this analysis he/she along with the help of author do the discussions and meeting. Leader also participates in the postmortem phase.

4.2.2.3 . Linguistic Expert

Linguistic expert performs the pre-review of the artifact after artifact preparation in the pre-initiation phase. He/She review the artifact for detecting and fixing the syntax, spelling and grammar related less critical defects at the spot before passing the artifact to the evaluation phase. He/She fill in the defects report form for the identified defects and correction made.

The work of linguistic expert leverages off the load of the expert reviewers and help them utilizing their precious time for detecting critical and less critical defects. The linguistic expert can work on multiple projects at the same time.

4.2.2.4. Reviewer

Responsibility of the reviewers is to identify defects individually from the allocated part of artifact. Number of reviewers depends upon the company budget, policy and size and complexity of the artifact. The suggested number of reviewers is five to six as it is proved from the literature that if team size increases from six the review effectiveness decreases.

One of the reviewers in the team should be domain expert and he/she has to check the appropriateness of artifact with respect to the domain. Reviewers also take part in the postmortem phase by sharing their experiences about the review process, artifact under review, identified defects their solutions and root cause of the identified defects. They also give the suggestion for future improvements.

PHASES	TEAM ROLES			
	Author	Leader	Linguistic Expert	Reviewers
Artifact Preparation	✓			
Planning	✓	✓		
Pre-Review			✓	
Setup		✓		
Artifact acquisition		✓		✓
Individual Review				✓
Defect Analysis and Resolution	✓	✓		✓
Rework	✓			
Authorized		✓		
Postmortem	✓	✓	✓	✓

4.2.3. MERITS AND DEMERITS OF PROPOSED REVIEEW PROCESS

Proposed review process is asynchronous with dual review activities. The reviewers have to review the specified portion of the artifact and they are responsible for that part only. First review is performed by linguistic expert in pre-initiation phase. This review runs in parallel with the planning phase so it does not consume extra time. This activity provides two fold advantages i.e. it helps in reducing the time taken by reviewers for defect detection and it also save cost.

Another advantage of the proposed process is that reviewers review the artifact individually at their own places without having problem of getting together for review at same time and place.

The involvement of domain expert in review team proposed by review process help in focusing the most critical defects and flaws related to design and overall working of the system. Another improvement done in the process is the introduction of leader role that should be the defect analyst and review expert. He/She with the help of author analyze the defects collected from individual review activity. They removes the false positive, discuss less critical defects with the person who has identifies them and discuss and resolves the critical defects in meeting.

The most important work done in the process is the introduction of the synchronous and efficient meeting procedure, which mean that synchronous meeting should be held in case of critical defects and conflicts, where the presence of all reviewers is not necessary. Only the reviewers who have identifies the defects, have conflicts or called by the leader are essential to attend the meeting. For other members it is not necessary to attend.

This meeting procedure helps in time save, as the purpose of the meeting is neither defects detection nor discussion of all defects with all reviewers. It also reduces the issues

related with the traditional meetings that are well disciplined, multiple small meeting, and meeting for defect detection or for discussion of all defects that lasts for large duration.

The postmortem phase introduced in the process helps to learn from the experiences. The member shares each others views. They recognize and identify hidden issues and problems. All the members sit together and try to find out the root cause of the defects that were identified during the review. The postmortem phase helps in two ways. It improves the defect detection of similar type of artifact in future and it also provides ways to think for future improvement of the review process.

Instead of all these benefits of the proposed review process there are some limitations of the proposed review process, like currently no supporting tool is available, only Asynchronous synchronous software inspection supporting tool can be adopted in this process as it is custom build tool and it can work with any review process. The post mortem phase is not mature and it needs to be improved. The proposed review process lacks the open communication between the reviewers as compared to the meeting based review processes but it utilized the meeting time for effective purpose.

4.2.4. TOOL SUPPORT

Conventional software review processes were manual and they require impersonal physical well discipline review meeting. To overcome the problems associated with the meeting based defect detection. Individual review processes was suggested by different researchers. After recognizing that the individual evaluation gives better results, the research regarding the asynchronous interaction of reviewers increases. Since then large researches has been performed to develop tools which provide asynchronous review facility to the reviewers. There are number of tools available currently which supports different review processes (Mishra & Mishra, 2007). The table 4.2 summarizes the tools and the feature they support.

- Intelligent Code Inspection in a C Language Environment (Brother's et al., 1990).
- Inspecting software in phases to ensure Quality (Knight & Myers, 1993).
- Collaborative Software Inspection (Mashayekhi et al., 1993).
- Scrutiny (Gintell et al., 1993).
- Collaborative Asynchronous Inspection of Software (Mashayekhi et al., 1994).
- Computer Supported Collaborative Review (Johnson, 1994).
- Asynchronous/Synchronous Software Inspection Support Tool (MacDonald & Miller, 1997).
- Web based Asynchronous Software Inspection Tool (Nwesri & Ahmad, 2000).
- Group Systems (Van Genuchten et al., 2001).
- Groupware-supported Inspection Process (Halling et al., 2001).
- Asynchronous Inspector of Software Artifacts (Stein et al., 1997).
- hyperCode (Perpich et al., 1997).
- Web inspection Tool (Harjumaa & Tervonen, 1998).
- Web-based Inspection Process Support (Laitenberger & Dreyer, 1998).
- XML Annotation Tool for Inspection (Hedberg & Harjumaa, 2002).
- Internet Based Inspection System (Lanubile & Mallarado, 2002).
- T Tool (Mishra & Mishra, 2007).

Tools	Artifact	Meeting	Voting	Reading Support	Data Collection	Defect Classification	Introduced by	Year
ICICLE	Source code	sync.	No	Adhoc	Yes	Yes	Brother's et al.	1990
InspecQ	Any	sync.	No	checklist	No	No	Knight and Myers	1993
CSI	Any	sync.	No	Adhoc	Yes	Yes	Mashayekhi et al.	1993
Scruitiny	Any	sync.	Yes	Adhoc	Yes	Yes	Gintell *et al.*	1993
CAIS	Any	Async	Yes	checklist	no	Yes	Mashayekhi et al.	1994
CSRS	Any	No	Yes	checklist	Yes	Yes	Johnson	1994
ASSIST	Any	Sync /async	Yes	checklist	Yes	Yes	MacDonald and Miller	1997
WASIT		Async	yes	Adhoc	yes		Nowesri and Ahmad	2000
GSS	Any	sync.	Yes	Adhoc	no	No	Van Genuchten *et al.*	2001
GRIP	Any	sync.	Yes	Checklist /scenario	Yes	Yes	Halling et al.	2001
AISA	Any	Async	Yes	Adhoc	no	Yes	Stein et al.	1997
WiP/WiT	Any html doc	Async (optional)	No	checklist	no	Yes	Harjumaa and Tervonen	1998
WIPS	None	sync.	No	Adhoc	no	Yes	Laitenberger and Dreyer	1998
XATI	Any html doc	No	No	checklist	Yes	Yes	Hedberg and Harjumaa	2002
Hypercode	Source code	No	No	Adhoc	no	No	Perpich et al.	1997
IBIS	Any	Sync/async (optional)	Yes	Checklist/ scenario	Yes	Yes	Lanubile and Mallarado	2002
T Tool	Any	Asunc	no	checklist	yes	yes	Mishra and Mishra	2007

The Asynchronous / Synchronous Software Inspection Supporting Tool (ASSIT) is developed by MacDonald and Miller (1997). It can be used with the proposed review process as it focuses on distributed environment and support any review process for any type of artifact. It is designed with custom based process language called IPDL

(Inspection process definition language). It supports both individual and group based review activity. Asynchronous / Synchronous Software Inspection Supporting Tool provide facilities to the reviewers like checklist, data collection and data classification. It supports both synchronous and asynchronous activities.

4.3. Comparative Evaluation Of Proposed Review Process

This section provides the detailed comparative evaluation of the proposed review process with existing review processes. The study has tried to minimize the issues and problems related to existing review processes. They were comparatively analyzed based effectiveness factors presented in detail in chapter 2. To overcome the issues related to them an effective and efficient review process is proposed for reviewing the artifacts. The comparative analysis of the proposed process is performed on the basis of the following effectiveness factors i.e. Review Procedure, Interaction mode and purpose, Team structure.

4.3.1. EVALUATION BASED ON REVIEW PROCEDURE

Many review processes have been presented by researchers since 1976 to enhance the quality of software. All of them have introduced different procedures to perform review of the artifact. Review processes introduced until now consists of three major phases i.e. initiation phase, evaluation phase and closing phase. Each of these phases has associated sub-phases. Every researcher has tried to provide effective combinations of sub-phase (activities) for review process. Most of them have focused largely on the evaluation phase of the review process and little work has been done on the initiation phase and closing phase.

Researchers have tried to improve defects detection rate through different combinations of activities. They have mainly focused on the improvement of evaluation phase. Some

pre-reviewed by linguistic expert is reviewed again. Due to pre-review phase the evaluation time decreases. This is proved from the experiment performed with undergraduates. The experimental details are provided in the chapter 5.

The evaluation phase of the proposed review process has provided three main phases i.e. individual review phase, defect analysis and resolution phase, rework phase. In the individual review phase the reviewers individually evaluate the artifact for defect detection. During this phase the reviewers focus more towards finding the critical defects because most of the less critical defects are identified and fixed in the pre-review phase. In the defect analysis and resolution phase unlike other processes the defects identified by reviewers are analyzed by the leader and not with the group of reviewers. Based on the defects criticality the defect are resolved synchronously or asynchronously.

In the closing phase the proposed review process has introduced the postmortem phase. The purpose of postmortem phase is to provide the improvement suggestion for the process like resource usage for particular type of projects etc. It is not restricted to the meeting it can be conducted through several ways i.e. through interviews, questioners, e-mail etc. Table 4.3 provides the clear sight of comparison of activities conducted between proposed and exiting review processes.

Review Process	Pre-Initiation Phases	Initiation Phases	Evaluation Phases	Closing Phases
Fagan's Review Process	.....	Overview➢	Preparation➢ Meeting➢	Rework➢ Follow-up
ADR	.....	Overview➢	Review➢ Meeting➢	Rework
N-Fold Review Process	.....	Planning➢ Overview➢	1...N Parallel Review➢ Collation➢	Rework➢ Follow-up
Gilb and Graham Inspection Process	.....	Entry➢ Planning➢ Kick off➢	Checking➢Logging➢ Brainstorming➢	Rework➢ Follow-up
FTARM	.....	Setup➢ Orientation➢	Private Review➢ Public Review➢ Consolidation phase➢ Group Review➢	Conclusion
Simplified Software Review Process	.....	Setup➢ Orientation➢	Private Review➢ Control Review➢ Meeting➢	Rework➢ Follow-up➢ Exit
Light weight Review Process	.....	Overview➢	Preparation➢ Meeting➢	Rework➢Follow-up
Proposed Review Process (EHRP)	Artifact Planning Preparation ➢ ➢ Pre-Review	Setup➢ Artifact Acquisition➢	Individual Review ➢ Defect analysis and Resolution ➢ Rework ➢	Authorized ➢ Postmortem

4.3.2. EVALUATION BASED ON INTERACTION MODE (MEETING) AND PURPOSE

Interaction mode (Meeting) refers to the way by which the review team members interact with each other. It can be synchronous or asynchronous. Literature shows that the synchronous meeting has its importance it can be formulized but can't be eliminated. Meeting modes suggested by different researchers were synchronous either with compulsory presence of all the reviewers, optional for the reviewers to attend the meeting or asynchronous. Purposes of the synchronous interaction mode suggested by different researchers were group defect detection, individual defect discussion with author, creation of unique defect list and defect collection.

4.3.2.1. Issues with the Synchronous Interaction Mode (face to face meeting)

This section discusses the issues present in the current review meetings.

- **Well Disciplined Meetings**

  Well disciplined review meetings are labor intensive, time consuming and require large resources. Persons having leader or moderator role turns the meeting into presentation. The personality and ego conflict problem arises in the well disciplined review meetings. Mostly the well disciplined meetings are dominated by one person who could be the moderator, leader or one of the reviewers who has dominating personality.

- **Multiple Small Meetings**

  Multiple small meetings for defect detection can be costly as require large human resources, time and contain overlapping defects. It takes extra time to eliminate the duplication and increases the cost of the review process. It also increases the load on the moderator to collect the defects from number of teams and eliminate the duplicates. It is difficult for moderator to coordinate with multiple teams participating in multiple meeting.

- **Meetings which Require the Presence of all the Reviewers**

  Meeting that requires every member to attend can be problematic. The reason is that all reviewers have to meet at the same time and same place. The reviewers' availability problem cannot guarantee an effective review meeting. It also wastes the time of those reviewers who have no conflict with the author.

- **Meetings Optional for Members to Attend**

  Meeting which are left open for member to attend or not, can fail when the person who have identified the defect and have conflict cannot attend the meeting.

- **Meetings Held for Defect Detection**

  If the purpose of the meeting is defect detection then it might happen that efficiency of different reviewers is different. Some reviewers can be efficient in reviewing and review faster other might take time to review. This efficiency differentiation can decrease the defect detection rate and increase the review meeting time.

- **Meetings Held for Defect Collection**

  Meetings for this purpose also require large time to complete. In these meetings the collection of defects, removal of duplicate and false positive takes place. Another problem is that no discussion of detected defects takes place with reviewers, this can increase the load of author due to ambiguity and misunderstanding of detected defects.

- **Meetings Held for Discussion of all Detected Defects**

  This type of meetings can be costly in term of time spent for it. As all the defects which were identified during individual checking are discussed in the meeting the meeting time can be lengthy. It may happen that the critical and most important defects may be neglected because of the detailed discussion on the minor defects.

Large amount of work has been done with respect to meeting but still there are issues with them as mentioned above. Meeting procedure proposed in the proposed review process can be a good attempt to reduce the above issues.

In the proposed review process the defects identified by the reviewers individually are analyzed by the leader. He/She categorize them and decide the next step towards defect removal. After analysis the defects which belong to less critical category are discussed with the person who has identified the defect. This discussion doesn't require face to face meeting. It can be done asynchronously. But if the defects belong to critical defect category i.e. the defect that the can cause the system failure are discussed in a short face to face meeting. This short meeting is not well disciplined, not for defect detection, collection and discussion of all type of defects even does not requires the presence of all reviews. Only the reviewers having the conflict, have identified critical defects or called by leader must have to attend the meeting. The advantage of such meeting is that it cannot waste the time of those reviewers whom have no conflict. The meeting time is also short. It does not require large resources. The comparison of proposed meeting procedure summarized in table 4.4.

Table 4.4 Comparative Evaluation Based on Interaction Modeling Concepts

Review Processes	Meeting Held	Meeting Session	Meeting Purpose	Meeting Type
Fagan's Review Process	Yes	Single	Defect Detection	Sync
ADR	Yes	Multiple	Discussion of all defects	Sync
N-Fold Review Process	Yes	Multiple	Defect Detection	Sync
Gilb and Graham Inspection Process	Yes	Single	Defect Collection, Remove false positive	Sync
FTARM	Optional	No	Discussion of all unresolved issues	Sync / Async
Simplified Software Review Process	Yes	Single	Discussion of all defects, Remove false positive	Sync / Async
Light weight Review Process	Yes	Single	Defect Detection	Sync / Async
Proposed Review Process (EHRP)	In case of critical defects & conflicts	Single	Discussion of critical defects only	Sync / Async

4.3.3. EVALUATION BASED ON TEAM STRUCTURE

The team structure as described in chapter3 consists of team size, role assignment and individual expertise level. Many researchers have provided an effective team size. The most optimal team size found in literature is five to six. The team size in the proposed review process is not fixed but suggested as six members. Roles assignment with respect to different researcher view point is also described in chapter 3. There is not much disagreement regarding roles in different review processes. According to Land et al. (2000) the role has not significant effect on the review process.

Proposed roles for the proposed review process (EHRP) author, linguistic expert and leader and reviewers. The benefit of having linguistic expert is to minimize the load from the reviewers. Linguistic expert performs pre-review before passing of artifact to the reviewers. Leader (defect analyst) with the help of author analyzes the detected defects and decides the interaction mode. The reviewers review with more focus towards finding the critical defects during individual review.

Considering the individual expertise level the proposed review process have introduced leader role with defect analysis and review expertise capabilities. None of the process so far has suggested such role. There should be at least one person in the review process who has the experience in the defect analysis. The benefit of having a defect analyst in a team is that he/she easily analyze the defect categories and based on it he/she decide to move forward successfully towards the defect resolution.

On the other hand one of the reviewers should be domain expert to find out the flaws related to domain. Because mostly the domain related defects are critical and they lead the project to dump. If these defects are not identified in the initial phases they can cause the project failure. Table summarizes the evaluation of proposed team structure via comparative analysis with existing structures.

Review Process	Domain Expert Considered	Roles
Fagan's Review Process	No	Author, Moderator, Reader, Recorder, Reviewer
ADR	Yes	Author, Reviewer
N-Fold Inspection Process	No	Author, Moderator, Reviewer
Gilb & Graham Inspection Process	No	Author, Leader, Checker, Scribe
FTARM	No	Producer, Moderator, Reviewer
Simplified Software Review Process	Yes	Author, Leader, SQE, Reviewer
Light Weight Review Process	No	Producer, Consumer, Independent Reviewers, Operational Manager
Proposed Review Process (EHRP)	Yes	Author, Leader, Reviewers, Linguistic Expert

CHAPTER 5

EXPERIMENTAL EAVALUATION

This Chapter provides the detailed description of the experiment performed to evaluate the proposed review process. It has following sections.

- **5.1.** *'Introduction'*: This section states the needs of the experiment performed using different review processes.
- **5.2.** ***'Experiment definition'***: This section gives the description of the experiment with its purpose and objective.
- **5.3.** ***'Experimental Preparation'***: This section describes the experiment preparation in detail.
- **5.4.** ***'Experiment Planning'***: This section states the planning of the experiment needed before its execution.
- **5.5.** ***'Experiment Execution'***: This section gives the detailed description of the execution of experiment.
- **5.6.** ***'Data collection and Analysis'***: In this section the data collection and its analysis to find out the results is described.

5.1. INTRODUCTION

Software Reviews are the most important way to make the artifact defect free at earlier stages. It is a way through which the number of detected defects increases within small amount of time. In this fast software development world it is not practical to conduct large reviews, which heavily relies on the presence of all members of review team for defect detection or discussion. It is impractical to call all members of the review team even for discussion of defects. It is very important to have some means in which all reviewers are not required to attend the meeting at the same time and place for defect detection or discussion, because it is impractical to call the reviewers whom have no concern with identified defects. Moreover there is a need to have some procedure in software review process through which the member get to the table and provide their suggestions for further improvements.

Numbers of researchers have suggested different review procedures, meeting suggestion and team structure but there are needs left behind such as

- To increase the defect detection rate through an effective review procedure
- To increase the reviewers' focus on most critical defects.
- To reduce the total time of review process.
- To reduce the effort spent by reviewers in defect detection.
- To conduct an efficient review meeting.

To fulfill these needs, the review process has been proposed named as Effective Hybrid Review Process (EHRP). This chapter describes the experiment conducted to verify the proposed review process. The experimentation is an important way to measure the performance and effectiveness of the review process (Basili et al., 1986), (Basili et al., 1998). Performing the experiment provides confidence in assumption about benefits and weaknesses of a process.

This chapter describes the hypothesis, experimental variables, experimental design, subjects participating in the experiment, details of execution of experiment, threats to the validity of experimental design. At the end the collection of data and its analysis performed to answer the research questions.

5.2. Experiment Definition

Experimentation refers to performing empirical studies in software engineering. It has the objective to evaluate strengths and weaknesses of processes and techniques that support software development.

Sometimes it is very difficult for experimenter to get the desired results because of variation sand differences in human capabilities. Experiments in software engineering field have to deal with the low number of subjects. The main reason behind this is that the use of professionals as subject is expansive. The economical limitations can be obstacle in performing experiments with professional.

The experiment described in this chapter compares the effectiveness of the different review processes. It also compares the meeting procedures used in different exiting review processes as well as the proposed review process. It compares following cases of meeting.

- Meeting held with the purpose of defect detection, where the presence of all reviewers is necessary.
- Meeting held with the purpose of discussion of defects which are detected individually by reviewers to remove false positive, where the presence of all reviewers is necessary.
- Meeting held with the purpose of discussion of critical defects only identified by reviewers individually, where the presence of all reviewers is not necessary.

5.3. EXPERIMENT PREPARATION

This section provides the detail of necessary preparation performed to conduct the experiment i.e. details related to the subject involved in the experiment and the review material provided during the experiment etc.

5.3.1. SUBJECTS

Subjects are the persons who participate in the experiment. In this experiment the students acted as subjects. The result of the experiment also depends upon the selected persons for the experiment. Besides the selection of review procedure they must also be selected with great care.

There were 18 subject enrolled in BCS honors program (NIIT, Islamabad). The subjects were selected on the basis of background assessment form, which were given to them to know about their educational background before selection. They were selected on the basis of their working experience in software industry and courses they have previously studied or studying currently. The background assessment form is attached in the Appendix B6. This form provided the detailed information of the subjects with respect to their education, working experience in software industry, interested courses, courses studied and studying currently. These details helped in selecting the most suitable students for the experiment. All the subjects had taken software EngineeringI, in their previous semesters and currently studying software EngineeringII, Most of the students had worked on the Automated Teller Machine (ATM) system development with the documentation in their previous semester. Many of them had internee level working experience in the software industry.

5.3.2. REVIEW MERETIAL

Review Material provided to the subject for review was

- **Software Requirement Specification of Automated Teller Machine (ATM)**

  Software requirement specification of the automated teller machine was written in natural Language (English). It was small enough to be usable in an experiment. It consists of 5 pages. The artifact specified the detailed requirement of automated teller machine.

- **Defect Report Form**

  Defect report forms were provided to all the subjects. In the case of group defects detection single defect report form was provided to the subject, acting as group moderator. In the case of individual checking every individual reviewer was provided separate defect report form.

5.3.3. DEFECT CLASSIFICATION

Defect can be anything that might cause the system to behave differently from the expectation. Inconsistency, incorrectness, ambiguity, incompletion can be the defect. Language defect can be grammatical or problems in wording structure etc. There can be functional defects which cause problems in functionality of the system, which results in its failure.

Defects classification characterizes the defects, based on their severity and impact on the quality of the software. Number of different defect classification types suggested by different researchers. The following defect classification scheme was constructed in the thesis.

5.3.3.1. Critical Defects

Critical defects are those defects which cause an application useless and system failure. Critical defects are consequential and can cause failure of system if not corrected in

requirement specification artifact. Their correction demands redesign of the software, if detect in later stages. They are expensive to handle at later stages of the development. They must be corrected at initial stages of the development in the software requirement specification artifact. Critical defects can be of the following type:

- Incorrect or missing functionality especially related to undesired output.
- Design related defects.

5.3.3.2. Less Critical Defects

Less critical defects can cause misinterpretation and ambiguity in understanding as a result they lead to serious flaws at the end of the development. If less critical defects are left they can take form of critical defects. It includes defects like:

- Spelling Mistake
- English Grammar Mistake
- Sentence defect that is incomplete or ambiguous sentence.
- Syntactical mistake
- Formatting style.
- False positives
- Misconceptions
- Missing functionality

The experiment is conducted with 20 seeded defects in requirement specification artifact of automated teller machine. This classification helped us to analyze the focus of the group on the type of defects during defect detection. Subjects were unaware of the defect classification. They were not required to classify the defects into classes. Leader (defect analyst) with author marked the defects into classes.

5.4. EXPERIMENT PLANNING

This section describes the necessary planning required to execute the experiment. It includes definition of variables for experimental study i.e. hypothesis description, experimental design and threats to the experimental study.

5.4.1. VARIABLES

There are two types of variables defined for the experiment i.e. independent variables and dependent variables. The aim of the study was to change the independent variables and study their effects on the dependent variables

5.4.1.1. Independent Variables

Independent variables are the variables that determine the experimental results. They have the effect on the dependent variables (Wohlin et al., 2000). Following independent variables have been used in the experiment.

- **Review Procedure**

  Different review processes has introduced different procedures for reviewing the artifact. The independent variable, review procedure was changed with respect to review process and the dependent variable was analyzed.

- **Interaction Mode**

  Interaction mode refers to impersonal physical interaction of subjects or online discussion using tools. It was not studied and changed because of the resource limitation. The experiment was done totally manually.

- **Interaction Purpose**

  Interaction purpose refers to the reason of review meeting. There can be different purposes of the meeting held in a review process. This independent variable was manipulated by changing the purpose. The effect of change was studied by analyzing dependent variables.

- **Team Structure**

  Team structure contains number of independent variables that is the team size, role assignments and individual expertise. The effect of independent variables, role assignment and individual expertise was studied with the help of dependent variables.

5.4.1.2. Dependent Variables

The dependent variables represent the outcome of the experiment. They are the variables whose values can change with the change of independent variables (Perry et al., 2000). They are not manipulated in the experiment. They are only measured to find out the results of the experiments. The values of dependent variables are analyzed to validate the hypothesis. Following are the dependent variables categories.

- **Review Process Effectiveness**

  Review process effectiveness refers to how many defects identified by using a particular review process.

Effectiveness can be measured as:

$$\text{Effectiveness} = \frac{\text{No. of defects identified}}{\text{Total No. of defects in artifact}}$$

- **Total Number of Defects Identified (by each group)**

  Total number of defects identified by a particular group can be calculated as:

  Total Number of defects identified by Group(x) =
  Total No. of (Critical +Less Critical) defects identified by Group(x)

- **Ratio of Defects Identified (by each group)**

  Ratio of defects identified by particular group can be calculated as:

  Ratio of defects identified by Group(x) =

$$\frac{\text{Total No. of defects identified by Group(x)}}{\text{Total N o. of defects in artifact}}$$

- **Number of Critical Defects Identified (by each group)**

  Total number of critical defects identified by every group can be calculated to analyze focus of every group towards this class of defect.

- **Ratio of Critical Defects Identified (by each group)**

  Ratio of critical defects identified by particular group is calculated as:

Ratio of critical defects identified by Group(x) =

$$\frac{\text{Total No. of Critical defects identified by Group(x)}}{\text{Total No of Critical defects in artifact}}$$

❖ **Number of Less Critical Defects Identified (by each group)**

Total number of less critical defects identified by every group can be calculated to analyze focus of every group towards this class of defect.

❖ **Ratio of Less Critical Defects Identified (by each group)**

The ratio of less critical defects identified by particular group can be calculated as:

Ratio of less critical defects by Group(x) =

$$\frac{\text{No. of less critical defects identified by Identified by Group(x)}}{\text{Total No. of less critical defects in artifact}}$$

- **Efficiency of Review Process**

Efficiency is defined as number of defects detected per hour. It is measured as:

$$\text{Efficiency} = \frac{\text{No. of defects identified}}{\text{Time (min) spent for defect detection}} * 60$$

❖ Time spent for complete review process (by each group)

- ❖ Time spent for pre-initiation phase (by Group3)
- ❖ Time spent for initiation phase (by each group)
- ❖ Time spent for evaluation phase (by each group)
- ❖ Time spent for ~~initiation~~ phase (by each group)
- ❖ Time spent for closing phase (by each group)
- ❖ Time spent for defect detection (by each group)

5.4.2. HYPOTHESIS

Hypothesis refers to the supposition made to draw out and tests its end results (Basili et al., 1998). Reason of stating the hypothesis is that, it clearly shows what an experimenter wants to evaluate in the experiment. To evaluate the hypothesis the dependent variables are scrutinized. These hypotheses were evaluated to find their consequences.

5.4.2.1. Hypothesis for Review Process Effectiveness

The following hypothesis considers the overall effectiveness of the groups participated in experiment to perform review using different review processes.

H_{01}: All groups (Group1, Group2 Group3) are equally effective

H_{A1}: All groups (Group1, Group2 Group3) do not have same effectiveness.

The above hypothesis compares the groups that whether all groups are equally effective or all groups do not have same effectiveness.

The following hypothesis consider the defect detection effectives of groups participated in experiment

H_{02}: Total number of defects identified by Group3 is greater than Group1 and Group2

H_A2: Total number of defects identified by Group3 is less than Group1 and Group2

As the defects divided into two categories (critical and less critical) the total number of defect can be found by summing up the critical defect and less critical defects. So for this purpose we have to identify critical and less critical defects found by every group and compare their effectives. The following hypotheses compare the critical and less critical defects effectiveness with respect to each group.

$H_0$3: Total number of critical defects identified by Group3 is greater than Group1

H_A3: Total number of critical defects identified by Group3 is less than Group1

$H_0$4: Total number of critical defects identified by Group3 is greater than Group2

H_A4: Total number of critical defects identified by Group3 is less than Group2

$H_0$5: Total number of less critical defects identified by Group3 is greater than Group1

H_A5: Total number of less critical defects identified by Group3 is less than Group1

$H_0$6: Total number of less critical defects identified by Group3 is greater than Group2

H_A6: Total number of less critical defects identified by Group3 is less than Group2

$H_0$7: Domain expert in a group can detect more critical defects.

H_A7: Domain expert in a group can not detect more critical defects.

5.4.2.2. Hypothesis for Review Process Efficiency

The following hypothesis considers the overall efficiency of the groups participated in experiment to perform review using different review processes.

$H_0$8: All groups (Group1, Group2 Group3) are equally efficient

H_A8: The efficiency of Group3 is more than Group2 and Group3.

$H_0$9: Meeting held for critical defect discussion are efficient than meeting for either defect detection or discussion of all defects.

H_A9: Meeting held for critical defect discussion are not efficient than meeting for either defect detection or discussion of all defects.

5.4.3. DESIGN

Experiment was conducted with three groups each group consists of 6 subjects. Total number of subjects who participated in experiment was 18. Division of the subjects into three groups was based on the requirement of the review process which will be used in experiment. Subjects have to perform review of requirement specification artifact of automated teller machine using Fagan's review process, Simplified software review process and proposed review process (EHRP). Fagan's review process does not consider expert in their review team and the other review processes do consider. The subject with knowledge and experience of the automated teller machine was the member of other two review processes except the Fagan's process. The experience and knowledge of subjects with respect to automated teller machine was analyzed by the background assessment form filled by the subjects before the selection for experiment.

Once the background and knowledge of subjects was analyzed they were selected and divided into groups. After division each group was allotted review process with which they had to review the requirement specification artifact of automated teller machine. Group1 performed review with Fagan's review process which is well disciplined meeting based review process, Group2 performs review with Simplified software review process which emphasized on small meeting for discussion of all detected defects and the Group3 performed review with proposed review process (EHRP) which emphasized on pre-review before initialization of review process and meeting for the discussion of critical defects only. Each group had to review the requirement specification artifact of automated teller machine with the procedure given in the allotted review process. It was 5 pages long which contain 20 known defects shown in table 5.2 out of which 8 were critical defects and 12 were less critical defects.

Before the start of the experiment each group was given lecture and training regarding allotted review process. The overview and description of automated teller machine was not given at this stage because this task was part of the review process. The tables 5.1 and 5.2 show the experimental design and defects in the artifact.

Group No.	Review Process	No. of subjects	Artifact
Group 1	Fagan's Review Process	6	ATM
Group 2	Simplified Software Review Process	6	ATM
Group 3	Proposed review process (EHRP)	6	ATM

Critical Defects	Less Critical	Total defects
8	12	20

5.4.4. VALIDITY THREATS

Validity threats are factors that affect the dependent variables but are not like controlled independent variables. This section describes the internal and external validity threats to the experiment and measure to control them.

5.4.4.1. Internal Validity Threats

Internal validity threats are opposite description of the experimental findings that make the cause-effect relationship between dependent and independent variables (Wohlin et al., 2000). The source of internal validity threats are:

- **Selection**

  This threat is related to difference in performance of human being involved in the experiment. Every individual has his/her own characteristics for example proficiency in reading and understanding of English language etc. This threat was controlled by assignment of roles to the subjects with their relevancy. Subjects at the top grade and having experience with the domain of the artifact were selected to review using the review process which needs domain experts.

- **Learning Effect**

  This threat is due to the change of behavior of the subjects during experiment. It was reduced by similar training of all subjects, similar requirement specification artifact of automated teller machine and collection of defects report forms immediately after the review was over. Defects report form were collected immediately to avoid the time differences as well as to prevent any changes made by subject at last moment.

- **Instrumentation Effect**

  Instrumentation effect deal with the problem that differences in result occurs due to difference in review material provided to the subjects and the way the subject used the review material. As the review of same requirement specification artifact of automated teller machine was performed, thus we had overcome this threat.

- **Processes Conformance**

  It refers to the instruction followed by subject completely. It might be possible that subjects did not follow the procedure of review processes allotted to them for defect detection. We were confident that the reviewers did not switch from the assigned review process to another. We tried to control this threat by asking them to what degree they had followed the rules and instructions.

- **Exchange of Information**

  Exchange of information is great threat for the experiment results especially when conducted in academic environment. This threat was controlled by monitoring the performance of the reviewers all the time.

5.4.4.2. External Validity Threats

External validity threats refer to generalization of the results to industrial practice (Wohlin et al., 2000). Following external threats were analyzed for the experiment.

- **Representative Subjects**

  The most important threat for the experiment was use of students as the subjects, because most of them had not much working experience in the software industry. They had internee level experience. They were not professional software

engineers. The most of the subjects did not have professional experience and domain knowledge that an industry reviewer could have. Due to this we cannot say that the results of the experiment are generalized for industry environment.

We had not considered that threat as much as critical because many researchers had investigated the use of students as a subject in experiment and they had provided argument both for and against them (Wohlin et al., 2000). Wohlin et al. did not identify any difference in their efficiency.

- **Representative Artifact**

  Artifact selected for the review was also not representative of the industrial problems. Software specification report of automated teller machine that was provided for review to the subjects cannot be comparable with the real artifact.

5.5. Experiment Execution

Activities performed for the experiment was background assessment of subjects for selection purpose, training for gaining knowledge, and the review process execution by each group to review the same artifact provided to them. The purpose of reviewing same artifact was to evaluate the effectiveness and efficiency of each process from single level.

5.5.1. SUBJECTS BACKGROUND ASSESSMENT

Background assessment of subjects was the pre-requisite of the experiment. Every subject was provided background assessment form to fill. This form provided educational details of subjects, their strength areas, working experience and review experience. On the basis of this form not only the subjects were selected and divided into groups, they were also allotted the review processes based on their experience.

5.5.2. TRAINING

Students were provided the training related to the aims and objective of the experiment, general procedure of the experiment and the review processes they were used in the experiment. Brief overview of all the review processes was provided to respected groups. Training session continues for one hour. All the students were prepared for the experiment in one hour lecture. Overview of the requirement specification artifact of automated teller machine was not provided at this stage because this process could be held during the experiment and all students were supposed to have the knowledge about the automated teller machine system.

5.5.3. REVIEW EXECUTION

Subjects performed review in three groups using different review processes. Review of the artifact was progressed differently by different groups with respect to allotted review process. Group1 performed review with Fagan's review process, Group2 performed review with Simplified software review process and the Group3 performed review with proposed review process i.e. Effective hybrid review process.

5.5.3.1. Group1 Review

Group1 performed review with Fagan's review process. Among the six members one of the subjects was selected as author, based on experience and knowledge about automated teller machine and one of them was selected as moderator, based on his capabilities mentioned in the background assessment form. The subjects followed these phases.

- **Overview**

  In the overview phase small meeting was held between all the subjects. The moderator gave the overview of the artifact which was to be reviewed i.e.

requirement specification artifact of automated teller machine. Moderator selects one reader, and one recorder. Three left subjects acted as reviewers. Role assignment took place based on their capabilities. Review material i.e. requirement specification artifact of automated teller machine was provided to all the subjects. With the margin of preparation time the members were notified about the defect detection meeting time by moderator.

- **Preparation**

  After the overview meeting all the members were asked, to individually read the requirement specification artifact of automated teller machine for understanding purpose only. They were not allowed to detect defects at this phase.

- **Meeting**

  After the individual preparation all the member attended a meeting for defect detection purpose. Moderator managed the meeting. Subject selected as reader paraphrased the artifact. The subjects acting as reviewers found the defects and the recorder noted down the detected defects. Moderator gave the defect report form to the author.

- **Rework**

  Selected author performed the changes based on the defects identified in the meeting.

- **Follow-up**

  Moderator verified that changes have been performed. Then all of the members signed of the artifact. When the review process was completed, the defect report form and noted time duration of each phase was collected from the moderator.

5.5.3.2. Group2 Review

Group2 performed review using Simplified software review process. Among the six member of team, one was selected as leader, one as software quality engineer and the four members worked as reviewer. One of the researchers acted as author. Group2 followed following phases.

- **Orientation**

  In the orientation phase the reviewers got the requirement specification artifact of automated teller machine which was to be reviewed and defect report form. Reviewers were allotted part of the artifact to review.

- **Private Review**

  In the private review phase the subjects selected as reviewers individually reviewed the artifact and noted down the defects on defect report form.

- **Control Review**

  In the control review phase the author marked the collected defects as agreed, disagreed and discuss. Agreed category defects belong to the defects which were identified by the reviewers and actually present in the artifact. They were seeded defects. Disagreed category defects belong to the defects which were not present in the artifact. Discuss category defects belong to the defects which were identified by the reviewers but reflected their confusion.

- **Meeting**

  In the meeting phase all the members attended the meeting. The author read agreed defects for once only. The disagreed and discuss category defects were discussed in detail.

- **Rework**

  In the rework phase the author performed the changes to rectify the defects

- **Follow-up**

  The Subject selected as software quality engineer verified that changes have been made by author.

- **Exit**

  After verification the subject selected as software quality engineer exit the meeting.

5.5.3.3. Group3 Review

Group3 performed review using proposed review process i.e. Effective hybrid review process. Among the six selected subject for Group3 one was selected as linguistic expert, and one as leader (defect analyst) based on their knowledge which was assessed from the background assessment form. Subject having high domain knowledge were selected as reviewer for Group3. One of the subjects acted as author. Three left subjects acted as reviewers. Unlike other Groups the Group3 followed pre-initiation, initiation, evaluation and closing phases. The phases followed by Group3 are as follows:

- **Pre-Review**

  In the pre-review phase the subject selected as linguistic expert reviewed the artifact for less critical defects like spelling mistake, grammatical defects and wording structure etc. He/she performed changes to the artifact at the spot and note down the defects and changes made to the artifact.

- **Planning**

  In the Planning phase leader and author planned to divide the requirement specification artifact of automated teller machine with respect to the reviewers' expertise. This phase runs in parallel with the pre-review phase. When the planning and pre-review phases ended the author and leader finalized the division of artifact.

- **Setup**

  In the setup phase the leader and author finally divided the artifact with respect to reviewers' expertise. They distribute the artifact along with defects report form to each individual reviewer.

- **Individual Review**

  Subjects acting as reviewers performed individual review in this phase. They read the artifact, identified the defects and noted down the defects on the defect report form.

- **Defect Analysis and Resolution**

  After individual review the leader analyzed the defects together with author and marked them as critical and less critical defects. Detail of this defect

classification is described in section 5.3. They passed the critical defects for the meeting. Accepted defect was fixed in the rework phase by the author. Less critical defects were discussed individually with the person who had identified them. They were not discussed in review meeting.

- **Meeting**

  In the review meeting only those members were essential to participate who had identified the critical defects or required by leader to participate. Other members could also participate in discussion but not necessarily. Author and leader discussed the critical defect one by one with the reviewer who had identified them.

- **Rework**

  Author performed the necessary changes to the artifact.

- **Authorized**

  Leader verified the changes made by the author.

- **Postmortem**

  After authorized phase members were provided postmortem form. It contained the question regarding the review process improvement. They wrote down their experience about the review i.e. what issues and defect could mostly occur in such kind of system.

5.6. Data Collection and Analysis

Data of the experiment should be collected very carefully. It should be made sure that the data collection activity was performed correctly and data collected was valid. It was checked that all groups had filled the defect report form. Data in case of group meeting was collected by group defect report form, created by the recorder. In case of individual defect detection the data was collected by individual defect report form.

Once the data was collected the detailed analysis of data was performed. Data analysis was performed to evaluate the hypothesis concerning the effectiveness and efficiency of review procedure, interaction mode and purpose and team structure.

Regardless of the reading technique used for defect detection, the effectiveness of review process heavily depend upon the factors i.e. review procedure, interaction mode and purpose and the team structure. These factors had effect on the overall review process effectiveness and efficiency.

In the experiment the subjects were divided into three groups based on the review process they had to use. The analysis of the experiment was performed in the following steps.

- Review process effectiveness compared at group level to find out the differences among different group.
- Review process efficiency compared at group level to find out the differences among different group.
- The effect of team structure compared in different groups.

Important data for analysis was the defect report form and the calculated time of every phase of the review process .Defect report form submitted by each group showed the detail of the defects they had detected.

5.6.1. ANALYSIS OF REVIEW PROCESS EFFECTIVENESS

Review process effectiveness refers to how large numbers of defects identified by using a particular review process (Wohlin et al., 2000b)

To analyze the effectiveness of the review process dependent variables must be analyzed. Analysis of dependent variables is summarized in the table 5.3.

Table 5.3: Analysis of defects identified at Group Level

	Group1	Group2	Group3
Defect detection mode	Group	Individual	Individual
No. of defects identified	11	12	16
No. of defects missed	9	8	4
Ratio of defects identified	0.55	0.60	0.80
Ratio of defects missed	0.45	0.40	0.20
No. critical defects identified	3	5	7
No. of critical defects missed	5	3	1
Ratio of critical defects identified	0.38	0.63	0.87
Ratio of critical defects missed	0.63	0.38	0.23
No. of less critical defects identified	8	7	9
No. of less critical defects missed	4	5	3
Ratio of less critical defects identified	0.66	0.58	0.75
Ratio of less critical defects missed	0.33	0.42	0.25

Before comparing the effectiveness of each group we must analyze that whether there was any group effective. For this the following hypothesis was formulated.

H_{01}: All groups (Group1, Group2, Group3) are equally effective

H_{A1}: All groups (Group1, Group2, Group3) do not have same effectiveness.

Above hypotheses compares that whether all groups are equally effective or all group do not have same effectiveness.

The statistical test Cochran was performed to analyze the hypothesis. Test result showed that as the decision rule was Chi-square that the hypothesis Ho would be rejected, if the values calculated (Q) from the Cochran's test statistic would be greater than the tabulated (P). The t statistic showed that when Q=10 the P = 9.2 at df =5 (Q>P), α=0.10. So we rejected Ho of equal effectiveness and concluded that one group was more effective than others.

It was proved from the Cochran's test, that there is one group effective than the others. The next step was to find out the group who had detected large number of defects, while performing the review. To analyze this following hypothesis were analyzed.

H_{02}: Total number of defects identified by Group3 is greater than Group1 and Group2

H_{A2}: Total number of defects identified by Group3 is less than Group1 and Group2

As the total number of defects calculated by adding the total number of critical as well as less critical defects we had to analyze the critical and less critical defects identification effectiveness for each group. For this following hypothesis were investigated.

Overall hypothesis was that the total number of critical and less critical defects detected was greater in Group3 than Group1 and Group2. For performing the test, the hypothesis was divided as:

$H_{o}3$: Total number of critical defects identified by Group3 is greater than Group1

$H_{A}3$: Total number of critical defects identified by Group3 is less than Group1

$H_{o}4$: Total number of critical defects identified by Group3 is greater than Group2

$H_{A}4$: Total number of critical defects identified by Group3 is less than Group2

$H_{o}5$: Total number of less critical defects identified by Group3 is greater than Group1

$H_{A}5$: Total number of less critical defects identified by Group3 is less than Group1

$H_{o}6$: Total number of less critical defects identified by Group3 is greater than Group2

$H_{A}6$: Total number of less critical defects identified by Group3 is less than Group2

5.6.1.1. Number of Critical Defects Identified (by each group), Ratio of Critical Defects Identified (for each group)

There were 8 critical defects which were seeded before giving the artifact of automated teller machine to the subjects for review. Figure 5.1 shown below compare the number of critical defects detected by each group.

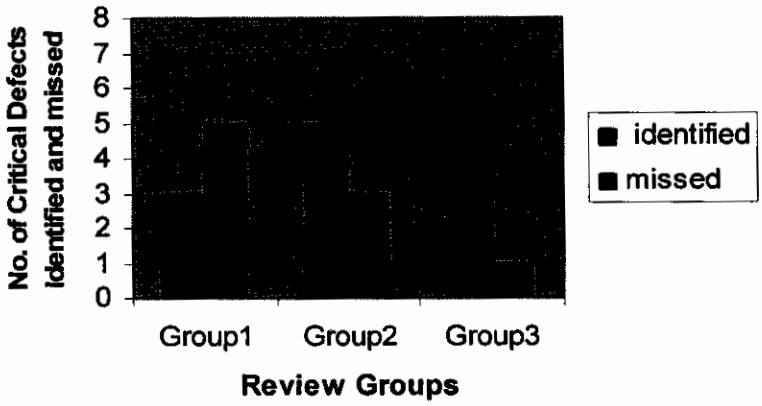

Figure 5.1. Comparison of No. of Critical Defects Identified and Missed by Each Group

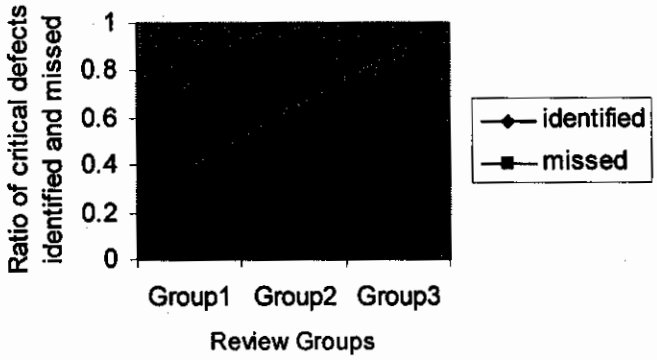

Figure 5.2. Comparison of the Ratio of Critical Defects Identified and Missed by Each Group

Total number of critical defects identified by every group could be calculated to analyze focus of every group towards this class of defect. Experimental result shown in table 5.3 shows that the Group3 had detected higher number of critical defects than Group1 and Group2. This shows that the subjects who had performed review with proposed review process had larger focus on finding critical defects. Graph shown in figure 5.1 presents the experimental result which clearly indicates the difference between three groups with respect to their focus on critical defect detection. Figure 5.1 shows the total number of

defects identifies by each group and figure 5.2 show the ratio difference among three groups. Group1 had identified 3 critical defects and missed 5 defects. Group2 and Group3 had identified 5 and 7 critical defects respectively and missed 3 and 1 critical defects. This shows the effectiveness of Group1 with respect to critical defect identification is 38%, Group2 has 63% and Group3 has 87 %.

To analyze the hypothesis ($H_0$3, H_A3), the Fisher exact test was performed on this data.

	Critical Defects Identified	Critical Defects Missed
Group1	3	5
Group3	7	1

Test results showed that at A=8, B=8, a=4 and at the significance level 0.05 critical value was 0.038, which was less then b (b=7, 7>0.038). As the test showed that at a=4 the critical value=0.038 and it increases as we moved up, so for a=3 the critical value must be low. Based on these results we accepted the hypothesis that total number of critical defects identified by Group3 was greater than Group1 and rejected the hypothesis that total number of critical defects identified by Group3 was less than Group1.

To analyze the hypothesis ($H_0$4, H_A4), the Fisher exact test was performed on the following data.

	Critical Defects Identified	Critical Defects Missed
Group2	5	3
Group3	7	1

Test results shows that at A=8, B=8 and a=5 and significance level 0.05 the critical value was 0.013, which was less then b (b=7, 7>0.013), so we accepted the hypothesis that total number of critical defects identified by Group3 was greater than Group2 and rejected the hypothesis that total number of critical defects identified by Group3 was less than Group2.

Above experimental results and the both Fisher exact test performed on the groups showed that the Group3 has detected more defects than Group1 and Group2 so the Group3 was effective with respect to critical defect detection.

5.6.1.2. Number of Less Critical Defects Identified (by each group), Ratio of Less Critical Defects Identified (for each group)

There were 12 less critical defects which were seeded before giving the artifact for review. Figure 5.3 shown below compare the number of less critical defects detected by each group.

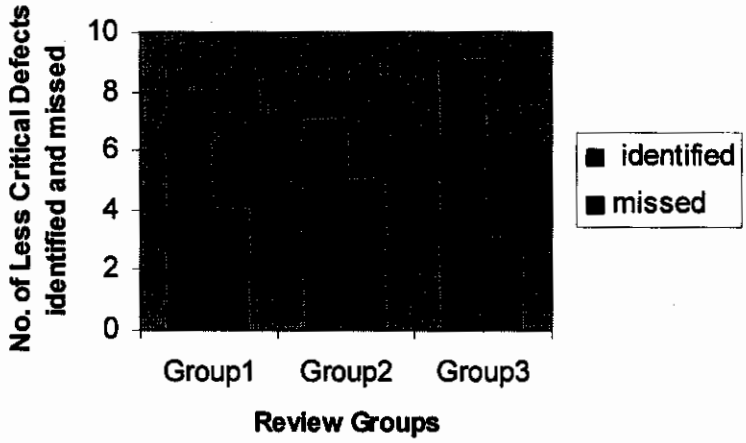

Figure 5.3. Comparison of the No. of Less Critical Defects Identified and Missed by Each Group

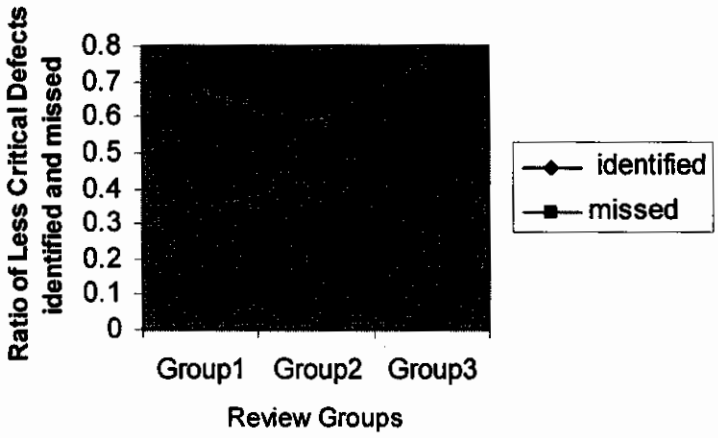

Figure 5.4. Comparison of the Ratio of Less Critical Defects Identified and Missed by Each Group

Total number of less critical defects identified by every group could be calculated to analyze focus of every group towards this class of defect. Like critical defect identification the graph shows effective results of Group3 with respect to less critical defects. Total number of less critical defects for Group3 was calculated by adding the less critical defect identified in pre-review phase and identified in individual review phase. Figure 5.4 shows the difference of less critical defect detection between three groups. Group1 which performed review with Fagan's review process did not show the significant results. It was also found from the graph shown in figure 5.4 that Group1 and Group2 had more focus on finding the less critical defects as compared to critical defects.

To analyze the hypothesis (H_{05}, H_{A5}), the Fisher exact test was performs on the following data.

	Less Critical Defects Identified	Less Critical Defects Missed
Group1	8	4
Group3	9	3

Fisher exact test results showed that at A=12, B=12, a=8 and at the significance level 0.05 critical value was 3.05, which was less than b (b=9, 9>3.05), so we accepted the hypothesis that total number of less critical defects identified by Group3 was greater than Group1 and rejected the hypothesis that total number of less critical defects identified by Group3 was less than Group1.

To analyze the hypothesis (H_{06}, H_{A6}), the Fisher exact test was performed on the following data.

	Less Critical Defects Identified	Less Critical Defects Missed
Group2	7	5
Group3	9	3

Fisher exact test results showed that at A=12, B=12 and a=7 and significance level 0.05 the b=9, critical value was 2.045, which was less then b (b=9, 9>2.045), so we accepted the hypothesis that total number of less critical defects identified by Group3 was greater than Group2 and rejected the hypothesis that total number of less critical defects identified by Group3 was less than Group2.

Above experimental results and the both Fisher exact test performed on the groups showed that the Group3 has detected more less critical defects than Group1 and Group2 so Group3 was also effective with respect to less critical defect detection.

5.6.1.3. Total Number of Defects Identified (by each group), Ratio of Identified Defects (for each group)

It was discussed previously that, the total number of defects identified by a particular group could be calculated by adding, all the critical and less critical defects identified by each group. It was proved that Group3 was effective in finding critical as well as less critical defects. So Group3 was also effective in finding the total number of defects.

Experiment analysis also shows that Group3 who had performed review with the Effective hybrid review process had detected collectively large number of defects than Group1 and Group2 using Fagan's and Simplified software review process. The graph shown in figure 5.5 clearly shows the differences. Graph shows that Group1, Group2 and Group3 had identified 11, 12 and 16 defects respectively and they had missed 9, 8 and 4 defects respectively. The left hand bar on figure 5.5 shows the number of defects identified while right hand bar shows the defects missed by each group. Similarly the calculated ratio of defect identified is 0.55, 0.60 and 0.80 for Group1, Group2 and Group3 respectively, represented by line in figure 5.6. These graphs shows that the Group3 had detected large number of defects then Group1 and Group2

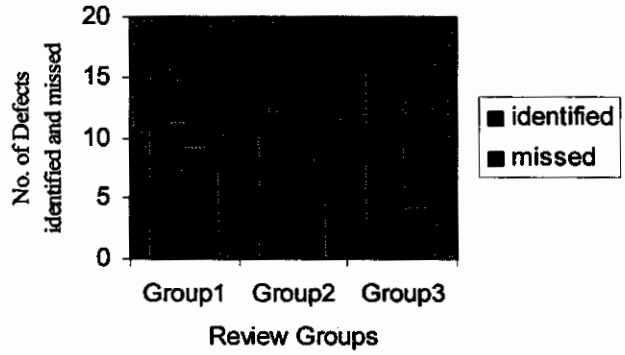

Figure 5.5. Comparison of the No. Defects Identified and Missed by Each Group

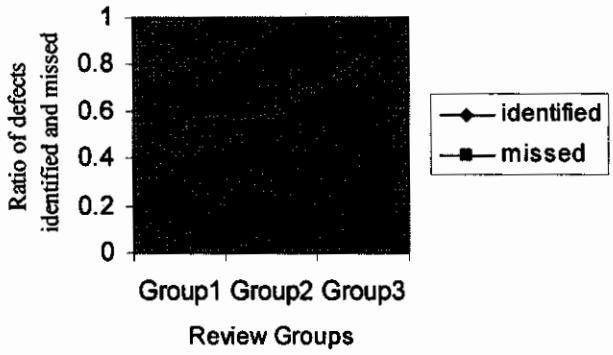

Figure 5.6. Comparison of the Ratio of Defects Identified and Missed by Each Groups

5.6.2. ANALYSIS OF REVIEW PROCESS EFFECIENCY

Review process efficiency can be described as number of defects identified within specific time period. (Wohlin et al., 2000b). The efficiency can be measured as:

$$\frac{\text{Number of defects identified}}{\text{Time spent to detect defects (min)}} * 60$$

To analyze the efficiency of the review process, dependent variables must be analyzed. Analysis of dependent variables is summarized in the table 5.8.

	Group 1	Group 2	Group 3
Total time spent for review process	5 h 20m	4 h 55 m	3 h 35m
Time spent for pre- initiation phase	*	*	20m
Time spent for initiation phase	30	30	10m
Time spent for evaluation phase	4h	3h 15 m	2 h 30m
Time spent for defect detection	4h	1h 45m	1h 20m
Time spent for closing phase	1h 20m	1h 10 m	35m
Time Spent for meeting	2h	1h	30m
Defect per hour	2.75	6.85	12

* The review processes used by Group1 and Group2 does not have pre-initiation phases

Table 5.9 summarizes the time results for the experiment conducted. The total time for completing the review process by each group was calculated by adding the time required for each sub-phase included in it.

Group 1		Group 2		Group 3	
Phases	**Time**	**Phases**	**Time**	**Phases**	**Time**
Overview	30m	Setup	15m	Pre-review , Planning	20m
Preparation	2h	Orientation	15 m	Setup	10m
Meeting	2 h	Private review	1 h 45 m	Individual review	1 h
Rework	1h	Control review	30 m	Defect analysis & Resolution	20m+ 30m
Follow-up	20m	Meeting	1h	Rework	40m
		Rework	40m	Authorized	15m
		Follow-up	15m	Postmortem	20m
		Exit	15m		
Total time = 5h 50 m		**Total time = 4 h 55 m**		**Total time =3 h 35 m**	

Table 5.9 shows that longest time taken by Group1 to complete the review process that is 5 hours and 50 min. Group2 completed the review process in 4 hour 55 min. Less time 3 hour 35min spent by Group3 to complete the review process. Figure 5.7 shows the time taken by each group to complete the review process.

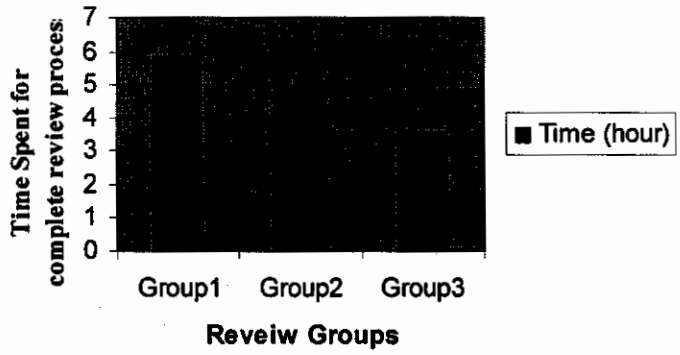

Figure 5.7. Comparison of Time Spent for Complete Review Process between Groups

The following hypothesis compares the groups with respect to their efficiency.

$H_0$8: All groups (Group1, Group2 Group3) are equally efficient

H_A8: The efficiency of Group3 is more than Group2 and Group3.

Page test was performed to analyze the efficiency of each group. Page test results showed that at level of significance 0.05 the calculated value 108 from test statistic was greater than the critical value 91. Hypothesis of equal efficiency of groups was rejected and the alternative hypothesis was accepted as critical value was less than 0.05 ($P<0.05$).

5.6.2.1. Time Spent for Defect Detection (by each group)

Results of performing three simultaneous reviews using different review process showed remarkable difference between the total defect identification time between three groups. Group1 who performed review with Fagan's review process takes 4 hour for defect detection. Defect detection time for Group1 was calculated by adding the preparation time and meeting time. The defect detection time for Group2 who used Simplified software review process was time spent for private review that is 1 hour 45 min. Similarly the Group3 who performed review using Effective hybrid review process spent 1 hour 20m for defect detection. It takes 1 hour for individual review and 20 min for pre-review. Figure 5.8 showed that the Group3 utilized the less time for defect detection as compared to Group1 and Group2.

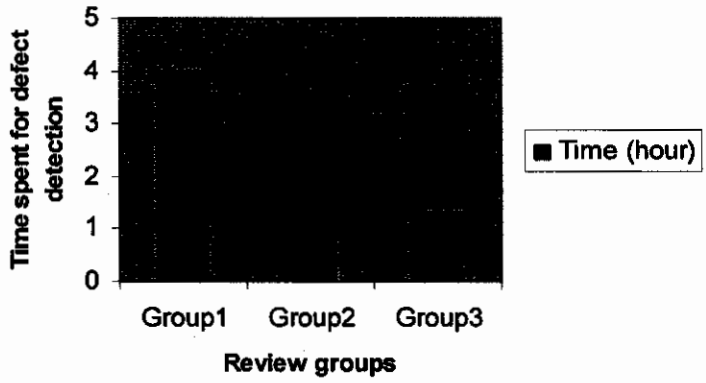

Figure 5.8. Comparison of Time Spent for Defect Detection between Groups

5.6.2.2. Time Spent for Pre-initiation Phase (by each group)

The pre-initiation phase was introduced only in the proposed review process used by Group3. Time spent for pre-initiation phase depends upon the planning and pre-review phases. As these phases run in parallel, if the time duration of planning phase exceed the

pre-review phase then the time before evaluation phase will be of planning phase. Otherwise the time will be of pre-review phase.

5.6.2.3. Time spent for Initiation Phase (by each group)

The time spent for initiation phase with respect to each Group is presented in the graph.

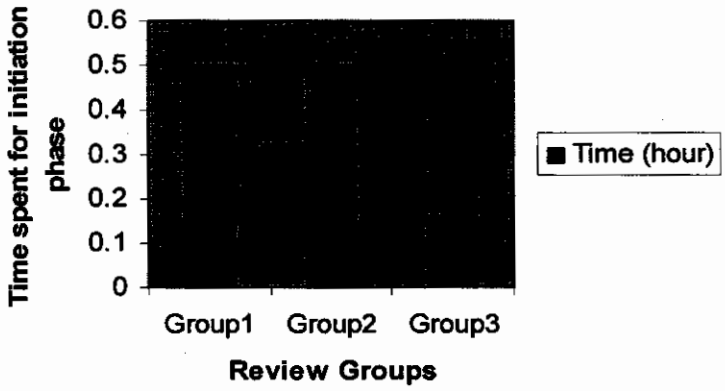

Figure 5.9. Comparison of Time Spent for Initiation Phase between Groups

Time was calculated for each review Groups. Calculation took place by adding the time spent for respected sub-phases in each review process. It is shown from the graph in figure 5.9 that Group1 and Group 2 had consumed equal time. Group3 had consumed only 10 min as most of the planning takes place in pre-initiation phase.

5.6.2.4. Time Spent for Evaluation Phase (by each group)

Time Spent by each group on their respective review process evaluation phase was calculated by adding the time of all sub-phases, which lie under the evaluation phase.

Figure 5.10 shows that the lowest time spent by Group3 in the evaluation phase as compared to Group1 and Group2.

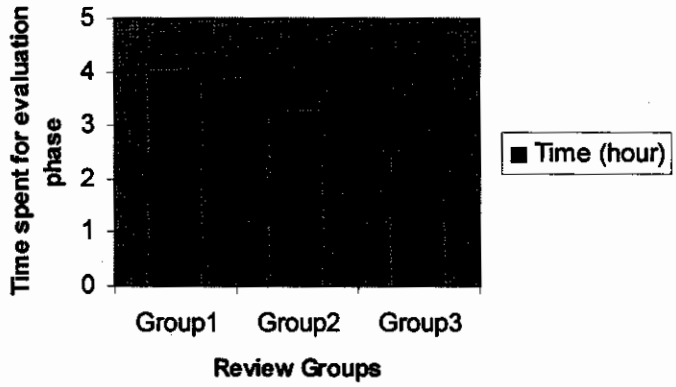

Figure 5.10. Comparison of Time Spent for Evaluation Phase between Groups

5.6.2.5. Time Spent for Closing Phase (by each group)

Time spent for closing phase by each group presented in graph figure 5.11. Graph shows that the least amount of time was consumed by Group3 who had performed review with the proposed review process.

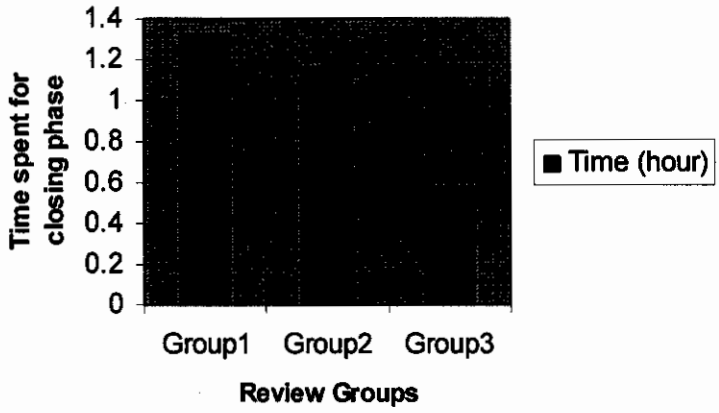

Figure 5.11. Comparison of Time Spent for Closing Phase between Groups

5.6.3. ANALYSIS OF REVIEW PROCESS INTERACTION MODE AND PURPOSE (REVIEW MEETING)

5.6.3.1. Time spent for Meeting (by each group)

Graph shown in figure 5.12 shows the time spent by each group for meeting.

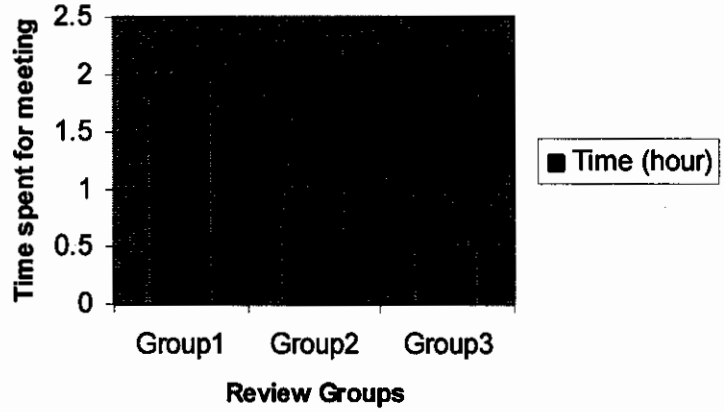

Figure 5.12. Comparison of Time Spent for Meeting between Groups

	Meeting	Purpose of meeting	Duration
Group 1	Yes	Defect Detection	2 hours
Group 2	Yes	Discussion of all defects detected in private review	I hours
Group 3	Yes	Discussion of Critical Defects only	30 min

Group1 has consumed highest time as the purpose of Group1 review meeting was defect detection. Then the Group2 had the second position in time consumption for review meeting as the purpose of their meeting was to discuss the all defects detected in private review phase. Group3 had consumed the least time for the review meeting as the purpose of the meeting was discussion of critical defects only. The table 5.10 shows the summary of review meeting analysis with respect to each group.

5.6.4. ANALYSIS OF REVIEW PROCESS TEAM STRUCTURE

As it is found from the literature that the optimal team size is 5-6 reviewers we had formulated team of 6 reviewers for each group. It was found from the team composition that the involvement of domain expert could be effective.

	Team Size	Domain Expert Considered	Roles
Group 1	6	No	Author, Moderator, Reader, Recorder, Reviewers
Group 2	6	Yes	Author, SQE, Leader, Reviewers
Group 3	6	Yes	Leader, Author, Linguistic Expert, Reviewers

5.6.4.1. Number of Critical Defects Identified by Domain Expert

Graph shown in figure 5.13 shows the total number of critical defects identifies by the domain expert.

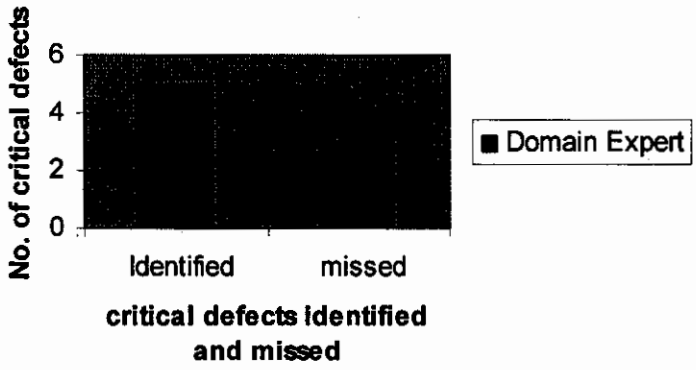

Figure 5.13. Number of Critical Defects Identified and Missed by Domain Expert

It is shown that if the domain expert is a part of review team. Then the review team has more focus on detecting the critical defects especially related to flow of the systems.

CHAPTER 6

CONCLUSION AND FUTURE WORK

This chapter provides the conclusion of the research and the future work. It has following sections.

- **6.1.** ***'Conclusion'***: This section describes the conclusion of the research.
- **6.2.** ***'Future Work'***: This section describes the improvement opportunities for future work.

6.1. Conclusion

The aim of the research was dual i.e. to find out issues of the review processes which decrease their efficiency and effectiveness and to minimize those issues with the help of an effective review process.

Stepping forward to achieve the goals of the thesis, detailed literature survey was performed to gather the knowledge related to software reviews with respect to their virtues and issues. After performing detailed literature survey the existing review processes were comparatively analyzed. Based on the results of comparative analysis a review process is proposed which is good attempt to reduce the issues presented in the existing review processes.

Proposed process named as Effective Hybrid Review Process (EHRP) has introduced different phases to leverage off the load from the reviewers. It has introduced pre-initiation phase for the purpose of pre-reviewing the artifact before passing it to the reviewers and planning for the review process. Keeping in mind the importance of the time the pre-review phase is suggested to run in parallel with the planning phase. It has also proposed an effective synchronous review meeting procedure.

In the start of process the pre-initiation phase is introduced which has the purpose of planning and pre-reviewing the artifact by linguistic expert. Linguistic expert looks for the less critical defects for example grammatical and spelling mistakes etc. After the pre-initiation phase the initiation phase commence, which includes division, allocation, and acquisition of artifacts. After that the individual review is performed by the reviewers in the evaluation phase. Once reviewers finished their review they send their feedback, which is then analyzed by the leader (defects analyst) and author in defect analysis and resolution phase. After that the leader together with author finds the ways towards defect resolution. Based on criticality of defects synchronous meeting, individual discussion can

be held or directly the rework can be performed. After performing rework the leader authorizes the artifact by signing it.

To improve the process and avoid the similar type of defect in future the process has proposed a postmortem phase. During this phase the members are asked, how to improve the process and how to avoid the same type of defects in future. Postmortem phase helps to learn from the experiences. In this phase members exchanges each others view point. They identify problems and their hidden causes. This phase improves the defect detection in the similar type of the artifact in future and it provides ways to think for future improvement of the review process.

Proposed review process (EHRP) is evaluated through experiment. It compares the effectiveness of the proposed review process with the Fagan's and Simplified software review processes. The meeting procedure was also compared and analyzed to know, in which case the meeting is most efficient. The experiment compares meetings held for different purposes i.e.

- Meeting held with the purpose of defect detection where the presence of all reviewers is necessary.
- Meeting held with the purpose of discussion of all defects, where the presence of all members is necessary.
- Meeting held with the purpose of discussion of critical defects only, which were identified by reviewers individually where the presence of all reviewers is not necessary.

The experimental finding shows that the proposed review process is effective and efficient from existing ones. Results collected from experiment shows that

- The subjects of Group3 have more focus towards the critical defect finding.
- Large numbers of defect were identified by subjects using proposed review process (EHRP).

- The total time spent by Group3 for meeting was less as compared to others.
- The subjects of Group3 utilized less time for individual review.
- Domain expert can detect more critical defects.
- Less time is required to complete the review process in case of Group3.

The comparison of effectiveness and efficiency of the groups, who participated in the experiment with different review processes is shown in table 6.1 and is also presented with the help of graphs shown in figures 6.1 and 6.2.

Groups (Review Process)	**Effectiveness** Defect detected/Total defects	**Efficiency** Defect detected /hour
Group 1 (Fagan's Review Process)	0.55	2.75
Group 2 (Simplified Software Review Process)	0.60	6.85
Group 3 (Proposed Review Process (EHRP))	0.80	12

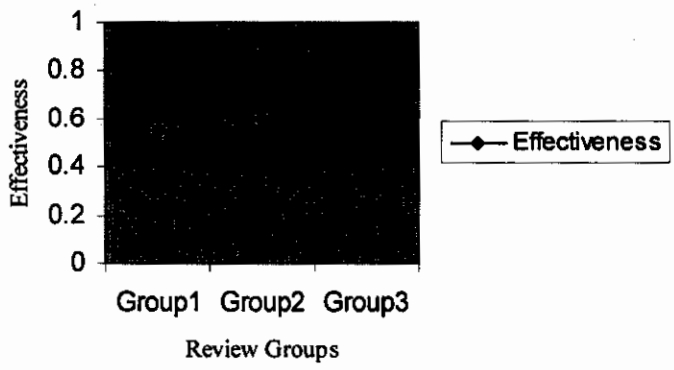

Figure 6.1. Comparison of effectiveness for Each Group

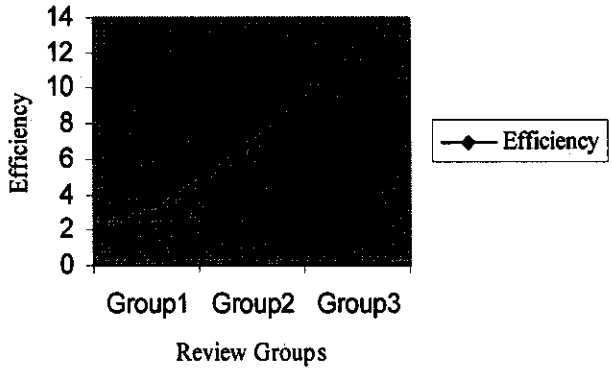

Figure 6.2. Comparison of Efficiency

It is clear from table 6.1 and figure 6.1 that Group3, who have performed review using Effective Hybrid Review Process shows effectiveness level of 0.80 as compared to Group1 and Group2, who uses Fagan's review process and Simplified software review process for reviewing the artifact. Similarly the efficiency level of the Group3 is also greater than the Group1 and Group2. Subjects of Group3 detected 12 defects per hour as compared to subjects of Group1 who detect almost 3 defects per hour and Group2 who detect almost 7 defects per hour.

6.2. Future Work

The aim of the study was to propose a review process which minimizes the problems and issues of existing review processes. For this purpose the impact of the factors that affects the effectiveness and efficiency of the review process was scrutinized. Based on the qualities and issues of the review processes and impact of effectiveness factor a new review process (EHRP) is proposed.

Due to the time and resource limitations all the effectiveness factors were not explored. The tool for the proposed process was out of scope of the thesis and could not be developed in such a limited time and resources. In future it is planned to further enhance the study by developing a tool for proposed review process. Tool named Asynchronous synchronous software inspection support tool can be used with this process as it is custom based and can be adopted with any review process. It is developed by MacDonald and Miller (1997). It focuses on distributed environment and can be used for any type of artifact. It is designed on custom based process language called IPDL (Inspection process definition language). It supports both individual and group based review activities. It provides facilities to the reviewers like checklist, data collection and data classification. It also supports both synchronous and asynchronous activities.

Effective hybrid review process has proposed the effective postmortem phase at the end of the review process. The postmortem refers to the steps taken with the aim to learn from the experiences. This stage is introduce at its very initial level in future there is need to enhance the procedure of postmortem with software review processes. There is a large room to improve the postmortem asking procedure for the review process improvement and avoidance of similar type of defects in future. There can be different ways that can be formulized to conduct postmortem at the end of the review process for examples interviews, small meeting or online session etc.

Similarly due to limitation of resources experimental evaluation for the proposed process was done manually. We have performed the single experiment and results were obtained from it. The drawback of the study is a small experiment that was performed with the small number of subjects of academic level. The results only are groundwork and need further investigations. It is encouraged for the researchers to perform different experiments with different settings to analyze the effectiveness and efficiency of proposed review process.

APPENDIX A: GLOSSARY

Artifact

It refers to any work product that is produced during software developmental cycle for example requirement specification, source code, and design etc (Pressman, 2002).

Asynchronous Interaction Mode

In asynchronous mode of interaction the review team members does not interact with each other impersonally. They use some other means of interaction e.g. telephone, online tools etc (Mishra & Mishra, 2007).

Defect

Defect is *"an instance in which a request is not satisfied"* (Fagan, 1976).

Defect Detection Techniques

Defect detection techniques are defined as the steps which guide the reviewers to get good understanding of artifact for detection of defects. Defect detection techniques help and guide the reviewers to easily find out the defects from the artifact (Laitenberger & DeBoud 2000).

Dependent Variable

The dependent variables represent the outcome of the experiment. They are the variables whose values can change with the change of independent variables (Perry et al., 2000).

Domain Knowledge

Domain knowledge refers to the knowledge related to the field.

Experience

Experience is the collective knowledge which increases with time.

External Validity Threats

The External Validity threats refer to generalization of the results to industrial practice (Wohlin et al., 2000).

False Positive

It refers to defect which is not true defect (Johnson, 1994).

Hypothesis

Hypothesis refers to the supposition made to draw out and test its end results (Basili et al., 1998).

Independent Variable

The independent variables are the variables that determine the experimental results. They have the effect on the dependent variables (Wohlin et al., 2000).

Individual Expertise Level

Individual expertise refers to the capability and expertise level of the individuals. Individual expertise can be defined in terms of technical skills, domain knowledge and experience.

Internal Validity Threats

Internal validity threats are opposite description of the experimental findings that make the cause-effect relationship between dependent and independent variables (Wohlin et al., 2000).

Interaction Mode

Interaction mode refers to the way in which the review team members interact with each other. The mode of interaction can be synchronous or asynchronous.

Review Rate

Review rate refers to the speed at which the review process progress (Russel, 1991), (Gilb & Graham, 1993), (Aurum et al., 2001).

Roles

Roles are referred to as titles associated with team members with specified responsibilities. They can be explicit or implicit (Kroyer, 2007)

Software Quality

Software quality refers to the conformance of the functional and nonfunctional requirements defined by the stakeholders of the software. It can be measured by number of bugs, defects rate (No. of defects/size unit), and the degree to which the product is compliant with the requirements (Melo et al., 2001).

Software Review

Software review process is a process of checking artifacts produced during the software development life cycle to detect the defects (Marri, 2001).

Software Review Procedure

It refers to how review process is organized, what activities involved in it and how they are conducted (Wong, 2003).

Software Review Process Effectiveness

It refers to how large number of defects can be detected during review (Gilb & Graham, 1993), (Thelin et al., 2003).

Software Review Process Efficiency

It is defined as the total number of defects detected per hour during review (Humphrey, 1995), (Thelin et al., 2003).

Synchronous Interaction Mode

In Synchronous mode of interaction the review team members interact with each other in impersonal face to face meeting (Mishra & Mishra, 2007).

Team Size

Team size refers to number of human beings involved in a team (Aurum et al., 2001).

Technical Skill

Technical skill is the knowledge of different defect categories and capability to find true defects (Biffl, 2000).

Validity Threats

Validity threats are factors that affect the dependent variables but are not like controlled independent variables (Wohlin et al., 2000).

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APPENDIX B: EXPERIMENTAL MATERIAL

APPENDIX B1: SRS of Automated Teller Machine (Without Defects)

SCOPE AND PURPOSE

This document covers the requirements needed for an Automated Teller Machine. The documentation will provide a basis for system design stage.

OVERALL SYSTEM DESCRIPTION

ATM will simulate a real world ATM machine. It will service one customer at a time. When the machine is idle, a greeting message is displayed. The keys and deposit slot will remain inactive until an ATM card has been inserted. As soon as Customer inserts a card, the card reader will attempt to read it. If the card cannot be read, the user will get a message saying the card is unreadable and it is ejected. If the card is readable, customer will be required to enter personal identification number (PIN), which will be validated with the account information in the database and the transaction continues only if a positive confirmation is received. The customer will then be able to perform one or more transactions. The card will be retained in the machine until the customer indicates that he/she desires no further transactions, at which point it will be returned.

The objective of this project is to provide an efficient system that simulates these functions in a real world ATM machine. The system is host-centered program supporting two types of users, customers and administrators. The system not only provides the end user with a user-friendly interface but has provided the system administrator easy access to perform system administration functions.

SOFTWARE PROJECT CONSTRAINTS

The ATM software has the following constraints:

- The ATM must support customers from more than one banking system.
- Each customer may have more than one account and they can transfer money from one account to another through ATM.
- Each account has limits as to how much they can withdraw at a time.
- Each account holder has limit of accessing ATM just for 3 times per day.
- In each session, whenever a customer enters incorrect pin and/or account information, ATM must provide only three tries, after which the card should be retained by the ATM.

FUNCTIONAL DESCRITION

A functional description describes the functions included in ATM. Detailed description is provided for each sub-system.

- **Access Validation**

  This is about controlling the level of access of bank customer and system administrator. ATM software will identify the level of access depending upon the account ID and

account PIN. Based upon the access level ATM software will trigger the appropriate menu display. If the card cannot be read or identified by the system, the user will be returned to the login screen and an appropriate error message will be displayed.

❖ **Login**

This function is both for scrutiny and to control the user's level of access. This function requires the user's Account ID and PIN number. ATM card reader will read the user's account number as soon as he/she inserts their card into ATM. It then verifies the AccountID and PIN number are correct before allowing access. If the information is incorrect user will get two more chances to enter the information correctly. After three attempts the card will be retained inside ATM which can then be retrieved from Bank. After a correct login, the user will be taken to the appropriate menu. System administrator will also be able to access the ATM system for user account management purposes, via login in to the actual ATM server from Banks's LAN connection. In that case too he will have to enter his AccountID and PIN. Access time for account validation and determination of user access is expected to be no more than two seconds.

- **User Account Management**

Customer accounts can be managed by the system administrator. There are two sub-functions create account, update account. System administrator can login into the bank's server directly to perform these functions. The menu will display these four options and the administrator will make appropriate selection.

❖ **Create Account**

For creating a new user account the screen will display a form with all appropriate attributes like UserID, name, address, phone, email and account status. Administrator fills in the information and submits it to create a new account. Unique Account number will be generated by system each time a new account is created.

❖ **Update Account**

For updating an account he will get a different form depending on which field he wants to update.

❖ **Delete Account**

For deleting an account he will get a different form with the user account number, name and address. He will be asked to double check if he really wants to delete the account before the account is permanently removed from the system.

❖ **Enable/Disable Account**

In addition he can also disable or enable an account temporarily. Disabling an account might be needed if customer complains about a lost or stolen ATM card. Account can

also be disabled temporarily if more than three failed login attempts happen or if a person exceeds his daily withdrawal limit. The administrator will have direct access to the bank database server and will perform most management functions while logged onto this server. This will result in immediate response times.

- **User Transaction Management**

  It includes following functions.

  - **Quick Cash**

    By default user's checking account will debited for quick cash withdrawal. If the user selects quick cash he will be presented with a menu of choices. There will be options for customer to choose from, 500, 1000, 2000, 3000, 4000 and 5000. Maximum quick cash amount limitation is 5000. If his checking account does not have enough money but other account has, he will be given an option to automatically transfer money to his checking account. If he wants to withdraw more than 5000, he should select the option "withdraw money".

  - **Withdraw Money**

    After selecting "withdraws money" option customer will then be asked to enter the amount and account type. In this case customer will have the option to choose account type (checking or saving). In both quick cash or withdraw money case amount is checked against his account balance. If his checking account does not have enough balance but other account has, he will be asked if he wants to use his other account. If none of his account has enough balance he will be presented with an appropriate message.

  - **Deposit Money**

    If user selects to deposit money he will be asked to roll the deposit envelop. By default all deposit will go to user's checking account. In case of deposit the account can not be credited immediately unless system administrator verifies that he actually has deposited the correct amount of money.

  - **Transfer Money**

    If user selects transfer money from one account to another account he will be presented with all the types of account he has with the Bank and then prompted to click from which account to which account he wants the transfer to happen. If the user just wants to check the balance on his account he can do that too. All these activities he can do with one logon. After every action he will have the option to either exit or continue next transaction. If he wants to exit ant any point he can do so by selecting that option. After every transaction he will be presented with a print receipt option.

- **Inventory Management**

  Inventory management is about managing the inventory of an ATM terminal. Only system administrator has the access right to any ATM inventory. System administrator can manage ATM inventory manually or by login to ATM server. This function is divided into four sub functions

  - **Deposit Money**

    System administrator can login to the ATM using his admin ID and admin PIN to deposit money into ATM. Once he chooses the deposit money option from the Admin menu, ATM software will send a signal to the ATM door to open. After depositing money he can print a receipt.

  - **Withdraw Money**

    System administrator can withdraw the money envelops after login into the system.

  - **Check ATM Status**

    System administrator can check the ATM status either from ATM terminal or by login into the ATM server. He can check total amount of money in ATM inventory, any information about customer account or any transaction.

- **GUI Management**

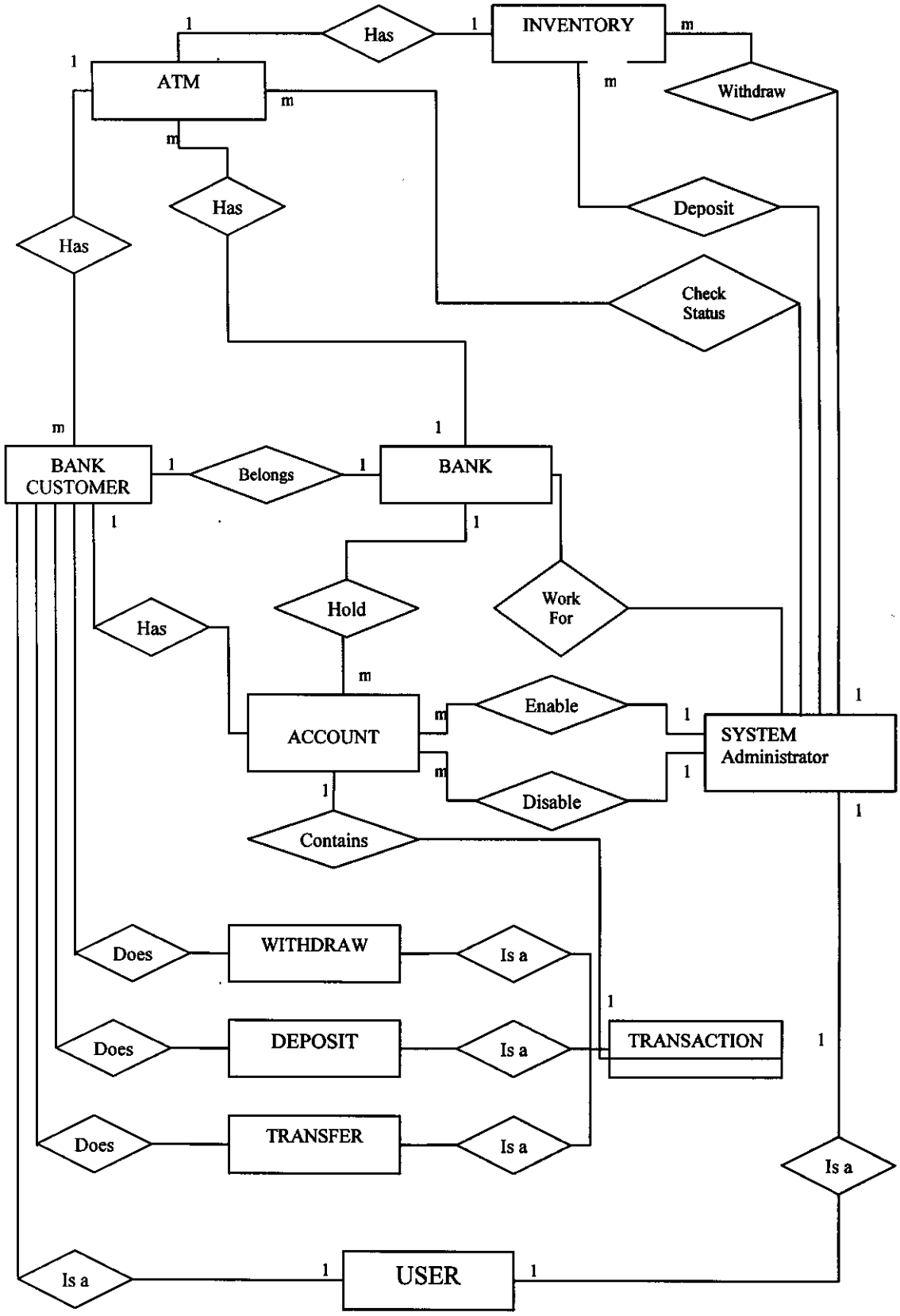
  This management can be divided into User GUI and system administrator GUI management. User will be presented with a different GUI then system administrator GUI.

- **Security Management**

  There will be an alarm system. An alarm is sent to the bank if some kind of vandalism is being done or any other kind of security threat is sensed at the ATM terminal.

ENTITY RELATIONSHIP DIAGRAM

ERD model is a very useful method for data modeling. It focuses on data, representing a "data network" in the system. It represents data objects, object attributes, relationships between the objects, and their cardinality and modality. Cardinality represents number of occurrences of one (object) that can be related to number of occurrences of another (object). Three types of cardinality ratios that may be seen in the ERD are one-to-one (1:1), one-to-many (1:N), and many-to-many (M:N).


Has
INVENTORY
ATM
Withdraw
Has
Deposit
Has
Check Status
BANK CUSTOMER
Belongs
BANK
Hold
Work For
Has
ACCOUNT
Enable
SYSTEM Administrator
Disable
Contains
Does
WITHDRAW
Is a
Does
DEPOSIT
Is a
TRANSACTION
Does
TRANSFER
Is a
Is a
Is a
USER

APPENDIX B2: SRS of Automated Teller Machine (With Seeded Defects)

SCOPE AND PURPOSE

This document covers the requirements needed for an Automated Teller Machine. The documentation will provide a basis for system design stage.

OVERALL SYSTEM DESCRIPTION

ATM will simulate a real world ATM machine. It will service one customer at a time. When the machine is idle, a greeting message is displayed. The keys and deposit slot will remain active until an ATM card has been inserted. As soon as Customer inserts a card, the card reader will attempt to read it. If the card cannot be read, the user will get a message saying the card is unreadable and it is ejected. If the card is readable, customer will be required to enter personal identification number (PIN), which will be validated with the account information in the database and the transaction continues only if a positive confirmation is received. The customer will then be able to perform one or more transactions. The card will be retained in the machine until the customer indicates that he/she desires no further transactions, at which point it will be returned.

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- Each account holder has limit of accessing ATM just for 3 times.
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FUNCTIONAL DESCRITION

A functional description describes the functions included in ATM. Detailed description is provided for each sub-system.

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  This is about controlling the level of access of bank customer and system administrator. ATM software will identify the level of access depending upon the account ID and account PIN. Based upon the access level ATM software will trigger the appropriate menu display. If the card cannot be read or identified by the system, the user will be returned to the login screen and an appropriate error message will be displayed.

❖ **Login**

This function is both for scrutiny and to control the user's level of access. This function requires the user's Account ID and PIN number. ATM card reader will read the user's account number as soon as he/she inserts their card into ATM. It then verifies the AccountID and PIN number are correct before allowing access. If the information is incorrect user will get too more chances to enter the information correctly. After three attempts the card will be retained inside ATM which can then be retrieved from Bank. After a correct login, the user will be taken to the appropriate menu. System administrator will also be able to access the ATM system for user account management purposes, via login in to the actual ATM server from Banks's LAN connection. In that case too he will have to enter his AccountID and PIN. Access time for account validation and determination of user access is expected to be no more than two seconds.

- **User Account Management**

Customer accounts can be managed by the system administrator. There are two sub-functions create account, update account. System administrator can login into the bank's server directly to perform these functions. The menu will display these four options and the administrator will make appropriate selection.

❖ **Create Account**

For creating a new user account the screen will display a form with all appropriate attributes like UserID, name, address, phone, email and account status. Administrator fills in the information and submits it to create a new account. Unique Account number will be generated by system each time a new account is created.

❖ **Update Account**

For updating an account he will get a different from depending on which field he wants to update.

- **User Transaction Management**

It includes following functions.

❖ **Quick Cash**

By default user's checking account will debited for quick cash withdrawal. If the user selects quick cash he will be presented with a menu of choices. There will be options for customer to choose from, 500, 1000, 2000, 3000, 4000 and 5000. Maximum quick cash amount limitation is 5000. If his checking account does not have enough money but other account has, he will be given an option to automatically transfer money to his checking account. If he wants to withdraw more than 5000, he should select the option "withdraw money".

❖ **Withdraw Money**

After selecting "withdraws money" option customer will then be asked to enter the amount and account type. In this case customer will have the option to choose account type (checking or saving).

❖ **Deposit Money**

If user selects to deposit money he will be asked to roll the deposit envelop. By default all deposit will go to user's checking account. In case of deposit the account can not be credited immediately unless system administrator verifies that he actually has deposited the correct amount of money.

❖ **Transfer Money**

If user selects transfer money from one account to another account he will be presented with all the types of account he has with the Bank and then prompted to click from which account to which account he wants the transfer to happen. If the user just wants to check the balance on his account he can do that too. All these activities he can do with one logon. After every action he will have the option to either exit or continue next transaction. If he wants to exit ant any point he can do so by selecting that option.

- **Inventory Management**

Inventory management is about managing the inventory of an ATM terminal. Only system administrator has the access right to any ATM inventory. System administrator can manage ATM inventory manually or by login to ATM server. This function is divided into four sub functions

❖ **Deposit Money**

System administrator can login to the ATM using his admin ID and admin PIN to deposit money into ATM. Once he chooses the deposit money option from the Admin menu, ATM software will send a signal to the ATM door to open. After depositing money he can print a receipt.

❖ **Withdraw Money**

System administrator can withdraw the money envelops after login into the system.

❖ **Check ATM Status**

System administrator can check the ATM status either from ATM terminal or by login into the ATM server. He can check total amount of money in ATM inventory, any information about customer account or any transaction.

- **Security Management**

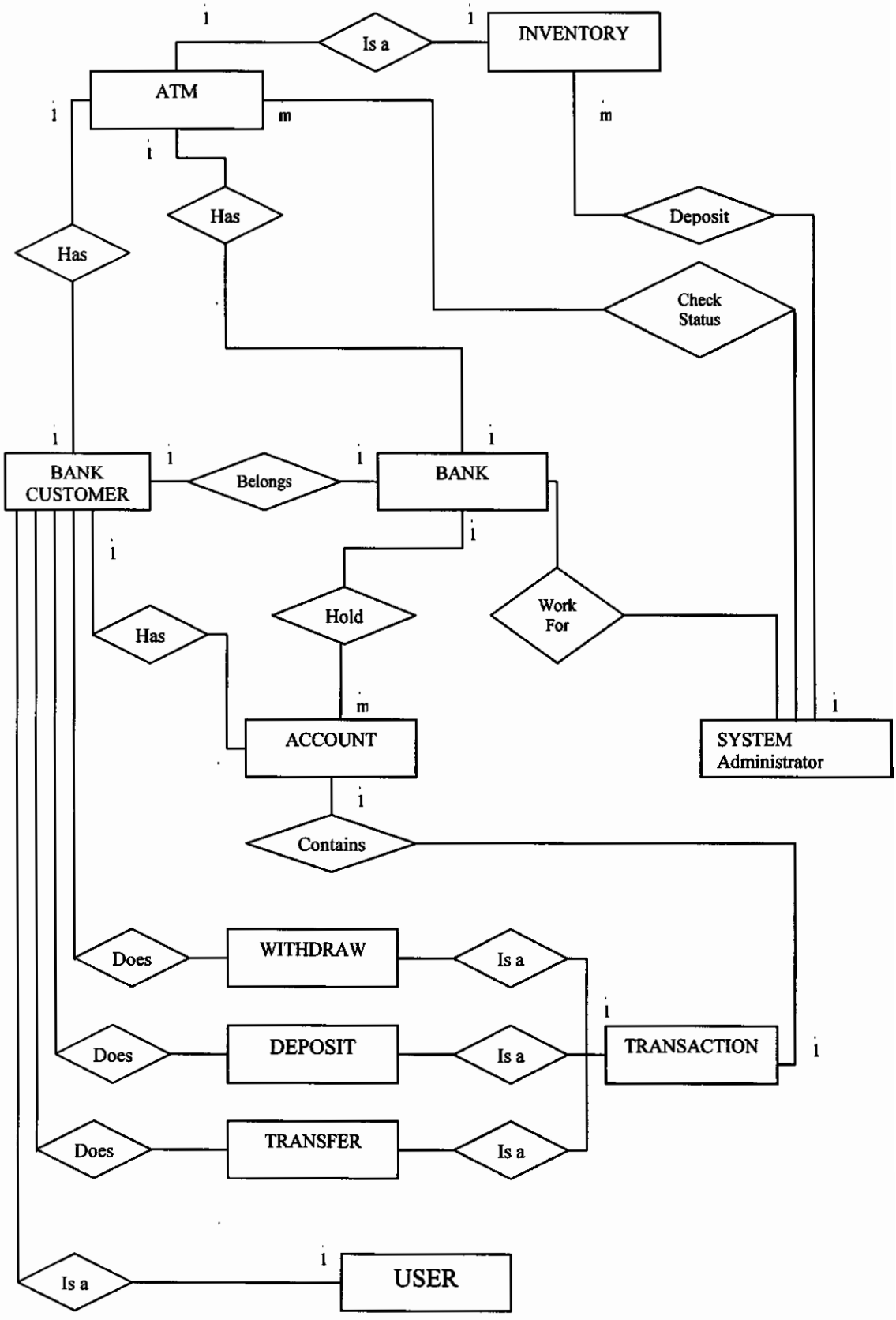
  This management can be divided into User GUI and system administrator GUI management. User will be presented with a different GUI then system administrator GUI.

- **GUI Management**

  There will be an alarm system. An alarm is sent to the bank if some kind of vandalism is being done or any other kind of security threat is sensed at the ATM terminal.

ENTITY RELATIONSHIP DIAGRAM

ERD model is a very useful method for data modeling. It focuses on data, representing a "data network" in the system. It represents data objects, object attributes, relationships between the objects, and their cardinality and modality. Cardinality represents number of occurrences of one (object) that can be related to number of occurrences of another (object). Three types of cardinality ratios that may be seen in the ERD are one-to-one (1:1), one-to-many (1:N), and many-to-many (M:M).


Is a
INVENTORY
ATM
Has
Has
Deposit
Check Status
BANK CUSTOMER
Belongs
BANK
Hold
Work For
Has
ACCOUNT
SYSTEM Administrator
Contains
Does
WITHDRAW
Is a
Does
DEPOSIT
Is a
TRANSACTION
Does
TRANSFER
Is a
Is a
USER

APPENDIX B3: INDIVIDUAL DEFECT REPORT FORM

Linguistic Expert Name:_____

Starting time: _____Ending Time:_____

SNo	Page No	Description of Defect and Corresponding Rule

APPENDIX B4: INDIVIDUAL DEFECT REPORT FORM

Subject's Name: _____

Subject's ID: _____ Group: _____

Starting time: _____ Ending Time: _____

SNo	Page No	Description of Defect

APPENDIX B5: GROUP DEFECT REPORT FORM

Group: _____ Date_____

Moderator: _____Author:_____

Recorder: _____Reader:_____

Reviewers: _____

Starting time: _____Ending Time:_____

SNo.	Page No.	Defect Description

APPENDIX B6: BACKGROUND ASSESSMENT FORM

Subject's ID: _____

Class: _____ Semester_____

Working Experience:_____

Grade/CGPA of previous semester_____

Please answer the question given below. The appropriate choice must be marked.

1. Knowledge of English Language

   Poor Average Good Excellent

2. Experience of Software Development

   Poor Average Good Excellent/Professional

3. Have you studied Quality assurance?

   _____

4. Experience with software reviews

   Poor Average Good Excellent

5. Knowledge about review processes names them.

   _____

6. Knowledge about ATM

   Don't know Average Good Practical

7. Have you participated in software review before?

   _____

APPENDIX B7: POSTMORTEM QUESTIONNAIRE

Subject's ID: _____

Class: _____ Semester_____

Please answer the question given below. The appropriate choice must be marked.

1. How much confident that you have detected the right defects
   a. 100%
   b. 80%
   c. 60%
   d. <50%

2. Does your previous knowledge related to ATM help in finding defects
   a. Strongly Disagree
   b. Disagree
   c. Agree
   d. Strongly Agree

3. Artifact which has minimum general English grammar confusion are lacking was help full for focusing important defects' detection. Mark all appropriate answers you feel.
   a. I have focused on important defects
   b. Less time spent to review
   c. I have found no ambiguities
   d. found more time to detect technical defects
   e. I have wasted my time.
   f. I do not found any difference.

4. The meeting procedure was
   a. Rigid
   b. Flexible

5. Less time spent for meeting
   a. Strongly Disagree
   b. Disagree
   c. Agree
   d. Strongly Agree

6. Individual defect detection help me to detect defects easily
   a. Strongly Disagree
   b. Disagree
   c. Agree
   d. Strongly Agree

7. Meeting for critical defect discussion was useful as it does not consumed extra time.
   a. Strongly Disagree
   b. Disagree
   c. Agree
   d. Strongly Agree

8. Assume you could have to chose to participate in a meeting with the purpose of defect detection, meeting with the purpose of discussion of all minor and major false positive, duplicates defect and meeting for critical defect discussion purpose only which one you will prefer and why?

9. Less time was consumed to complete the review process as compare to other groups.
   a. Strongly Disagree
   b. Disagree
   c. Agree
   d. Strongly Agree

10. What would be your suggestion to improve the review process, its procedure, meeting procedure, team structure etc.?

APPENDIX C: THEORY OF SATATISTICAL TEST

Page Test

The Page test can be performed in case of multisampling situations where an ordered alternative hypothesis is more meaningful than one in which is order is ignored. The assumptions for the test are:

- The data consists of b mutually independent samples (blocks).
- The variable of interest is continuous.
- The observation within each block may be ranked in order of magnitude.

Test Statistics:

$$L = \sum_{J=1}^{k} j\, R_j = R_1 + R_2 + R_3 + \ldots kR_k$$

$R_1 \ldots R_k$ are the treatments rank sum obtained in the manner.

Decision Rule:

Reject Ho at α level of significance if the computed value of L is greater than or equal to the critical value of L for k, b and α given in the table.

Fisher Exact Test

The Fisher Exact test can be performed on the data when we want to compare two treatments or groups and classify subjects as either responding or not responding.

The research objective in studies of this type is to determine whether the two groups differ with respect to the population of subjects that fall into the two classifications. The test is most useful when samples sites are small. The assumptions for the test are

- The data Consists of A samples observation from population 1 and B sample observation from population 2.

- Each observation can be categorized as one of two mutually exclusive types

Test Statistics:

b, the number in sample two with the characteristic of interest

Decision Rule:

For two sided: with A, B and a. if the observed value of b is equal to or less than the integer in given column reject Ho at a level of significance.

Cochran's Test

This test provides procedure for testing the null hypothesis of equal treatment effectiveness. The assumptions of the test are:

- The data for analysis consists of the responses of r blocks to c independently applied treatments.
- The responses are 1 for success and 0 for failure.

Test Statistics:

$$Q = \frac{C(C-1)\sum_{j-1}^{c} Cj^2 - (C-1)N^2}{CN\sum Rj^2}$$

APPENDIX D: RESEARCH PAPER

Effective Hybrid Review Process (EHRP)

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Abstract
Software review is an effective and best practice to verify the software quality. This paper presents an effective and efficient review process. It overcomes the obstacles facing the current review processes. Current review processes face these obstacles due to their rigid and time consuming nature. Proposed review process introduces twofold review activity, an effectual meeting procedure and course of actions for future improvements. It is an attempt to minimize the inflexible requirements of the review meetings. It aimed at reduction of synchronous review meeting by removing less critical defects before synchronous review meeting. It is evaluated through an experiment and comparative analysis, which has provided effective results.

Keywords: Software Reviews Process, Effectiveness, Efficiency, Software Quality, Review Meeting

1. Introduction

Fast and enormous growth of computer has made software development more and more challenging. The basic goal of software development is to develop a quality system that satisfies explicit and implicit needs of users [19]. Artifacts (requirement document, design, source code etc.) require continual insight and modification throughout the development cycle to make it defects free [2].

Unfortunately instead of the best development techniques the defects cannot be avoided completely. These defects lead to the poor quality software. To provide good quality software continual effective review process is required as its goal is to improve the software quality. It provides timely feedback to the author.

Software review is visual examination of the software artifact. It is a process of checking artifact with the aim to detect defects. In fact software reviews purifies the software engineering process [8]. It is an effective way to statistically analyze and verify the artifacts. This static verification can be applied throughout the developmental phases while the dynamic verification needs an executable program [25]. Software reviews at one hand save the cost and on the other hand they reduce the time for dynamic verification (testing). Effective reviews enhance the quality of the software.

A new review process is presented in this paper. This review process is an attempt to overcome the obstacles facing the current review processes. Proposed review process has tried to minimize the inflexible requirements of review meetings. Meetings are the centre points of discussion after Fagan's review process. The paper is organized as firstly the existing work done in the field of review processes is discussed. Secondly the issues and virtues of existing review processes are discussed. Thirdly the proposed review processes is discussed in detail with respect to its structure, requirements, benefits, issues and evaluation. In the end the conclusion and future work directions are explored.

2. Existing Work

Multiple review processes exists to detect defects early in the software development. Most of them faced obstacles because of their simplicity, complexity and rigidity. The first review process was introduced by Fagan in 1976 [7] and largely used ever since with modification. Main focus of the Fagan's review process was on the well disciplined review meeting for defect detection. It requires sufficient preparation of reviewers with respect to the artifact, which is to be reviewed in a meeting. Fagan's review process consists of five phases. Fagan believed that meeting has synergy effect which helps in defect detection [7].

After Fagan's review process many questions arise related to the review meeting effectiveness, their purpose, team structure and need of roles assignment with associated responsibilities etc.

Based on these questions number of review processes were introduced. Numbers of contradictory findings are present in literature regarding the review meeting. Review meetings criticism and questions are normally based on two facts. Firstly it delayed the project. Secondly many empirical studies show that most of the defects are detected during individual checking.

Parnas and Weiss criticized and questioned the meeting based approach of the Fagan's review process. They believed that meeting can be the cause of the wastage of time for developers. It diverts the focus of reviewers from defect detection task [19],[21].They argued that the meetings only consumes the developers time, increases cost and has minimal effect in defect detection task. They suggested multiple small individual synchronous reviews meeting with author. Bisant and Lyle believed that large number of team members increase the meeting complexity and cost. They suggested to reduce the members only two, to save the time and cost [4].

Martin and Tsai emphasized on multiple small parallel review meetings for reviewing the same artifact. According to them single large review meeting is ineffective as compare to multiple small meetings [17]. Knight and Myers also suggested individual defect detection and utilization of meeting for collection of defects [15]. Gilb and Graham also had the same view point as of Knight and Myers with respect to defects detection. They strictly emphasized on the detailed well discipline meeting for collection of defects and removing false positives [9].

Votta in 1993 criticized the synchronous meeting and emphasized on the meeting-less review process. He argued that strict and scheduled meetings can delay the developments and increase the review meeting time [26]. According to him only two members can successfully interact in a meeting at a time, other members waste their and others time. Votta also found that during individual checking majority of defects can be detected almost 90% [13],[18],[26]. D. Mishra and A. Mishra emphasized on small meeting based review process. According to them the purpose of synchronous meeting is discussion of all defects detected during individual review [19].

Instead of large negative views about review meetings, one cannot forget the core importance of synchronous meeting. Sauer et al. believed that synchronous review meetings are important for defect collection and defect discrimination. Votta, Porter and Jhonson also supported the Sauer's idea [23],[26]. Shifting of group based defect detection to individual defect detection does not mean that synchronous meetings should be eliminated completely [24].

It is concluded that meetings are important and essential part of the review processes. Defect collection meetings are more beneficial as compared to defect detection meetings. It helps to remove the false positives. So it seems that the cost of meetings depends on their purpose, member strength, formality and time availability of reviewers. Meetings are costly when they are complex and their purpose is defect detection, very formal, need to be rescheduled again and again because of unavailability of reviewers. But they are less costly and effective when the purpose is general discussion regarding defect clarification and are independent of availability of all reviewers.

In this regard the Meeting approach of Formal technical review method proposed by Johnson and Simplified software review process propsed by D. Mishra and A. Mishra seems to be good but need to be improved. Formal Technical Asynchronous Review Method has opened the meeting as an optional. Simplified software review process and Formal Technical Asynchronous Review Method have emphasized the presence of all reviewers in a meeting, which depends upon the availability of reviewers to attend the meeting. It may results in the wastage of time for such reviewers who have no conflict with author.

3. Issues of Software Review Process

There are large numbers of advantages of software reviews but certain issues are also associated with them. Some issues are summarized below.

Group Review: The behavior of individual involve in review process effects the reviews [29], The group reviews can have many issues associated with them like insufficient

preparation, incorrect review rate, coordination of schedule and location [3], [13].

Selection of Reviewers: The most important issues which must be resolved are the selection of right reviewers for review process [30]. Reviewers act as an input in the software review process. If the input will be effective then ultimately the output will be effective.

Time and Recourse Constraints: The other issue with the software reviews is the time and resource constraints. Sometimes organization does not have resources to employee review process. Sometimes the reviewers have time limitations to participate in a review process [14], [30].

Well Disciplined Review Meetings: Well disciplined review meetings are time consuming and require large resources. Personality and ego conflict arises in the well discipline review meetings. Mostly the well disciplined meetings are dominated by one person who could be the moderator or leader or one of the reviewers who has dominating personality.

Multiple Small Meetings: Multiple small meetings for defect detection can be costly. They require large human resources, time and contain overlapping defects. It takes long time to eliminate the duplication. It also increases the load on the moderator to collect the defects from number of teams and eliminate the duplicates. It is difficult for moderator to coordinate with multiple teams.

Meetings which require Presence of all Reviewers: Such meetings can be problematic because reviewers have to meet at the same time and same place.

Meetings Optional for Members to Attend: Such meetings can fail, when the person who have identified the defect and have conflict can not attend the meeting.

Meetings held for Defect Detection: If the purpose of the meeting is defect detection then it might happen that efficiency of different reviewers is different. Some reviewers can be efficient in reviewing and review faster other might take long time to review. This efficiency differentiation can decrease the defect detection rate and increase the review meeting time.

Meetings held for Defect Collection: Meetings procedures suggested for defect collection requires large time to complete. In this meeting the collection of defects, removal of duplicate and false positive takes place. Another problem is that no discussion of detected defects takes place with reviewers. This can increase the load of author due to ambiguity and misunderstanding of detected defects.

Meetings held for Discussion of all Detected Defects: Meetings held for discussion of all detected defects can also be costly in term of time spent for it. If all identified defects which were identified during individual checking are discussed in the meeting then the meeting time can be lengthy. It may happen that the critical defects may be neglected because of the detail discussion on the minor defects. Large amount of work has been done with respect to meeting but still there are issues with them as mentioned.

Large amount of work has been done with respect to meetings but still there are issues with them as mentioned. The meeting criteria should be such that it should be independent of reviewers' availability and dose not become a reason of wastage of reviewers' time. The meeting procedure proposed in the proposed review process can be good attempt to reduce the issues present in current review process.

4. Proposed Review Process Effective Hybrid Review Process (EHRP)

EHRP is especially designed to address the problems which exist in current review processes. It increased focus of reviewers towards critical defects detection. It has introduced an efficient way to conduct review meeting which saves reviewers' precious time. Proposed suggestion of the meeting decreases the load of the reviewers and handles the time availability problems of the reviewers. Most important improvement suggested in this process is procedure for future improvements.

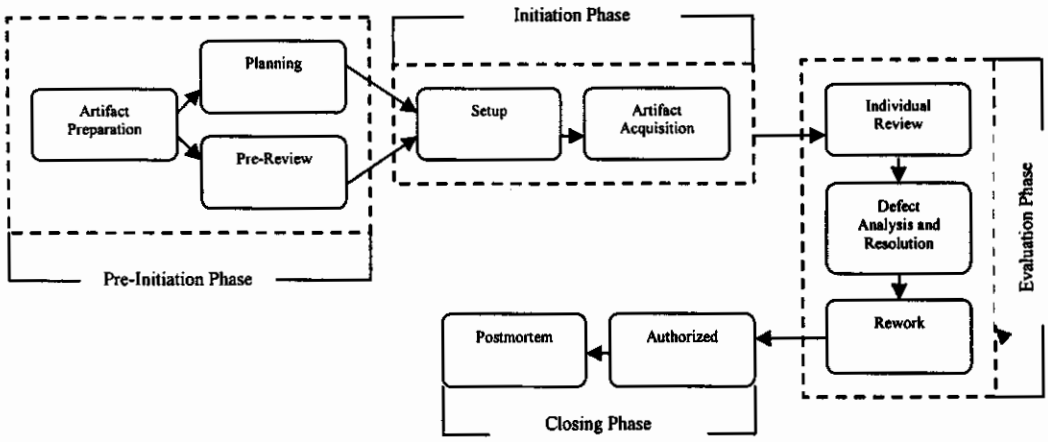

Figure 1. Model of Proposed Review Process (EHRP)

4.1. Phases of Effective Hybrid Review Process

Proposed review process consists of four major phases pre-initiation, initiation, evaluation and closing phase. Each phase has some associated sub phases as shown in figure1.

a. Pre-Initiation Phase
Purpose of this phase is preparation of artifact, planning the review activities and creating the artifact free of syntax, spelling and grammatical defects. It has three sub phases i.e. artifact preparation, pre-review and planning.

Artifact Preparation: Purpose of artifact preparation is to perform the necessary preparation to make the artifact available to review. In this phase the author modified the artifact into review-able form.

Pre-review: In this phase the linguistic expert review the artifact for less critical defects for example mistakes of grammar, spelling, formatting style and syntax etc. There are general defects which do not need an expert reviewer they should be found before passing the artifact for review.

Planning: Planning phase run in parallel with pre-review phase. Leader selects the reviewers to review the artifact. There must be at least one domain expert among the reviewers. Another purpose of this phase includes the planning of time for the completion of the review procedure. Leader with the help of author plans the division of artifact among the reviewers based on their expertise.

b. Initiation Phase
In the initiation phase the artifact's division, distribution, and notification activities takes place. It has following sub-phases.

Setup: In the setup phase the leader with the help of author divide the artifact into the parts according to the plan. He/She distribute the whole artifact to all the reviewers with the specified allocated part. The whole artifact is distributed for the understanding purpose. Reviewers are also notified about the allocation and distribution of the artifact with the specified feedback time limit.

Artifact Acquisition: In this phase the reviewers acquire the artifact which is to be reviewed with their defined parts and specified time to give the feedback. The reviewers send the reverse notification about receiving the artifact to the leader.

c. Evaluation Phase
In this phase the artifact is reviewed again by the reviewers. The identified defects and issues are resolved and fixed. It has following sub-phases.

Individual Review: In this phase the reviewers individually review the specified part of the artifact for defect detection. They give their feedback to the leader within the allocated time

limit. In the feedback the reviewers sends the identified defect with the comments and possible solutions.

Defect Analysis and Resolution: In this phase the leader and author analyze and categorize the identified defects as less-critical and critical defects. Based on the defects analysis they decide the ways towards the defect removal.

If there are any defects which are accepted and need no discussion or meeting these are fixed without meeting and discussion.

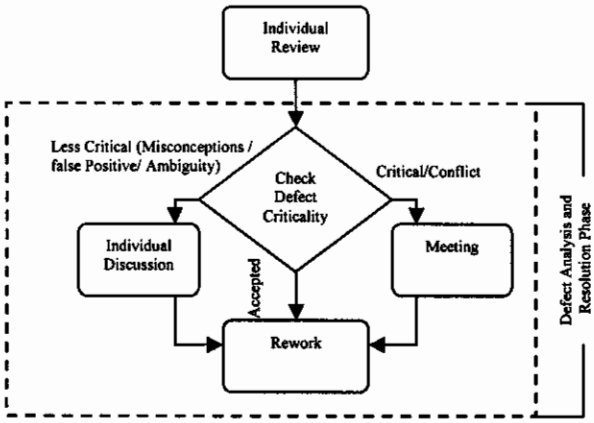

Figure 2. Logical Model of Defect Analysis and Resolution Phase

Rework: In this phase the author based on identified defects, issues, recommendations, the results of the meeting and discussion if held fix the defects of the artifact. After defect fixation the artifact is send to the leader for authorization.

d. Closing Phase

Closing phase initiate when all defects and issues are resolved and based on it the rework is performed by the author. It has following sub-phases.

Authorized: In this phase the leader verifies that all the changes have been made by author.

Postmortem: In this phase two types of the postmortems are performed i.e. postmortem of the review process and of the artifact. In the postmortem of the review process the suggestion

If the defects belong to the less critical defect category i.e. misconceptions or ambiguity they will be discussed individually in a synchronous (face to face interaction) or asynchronous (through telephone or e-mail) way.

If the defects belong to the critical defect category or the reviewers have conflict between them. They will be discussed in the face to face meeting. Meeting doesn't require the presence of all the reviewers. Only those reviewers are compulsory to attend the meeting who have identified the defect, have conflicts or called by leader to attend the meeting.

about the improvement of the review process are taken from the reviewers. It also includes the analysis of the resources used during review process and the outcome of the review process.

In the postmortem of the artifact the experiences of the reviewers are shared about the issues and defects identified and their solutions. Root causes of the defects are also identified and the suggestions to avoid similar type of defects in future projects are also discussed. This helps when the same type of the artifact comes under review in future. Postmortem phase can be conducted in different ways. It may be a synchronous meeting of short duration, offline interviews or survey questioners etc.

4.2. Team Roles of Proposed Review Process

Author: Responsibility of the author is to prepare the artifact for review, to help the leader in the planning of the division and allocation of the artifact to the reviewers, to perform rework He/She also participates in the discussions and meeting if held and required. He/She also actively participates in postmortem phase.

Leader: Leader must be the defect analyst and the review expert. He/She plans and manages the review process and its recourses. He/She with the help of author does the division and allocation of the artifact to the reviewers. He/She also performs the authentication of all the changes made by the author. During the defect analysis phase the leader analyzes the defect and decide them as critical and less critical with the help of author. Based on this analysis he/she

along with the help of author do the discussions and meeting. Leader also participates in the postmortem phase.

Linguistic Expert: Linguistic expert review the artifact in pre-review phase. He/She review the artifact for detecting and fixing the syntax, spelling and grammar related less critical defects before passing the artifact to the evaluation phase. He/She fill in the defects report form for the identified defects and correction made. He/she may not be a technical person can work on multiple projects at the same time

Reviewer: Responsibility of the reviewers is to identify defects individually from the allocated part of artifact. One of the reviewers should be domain expert. Reviewers also take part in the postmortem phase by sharing their experiences about the review process, artifact under review, identified defects their solutions and root cause of the identified defects.

4.3. Merits

- Proposed review process is asynchronous with dual review activities.
- Reviewers have to review the specified portion of the artifact and they are responsible for that part only.
- Pre-review runs in parallel with the planning phase which does not consume extra time. Pre-review helps in reducing the time taken by reviewers for defect detection and it also save cost.
- Reviewers review the artifact individually at their own places without having problem of getting together for review at same time and place.
- Involvement of the domain expert in review team proposed by review process help in focusing the most critical defects and flaws related to design and overall working of the system.
- Leader role with defect analyst and review expertise capabilities analyzed the defects collected from individual review activity which reduces the meeting overhead.
- The review process has introduced synchronous and efficient meeting procedure. Synchronous meeting should be held in case of critical defects and conflicts, where the presence of all reviewers is not necessary. Only the reviewers who have identifies the defects, have conflicts or called by the leader are essential to attend the meeting. For other members it is not necessary to attend.
- This meeting procedure helps in time save, as the purpose of the meeting is neither defects detection nor discussion of all defects with all reviewers. It also reduces the issues related with the traditional meetings.
- Postmortem phase introduced in the process helps to learn from the experiences. Postmortem phase helps to improve the defect detection of similar type of artifact in future. It also provides ways to think for future improvement of the review process.

4.4. Demerits

Instead of all these benefits of the proposed review process there are some limitations of the proposed review process. It does not have its own tool. An existing tool asynchronous synchronous software inspection supporting tool can be adopted in this process. It is custom build tool and can work with any review process. Post mortem phase is not mature and it needs to be improved. The proposed review process lacks the open communication between the reviewers as compared to the meeting based review processes, but it utilized the meeting time for effective purpose.

5. Experimental Evaluation of Proposed Review Process (EHRP)

The proposed review process was evaluated through experiment. It compares the effectiveness and efficiency of the proposed review process (EHRP) with the Fagan's review process and Simplified software review process. The experiment was performed with 18 subjects divided into three equal groups. The subjects were students of BS (CS), NIIT Islamabad. They performed review of the same artifact i.e. Automated teller machine (ATM). The defects

were seeded in the artifact before the start of experiment.

The experimental data was analyzed. Analysis shows that the number of defects detected by Group3 who performed review with Effective Hybrid Review Process was greater then the other groups.

The analysis details showed in table1 and 2. Table1 shows the analysis of review process effectiveness. Table2 shows the analysis of review process efficiency. The graph in figure3 shows the comparison of ratio of defects identified by each group.

	Group1	Group2	Group3
No. of defects identified	11	12	16
No. of defects missed	9	6	4
Ratio of defects identified	0.55	0.60	0.80
Ratio of defects missed	0.45	0.40	0.20
No. critical defects identified	3	5	7
No. of critical defects missed	5	3	1
Ratio of critical defects identified	0.38	0.63	0.87
Ratio of critical defects missed	0.63	0.38	0.23
No. of less critical defects identified	8	7	9
No. of less critical defects missed	4	5	3
Ratio of less critical defects identified	0.66	0.58	0.75
Ratio of less critical defects missed	0.33	0.42	0.25

	Group 1	Group 2	Group 3
Total time spent for review process	5 h 20m	4 h 55 m	3 h 35m
Time spent for pre- initiation phase	*	*	20m
Time spent for initiation phase	30	30	10m
Time spent for evaluation phase	4h	3h 15 m	2 h 30m
Time spent for defect detection	4h	1h 45m	1h 20m
Time spent for closing phase	1h 20m	1h 10 m	35m
Time Spent for meeting	2h	1h	30m
Defect per hour	2.75	6.85	12

The experimental finding shows that the proposed process (EHRP) is effective and efficient from the existing ones. Results collected from experiment show that.

- Subjects of Group3 have more focus towards the critical defect finding.
- Large number of defect identified by subjects using proposed review process (EHRP).
- Total time spent by Group3 for meeting was less as compared to other.
- The Group 3 subjects utilized less time for individual review.
- Domain expert can detect more critical defects.
- Less time is required to complete the review process.

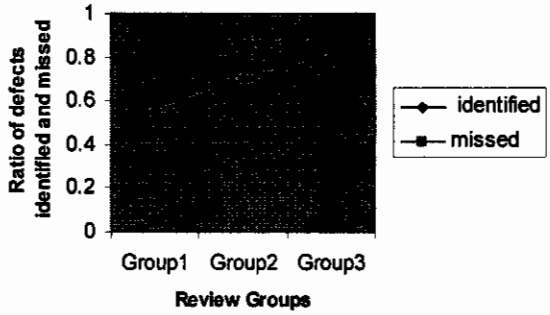

Figure 3. Compares the Ratio of Defects Identified and Missed for Each Groups

Groups (Review Process)	Effectiveness	Efficiency
Group1 (Fagan's review process)	0.55	2.75
Group2 (Simplified software review process)	0.60	6.85
Group3 Proposed review Process (EHRP)	0.80	12

It clear from table3 that Group3, who have performed review using Effective Hybrid Review Process shows effectiveness level of 0.80 as compared to Group1 and Group2, who uses Fagan's review process and Simplified software review process for reviewing the artifact. Similarly the efficiency level of the Group3 is also greater than the Group1 and Group2. Subjects of Group3 detected 12 defects per hour as compared to subjects of Group1 who detect almost 3 defects per hour and Group2 who detect almost 7 defects per hour.

Review Process	Pre-Initiation Phases	Initiation Phases	Evaluation Phases	Closing Phases
Fagan Review Process [7]	.....	Overview➢	Preparation➢ Meeting➢	Rework➢ Follow-up
ADR [21]	.....	Overview➢	Review➢ Meeting➢	Rework
N-Fold Inspection Process [16]	.....	Planning➢ overview➢	1...N Parallel Review➢ Collation➢	Rework➢ Follow-up
Gilb & Graham Inspection Process [9]	.....	Entry➢ Planning➢ Kick off➢	Checking➢Logging➢Brainstorming➢	Rework➢ Follow-up
FTARM [13]	.....	Setup➢ Orientation➢	Private Review➢Public Review➢ Consolidation phase➢Group Review➢	Conclusion
Simplified Software Review Process [19]	.....	Setup➢ Orientation➢	Private Review➢ Control Review➢ Meeting➢	Rework➢ Follow-up➢Exit
Light weight Review Process [20]	.....	Overview➢	Review(Group/Individual) ➢	Rework
Proposed Review Process (EHRP)	Artifact Planning Preparation ➢ ➢ Pre-Review	Setup➢ Artifact Acquisition➢	Individual Review ➢ Defect analysis and Resolution➢Rework➢	Authorized ➢ Postmortem

6. Comparative Evaluation of Proposed Review Process (EHRP)

6.1. Based on Review Procedure

Researchers have tried to improve defects detection rate through different combination of activities. They have mainly focused on the improvement of evaluation phase. Proposed review process have tried to improve the review process not only through evaluation phase but also through the pre-initiation phase and closing phase. The details are summarized in table4.

6.2. Based on Interaction (Meeting) Mode and Purpose

Large amount of work has been done with respect to meeting but still there are issues with them as mentioned. The meeting procedure proposed in the proposed review process can be a good attempt to reduce the above issues. The details are summarized in table5

Review Processes	Meeting Held	Sittings	Meeting Purpose	Meeting Type
Fagan's Review Process	Yes	Single	Defect Detection	Sync
ADR	Yes	Multiple	Discussion of all defects	Sync
N-Fold Inspection Process	Yes	Multiple	Defect Detection	Sync
Gilb and Graham Inspection Process	Yes	Single	Defect Collection, Remove false positive	Sync
FTARM	Optional	Single	Discussion of unresolved issues	Sync/ Async
Simplified Software Review Process	Yes	Single	Discussion of all defects, Remove false positive	Sync/ Async
Light weight Review Process	Yes	Single	Defect Detection	Sync/ Async
Proposed Review Process (EHRP)	In case of critical defects & conflicts	Single	Discussion of critical defects only	Sync/ Async

7. Conclusion and Future Work

Keeping in mind the importance of face to face interaction, reviewers' precious time and experience, the proposed review process has introduced twofold review activity, an effectual meeting procedure and course of actions for future improvements. The pre-review activity performed by the linguistic expert save the time of experts reviewers, reduce defects analysis and resolution effort, increases the quality of review as well as quality of software. Reviewers review their specified part individually without having problem of getting together for review at same time and place. The effective meeting procedure introduced, minimized the inflexible requirements of the review meeting i.e. presence of all reviewers for detection of defects, collection of defects or discussion of all detected defect. The proposed meeting procedure does not require all reviewers to attend meeting compulsory.

To improve the review process and avoid the similar type of defect in future the proposed review process has introduced a postmortem phase. In future it is planned to further enhance the study by developing a tool for this proposed review process. Postmortem phase is introduced at its very initial level in future there is need to enhance the procedure of postmortem with software review processes.

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