INTRODUCTION

The Institute of Electrical and Electronics Engineers (IEEE) describes Software Engineering as "the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, “the application of engineering to software”.

The objective of this coursework is to tremendously reconfigure the Railway Reservation System. Thus,creating a well detailed insight of software engineering methodologies, how and when they can be applied, implemented and their respective outputs to produce a turnaround effect in the Railways Company. The Railways system used to be a leading innovator in the supply of dedicated products and services, designed to improve the supervision and control of railways worldwide. In recent times, the value of its shares have experienced a diving trend which leaves the stakeholders baffled and in need of a solution.

After thorough research had been carried out by the R & D wing (Research and Development) the idea of an extension to the Travel services came up. The following documentation would depict the software engineering process to which the selected group of five (5) members would carry out to produce a long lasting output that would entail;

- Intrinsic plans on minimizing the overhead.
- Slashing current rates on trip fares to meet current Market trends.
- Development of an ultra-modern reservation system aimed at attracting customers.
- Advance booking at cheaper and affordable costs.
- Efficient Cargo services.
- Online booking.
- Proficient customer service.

On the long run, the overall reconfiguration would fabricate a wide range of knowledge in the case study and in turn sort out thechallenges of the Railway Company during which the analysis, design and quality management of a competent system would be produced through the development of software engineering applications for the reservation system.

SCOPE

The System provides an online interface to the user with the sole aim of achieving an efficient online reservation system, which significantly speeds up and simplifies the process of booking tickets by customers. To bring about;

- Extension of routes.
- Minimizing cost.
- Cheap rates.
- On-board comfort.

Objectives

- Reliability improved by up to 50% for the system through optimized maintenance.
- 30% availability improvement and reduction in irregularities.
- 10% reduction in maintenance costs.
- Increased capacity in line with the Railway Company's objectives.
- Information sharing within the railway community, enabling optimization of decision-making for improved performance.
- Impoverished standard operations.

Problem Statement

The Stakeholders of the Railway Company sat down and carefully analyzed the current situation they are faced with and came up with the fact that its competitors have possessed a fair share of their hard earned successes by overhauling them in all business ramifications.

In the end, they took an immediate action of initializing the proposed project of developing an ultra modern Reservation System to attract the passengers. The selected Project Team is required to continue its dedicated efforts to provide the intending customers with better and more efficient services by integrating a direct reservation system to its website.

SELECTING THE MOST SUITABLE SOFTWARE ENGINEERING METHODOLOGY

The challenge in selecting a methodology is to do it wisely so as to provide sufficient process disciplines to deliver the quality required for business success, while avoiding steps that misuse time, squander productivity, demoralize developers, and create tension within the project team. The best approach for applying a methodology is to consider it as a means to manage risk. A candid way to identify risks is by looking at past projects.

In this study, the methodologies listed below would be briefly elucidated by documenting the basic fundamentals of the methodologies incorporated with their respective *pros* and *cons* in other to bring about better understanding on their individual qualities,the criteria for Methodology selection, their implementation procedures and the user requirements so as to meet up with the customer demands for intrinsic Software Development of the Railway Reservation System within a very short duration. All these processes would be put in place in the successful output of analyzing, designing and the production of an exceptional Information System Management for the Railway Company as provided in the scenario. The following document would illustrate respective arguments integrated with the key factors in making use of the methods below for the creation of the reservation system.

- Object Oriented Methodology.
- Agent Oriented Programming.
- Extreme Programming (XP).

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OBJECT ORIENTED PROGRAMMING

An object oriented system is made up of interacting objects that maintain their own local state and provide operations on that state. O.O design processes involves designing object classes and the relationship between these classes. In object oriented languages, the word object is often used to refer to an instance of a class.

[Sommerville 2011]

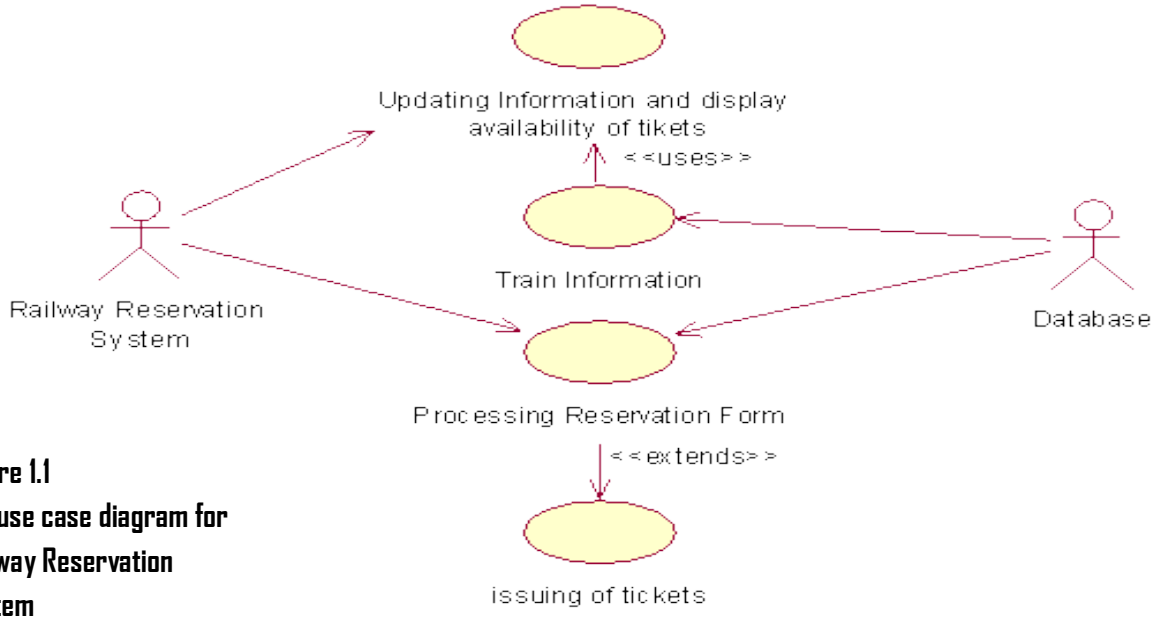


Figure 1.1
O.O use case diagram for Railway Reservation System

The Figure above is a diagrammatic representation of a use case diagram showing what the proposed reservation system would look like using Object Oriented methods.

Object-oriented development (OOD) methods have been shown to be valuable in constructing software systems that are easy to understand and modify, have a high potential for reuse, and are relatively quick and easy to implement. Despite the demonstrated successes of OOD, many organizations have been reluctant to adopt object-oriented techniques, largely due to concerns over performance.

[Perfeng, 97]

Basic Object Oriented Concepts;

Object: A collection of data and its functions. (Noun)

Class:A group of objects.

Data Abstraction: It captures only those details about an object that are relevant to the current perspective.

Encapsulation: Protection of the variables and information with the help of an object. (Preventing the users from using the derived data by shielding it from the GUI)

Polymorphism: The creation of more than one class by using a single base class. This feature enables different properties.

Association: Relationship between instances of two classes.

Inheritance: The generation of a new class from an existing one.

Aggregation: A condition whereby one class belongs to another.

Some successful examples of systems created by Object Oriented Methodologies are stated below;

- Modular Reasoning Systems.
- Banking Systems.
- Patient attendance Systems.
- Railway reservation systems.
- Customer Address Systems.

Benefits of Object Oriented Methodology

- OOP creates a platform to which maintaining and modifying existing code as new objects can be created with small differences to existing ones with ease.
- The Methodology providesavery good structure for code libraries where supplied software components can be easily adapted and modified by the programmer. This is particularly useful for developing graphical user interfaces.
- *Simplicity*; O.O software objects model real world objects, so the complexity is reduced and the program structure is very clear.
- Objects in O.O can be reused in different programs hence, providing a clear modular structure for programs which makes it good for defining abstract data types where implementation details are hidden and the unit has a clearly defined interface.

AGENT ORIENTED PROGRAMMING

Agent-oriented programming is a fairly new programming paradigm that supports a societal view of computing. In AOP, objects known as agents interact to achieve individual goals. Agents can exist in a structure as complex as a global internet or one as simple as a module of a common program. Agents can be autonomous entities, deciding their next step without the interference of a user, or they can be controllable, serving as a intermediary between the user and another agent. A.O.P was first used by Yoav Shoham within his Artificial Intelligence studies, in 1990.

What is an Agent?

An agent is an encapsulated computer system that is situated a CGI environment, and that is capable of flexible, autonomous action in that environment in order to meet its design objective.

[IEEE Standard 610-1990]

A candid and fair example of A.O.P is the implementation of *Artificial Intelligence* introduced by Shoham.

A.O.P Usage and Strengths; At present, there is a great deal of ongoing debate about exactly what constitutes an Agent Oriented System. In the end, there was nothing approaching a universal consensus because of its complexity and the fact that is a new programming paradigm without a reputable success record in developing systems. Below are a few ways of inculcating A.O.P;

- Clearly identifiable problem solving entities with well-defined boundaries and interfaces.
- Designed to fulfill a specific role they have particular objectives to achieve, that can either be explicitly or implicitly represented within the agent.
- Autonomous they have control both over their internal state and over their own behavior.
- Capable of exhibiting flexible (context dependent) problem solving behavior they need to be reactive (able to respond in a timely fashion to changes that occur in their environment in order to satisfy their design objectives) and proactive (able to opportunistically adopt new goals and take the initiative in order to satisfy their design objectives).

Pitfalls of Agent-Oriented Development

The following sets of problems are directly attributable to the characteristics of agent-oriented software and are, therefore, intrinsic to the approach. Naturally, since robust and reliable agent systems have been built, designers have found means of circumventing these problems. However such solutions tend to be very much on a case by case basis;

- Striking a balance requires context-sensitive decision making. This, in turn, means there can be a significant degree of unpredictability about which objectives the agent will pursue in which circumstances and which methods will be used to achieve the chosen objectives.

- Agent Oriented Systems have to act in pursuit of their objectives while maintaining an ongoing interaction with their environment. Such situation makes it difficult to design software capable of maintaining a balance between proactive and reactive behavior.
- A.O.P is also inherently unpredictable in the general case. As agents are autonomous, the patterns and the effects of their interactions are uncertain. (Decision making attributes).

EXTREME PROGRAMMING (XP)

Extreme Programming (XP) is an agile software engineering methodology which is perhaps the best known and widely used agile methodology. Due to the obvious fact that the approach was developed by pushing recognized good practices like Iterative Development to extreme levels. The name XP was invented by "**Kent Beck**"; an ***American Irish Armenian*** software engineer and the creator of the Extreme Programming and Test Driven Development software development. The exquisiteness of XP is that, several new versions of a system can be developed by a series of very good programmers, integrated and tested in one day.

XP Definition: Extreme Programming is a discipline of software development based on values of simplicity, communication, feedback, and courage. It works by bringing the whole Project Team together (In a Joint Application Development JAD) session in the presence of simple practices, with enough feedback from the Users/Customers to enable the team to see where they are and to tune the system development to meet the user requirements. [E. Jeffries 1999]

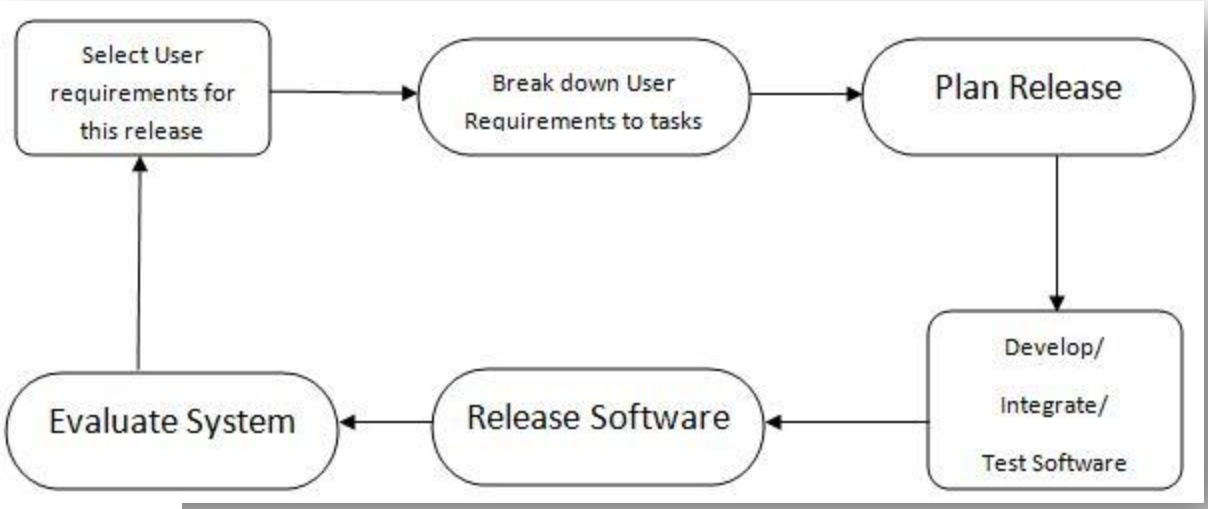


Figure 1.2
XP release cycle

Source;*Software Engineering 9th Edition, Sommerville 2011*

The figure 1 above illustrates the XP release cycle. In extreme programming, the user requirements are implemented directly as a series of tasks. Programmers work in pairs and develop tests for each task before writing the code. All tests must be successfully executed when new code is integrated into the system. The image above depicts the XP process to produce an increment of the system that is being developed.

Benefits and Pitfalls of Extreme Programming

Benefits	Pitfalls
➢ XP allows the developers and programmers to channel their focus on coding. This measure succeeds in the avoidance of unnecessary paperwork.	➢ It's difficult to get many developers to accept the practices, and it takes a lot of discipline to keep doing them all.
➢ XP creates working software faster, experiencing only a few errors.	➢ XP teams are reluctant to agree to fixed-price, fixed-scope terms, because they realize that change will happen
➢ For the Management, it maximizes early return on investment.	➢ Investors are left skeptic about making use of it due to its Financial Implications.

Figure 1.3 XP Pros & Cons

SELECTED METHODOLOGY FOR THE PROPOSED SYSTEM

It is important to make Methodology decisions at the right time and for the right reasons. Good business decisions provide developers with the appropriate supporting tools so they can produce good systems. The selected three methodologies have their individual strengths and weaknesses which have been reviewed to produce a substantial knowledge and qualitative Methodology selection for the development of the Railway Reservation system

Reasons for choosing Extreme Programming;

- XP provides a platform to which the users can interact with the system during a JAD (Joint Application Development Session) and make their decisions if they are satisfied with the system or they need inclusions to its functionality.
- During the planning phase, it was discovered that the system was needed within a very short time. Among the three Methodologies, only XP can be used to complete the system with that sort of time frame.
- XP also stresses the need to work as a team which we the group members of this project needed for the system development.
- *Familiarity with the technology*; All (5) five of us in the group are significantly conversant withthe use of XP which gives us a good edge in developing the Railways System.
- The system is meant to be online, thus, giving the developers a major task and leaving them with no choice but to choose a methodology they are collectively certain will develop and deliver the system without glitches.

Reasons for avoiding Object Oriented Programming and Agent Programming;

- Both methodologies cannot be delivered within the provided time frame.
- The developers are not familiar with the use of O.O and Agent Programming.
- The system is not a complex system thus, the use of O.O and Agent programming is not suitable.

EVALUATION PLANNING AND SOFTWARE ENGINEERING DESIGN PROCESSES

The Project Team (Group members) jointly recommended and put to use, Extreme Programming for the development of the R.R.S due to the imminent fact that its basic advantage makes the whole process of developing the system visible and accountable. The team made use of concrete commitments about what was to be accomplished, prove concrete progress in the form of deployable software. KentBeck stated XP as the practice and pursuit of effective simplicity, as applied to software development which gave the team a clear picture of the user requirements and ease of system development.

Evaluation

The unprecedented combination of JavaScript and scripting expertise in the project provedsuccessful. Suddenly the developers in the project team in charge of defining the interfaces, got a very wide understanding of how beneficiary XP would be. Hence, they could design and adapt the designaccordingly. The script programmers finally found it possible to influence the design of the R.R.S interfaces to better suit the Stakeholder's needs. The most important areas for improvement in this project are hereby defined as;

- Introduction of acceptance testing.
- Broadening the customer base.
- Finding an efficient test framework for coding.

Compared to other sub-projects within the Railway Company, we consider our main edge as the usage of aflexible methodology, and at that, we had a clear road map of how to completethe task we were given and a set of practices to follow. But we also claim that the usage of Extreme Programming as a software development methodology for our project would be very successful. It is easy to learn, and in actual practice it becomes more transparent than manyother models. Secondly, instead of processing and working with meta-information, in theform of, for example, specification documentation, the team will stay more focused onthe core of the product – the source code. Thirdly, the flowing of oral communicationwithin the team, together with the united design decisions, led to a tighter team with aconsiderably stronger identity and pride for

the finished product. Fourthly, the pairprogramming practice led the team members to enjoy their everyday work much morethan before.

Developers	Customers	Stakeholders	Adherence Measures	Outcome Measures
The development of the user stories for this project required a varied set of skills from the programmers; Java, C++, ASP and MYSql. Only one of the four had any previous experience in writing ASP code.	The rail company's customers had extensive previous experience in using systems; therefore they are well prepared for the R.R.S usage. However, the Railway Reservation project is huge,with close to 200 000 man-hours invested to date. This implies that a customer must also have to pay close attention to a lot of other issues, e.g. usability and adherence to the existing graphical design during the JAD session.	The system is en-route to meet the wishes of the Stakeholders for it to meet up with the current market trend. A very attractive ultra-modern reservation system would be achieved on the long run.	The project team and team members judiciously followed the specific practices associated with the chosen development process and came up with astounding results eminent in the end product.	One of the major results achieved in the project is its simplicity. Meeting user requirements and staying less complex is a mercurial task in software development. The team members bridged that gap by producing a very simple Reservation System.

Figure 1.4
Railway System Evaluation Framework

[Agile Teams 2011]

The figure above depicts the authenticity of the Railway system and the ways to which it has an effect on the core values, the user/stakeholder requirement and the velocity to which the Project Team followed Software Engineering Processes in developing the R.R.S.

Planning

In planning for use of Extreme Programming (XP), the User requirements would be initially written as user stories. They tend to be brief lines of description about what the

customers expect of the system in order to meet up with their requirements.The User requirement would briefly describe and explain initial details which would identify the effort estimated; risk factors involved in the planning of the railway system, and begin to identify basic acceptance test cases. User stories functions similar to use-cases but at very high levels.Once user stories are developed, the XP team performs a formal meeting with the Stakeholders; developers, testers and other key players to identify the priority of the user stories, and formally decide about a release plan. The team develops the estimates for each story and projects how much a team can produce in a given time interval. Project planning is generally performed by either time or scope of the project.Previous historical statistics can be used to identify the estimates for the subsequent iterations. Some of the following statistical measures can be used to analyze prior history during planning.

[Beck, 1999]

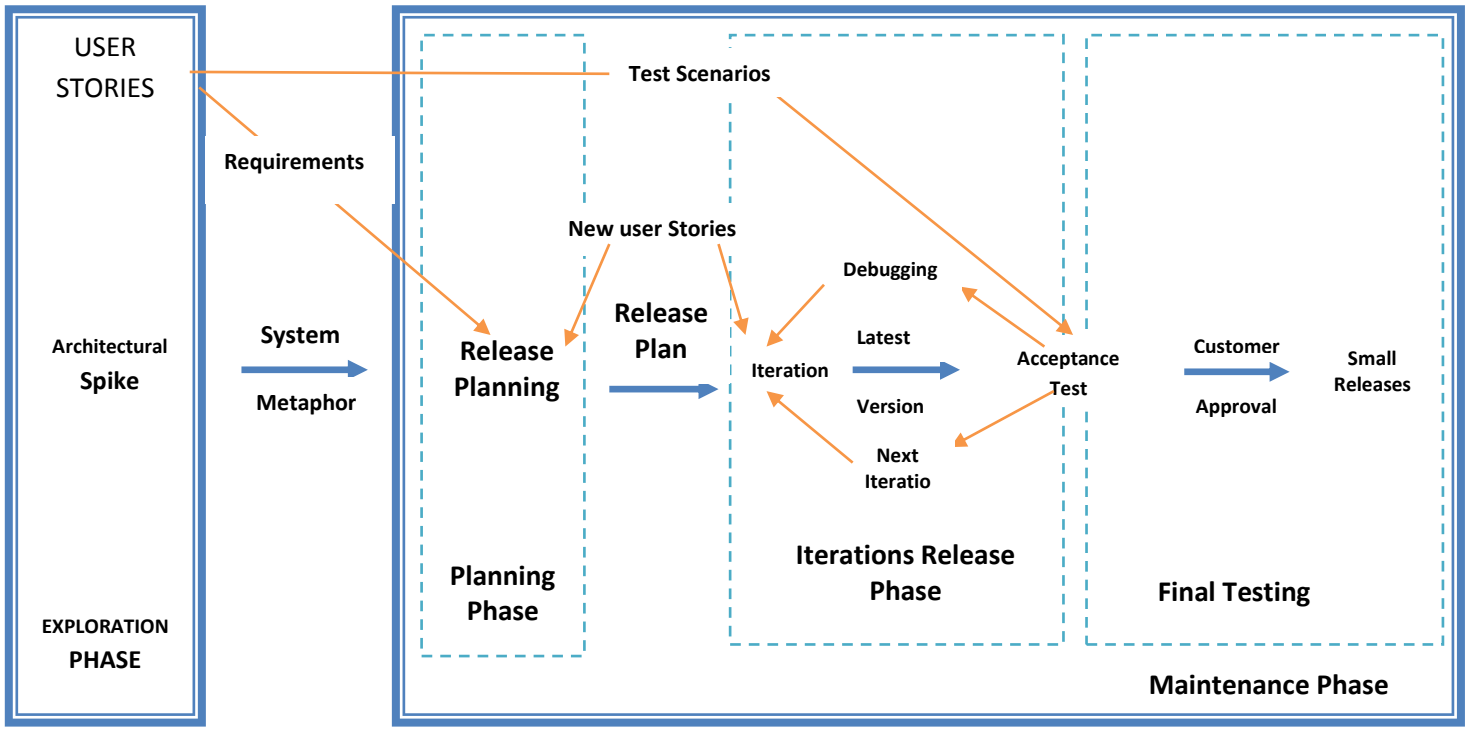


Figure 1.5
The XP Project lifecycle

The image above is a distinctive illustration of Extreme Programming process of system development. It shows a well detailed and structured lifecycle to corroborate the procedure carried out in the development of a system with the use of XP. The cycle

comprises of Phases that work communally to produce a desired end result. Such phases are elucidated below;

Exploration Phase: This is the first phase and as stated by (Beck, 2000), it includes all the initial requirements modeling and preliminary architectural modeling features of building the system. It entailsthe conception of an*architectural spike* which 'intends to identify areas of maximum risk, to get started with estimating them correctly' and the development of the initial user stories. In this phase, it is imperative that good enough materials are required in the user stories in order to produce a first good release and the developers should be sufficiently confident that they can't estimate any better without actually implementing the system.

Planning Phase: This segment is the sophomore phase of the XP lifecycle which trails the exploration phase directly, the sole aim of this phase is for the stakeholders and the project team is to congregate agree and prepare to implement the most important part of the user requirements.

Iterations to Release Phase:(Beck 2000) clearly stated that this phase is where the major development efforts including modeling, programming, testing, and integration occur. Iteration planning is the same type of effort as release planning; the only disparity is that it focuses on the user stories assigned to the current iteration.

Final testing Phase: Also known as the Productionizing Phase, it consists of the acceptance testing and small releases in the XP lifecycle. It is typically a process for confirming that the system is ready to go into production. During this phase the Project team wouldreduce the pace to which the system is being evolved, evolution doesn't stop, but the risk of whether the development should go into the next release becomes significant.

Maintenance Phase: The XP Maintenance phase (Beck, 2000) is the normal state of XP projects because it keeps evolving over time. After the initial release when all acceptance test cases are completed, any subsequent iteration will fall under

maintenance phase. In maintenance phase, developers and the Project Team need to handle the request for current production system and next iteration tasks. This development effects development velocity.

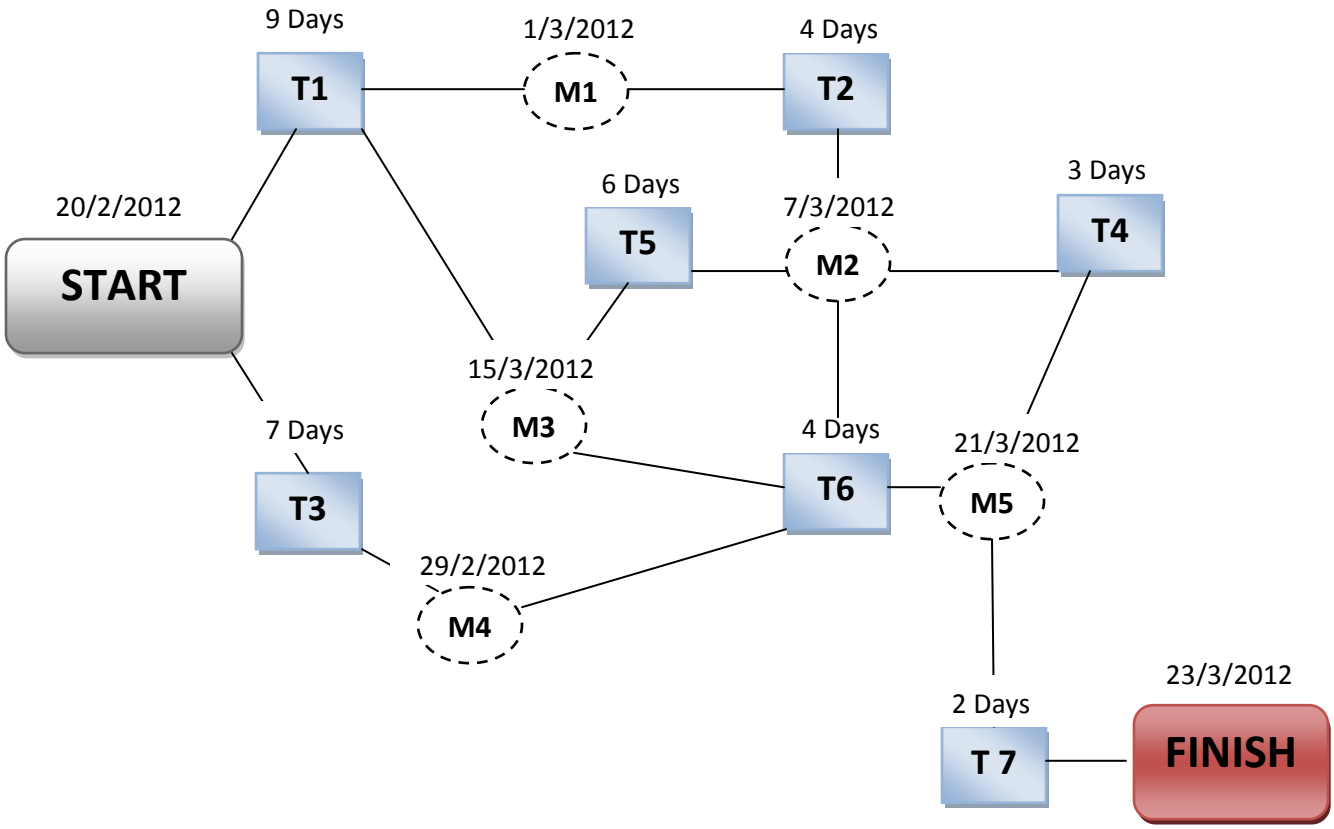
Additionally, this phase alsoinvolves the Planning, Iterations to Release, and Productionizing phases for releases of the system. It is essential to recognize that systems built taking an XP approach are put into production just like systems built using any other approach. It is also very paramount to recognize the immediate team needs to take production-related issues into account which is why Agile Methods explicitly includes operations and support staff as potential project stakeholders. The value of building any given system is minute if it cannot be deployed, maintained and kept competent in production.

Task Durations & Dependencies:

	ACTIVITY	TASK DURATION	DEPENDENCIES
1	TASK1 SUB 1 (O.O Methodology) SUB 2 (Extreme Programming) SUB 3 (Agent Programming) SUB 4 (Pros and Cons)	2 DAYS 2 DAYS 2 DAYS 3 DAYS **9 Days**	
2	TASK 2 (Planning, Evaluation and Design)	4 DAYS	T1, (M1)
3	TASK 3 SUB 6 (Risk Management) SUB 7 (S.D Steps)	3 DAYS 4 DAYS **7 Days**	
4	TASK 4 (Metrics Discussion)	3 DAYS	T2, T5 (M2)
5	TASK 5 (Planning and Evaluation of S.E processes)	6 DAYS	T2 (M2)
6	TASK 6 (Documents design of vital S.D phases)	4 DAYS	T5(M3)
7	TASK 7 (Presentation)	2 DAYS	T6 (M4)

The above table describes the estimated time the Reservation System would take to be completed and delivered to the demanding Stakeholders. The dependencies also show how the tasks are dependent on another upon finishing the project all in the aim of delivering the system on or before the deadline date. Activity charts are a schedule representation that highlights the dependencies between project activities or tasks. The activity chart shows which activities can be carried out in parallel and which must be executed in sequence because of a dependency on an earlier activity.

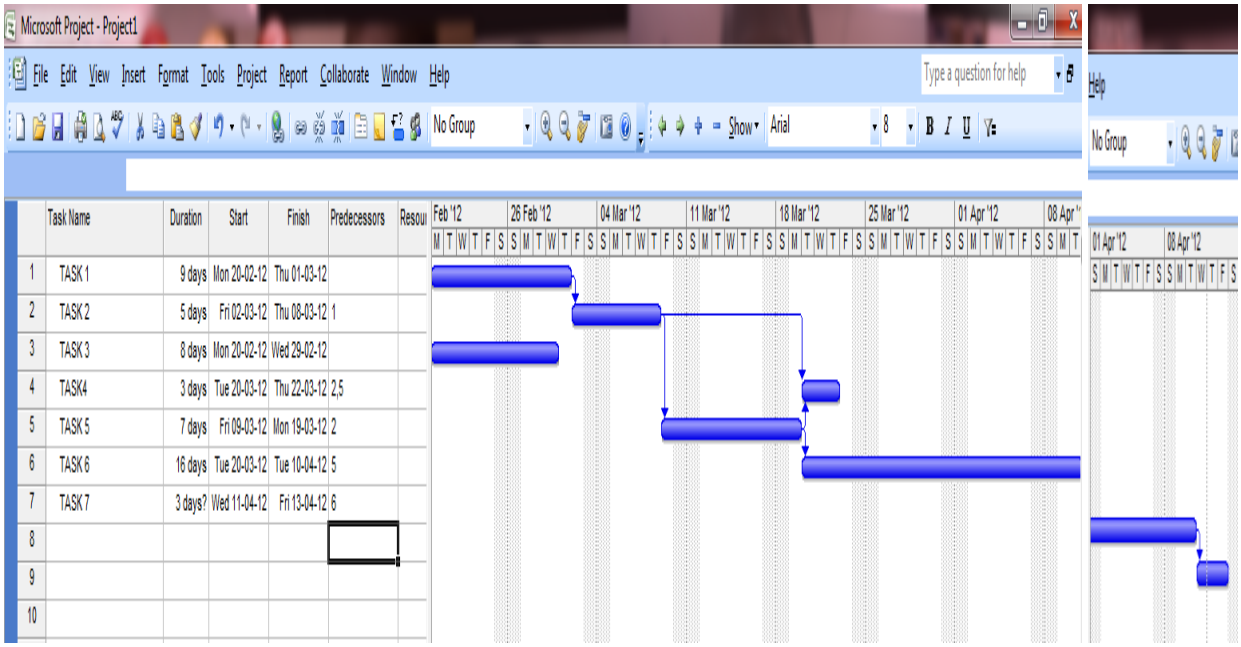
Activity Network:



Activities are represented as rectangles; milestones and project deliverables are shown with rounded corners. Dates in this diagram show the start date of the activity and are written in British style, where the day precedes the month. Thus, showing how the Railway Reservation System would be carried out from start to finish.

[http://www.cs.st-andrews.ac.uk/~ifs/Books/SE9/Web/Planning/activities.html]

Activity Timeline:



The image above illustrates the activity timeline, elucidating the amount of time elapsed in the completion of the Project.

Staff Chart:

STAFF	TASK TAKEN	START DATE	FINISH DATE	RESULT FROM TASK
NNABUIKE FRANCIS UNIGWE	TASK 5 , TASK 3, TASK 4	09/03/2012	19/03/2012	completed
GIDEON AKITOYE ADEMOLA	TASK 2 , TASK 5, TASK 4	02/03/2012	08/03/2012	completed
MUHAMMED ZAKARI ADAMU	TASK 3 , TASK 1	20/02/2012	29/02/2012	completed
MUHAMMED AHMED	OBJECT ORIENTED EXTREME PROGRAMMING AGENT PROGRAMMING	20/2/2012	1/3/2012	completed
JENNIFER CHIAMAKA ONWUDINJO	Metrics (TASK 4)	20/3/2012	22/03/2012	completed

The table above is an elucidation of how the Tasks allocated for each group member, the start and finish date and the result achieved from the tasks.

RISK MANAGEMENT

Risk Management is one of the most important problems faced by today's project Manager. It involves the anticipation of risks that might affect the project schedule or the quality of the system that is being developed and in turn, carry out procedures to utterly evade these risks. In other words, it is concerned with assessing the possible losses that might ensue from attacks on assets in the system and balancing these losses against the costs of security procedures that may reduce these losses. It may be cheaper to accept losses than to protect against the attacks that might lead to these losses.

[Ian Sommerville 2008]

Hall, 1998: Ould, 1999 described risk as something you'd prefer not to happen. Risks may threaten the project, the system being developed or the Organization.

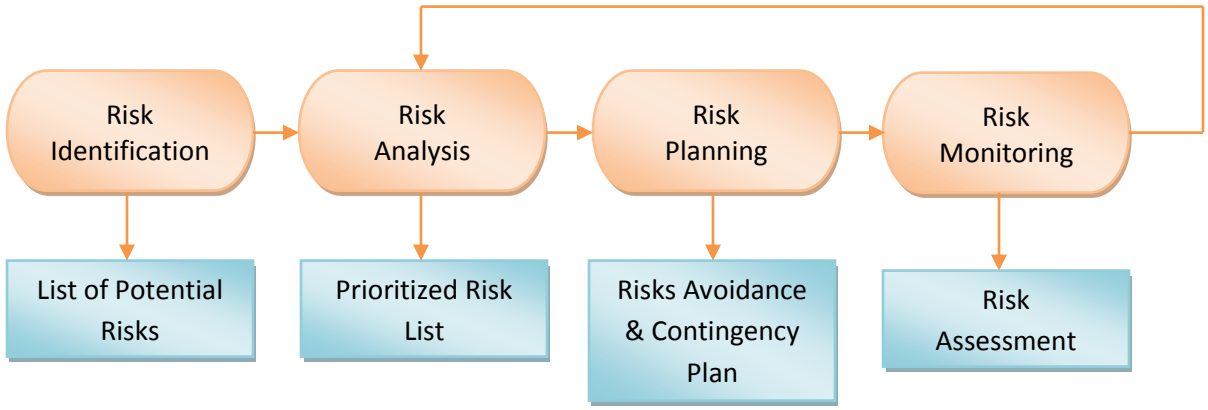


Figure 1.6
Risk Management Process

The risk management process is an iterative continual process that was carried out all through the project. The project team devised an initial risk management plan that underwent monitoring of the system's condition in order to detect emerging risks. The Railway reservation system poses no complexity which made XP the better choice.

RISK IDENTIFICATION

Risk identification is tagged by 'Sommerville' as the first stage of the risk management process. It is apprehensive with the identification of risks that could cause a massive setback to the Software Engineering process, the development of the Organization or to the development of the system. In view of this, we the selected group of five (5) have brought our views together, done a couple of brainstorming on the possible risks and our leader (The Project Manager) has successfully identified the critical risks involved with the project.

The Railway Company's basic services began to diminish due to lack of healthy capital caused by *excessive operating cost* i.e. *exorbitant overhead.* All these boiled down to poor management which could be tagged as the organizational risk.

Amongst all these risks there exist some categories of risk often called **Risk Identification** which could be generalized as follows;

- *Technology Risks;*a kind of risk derived from the Hard and software technologies used to develop the Railway Reservation system.
- *Estimation Risks;*these are risks emanated from the management estimates of the resources and methodology (XP) required to develop the system from start to finish. With the inclusion of Activity Timelines.
- *Requirement Risks;*These sorts of risks are those that are caused by the numerous changes to the processes of managing the requirements/changes and the amendments of the customer requirements made by the Railway Stakeholders.
- *Organizational Risks;* these is created by the Organizational environment incorporated with the Management of the system and its location of development.
- *People Risks;*these are risks related to the individuals (Group Members) in the development team. Such occurs when the project team members do not follow the organization's procedures, practices or rules", i.e. that they "deviate" from expected behavior.

Identification of the Risk posed by the Project as seen at its outset;

There are a handful of risks that were lurkingaround the project from its commencement which are listed below;

- Collapse of I.T infrastructure.
- Development procrastination.
- Loss of project team loyalty and goodwill if project fails.
- Inadequate Logistics.
- Expenditure and outflow of excessive funds.
- Decrease in Service price.
- Indecent time management.
- Increase in operating cost.
- Inexperienced workers and “on the Job” training.
- Railway Diminishing returns.

Outlined Key Risk Factors (Prioritized Risk)

Amongst the risks procured by the project, some are categorizedinto prioritized risk. Having stated that, the major factors that would hinder the project from coming to a closure are;

Loss of Project Team Loyalty; this causes loss of credibility from customers and clients, creating a declining self esteem and below par technical abilities by the Project team.

Indecent time management; this transpires when some of the Project team members are fond of putting off or delaying their tasks, particularly those that require immediate attention. The system needed to be planned in a proper way such that it would stand the test of time. If time is not managed judiciously, activities like; planning, organizing, staffing, directing, coordinating, reporting, and developing the system would not be completed efficiently and effectively.

Inadequate Logistics;Once the capital is not sufficient, the project wouldn’t meet up.

Steps to Control the Risks (Risk Avoidance and Contingency Plan)

- Minimization of task dependences.
- Define the project purpose.
- Risk assessment.
- Anticipation and observation of impending risks.
- Careful planning; with the use of diverse planning techniques with the aim ofconcluding the projectbefore its estimated completion time. For instance; generating Gantt charts and setting objectives and incentives for team members.This would therefore motivate themto workswiftly.
- Reduction of expenditure on systems by acquiring a software vendor that is compatible with most systems.
- Adequate testing.
- Extra intense training of Project Staffviaseminars, workshops andoverseeing progress reports.

METRICS EMPLOYED ON PROCESS AND PRODUCT

The metrics employed in the development of the Railway Reservation System was indeed of huge significance as it gave the Project Team an avenue to guarantee a quality system and quantify the following;

- Software schedule.
- Work effort.
- Systemsize.
- Project status.
- Software quality
- System performance.
- System efficiency.

Ultimately, these processes helped the Project Team control the software venture while learning more about the way the software organization works.

In view of the above, the use of Extreme Programming proposes a set of software development practices to increase productivity while maintaining quality. It could be grouped into according to three key areas: customer satisfaction, software quality, and development process organization.

Customer Satisfaction: XP supported customer involvement through the development process of this system, to ensure that their requirement is been met in other words the on-site customer works with the team; It also improved the software's business value. When issues arise, programmers can get customer input immediately rather than guess on customer preferences. This also lets customers change requirements on very short notice thereby helping the team flexibly refocus development efforts on the most pressing needs of the system.

Software Quality: Software development is one of the major goals is to produce high quality software. The concept of quality depends heavily on the view of the system, the combined effects ensure that the team maintains high standards without slowing down the development process, The Project team also used test drivers to verify if the system exhibits the proper functionality after the code is written.Changes are embraced

because of the continuous testing which enable low risk expectation, allows programmer collective ownership of the system code and sustainable development process.

Development process organization: In other words to ensure a quality software system, requirement gathering technique is needed, requirement gathering technique is the process collecting all the functional and non functional requirement of the system for the development process.

PRODUCT METRICS

Product metrics according to (Sommerville 2011) are 'predictor metrics used to measure internal attributes of a Software System'. In relation to the Railway Reservation System, the size of the system is measured in lines of code.

Product metrics plunge into two (2) classes namely;

1. *Dynamic Metrics;*this entails the number of bug reports ascertained during the development of the system and the time it took to complete the system.
2. *Static Metrics;*these are the average length of identifiers used and the size of the code implemented.

'These strings of metrics are related to different quality attributes. Dynamic metrics help to assess the efficiency and reliability of the Reservation System while the Static Metrics assesses the understandability, maintainability and complexity of the system and its components'. [Sommerville 2011]

The Software characteristics for the said system are as follows;

- Cyclomatic Complexity; *developed by Thomas J. McCabe, Sr. in 1976. It was used to indicate the complexity of the Railway System. It directly measured the number of linearly independent paths through the program's source code.*
- System Size.
- Maintainability.
- Usability.
- Aptitude Compactness.

All the above characteristics work in an interwoven manner to meet up with the production of an ultra-modern reservation system. Hence, the **"*fitness of use*"** and the output that is produced would be exceptional.

Metrics set for the project

Indicator Category	Management Insight	Indicator
Project	Provides information on how well the project is performing with respect to its schedule.	Planned task completions and duration analysis for the system.
Effort	Provides visibility into the contributions of staffing on Project costs, schedule adherence, and product quality.	Planned staffing profiles.
Requirement Stability	Provides visibility into the magnitude and impact of requirements changes.	Number of requirements changes/clarifications and distributionof requirements over releases.
Review Results	Offers status of action items from the Project's life-cycle review.	Status of action items.
Reports	Produces an insight into product and process quality and the effectiveness of the testing.	Number of hitched reports.

(http://sunset.usc.edu/classes/cs577b_2001/metricsguide/metrics.html)

Figure 1.7
Metrics inculcated for the Project

The above Table depicts the cumulative number of planned and actual completions or milestones over time. Where; indicators are used to denote a representation of metric data that provides insight into an ongoing software development project. Indicators are metrics in a form suitable for assessing project behavior or process improvement. The chart is generic, and each indicator categorywill substitute specific tasks units and milestones. In addition, each scheme is expected to produce multiple progress charts for different types of tasks in order to bring about quality management of the Railway system.

Figures 1.7 also connotes and show the indicator categories, the management insight provided, and the specific indicators for the employed metrics. Due to the nature of the project, specific contractual requirements and management preferences made the quality of the system rated on a high scale.

SOFTWARE ENGINEERING PROCESSES TO SUPPORT THE MANAGEMENT OF RAILWAY SYSTEM

FEASIBILITY STUDY

The aim of the feasibility study is to analyze if the system can be developed and also if the system if worth implementing given the available budget stated by the organization of the Railway System.

From the feasibility study, the Project Team would determine the cost effectiveness of the system if it would be lucrative to continue developing the system. Hence, the team would inform the organization and give the Stakeholders the aptitude to decide on whether or not if they should go ahead in the development of the system with more details. (Sommerville 2011)

The feasibility study is further disbursed into three (3) parts; the technical, economic and organizational feasibility of the system.

TECHNICAL FEASIBILITY

In the race for the system to be successful, we would acquire the necessary hardware and software requirements to handle the Railway system. With the research been carried out we would be able to know from the cost of the system how important the Railway system is and handle it well from the research we found out thereby keeping the railway system as simple as possible by using familiar application or to provide manuals for the customers of the railway system so as to understand the system when it has built completely. For us to carry out the technical feasibility some steps would be taken into consideration described below;

Familiarity with the Application: less Familiarity would generate more risk.

Simplicity has been the driving force in the system's creation. As such, the system has been made to suite the requirements of the users by its user friendliness. It is easy to use through simple commands and it brought about a massive decrease in the risk of familiarity. Once the user creates and account and is authorized, he/she would be able to navigate the system with ease.

- The Railway system would provide information tips for every function of the system.
- User manuals are provided for Customer understanding of the system.

Familiarity with the Technology: Less familiarity would also generate more risk.

This system will run on Windows 7 Operating System, other software are stated below in the System requirements and dedicated applications customized for the system tour operator.

- The technique of analysis that was used in building the system would be JAD session thereby; enabling the users interact with the system and review their contentment or discontent.
- Experts and skilled personnel would be available for the training of new staff and intakes in the organization about the fundamentals of the reservation system.
- The maintenance department of the Railway system in the organization would possess basic knowledge about the technology used in developing the Railway system so as to keep it running within maximum time.

Project Size: Large Projects attracts a handful of risks.

If the size of the project team is huge, problems are bound to loom. As long as all the financial necessities are available for the venture, the project would be carried out on a minute scale with the involvement of minimal risk. It is an internet inclusive project and it comprises a project team of five individuals to complete the task within two months and above. Thus, reduction of the project team would enable ease and evade complications.

- The project completion time set by the board members of the Railway system is very vital because we the project team has taken this project to be a large and important one which would require lots of time to accomplish.

Compatibility: The harder it is to integrate the system with the organizations existing technology the higher the risks involved.

- The internet infrastructure has to be in place in order for the Railway Reservation system to be accessed by order branches of the company.

ECONOMIC FEASIBILITY

From the economic feasibility we the project team are looking at making the system successful by looking deeply into the cost and benefit of the system for the organization. Having a full knowledge at the back of our hand that this process would enable us know if the system can be built or not. This would now help us to understand areas which we have to set our focus on and indicate areas which needless monetary attention.

The most important plan is having a good speculation of achieving the return in investments of the system after it has been implemented over a period of three (3) – five (5) years. Hence we can say that the system is a profitable to the organization.Therefore we would be looking at the processes which we would take in analyzing the economic feasibility like development cost, benefit outcome and operational cost of the Railway system.

Development Cost

Aimed Date	**2012**	**2013**	**2014**	**2015**
Domain Name @ $15,000	15,000	0	0	0
2 Intel dual sever @ $100, 000	200,000	0	0	0
Microsoft Sever 2011 Software @ $700	700	0	0	0
3 HP desktop @$1000	3000	0	0	0
2 printers @ $350	700	0	0	0
Labour @ $200,000	200,000	0	0	0
SQL data management @ $350	350			
Internet connection @ $400	400			
Total	**$420,150**	**0**	**0**	**0**

Benefits

	2012	2013	2014	2015	Total
Increase in sales	0	$150,000	$151,050	$161,624	$462,674
Reduces in Customer Complaints	0	$40,000	$40,000	$40,000	$120,000
Running Expenses	0	$50,000	$50,000	$50,000	$150,000
Reduce in Stationeries Expenses	0	$30,000	$30,500	$30,500	$91,000
Reduced Customer Transport	0	$20,500	$20,500	$20,500	$61,500
Reduced inventory cost	0	$30,000	$30,000	$30,000	$90,000
Total	**0**	**$320,500**	**$322,050**	**$332,624**	**$975,174**

Operational cost

	2011	2012	2013	2014	Total
Hardware	0	$20,000	$20,000	$20,000	$60,000
Software	0	$15,000	$18,000	$20,000	$53,000
Labour (Salaries)	0	$50,000	$50,000	$50,000	$150,000
Total Operational Cost	0	$85,000	$88,000	$90,000	$263,000
Total Cost	$420,150	$85,000	$88,000	$90,000	$948,850
Total benefits-Total cost	$420,150	$235,500	$234,050	$242,624	$26,324
Cumulative net cash flow	$420,150	$420,350	$186,300	$-56,324	
Return in Investment	**2.77% (26,324/948,850)**				
Breakeven point	**2.077years (cost are fully covered after 3years) 242,624-56324/242624=0.77**				

The break-even point will be reached after three (3) years.

From the economic feasibility we the Project Team members found out that the Railway system can be built following a high return in investment after a period of three years.

ORGANIZATIONAL FEASIBILITY

The organizational feasibility would show and tell the organization that the project (Railway system) would be at a low risk. The executives of the organization has taken the railway system to be a very vital project which they would like to accomplish thereby making we the project team take it with outmost importance to accomplish the task in due time given by the organization.

The Managerial problems of the old system are loss of data and information accessing by unauthorized users of the system so therefore the team would make sure that data and information security would all be put into consideration on the building of the new system (Railway system).

In order to keep away from a situation whereby the system would not meet the required standard of the stakeholders i.e. the organization, and the system users, the project team would call for a JAD session to get down all the requirements required by them i.e. stake holders.

REQUIREMENT ELICITATION AND ANALYSIS

After a thorough feasibility done above, we now look into the requirement elicitation which means requirement engineering process of gathering information and analyzing the railway system as described by (Sommerville 2011). In view of this, for requirement gathering we the project team would interact with the customers, the management and the end users of the system to get all the information required for building the system and also what the system should developed with and what the system should provide for the customers.

In requirement elicitation it may and would involve the stakeholders of the organization in so many ways that the organization board members would influence the Railway system requirement.

The processes of requirement elicitation used by the project team in the railway system would differ based on the approach. The board members of the organization would want to take thereby allowing us the project team to choose from the following different types of requirement elicitation;

- *Requirement Discovery:* This is a process of interacting with the stakeholders of the Railway system and finding/discovering the requirement which they would want for the railway system and also the documentation can be done and discovered during the requirement gathering activities.
- *Requirement classification and organization:* This would take so many unstructured ways of the gathering the requirements of the Railway system including grouping the requirements and also organizing them with means of importance.
- *Requirement prioritization and negotiation:* This process involves the presence of all the stakeholders of the Railway system so as for them to deliberate and we the project team would then help them to find out the solution to the problems which

(Sommerville 2011)

Therefore from the following requirement elicitation stated above we the project team would use Requirement discovery because we would be interacting with the stakeholders who maybe the board members, customers and end users of the Railway system to develop and come out with the requirements that would be needed to develop the Railway system.

In trying to come out with the requirements of the railway system certain requirements gathering techniques where considered and used in the process of coming out with requirements needed to develop the Railway system for the organization, which are follows;

- Interview
- Scenarios
- Observation
- Questionnaire
- JAD session

In the process of gathering all the requirements needed to develop the system we the project team made used of some of the following requirement gathering techniques mentioned above like interview, Scenario, Questionnaire and JAD Session in order to gather all the requirements needed to develop the system.

Interview: We the project team conducted an interview session with important board members of the Railway system whom have really busy schedule on their daily activities by asking them questions on what functionalities they would want to see in the system and questions on what they think made the old system a failure.

Scenarios: The project team members were given a scenario which we collectively had to study intensively so as to come out with the requirement of the Railway system for the organization based on what they have written in the proposal/Scenario given by the organization.

Questionnaire: For the purpose of creating an exceptional system, the project team drafted out questions which were given out to all the stakeholders involved in the Railway system and also staff and end users. All these measures were put in place in order to get a feedback from the users on what they would like to see in the Railway system which we the project team would develop.

JAD Session:A state of the art conduction of a JAD Session was taken, where all stakeholders, customer, end users and all the project team members were present to deliberate to come out with the Requirements of the Railway system.

Therefore, we the project team found out that we were able to get the requirements of the Railway system using the questionnaire and JAD session because in the questionnaire, the questions drafted where able to get into the hands of so many stakeholders and end users and also the JAD session because the presence of every stakeholder was present thereby allow us to get what they want and would need in the Railway system.

Improvement qualities of the to-be system;

- Onboard train applications, including in seat video entertainment and round the clock surveillance.
- Stationed application such as automated fire alarm and fare collection.
- Directed network selection,as a train approaches the limits of the coverage of the PLMN (public land mobile network) it is registered with.PLMN is;*a network that is established and operated by an administration or by a recognized operating agency (ROA) for the specific purpose of providing land mobile telecommunications services to the public i.e. the train passengers.* This kind of network is inculcated in the system to deliver utmost customer satisfaction.
- Features to aid people with difficulties in walking, gripping, reaching or balancing (Including non-slip surfaces, handrails and handholds)
- Facilities to assist blind and partially sighted people.

REQUIREMENT SPECIFICATION

'Requirement Specification as stated by (Sommerville 2011) is the process of writing down the user and system requirements in a requirements document. Ideally, the user and system requirement are expected to be clear, unambiguous, easy to understand, complete and consistent'.

In view of the above, the System requirements are expanded versions of the user requirements that were used by the Project team as a preparatory point for the system design. We added details and came up with a long lasting, state of the art solution of how the user requirements should be portrayed by the system. The following document would further explicate the user requirements as perceived by the Stakeholders and refined by the Project team for the Railway Reservation System.

User Requirements;Alsocalled requirements engineering is the process that determines user expectations towards new or modified merchandise. These features, called requirements, must be quantifiable, detailed and significant. It consists of two main types:

- Functional Requirements.
- Non-Functional Requirements.

The system possesses three major actors, the Passenger, the Administrator and the Manager. Each of these users, have limits on how they can interact with the system.

FUNCTIONAL REQUIREMENTS

Functional requirements define the functions of a system or its components. A function can be described as a set of inputs, behavior and outputs. Functional requirements may be in technical details, calculations, data manipulation and processing and other specific functionality that describe what a system is supposed to accomplish. I.e. what the system is able to do.

The Functional Requirements of the system are outlined in the table below;

KEY

H – High

D- Desirable

E- Elective

ID	Functional	Description	Priority

	Requirements		
1.	Purchase Ticket	Allows Customers/Passengers buy Tickets via the system at one click.	**H**
2.	Reserve Ticket	User(s); Admin and the Passengers can reserve tickets pending time of purchase.	**E**
3.	Add Ticket Fare	The Administratoris meant to add Ticket Fare following instructions from the Management.	**D**
4.	Train Timing	Allow Manageredit and improve the designated timing of the Trains.	**H**
5.	Add New Route	This feature allows the Manager add new routes to the System.	**D**
6.	Remove Route	The manager would eliminate any dormant route from the system through this function.	**H**
7.	Update Fare Price	Facilitates Merchandise price update by the Manager.	**E**
8.	Cancel Ticket	Allows Passengersterminate already placed ticket purchase.	**H**
9.	View Train Details	Enables Passengers viewdetails of available Trains online.	**E**
10.	Arrival and departure Platform	This function allows the Admin alert the Passengers on what Platform to expect delegated trains.	**H**
11.	View Ticket Fare	Allows the Passengers view the respective fares for particular routes and trips.	**H**
12.	Update Train Details	This Facilitates the Administrator to review the availability of Trains.	**H**

NON FUNCTIONAL REQUIREMENTS

These are requirements that indicate the criteria that can be used to evaluate the operation of the Railway System. Non-functional requirements are frequently called qualities of a system. Additional vocabulary for non-functional requirements are "constraints", "quality attributes", "quality goals", "quality of service requirements" and "non-behavioral requirements. Briefly listed below are some main non-functional requirements of the said system;

Operational

- The system provides a single point of data entry.
- The system is able to liberally interact with the database system.

Usability

- The main focus of the system is on the users. Thus, they decide if the system is easy to use.
- The system is easy to use through simple and complex commands.
- The system possesses a user-friendly interface.
- The usability of the system was achieved through Iterative practices which were completed several times during development design; this brought about user satisfaction.

Reliability

- Consistency is imminent in the system to enhance smooth and desirable results.
- The system is readily available and would work round the clock.

Security

- Utmost security measures like; *Cryptography*is put in place to ensure data/information safety.
- The system is ultimately protected to avoid unauthorized access and modification of data.

Maintainability

- The System is designed in a maintainable manner. Easy to incorporate new requirements and individual components as time elapses.

Performance

- The response time of the system ought to be as swift as possible to facilitate very fast navigation by users.

SYSTEM REQUIREMENTS

The RRS system needs certain hardware and software components to be present in order to perform optimally. These pre-requisites are known as system requirements which the Project Team put together a remarkable calibre of equipments to facilitate the excellent performance of the Railway System.

Hardware	Software	Network
CPU (Intel Core i7-640UM Processor (M Cache, 1.20 GHz)	MYSql server	LAN
VGA (Monitor)	Adobe Dreamweaver CS5	WAN
Mouse	Windows 7 Operating System	Router
Keyboard	Point of sales Systems	Network Cables (CAT6)
Barcode Reader	IBM Storage Management Software.	Multiplexer
Display Adapters	Macromedia Flash 8	Hub
Disk Drive	Ultimate Boot CD for Windows	ISDN terminal adapter
Printer	TuneUp Utilities	TXS 10/100 Mbps & Gigabit Ethernet Load Modules

REQUIREMENTVALIDATION

Quality is the major business differentiator in IT. Studies such as; the Chaos Report show that the most common cause of low quality is having poor, or poorly understood, requirements. Other common causes are poor design, code, and installation. While prevention of defects is the best cure, identifying and fixing defects as early as possible is key, and some of the responsibility for doing that falls on the Project Team Leader.This stage of the system, therefore, concentrates on the validation techniques for the proposed R.R.S.

The Project team leader and the members successfully carried out authentication processes of checking that the requirements actually define the system that the customer/stakeholders really want. It was made certain by the leader that the system was re-tested. During the requirement validation process, several kinds of checks were carried out which would be described in the requirement document. Those checks comprises of;

Validity ChecksThe user(s) may think that the system ought to carry out or perform some particular functions. The purpose of the validity check is to give the stakeholders a chance to check early whether the solution proposed will really solve their problems. And as a result, the Railway Reservation System met their envisaged needs.

Consistency Checks Amongst these checks, it was strongly imposed by the team of developers that the requirement in the document did not conflict each other. Meaning; there shouldn't be an iota of contradicting constraints or diverse depiction and description of the same system.

Realism Checks To facilitate a reputable and blemish free system, we the project team members carried out a hand full of research on successful and existing Railway Systems for example; The Singaporean Railway System to make sure that the system under construction would be a sheer success. This process is called; using knowledge of existing technology. The requirements were duly checked to make sure that they can actually be implemented. These checks took account of the budget and schedule for the system development.

Verifiability This process was done to reduce the potential dispute between the Customers-Stakeholders and Contractors-Project Team. The System requirements were written so that they can be verifiable. I.e. the Project Team wrote a series of tests that demonstrated that the system met each specified requirement.

Figure 1.8
Requirements
Evolution

The above figure is an illustrative cycle of the evolution of the requirements. There exists a number of requirements validation techniques that can be used individually or in conjunction with one another:

- Test-case generation; *the requirements of the system are testable, therefore given Project Team's group of testers an avenue to conduct requirements test as it is an integral part of the validation process.*
- Requirements reviews; *these are analyzed systematically by a team of reviewers who check for inconsistencies and errors.*
- Prototyping; *this approach involves an executable model of the R.R.S to be demonstrated to the customers and end-users of the system so they can experiment and interact with the model in order to see to it that it meets their respective needs.*

[Sommerville 2011]

ARCHITECTURE DESIGN

The Architecture design slated for the proposed system is structured and designed specifically to meet up with the will of the Stakeholders. It entails the system's component diagram showing; how the different modules of the system communicate with each other and its users. In a nut shell, the Architecture of the system is based on the allocation of system requirements to the system elements.

UML Diagrams

UML is an evolutionary general-purpose and industry-standardized modelling language for specifying, visualizing, constructing, and documenting the activities and parts of a system-intensive process of the Railway Reservation System that is externally visible. The diagrams used to display the functionality of this online system consist of:

- Use Case Diagram.
- Component Diagram.

Use Case Diagram

UML (Unified Modeling Language) use case diagrams describe the interaction of any person or an external device with the system under design. The Use case for the R.R.S is therefore developed in collaboration between the Project Team and its stakeholders. Its purpose is to present a graphical overview of the functionality provided by the Railway system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases.The use case diagram for the System is exemplified on the next page below:

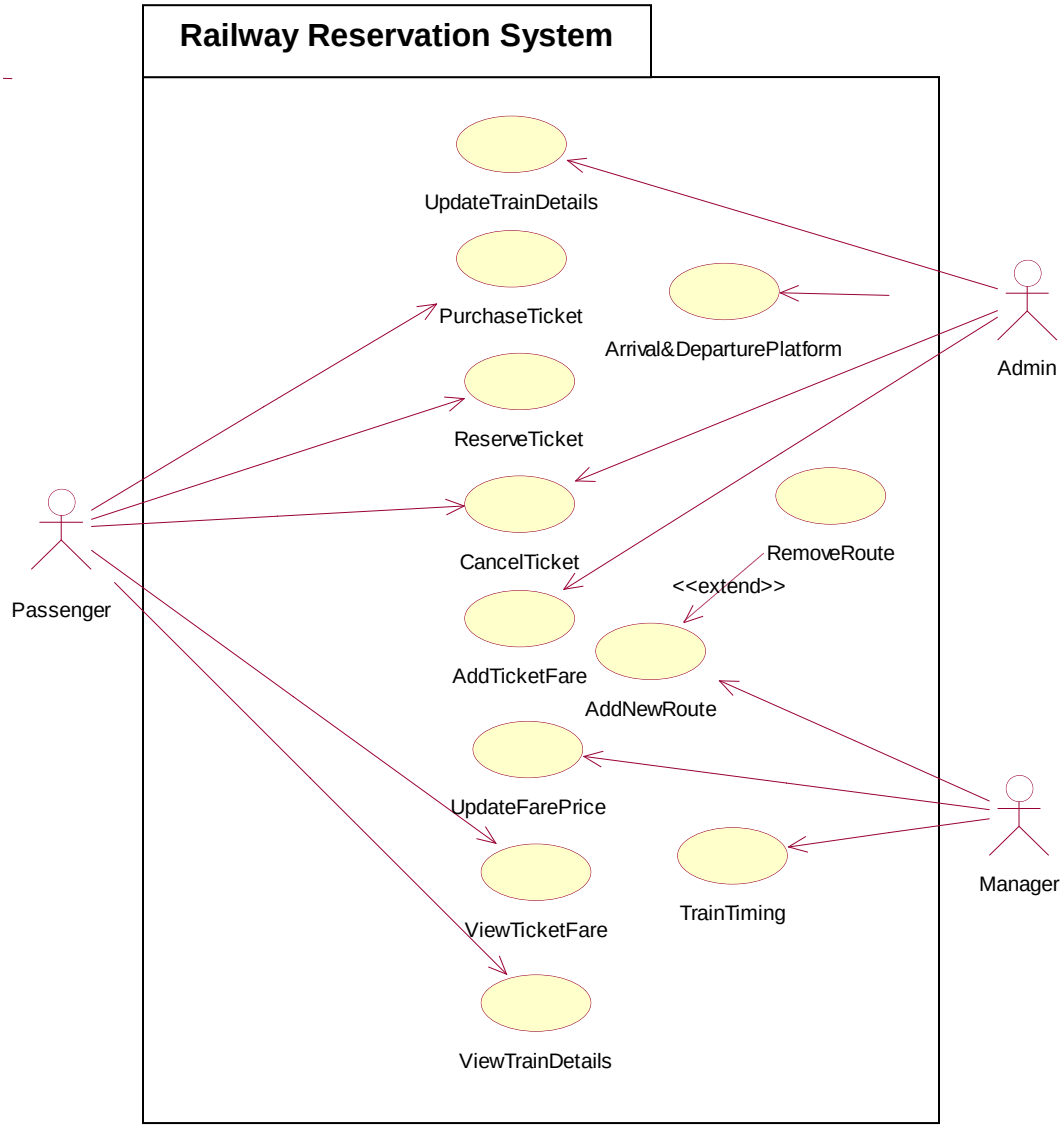


Figure 1.9
Use Case diagram for the proposed System

The above image is a diagrammatic representation of the respective functions of actors/users of the system. It depicts the ideology of activities that can be performed by each actor/user.

INTERFACE DESIGN

The Interface design in the system development process provides a platform whereby we the Project Team defined the interfaces between the Railway system's components. It was mandatory that the specification turned out unambiguous. The moment the Interface specifications where agreed, the components of the system where designed simultaneously otherwise; concurrently, producing a very accurate user interface with the use of;

- Visual Basic.
- Adobe Dreamweaver CS5.

The User Interface design process proved delicate because the design process activities are interwoven in the sense that; feedback from one stage to another and consequent redesign was uncontrollable.

The Railway Reservation System's beauty is achieved in the embodiment of other software systems which includes; Operating system, Database, Middleware, TuneUp utilities and other useful applications. All these facilitated the production of a software platform; *the environment to which the system would execute.* Information about this platform is an essential input to the design process.

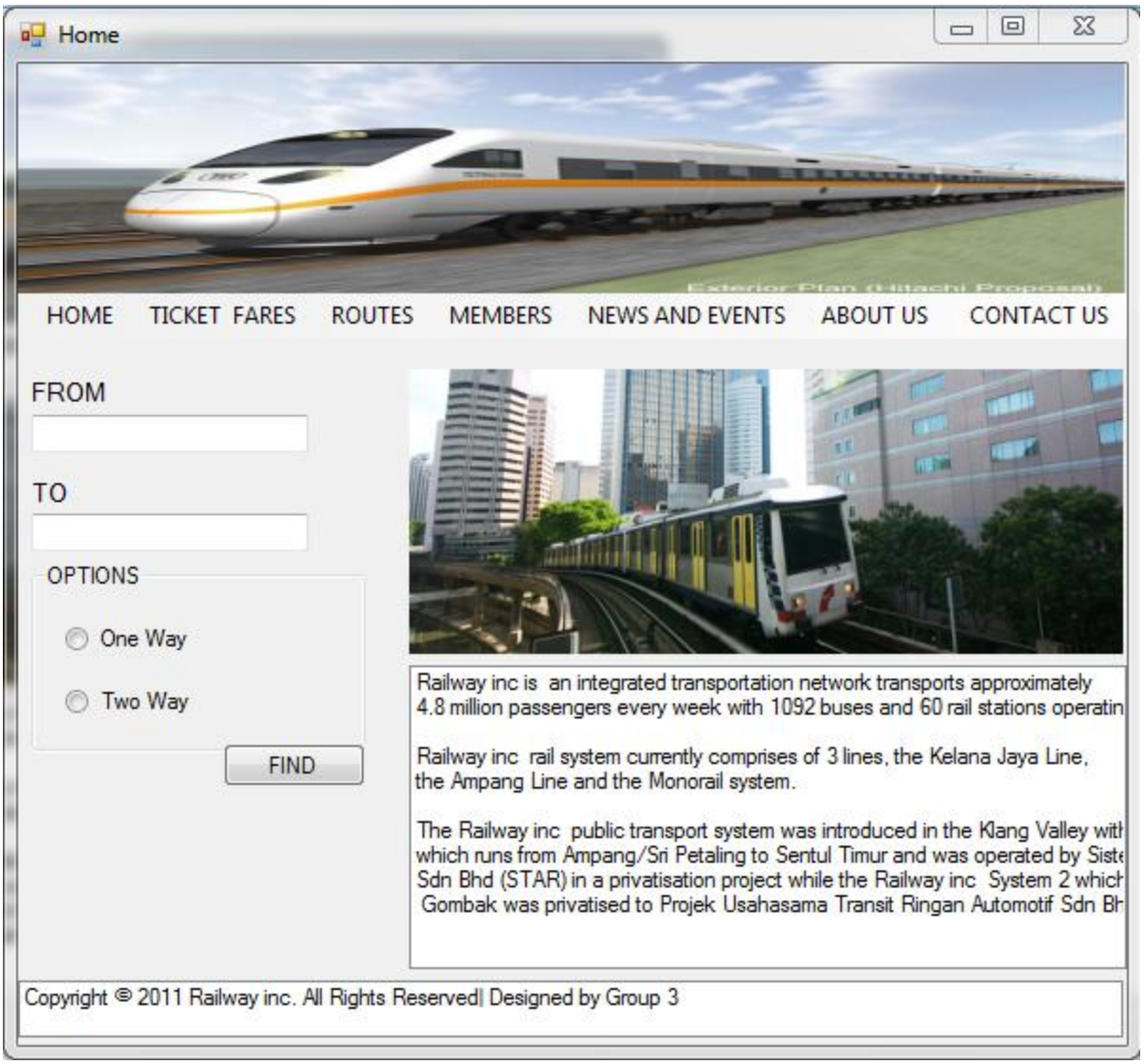


Figure 10.1
Graphic user Interface
for the R.R.S

The Interface depicted in Figure 10.1 above is a diagrammatic representation of the Railway system as designed by the programmer in the Project team (Group 3). It shows the 'ease of use' produced in the system's navigational structure. See Appendix A fo the results on its usability and user friendliness.

COMPONENT DESIGN

In component-based development (CBD), component diagrams offered theProject Team with the use of IBM Rational Rose, a natural format to begin modeling the R.R.S. it gave us a platform to verify that the system's required functionality is implemented by components, thus ensuring that the eventual system will be acceptable.

In addition, the component diagram drawn for the furtherance of the system proved a very useful communication tool for the Project team. The diagramis aimed at presenting to the key project stakeholders and implementation staff. While it was generally geared towards a system's implementation, it would generally put the Stakeholders at ease because the diagram presents an early understanding of the overall system that is being developed.

The component diagram of the R.R.S is situated on the next page;

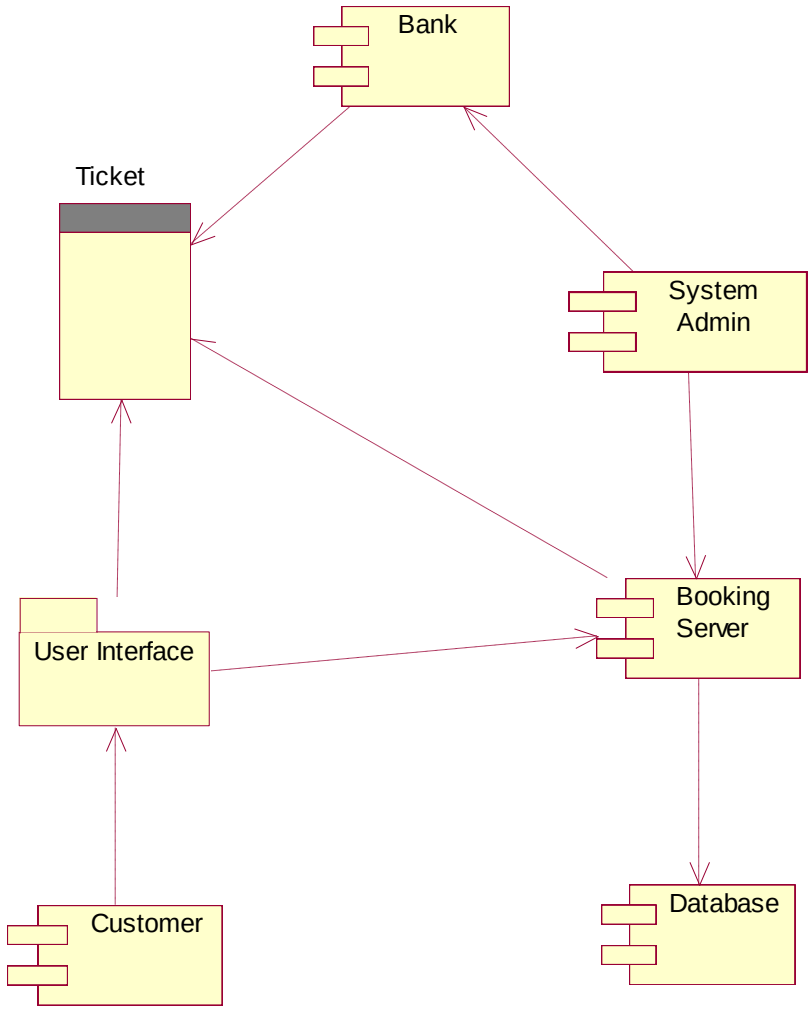


Figure 10.2
Component Diagram

The Component diagram above is a description of how the Railway Reservation System is divided into components showing the dependencies among each other. From the figure above, the components of the Railway System are;

- Booking server.
- Bank; *for verification and validation.*
- Database.
- System admin.

SPECIFICATION OF DATABASE MODEL FOR THE SYSTEM

Database;The database for the system is basically an organized collection of data for one or more purposes compacted in a digital form. The data are typically organized to model relevant aspects of reality for example, the availability of tickets online, in a way that supports processes requiring this information.

DATABASE DESIGN

The R.R.S's Database design was achieved before building it to meet needs of end-users within the Stakeholders circle. The database is intended to support the system in keeping prudent track of customer, staff and client records. The database design defines the needed data and data structures that such a database comprises. In the process, a suitable Database model was selected by the Project Team to foster the following;

- Greater data integrity and independence from applications programs.
- Improved data security.
- Reduced data entry, storage, and retrieval costs.
- The Reduction of data redundancy.

Below is a detailed elucidation of the Relational Database model embedded in the system.

After all have been pondered upon and all considerations have been put in place, a collective recommendation of **MYSql** database was approved and implemented by all the Project Team members as it is a Relational Database Model. It is an open source Relational database model and its security is topnotch.

The database server used in the development of the Railway Reservation System proved all reliable and successful. The database is used to keep a well structured and detailed record of the intending Customers, all categories of Staff and the management. As such, it is measured in terms of accuracy, availability, usability, and resilience.

TESTING

Based on [Hetzel 88],'Software testing is any activity aimed at evaluating an attribute or capability of a program or system and determining that it meets its required results. Although crucial to software quality and widely deployed by programmers and testers, software testing still remains an art, due to limited understanding of the principles of software. The difficulty in software testing stems from the complexity of software: we cannot completely test a program with moderate complexity. Testing is more than just debugging. The purpose of testing can be quality assurance, verification and validation, or reliability estimation. Testing can be used as a generic metric as well. Correctness testing and reliability testing are two major areas of testing. Software testing is a trade-off between budget, time and quality'.

The following are the testing paradigms carried out by the programmer; *Francees Unwabuike* to ensure that the Railway system meets the Stakeholders requirements and produces outstanding quality.

DEVELOPMENT TESTING

Development testing involves the testing of all the activities of the Railway system carried out by the developing team of the project.Theprogrammer in the project team is the designated tester of the system. With the programmer's expertise, we were able to come up with outstanding results at the end of the testing process.

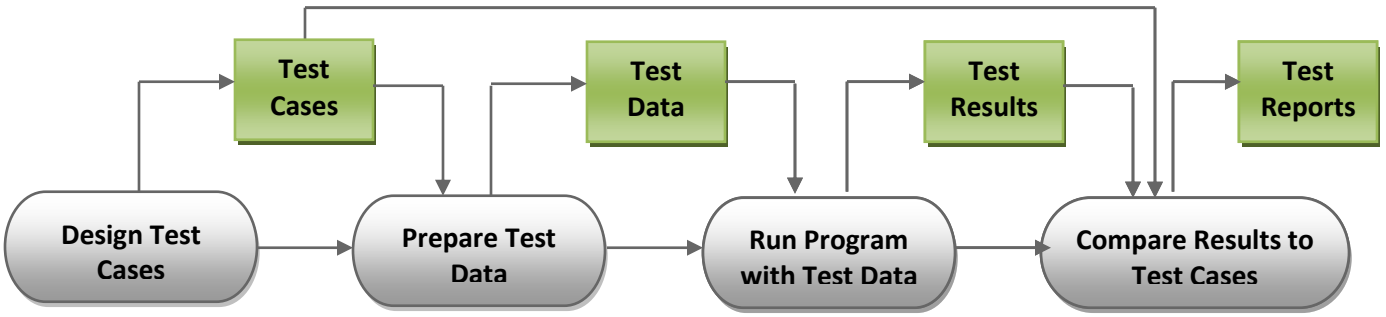


Figure 10.3
Software testing process

A software testing process has to typically go through three stages of testing as described in Figure 10.1 above. The Programmer being the tester of the system in our

Project Team ran the program with some test data and compared the results to the Stakeholders expectations.

The development testing was carried out in three stages:

- ✓ Unit testing.
- ✓ Component testing.
- ✓ System testing.

Unit testing: 'where individual program units or object classes are tested with the testing phase laying more focus on testing the functionalities of the objects or methods of the Railway system'. (Sommerville 2011)

In performing Unit testing, programmer in charge of testinghad to create a paradigm which would test for;

- All the operations associated with the Railway system.
- Setting and checking the values of all the attributes associated with the Railway Reservation System.

Unit testing can be expensive and time consuming but it was also important for the developers of the Railway system to choose effective units to test in the Railway system of which some measures were also taken. They are as follows;

- Once tested, the tested function should show what has been tested when used functions has been used with the testing actions.
- Once tested and there is any defects the tested function should show the errors in the function.

Therefore once the Programmer is testing the functionalities, he would need to first reflect on the normal operations of the Railway system and show that each functions tested actually works at full fledge.

The following strategies were of utmost help to the programmer in achieving effective unit testing of the R.R.S's functionalities:

- *Partition Testing:* This helps the programmer to identify groups of inputs that have common characteristics in the Railway system and that has to be processed the same way. The test should be done by choosing the unit test from each of the chosen groups in the Railway system
- *Guideline-based testing:* when programmers are testing guidelines to choose and run unit testing on, these guidelines would reflect on the experiences of the past experiences on the errors that the programmers has come across when developing the components. (Sommerville 2011)

Component Testing: This involves the testing of the synchronization between different components of the system which entails;

- ✓ Tests derived from the Programmers experience.
- ✓ Testing composite components to show cohesion between the R.R.S's components.
- ✓ Testing of individual program components.

System Testing: Involves the integration of the R.R.S's components to create a version of the Railway system.Then, testing for the integrated system can now be done. System testing would check if the Railway system and its components are compatible, and if they interact correctly. This includes; transferring the right data to the customers of the Railway system at the right time across the interface of the Railway system.

- ✓ In System testing, the components which are reusable and that has been separately developed off the 'as is' system may be integrated with the new components of the Railway system which is about to be developed. Then the complete system can now be tested.
- ✓ Responsibility of the testing team of which testing is based on the system specification. Thus, testing groups of components.

The system testing possesses two phases;

- ***Integration Testing;*** Testing team led by the programmer, have access to the System's source code which delivered integrated test components with candid results.
- ***Release Testing;***This test was also done by the programmer which entailed testing the entire system intended to be delivered to a black box.

The reason why release testing was done was to increase the Team's confidence that the Railway System meets the Stakeholders requirements.

Further tests that were carried out are as follows;

i. Black box testing; *Tests involving the functionality of the system carried out by the Project Team's Programmer from the user point of view. (see appendix 'A' for results)*
ii. White box testing; *In this process, the tester accessed the internal data structures and algorithms including the coding implemented in the system to make certain that the system is error free.*
iii. Performance testing.
iv. Acceptance testing.

All these were done in the race towards the development of a very reliable, state of the art system to meet the needs of the Railway organizations Stakeholders.