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# Chapter 1 Introduction

T

he past two decades is the era of the personal computers and information technology . The mathematical algorithm is no longer just participating with our world – they shape it. Algorithms are used in calculation, data processing and automated reasoning. From Financial market to small mobile device, everything uses a smart algorithm to reduce the complexity of some problem and make the technology looks wonderful. But there are questions that remain unanswered? How the Information Technology Field will change in the next 10 years. If we will find some algorithmic approach to solve a problem that is best suited and most optimized.

## Topic of the System

The Primary goal of the project “Beacon (Hi-Tech Marine Loading and Path Detection System)” is to resolve the logical and mathematical complexities in the Logistics System. The project provides a new approach of solution to two popularly known NP-hard problems, Travelling Salesman Problem (TSP), Container Loading Problem (CLP). Beacon keeps everything organised, updated, smart and accessible.

## Purpose of the Situation

The Developer is sensing immense scope and intelligent system name Beacon that uses advanced genetic and greedy approach of solving the problem, a new algorithm is generated to solve the complex and unsolvable problem. The approach results a optimize solution of the scenario.

Every Logistics company that transfer heavy goods materials to different destinations plans the routing of the vehicle (Trucks/Ships) to manage the cost of travel. This cost is very critical to the business process and can save lots of money. Route Planner is basically required here to get the optimized and shortest route. Since the number of stops are uncertain and a very large number of stoppage can cause a very problematic situation to find the best possible solution. This problem is commonly known as Travelling Salesman Problem in Algorithms.

|  |
| --- |
| http://mathworld.wolfram.com/images/eps-gif/TravelingSalesmanProblem_1000.gif  Figure : Travelling Salesman Problem (Weisstein, 1999) |

The second algorithm developer is doing is related to marine loading. Large numbers of container are being loaded to ships and other vehicle for supply. It is always a tedious task for loading staff to manage the containers and make a optimize load plan. The load plan should be made so that the maximum number of container gets load without affecting the balance of the ship. The problem arises due to different number of containers get transported with various size of goods materials.

|  |  |
| --- | --- |
| Figure : 3 Dimensional Container Loading graph (F. Parre, 1994) | Different Boxes are arranged in order so that there must be maximum number of the box in the ship. |

## Target User of the System

Target users are group of those people for whom the system is going to be developed for.

* **Shipping Companies/SMEs /Courier Company** - Organization who manages a large supply or export/import packages to move on.
* **Skilled People targeted** – Package planner, Package Loader, Insurance People, Manager, Accounts. The system also targets different worker of same enterprise according to work divided.
* **General/Typical Users -**Any person who wants to control their data can use the system.
* **Research peoples and Students** – The advance algorithm and problem solving techniques can be used in academics and research.

## Topic Background

The basic idea of the system is to solve the complexity in the enterprises in route mapping and container loading. Both the Idea is unsolvable due because of being a NP hard problem that cannot be solvable and verifiable in polynomial time. To solve this algorithm in the feasible time, a backtracking approach needs to be applied. Genetic algorithm is one of the various effective ways to approach for solutions of NP-hard and NP-complete problems.

**Bin Packing Algorithm** is a mathematical way to deal with efficiently fitting Elements into Bins. The hitch is that Bin packing problem is classified as the NP-complete problem. Basically means that there’s no way of being guaranteed the best solution without checking every possible solution. The goal of every Bin Packing algorithm is to use the least amount of Bins to hold the required number of Elements. (Dirk, 2009)

**Genetic Algorithm** is a search heuristic algorithm that is routinely used to generate useful solutions to optimizations and search problems. It generated solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection and crossover. Genetic algorithms are one of the best ways to solve a problem for which little is known. (Bajpai, 2008)

|  |
| --- |
| Figure : Analogy between a numerical GA and biological genetics (Haupt, 2004) |

## Problem Context

In the present world, Information System and calculations plays a very vital role in every place. Every real world problem can be linked as an entity and the corresponding relationships can be defined in between.

Beacon is responsible to solve the complexity of the problems and system of any logistics company. Its solves the mind jolting and tedious tasks automatically using its advanced algorithms and data flow design .Complex problems like TSP (travelling salesman problem ) CLP (container loading problem ) can’t be solved manually or any other way .Beacon keeps everything organised ,updated ,smart and accessible.

## Description of the Problem Area

* To enter data of the goods to be transported and organizing the relationships between data is a complex and time-taking tasks. Every goods from nail to big industry parts are needed to be logged into the system with its specifications and related data .What are the materials going to transfer in which container and vehicle.
* The information related to the goods, transported like basic price of goods, charge of transportation, value, size, weight, owner, destination, insurance papers etc. This data are needed to be arranged in the normalized manner to solve the data redundancy and availability.
* Efficient algorithm for solving the TSP with the facility to import map coordinate or create a weighted graph. To solve the problem with the advanced genetic algorithm is also a tedious and brainy task that includes various constraints like time, amount of goods, traffic etc.
* Second most important algorithm need to generate to solve CLP of ships. To generate whole new algorithms is the research part in the project .Also the system is responsible to generate 2D/3D graphs to show the efficient container loading .This features include a high level of challenge and skills.
* Implementing the unique ID generation for the transport and the goods is also a challenge, these Ids can be used to track and update the status. Also small mobile app can also be used for the customer of the company to manage their goods.
* Features like language support and import of data through excel sheets, interactive reports are also the problem areas which are not clear.
* **Setting an example** – Mr Sharma is a famous business man from India. His company exports various things like natural resource (coal, iron ores, etc.), agriculture product, couriers, vehicles and everything from ships and trucks. He needs to cut the expenses from the TSP and CLP problem in the system .Company can saves thousands of dollars if they have efficient algorithms for the best loading and supplying .And also they need the interactive system to deal with the various constraints, data and reports of every transportations.

## Rationale behind the System

As obvious from the problem context presented above the situation warrants such a system that helps reducing the complexity , solve the TSP , CLP problem that is impossible to solve in any manual way or by supercomputers . In TSP and CLP the problem grows exponentially fast in every turn that makes its unsolvable when the inputs of data is in more in numbers. When the destination in TSP is more than 20 or in CLP .It’s very tough to create the optimal solution of the problem using any straight approach.

**Setting an example**: A company like DHL is known for exports/imports business and they need the system to plan, organize and track the goods. Beacon is perfect in this situation .It’s also has small mobile app for users to track the products.

**Benefits of the System**

The system implemented could bring about significant tangible and intangible benefits. Given below is a list of tangible and intangible benefits expected from the system:

**Tangible Benefits**

* **Reduced Complexity of Problem**- This system generates the optimal solution that seems impossible to solve manually or technically .TSP and CLP problems are being solved with the most efficient problem solution being designed and implemented by developer.
* **Graphical view of route and container loading** – The system will generate 2D/3D view of the containers to show the best loading graph in CLP and the best route graph in TSP. Its gets easier to load container using graph and route map makes the route clear.
* **Organized Data and accessibility** – The Data of every container is very much organized and validated during entry and can be used to plan a consignment. Also every goods/material will gets easily to track as per the unique id provided .The status can be made available for the customer in the current time.
* **Cost Benefits** - Cost being “the most” important factor for any organization, it’s always beneficial to adopt cost-cutting or cost-saving measures. With Beacon, cost benefits come in following ways-

Most efficient route will be produced, results in precious fuel saving hence cost cutting. Best Container loading plan optimizes the overall loading with the ships and also maxims the number of container .Hence this reduces the administration and managerial overhead results into cost benefits

* **Time Benefits-** with Beacon, the time of container loading reduced efficiently as everything will be decided by the system will be pre-planned. Report generation and task assignments are easier to discuss and also proper planning and scheduling make the most out of work in minimum time. Trucks and ships save time by going through the shortest path provided results in more resource availability. For Example: More the trucks reduce the time of travelling; more the loading of trucks will be possible. Also the container loading takes the minimum time in ships.

**Intangible Benefits**

Increased Employee /Enterprise productivity – With employee being aware about the task and work division among the organization, it results into employee task productivity. For Example – The Work load is very much reduced by the algorithms of TSP /CLP and also the planning tool makes the productivity easier .The Consignment planner can easily arrange every box and goods.

* **Increased work flexibility and easier to understand and operate** – The work load assigned are easier to plan and manage and keep track of the work progress .Also the Beacon makes it easier to understand the problem statement and to organize and plan the things based on different constraints. **For example** - Desirable production and better planning can be targeted as the vision of the project.
* **Increased customer satisfaction** - All organizations churn out some services whose final consumer is the customer .With Beacon promising to deliver so much for improving the productivity and uptimes for the businesses they are surely going deliver better results for their end customers thereby promoting customer satisfaction and customer loyalty thereby increasing business for the organizations.
* **Reduces stress**- – The automated advanced application that works on backtracking can automatically reduce the stress and work overhead of the users.

## Project Objectives

* To learn advanced programming techniques, software engineering principles, project management concepts, advanced algorithms and integration of varied technologies.
* Learn about domain area, i.e. Genetic algorithms and Greedy Approach of solving graphs in algorithms
* To implement the knowledge gained in Objective 1 to develop such a system which leads to goal mentioned above.
* To make efforts to ensure that the system being developed will fulfil all the tangible and intangible benefits mentioned in the previous section.

The Proposed system intends to allow engineers to manage their container loading provided with the unique id of every container. The system manages all the data using an integral optimum methods to organise them as the weight remain same and the overall container loading doesn’t affect the balance of the ship or anything .In second stage it provides the route map of the ship. All the input data are verified and validated with unique ID. Custom report generation, language support, data entry through excel/xml files and other are some other enhanced features. The important feature of the system is the graph generation of the container loading in 2D/3D.

The modules for the proposed system have been listed below:

***Software Module:*** This module will be installed on desktop machine of the organization .Different software are divided mainly for data entry, container loading and route map and report generators.

***Database Module:***  This module will save every single consignment for the company with details of final results of TSP and CLP.

## Academic Objectives

* To learn advanced algorithmic approach like greedy algorithms, genetic algorithms and implementation of algorithms.
* To create a research paper and whole new approach to solve the travelling salesman problem and container loading problem.
* Project management concepts like methodologies, scheduling, time estimation, work breakdown techniques and tools etc.
* Implementation of the algorithms derived into visual basic to create a running application while learning the programming background of the technology.
* To make efforts to ensure that the system being developed will fulfils all the tangible and intangible benefits mentioned in the previous section.

## Traceability Matrix between problems and functionalities

|  |  |
| --- | --- |
| **Problems** | **Solution** |
| Map Design | Editor to draw a weighted graph of route |
| Best Route | Best optimized route generator using Genetic Algorithm |
| Container Information | Data entry and Validate of each container |
| Optimized Load Plan | Best solution using Bin Packing Algorithm |
| View Load | 2D /3D view of the final loading |
| Different Language | Language Support |
| Easy data entry | Using Excel sheets/Export –Import / XML |
| Document Generation | Printable document generation as a report |

Table : Traceability Matrix between Problems and Functionalities

## Assumptions

The successful implementation of the project is much depends on the understanding of the user towards the system. So as this system is developed for a logistics company so it is believed that all the users are expert user and know about it. Since developer is providing a solution based on his own research, so there may be other best possible way to solve the problem. One or more than one user may be responsible to use the system, developer is using work break structure of company. Predefined boxes and map are included in the system to show the usability, however one can change specification according to their needs. Language support is very vast. The system can be installed and ready to be used and developed to work on windows environment. The final output/result of route/load plan can be saved in image or pdf file and can be copied or used elsewhere.

## Success Criteria

Success Criteria depends upon the depth of understanding and experience gained from this project and how efficiently developer solves the problem described above.

## Project Scope

The proposed solution is desktop-based standalone application for solving to algorithmically complex task. The system can be downloaded or used by directly installing into the windows machine. The final output or result produced by using the application can be used as image or word files and can be used later

The features of the application are –

* **Editor for graph Design**: This will be the simple editor to design a weighted graph on the system .It includes toolbox and other specification of node and path in the graph.
* **Route Optimizer Module**: This is particularly the research part in the system .It create the major algorithmic approach that will take data from the editor or predefined map and solve the problem to create the best optimized path.
* **Data entry and Validate Module**: This module can be used to create new specification of boxes (weight, size etc) and the good contained in every box. All the entry must be verifiable cannot exceed the specification.
* **Loading Planner Module**: This module is the main feature and research part in the system that used advanced algorithmic approach to solve the loading plane based on the data entry and validate module. This will result a best optimized load plan for the ship or trucks.
* **Graph generator Module**: The final 2D /3D graph of loading is generated in this module using the load planner module.
* **Language Support Module**: More than 3 languages support are provided in the system. All the name, word will be changes by selecting one option.

## Limiting the Project Scope

* The application is strictly desktop based standalone application include no support from the external source or web. Although the result of route and load can be used as image or word file.
* There is no support for third party application or Google map.
* There is no major database role in the system, it can use some simple excel file or MS Access records.

## Functionalities of the System

**CORE FUNCTIONALITIES**

|  |  |  |
| --- | --- | --- |
| # | Functionality | Description |
| 1. | Data entry and Unique ID | The information about each goods and container need to be logged in the system with unique identification. |
| 2. | New Algorithms for TSP  ( Research Paper ) | Intelligent Genetic Algorithm to determine the shortest and the best path for transportation. Mapping real world Natural Selection process into programming to solve TSP |
| 3. | Implementation of TSP | Implementation of TSP problem on graphs taking co-ordinates from a real world scenario |
| 4. | New Algorithms for CLP  (Research Paper) | Bin Packing Algorithm that solves CLP that provides the optimal container loading solution and ship balance. |
| 5. | Implementation of CLP | Implementation of Container loading for a ship with various box of different size |

Table : Core Functionalities Table

**ENHANCED FUNCTIONALITIES**

|  |  |  |
| --- | --- | --- |
| # | Functionality | Description |
| 1. | Language Support | Different Major Language Support for the system. |
| 2. | XML Data Reader and Writer | Data entry through xml files |
| 3. | Interactive Report and Document Generation | Automatic and downloadable Insurance , Bill , Transport Agenda and other report generation |

Table : Enhanced Functionalities Table

**SPECIAL FUNCTIONALITIES**

|  |  |  |
| --- | --- | --- |
| # | Functionality | Description |
| 1. | 2D /3D view of CLP | Loading Plan of containers |
| 2. | Map Editor for TSP | Map Editor for TSP |

Table : Special Functionalities Table

## Feasibility Analysis

Feasibility studies addresses things like where and how the business will operate. It provides in-depth details about the business to determine if and how it can succeed and serve as a valuable tool for developing a winning business plan.

**Schedule Feasibility Report**

It consist of assess the work to which the time frame and the completion date for all major activities within the project that meets organizational deadlines and constraints for affecting change.

The main part of schedule feasibility report is-

**Gantt chart** - Developer has used this chart for the time estimation.

**Technical Feasibility**

Technical Feasibility mainly involves the hardware and the software requirements of the system regarding all the tasks of the system to be done

**Minimum Hardware Requirement**

* CPU: 2.0 GHz Pentium IV or above,
* Memory: RAM 512 MB
* Disk Space: 5 GB space (at least)
* Monitor: Any Standard Monitor
* Peripherals: Mouse, Keyboard

**Software Requirement**

* Operating System: Windows® 7, Windows XP,
* Software Development Tools: Microsoft Visual Studio 2010,
* Project Management Tools: Microsoft Project, Visio 2010,
* Case Tools: Smart Draw, Visual Paradigm 6.0,
* Graphic Design Tools: Adobe Photoshop CS4,
* Database : Microsoft SQL Server 2008,
* Documentation: Microsoft Office 2010.

**Operational Feasibility**

It may be defined as, the process of assessing the degree to which a proposed system solves business problems or takes advantage of business opportunities. Problems addressed and advantages of this system are provided in the documentation.

**Economic Feasibility**

The purpose for assessing economic feasibility is mainly to identify the financial benefits and costs associated with the development project. Economic feasibility is referred as cost and benefit analysis for any system.

Once the technical feasibility is established, it is important to consider the monetary factors also. Since it might happen that developing a particular system may be technically possible but it may require huge investments and benefits may be less. Cost Benefits are included under Rationale by the developer.

## Project Planning

**Project Management**

*“ Process of planning, directing and controlling the development of an acceptable system at a minimum cost within a specified time frame.”* (Whitten et al, 1994)

**Time Management**

Project started on date and will be completed on the date specified in the academic requirement. Start and End Date is already specified in the Project Development Plan. After estimating the time, activities were sequenced to create the Gantt chart. Activities can be adjusted to meet the academic dead line through change control process. (For Gantt chart see Appendix Section)

**Deployment Plan**

V-Mode has five stages these are: are Concept and operation, Requirement and Architecture, Detail Design, Implementation, Elaboration Phase, Construction Phase and Transition Phase. Below it describes, how there phases are involving in my project. (Time Division for Deployment Plan is fully explained in 4.2.3.3 Section).

## Ethical Issue

It ensures that the project won’t do any harm to the society or anyone in anyways. It contains issues like no animal harm & no copying of data without prior permission etc and to ensure that the developer has filled up an ethical form and it will be provided in documentation.

# Chapter 2 Problem Description

## 2.1 Introduction to Problem Area

In this era of Information Technology and Computation ,every little work is expected to done smartly and speedily .Sorting is by no means the only computational problem for which algorithms have been developed .Practical Applications of algorithms are ubiquitous and include various problems like Travelling Salesman Problem and Container Loading Problem.

## 2.2 Problems Identified

Beacon is going to solve many real time problems that companies face on daily basis as –

* **Easy Data Entry** – Co-ordinate of map need to be easily entered. Specifications of Containers are different and must be defined by shape and weight.
* **Route Map Plan** - Best optimized path of travelling with downloadable plan. Easy solvable for large number of problems.
* **Load Plan** – 2D /3D view of optimized container loading for a single consignment.
* **Path Editor** – Easy Path Editor so that destination can be altered accordingly
* **Language Support** – Different Language Support
* **Consignment Planner** – Easy Planner for each consignment and goods on go.

## 2.3 Problem Importance and Justification

* **Easy Data Entry** – Since the number nodes entered in route planner is huge, it should be easy and portable. Same in Load planner, there are various boxes of different sizes and shapes. Excel file based entry makes data easier to input. Also the graphical user interface are need to be with the design principle of human interaction .The information entered must be validated and crosschecked before getting a final output.
* **Route Map Plan** - Best optimized path of travelling with downloadable plan. There’s no solution that is verifiable within the polynomial time to solve this problem because it grows exponentially at every step. In any Logistics company, the problem is same as Travelling Salesman Problem. The possible paths can be predetermined and can be solved to get the best way when the number of destination is high.
* **Load Plan** – 2D /3D view of optimized container loading for an every consignment need to generate. This is the main feature plus the most tough and complex problem of the project. It is very hard to map a large number of uneven containers into an algorithm to get a 3D model of optimized load. Also the loading include longitudinal balance of the vehicle /ship and the mass must be distributed evenly.
* **Path Editor** – Editor is the graphical feature and challenging to develop. The entire route can be defined manually in the editor by drawing a weighted graph. It includes direction and weight in the graphs same the distance and direction of the road map.
* **Language Support** – More than 1 language support are provided to the software, so that it can be used by different users who differs in their demographic background.

## 2.4 Challenges in the Project

The development of Beacon calls for numerous challenges to be faced by the developer which includes learning curve of new concepts, learning new development tools, mastering already known tools, domain analysis, new programming languages etc.

**Challenges**

The development of Beacon (Hi –tech Marine Loading and Path Detection), calls for numerous challenges to be faced by the developer which includes learning curve of new concepts, learning new development tools, mastering already known tools, domain analysis and new programming languages etc.

## 2.5 New Concepts, Theories and Technologies to be learnt

**Concepts**: Various new concepts includes in the project mainly in the research part. Genetic algorithms, Greedy Approach, Heuristic approach of algorithms are the new concepts in the algorithm. Concepts include generation of algorithm, mapping it into programming and generation the right user interface. It includes matching of real word problem as an entity to the scientific approach of problem solving followed by defining the relationship between them to get a best optimized solution.

**Theories:** The theory is very complex to map with the algorithms and solvable approach. To map the real world problem into the binary or any data structure and generating a backtracking approach is real tough task. All the best solution comes after mutation and theory of natural selection in the genetic approach.

Next challenge is to map this solution of the real world problem into the programming language. It includes various graphs theory and complexity of the programming modules. The parameters of data entry and entity are identified by the data gathering and research theories.

**Technologies**

**Programming Language Skill**

**Visual Basic** – The application running on the windows machine is going to be developing using visual basic. Mastering Visual Basic is a significant challenge given the steep learning curve it requires with pre-requisites involving skills of working with graphs, procedures, class, libraries and implementing algorithmic approach in it. **(Refer to 4.2.1 for Programming Language Research)**

**Graph Technology** - The identification, generation and working on a graph is the tough task especially when it is random and created by some logics. The graph of TSP is created using edit and the final output of the CLP is some 2D or 3D graph .This part is very hard and need constants learning curve.

# Chapter 3 Literature Review

## 3 Literature Review

A literature review is a description of the literature relevant to a particular field or topic. It gives an overview of what has been said, who the key writers are, what are the prevailing theories and hypotheses, what questions are being asked and what methods and methodologies are appropriate and useful. As such, it is not in itself primary research, but rather it reports on other findings. This contains following things-

## 3.1 Advanced Preliminary

The Idea of this project came into developer mind while he was learning the applications of algorithms and capability of doing smart stuffs. The idea has been derived in the process of learning a blog on genetic algorithm and its application. Developer thought of this idea could be implemented for big and small logistics company that can be a highly cost and time beneficial .Also developer was quite interested in learning the advanced and scientific approach of algorithms that he knows a little bit from course module.

The developer performed an extensive research of the topic & found IEEE research papers that guided the developer towards the logic and approach on algorithms design and implementation

The **excerpts from these research papers** are given below-

**“The Single Container Loading Problem (CLP) is a three-dimensional packing problem in which a large parallelepiped has to be filled with smaller parallelepipeds, available in different sizes and limited quantities, so that empty space is minimized**

**When speaking about real-world container loading problems space usage is the most important objective, but other issues have to be taken into account, such as cargo stability, multi-drop loads or weight distribution. Among these additional considerations, cargo stability is the most important one.**

**In this paper we present a new algorithm for the container loading problem that is based on an original heuristic enhanced by a GRASP solution space search strategy. “** (F Pareno and R. Alvarez ,2009, pp.1-3)

**“For solving TSP, numeric, heuristics, genetic, hybrid or other algorithms may be used, as this problem is not easy to solve for large number of cities, the computation is often deployed on multi-processor or clustered hardware**

**The problem has to be coded into data structure, which can be handed like a chromosome.**

**For TSP, the chromosome is set of ordered indexes of cities, through which the traveller goes. For other problems, it could be integer or real number, for difficult tasks, there is idea of using Neural Networks for coding the problem”** (Dusan Saiko ,2005 pp. 1-4)

The Developer knew few things before developing the project:

1. **2D load Packer**- It is popular application that is used for creating load plan. It uses some algorithmic approach to solve the problem of loading while taking care of the longitudinal balance of the vehicle in terms of weight. Tasks, Containers and Boxes are entered, edited and manipulated. It generated a load plan in 2D after getting all the validated input from the user.

|  |
| --- |
| http://www.astrokettle.com/2dlp1.gif  Figure : 2D Load packer Software  **Source : http://www.astrokettle.com/pr2dlp.html** |

## 3.3 Depth of Secondary Research

The developer conducted secondary research from various Books, Websites and Magazines etc. to find out about the development process of proposed system and for this the developer needed to find about following areas-

**Domain Research**

**Topic Background**

Algorithms are the key change process in any problem in the market that results into various benefits in today scenario of computation. Particularly genetic approach of solving problem with natural selection is applicable in most of the NP problem and treated as the best approach of solving discovered in most of the cases. Marine Loading and Path Detection is such a system. Kevin Slavin believes the power of algorithms in shaping our world in TED Global Conference 2011

**“All the fun is powered by algorithm, we may not realise it but we live in the algorithm world “** (Slavin:, 2011)

**Conclusion Drawn**: Advanced algorithms are a smart changing key to change the way anything computes. It makes the things readable and processed smartly at the same time , that is not possible in any other way .They acquire the sensibility of truth because they repeat over and over again. And they ossify and calcify and they become real.

**Travelling Salesman Problem**

**"If there are n cities a salesman must visit, and the distance between each pair of these cities is given, find the shortest tour where each city is visited exactly once and returning to your starting point."** (Anonymous, 2000)

Euler introduced a form of the travelling salesperson problem in 1759, and it was formally named and introduced by the Rand corporation in 1948 (Michalewicz, 1992)

This problem in the route planning of Logistics Company is exactly same as in TSP. To find the best route between different destinations could be best found using genetic algorithm.

**Container Loading Problem:** a genetic algorithm (GA) for the container-loading problem. The main ideas of the approach are first to generate a set of disjunctive box towers and second to arrange the box towers on the floor of the container according to a given optimization criterion. The loading problem may include different practical constraints. The performance of the GA is demonstrated by a numerical test comparing the GA and several other procedures for the container-loading problem. (Gehring, Borltfeldt 2008, pp 1)

**Design Principle**: The design principles that need to be studied in order to provide are as follow:

* **Visibility:** Visibility is one of the most important design principles and what it means is that, as and when the user looks on the system screen he/she may feel the possibility for action. The developer will keep an eye on this principal in order to provide better visibility.

**Conclusion**: The developer will provide colour schemes in a way that users of this system can easily find suitable content.

* **Feedback**: Feedback is the response to the user of the action performed.

**Conclusion**: The developer will provide appropriate message box and notification to provide feedback.

* **Constraints:** Constraints are some universally accepted conventions which notify some specific actions.

**Conclusion:** Inclusion of warning messages to show the errors.

* **Consistency**: Consistency means maintaining similar colour schemes, backgrounds, font colour and size etc.

**Conclusion**: The developer will provide Consistent Colour, Same background, same font size and colour for the whole application

* **Affordances**: Affordance means expected behaviour like cursor of mouse changes into hand symbol on roll-over the link.

**Conclusion**: The developer will provide features like double clicking etc on editor.

**3.4 Programming Language Research**

**Visual Basic**

* Provides very easy GUI creation using its tools, picture box and user control features.
* Provides built in support for data grid view and other custom reporting.
* Easy event handlers, procedures can be designed
* Partial classes and static method can be easy implemented
* Generic library class and Array list can be easily inherited within classes.

## 3.5 Research on Similar Systems

|  |  |
| --- | --- |
| **Contents** | **Description** |
| **Product Name** | **2D Load Packer** |
| **Description** | 2D Load Packer (2DLP) is the unique space optimizer designed to help you plan quickly and easily the best compact arrangement of a number of different size 2D rectangular objects ("Boxes") within one or more 2D rectangular Container. 2DLP is based on the truly two-dimensional original packing algorithm. |
| **Functionality** | * The overall load weight limit and truck axle weight limits can be taken into account as the additional constraints or actual optimization factors. * The program has a facility for specifying the associated cost for each box (part) / container (sheet) item in order to calculate totals and affect the optimization as an additional priority factor. Optimizer goal and other main settings are adjustable. * The program can optimize over multiple containers (sheets) in multiple sizes at the same time, taking into account overall item set considered, as well as allowed item orientations specified for each item separately or for all together * The Image Page presents 2D views of the container (sheet) layouts and Area / Weight utilization diagrams. Layout patterns are displayed graphically as the complete adjustable full-colour images. You can observe step-by-step load sequence and print any image view, as well as other task and solution data reports. * The system supports network data sharing and has some specific DB export / import facilities, allowing a user to exchange selected task / solution data with another 2DLP system. |
| **Limitations**  **(if any )** | The program takes generates only 2D image of the final loading as it takes only one surface to load on.  Suited for container of same height only. |
| **User Review** | User rated it with 3 stars, but algorithms, speed and designs are really appreciable. |
| **Link -** | http://www.astrokettle.com/pr2dlp.html |

Table : 2D Load packer , Similar System

**Conclusion:**

* Container includes the size and amount of goods inside it to the file.
* 2D application can be generated if the height are the same but it is a limitation
* Sample Container can be defined and used further.

|  |  |
| --- | --- |
| **Contents** | **Description** |
| **Product Name** | **OptiMap - Fastest Roundtrip Solver** |
| **Description** | OptiMap is an online application that solves travelling salesman problem and any other cyclic route problem and provides shortest distance route. It is developed using Google API and use latitude/longitude as co-ordinates to solve. |
| **Functionality** | * Can substitute address for a city making it an intra-urban travelling problem * Can enter the nodes by clicking in Google map interface * Can also enter address manually by using text fields * Can also add text list, all the address at one time * Can specifiy walking directions and avoiding highways * Toogle raw path gives you exact latitude/longitude co-ordinates in the sequence for this route |
| **Limitations** | Can solve upto 100 nodes only |
| **User Review** | Give 2 out of 10 |
| **Link -** | http://gebweb.net/optimap/ |

Table : Opti-Map ( similar systems)

**Conclusion:**

* To deal with high number of container it requires connecting with some database.
* Weight distribution can be analysed along the longitudinal axis.
* Loading rules can be imposed using panel permit or something.

## 3.5 Market Value of the Project

There is no product in the market that solves both route complexity problem with travelling salesman problem. The approach of and the solution is still not identifiable as the best possible. Genetic approach is hard to apply but it gives a near to optimized output for larger number of products

Effland from Denmark rate CLP as five star in terms of complexity with average budget of $500 at website(freelance.in) .

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| 17 Bids  $750  **Freelancer.in, A leading freelancing website**    Only half of the functionality of this Final year project |

# Chapter 4 Research Methods

## 4.1 Primary Research

The chapter focused on primary of the project. Developer has done this in the initial stage primarily for gathering the information from the potential user of the system. The information is critically analysed and documented so that at the end it is user acceptable. Primary researches are done through following techniques.

### 4.1.1 Questionnaires

Questionnaire (Refer to appendices for questionnaires) is a part of data gathering technique in which a series of questions designed to gather specific information. Questionnaires will specially be designed for users who would use the system which will include people who are either staff of the logistics company or on crew of ship. They have few advantages as Questionnaire –

* Can be used to collect both qualitative and quantitative data
* Can be distributed manually or electronically
* Can reach a vast number of people regardless of physical location or geographical dispersion
* Can be distributed quickly and cheaply
* Can be used when human and financial resources are not available to conduct interviews

**Why Questionnaire?**

As this application is basically targeting to a specific group of professional who are going to use the proposed system, so they are huge and difficult to contact, so it is not possible to take interview of them because it will be huge time consuming. There are some reasons for using Questionnaires-

* The analysis of questionnaire is most efficient than other techniques as we can draw the graphs and analyse the data.
* It can reach a vast number of people regardless of physical location or geographical dispersion.
* It can be distributed quickly and cheaply.

### 4.1.2 Interviews

Interview (Refer to appendices for Interview) is a part of data gathering technique in which a series of question asked face to face from users of the system, designed to gather detailed information. They have few advantages as Interview –

* Can be used for evaluating information needs as interview will allow us to gather detailed information about functionalities of project
* Can be used for gathering knowledge about perceptions of the staff about the application.

**Why Interview?**

* It provides us with immediate an response which saves the developer’s precious time
* It allows participants to express themselves in their own words
* It allows the collection of a large volume of rich data
* It allows discussion, probing and unexpected insights
* It is best for investigating problems

## 4.2 Secondary Research

Secondary research means finding information from third-party sources such as marketing research, websites, magazine articles, and other sources that is already published or gathered by somebody. Books, journal articles and research paper those are necessary in order to understand the project.

### 4.2.1 Technical Research

This part is going to research the proposed system technically means what programming language the system is going to use. As the proposed system is an algorithmic application, so only few languages to choose from and these are C++, C#, Visual Basic and Java. To choose the best suitable development language for the proposed system, developer carried out a lot of research on different languages.

### 4.2.1.1 Programming Language Research

This part is going to research the proposed system about the programming language, the system is going to use.The selection of right platform for development of project is prior requirement of developer. While selecting the programming language the developer takes care of following issues:

* Modules to be developed
* Time of development
* Interface required
* Application programming

Developer had decided to go for Object Oriented Language which supports GUI interface, and can reduce developer’s time in designing the interface itself. The best options available with him are:

### 4.2.1.1.1 Visual Basic, Java and C++ comparison based on project

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| --- | --- | --- | --- | --- |
|  | **Visual Basic** | **Java** | **C++** | **Python** |
| **Learnable** | Very Easy | Hard to Easy | Easy to Hard | Easy |
| **Graphic generation and Support** | Best suited for Graphics , Reporting Applications | Can be used using Libraries, Need extra effort to learn | Very Hard to implement in C++ | Tedious task |
| **OOP feature and Exception handling** | Fulfills totally | Fulfill | Fulfill | Fulfills |
| **Error Elimination** | Easy | Hard | Hard | Hard |
| **File Stream and Database** | Easily compatible with Excel and Java | Hard | Very Hard | Very Hard |

Table : Language Suitability Table and comparison

### 4.2.1.1.2 Reasons for choosing Visual Basic .NET as the programming platform for Beacon

**RAD**: Rapid application development tool, reduce time and efforts in application development.

**Multithreading:** Visual Basic .NET applications can perform multiple tasks simultaneously using multithreading (or free threading), a process in which individual tasks execute on separate threads. Multithreading improves the performance and responsiveness of your applications.

**Globalization:** Using dozens of different objects in the **System.Globalization** namespace, developer can customized language difference such as fonts and right to left writing styles, calendars and different patterns for dates, currency , numbers etc. VB.NET is fully Unicode compliant and the advantage is that developer can display virtually all characters in all languages.

**User Control**

Wizard can be used as a powerful tool which can generates the code automatically, help a lot as less prone to typing error. Using wizard user do not help to enter code line manual but just have to configure the things within the project.

Supports object oriented concepts and a class can inherit other class as a base class and can also define its own properties in derived class.

Classes created in VB.NET have public access modifier by default and can be inherited by any other class within the same project.

Compatibility with all kinds of database available in the market.

## 4.2.1.1.3 Packages to be used

|  |  |
| --- | --- |
| Imports system .globalisation |  |
|  |  |
|  |  |

Table : Packages to be used

## 4.2.2 Methodology: Advanced Waterfall

## 4.2.21 Description

The Advanced waterfall provides an orderly sequence of development steps and helps ensure the adequacy of documentation and design reviews to ensure the quality, reliability, and maintainability of the developed software.

|  |
| --- |
| Requirements Analysis  Usability Testing Design  System Design  System Testing  Architecture Design  Integration Testing  Module Design  Unit Testing  Implementation |

Figure : Advanced Waterfall follows V model

Advanced waterfall methodology follows V model in development stages.

## 4.2.2.2 Justification

After some deliberation and discussion the developer settled upon using Waterfall Model for the development of this system. The most tempting factor for selection of Waterfall model is-

* Stable project requirements: As in our project most of the user requirements are freeze at the time of PSF so it indicates a stable project requirements and Waterfall methodology completely supports a project which has requirements decided in advance.
* Progress of system is measurable: After each step it produces the documentation and as the structure of our Final year project we need to submit the documentation after each phase so it will be best suitable.
* Strict sign-off requirements: As the developers goal will be to satisfy the user and until the user will be satisfied the developer will be providing the user desired functionalities and proper features so this methodology will be best suitable.
* The emphasis on requirements and design before writing a single line of code ensures minimal wastage of time and effort and reduces the risk of schedule slippage, or of customer expectations not being met.
* In modified waterfall model life cycle phases are permitted to overlap. Because of the phases overlap, a lot of flexibility has been introduced in the modified waterfall model in software engineering. At the same time, a number of tasks can function concurrently, which ensures that the defects in the software are removed in the development stage itself and the overhead cost of making changes to the software before implementation is saved.
* Making changes to the basic design is also possible, as there are a number of phases active at one point of time. In case there are any errors introduced because of the changes made, rectifying them is also easy (Testing can be done). This helps to reduce any oversight issues. The modified waterfall model diagram does not differ from the traditional waterfall model diagram, as to every phase of the model verification and validation step has been added. (Satalkar, 2010)

## 4.2.3 Algorithms: Why Particular Algorithm?

### 4.2.3.1 Reasons for choosing Genetic Algorithm for Route Planning

* TSP is known as the NP-Complete problem means it cannot be solved in polynomial time, so we need to use an approximation solution that fits right in. Genetic Algorithm is the successful way to approach to get optimized results.
* Testing every possibility for an N city tour would be N! math additions. A 30 city tour would have to measure the total distance of be 2.65 \* 1032 different tours. Assuming a trillion additions per second, this would take 252,333,390,232,297 years. Adding one more city would cause the time to increase by a factor of 31. Obviously, this is an impossible solution.
* Genetic Algorithms mimic nature and evolution using the principles of Survival of the Fittest. Although it might not find the best solution, it can find a near perfect solution for a 100 city tour in less than a minute.
* Greedy approach can be used in between the Genetic algorithm to map closet cities in the initial population generation

### 4.2.3.2 Reasons for choosing Bin Packing Algorithm for Load Planner (CLP)

* 2D-Bin-Packing works on pack a given set of 2D-rectangles into unit square bins so that the number of bins is minimised. Even very simple cases of these problem are known to be NP-hard, and hence, it is very likely that no efficient algorithms for them exist
* In the design of such algorithms, a simple shelf technique is used: order the rectangles according to a sorting rule like decreasing width, increasing height, etc., and then greedily pack them one by one in this order over package shelves according to some rule, like **First-Fit**, **Next-Fit**, **Best-Fit**, **Worst-Fit** and so on. This allows a simple code design, a very fast running time, and a relatively good quality guarantee.
* Beacon has an assumptions that all the **container are of same width**, only the height of containers gets changed, that fixes the width of the rectangle and makes work easier enough in one dimension.

|  |  |
| --- | --- |
| Tall Containers | Container used |
| Figure : Bin Packing Example (Gordon, 2011) | 50x400  50x300  50x200  50x100  50x50 |

## 4.3 Academic Research

There are varied areas in which research has to be accomplished in order to derive some deductions during the development of the proposed system. This system is going to involve all three kinds of research namely, Primary, Secondary and Academic research. Following areas have been shortlisted which needs to researched:

* Key Concepts Genetic Algorithms and Greedy approach
* Concepts of Implementation of Graph theory with data structure
* Bin Packing algorithm and Greedy approach
* Database concepts
* Visual Basic / .NET
* Software Methodology and Software Engineering
* Human Computer Interaction Principles
* Design Pattern

**Books:**

**Algorithms:**

1. Clifford Stein, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest ,2010, Introduction to Algorithms ; Massachusetts USA: PHI Learning.
2. David E. Goldberg ,1989, Genetic Algorithms in search, Optimization & Machine Learning, 1/e; USA ; Pearson Education
3. Steven Holzner ,2009 Visual Basic .NET Programming ;USA; Paraglyph Press

**Software Methodology and Software Engineering**

1. Kendall and Kendall (2005); System Analysis and Design; 4th Ed; New York: Prentice Hall.
2. Jeffry L Whittem, Lonnie Bentley (2005). System Analysis and Design; London: Mc Graw-Hill.
3. Shelly Cashman (2002). System Analysis and design; 2nd Ed. Sydney: Shelly Cashman Series.
4. Shari Lawerence Pfleeger (2002). Software Engineering; 2nd Ed; New Jersy: Pearson Education.
5. Daniel MB(ed) 2008, Software Engineering for Modern Methodologies and Technologies, IGI Global, USA
6. Shari LawerencePfleeger (2002). Software Engineering; 2nd Ed; New Jersy: Pearson Education.
7. Jeffry L Whittem, Lonnie Bentley (2005). System Analysis and Design; London: McGraw-Hill.

**Websites**

***PDF- ebooks:***

http://www.sdprocess.com/pdf/S1-Kruchten2004Toronto.pdf

http://www.relativitycorp.com/projectmanagement/article1.html

http://www.buzzle.com/articles/waterfall-model-advantages-and-disadvantages.html

**White Paper and Journals**

A Guide to the Project Management Body of Knowledge (PMBOK ® Guide) By Project Management Institute.

Approximation Algorithms for Deadline-TSP and VehicleRouting with Time-Windows by Nikhil Bansal.

Hybrid binary ant colony algorithm for container loading problem by Yuan Junliang

**Magazines**

# Chapter 5: Research Analysis

## 5.1 Questionnaire Analysis

Refer to appendices for analysis of questionnaire.

## 5.1.1 Questionnaire Conclusion

After analysis of questions, the developer concluded on some points which are following –

Most of the user’s in India are unaware of the situation and complexity, although they area affected. They have no knowledge of the software and its benefits in terms of time and cost cutting.

The developer has decided to provide metaphors for increasing learning ability. Also the application has scope for lots of design principles to increase usability and interaction.

For data entry purpose, developer is not using any advanced database system but a simple excel file or csv file. Also users will be allowed to enter data directly into the application and defining the parameters (e.g. specification of boxes).

Time complexity is the crucial factor in terms of speed, Most of the companies have more than 100 consignments per day, and so without using an advanced approach of solving, the system would be very slow and result into no benefit.

## 5.1.2 Recommendation

Graphical tour generation is motivated by user to showcase the real working of algorithms. Also user can stop running algorithms at any moment.

Since the co-ordinates required for working is very small in size, XML file is recommended to store, edit and change the values of co-ordinates of cities

City Entry ( XML file entry) module required to create co-ordinates so that it can be further used in the algorithms.

Time is crucial factor to solve such big problem, so only the best approach should be applied (like genetic algorithm) to reduce time complexity.

## 5.2 Interview Analysis

Refer to appendices for analysis of Interview.

## 5.2.1 Interview Conclusion

After analysis of Interview, the researcher conclude various points from other interviewee,

Travelling Salesman Problem and Container Loading problem are known as the NP-hard problems and no exact solution is invented yet for this problem. Although real world algorithms like Genetic algorithm, Ant Colony Algorithm, Simulated Annealing are suggest solving this problem to most optimized state.

Major parameters used in the TSP are the cost calculation, crossover, tournament and mutation factor. Tours are the arrays of cities in a particular order and initial population needs to be created to crossover between them.

## 5.2.2 Recommendation

## 5.3 Traceability Matrix for Questionnaire and Functionality Mapping

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RI** | **FC**  **1** | **FC**  **2** | **FC**  **3** | **FC**  **4** | **FC**  **5** | **FE**  **1** | **FE**  **2** | **FE**  **3** | **FS**  **1** | **FS**  **2** |
| **Questionnaires** |  |  |  |  |  |  |  |  |  |  |
| **Q1.6** |  |  |  |  | **X** |  |  |  |  |  |
| **Q1.7** |  | **X** |  | **X** |  | **X** |  |  |  |  |
| **Q1.8** | **X** |  |  |  |  |  |  |  |  |  |
| **Q2.6** |  |  |  |  |  |  | **X** |  |  |  |
| **Q2.7** |  |  |  |  |  |  |  | **X** |  |  |
| **Q2.8** |  |  |  |  |  |  |  | **X** |  |  |
| **Interview** |  |  |  |  |  |  |  |  |  |  |
| **I1** |  | **X** |  | **X** |  |  |  |  |  |  |
| **I2** |  | **X** |  | **X** |  |  |  |  |  |  |
| **I4** |  |  | **X** |  | **X** |  |  |  |  |  |
| **I6** |  |  |  |  |  |  |  |  | **X** |  |
| **I7** |  |  |  |  |  |  |  |  |  | **X** |

Table : Traceability Matrix between Questionnaire, Interviews and Functionalities

# Chapter 6: System Design

The aim of design is to produce a model that will provide a seamless transition to the coding phase, i.e. once the requirements are analysed and found to be satisfactory, a design model is created which can be easily implemented.

**Selected Methodology: Object-oriented design**

In the object-oriented design approach, the system is viewed as collection of objects (i.e. entities). The state is decentralized among the objects and each object manages its own state information. For example, in this project Objects have their own internal data which define their state. Similar objects constitute a class. In other words, each object is a member of some class. Classes may inherit features from super class. Conceptually, objects communicate by message passing.

**Why object-oriented design approach?**

Unlike function-oriented design methods, in OOD, the basic abstraction is not real-world functions such as sort, display, track, etc., but real-world entities such as cities, tour, population etc.

Function-oriented techniques such as SA/SD group functions together if, as a group, they constitute a higher-level function. On the other hand, object-oriented techniques group functions together on the basis of the data they operate on.

**Justification of using these diagrams (object-oriented design Methodology):**

**Use Cases:** Use cases will show who will use the system and what they will do with it. This will specify the system requirements in the context of the user.

**Activity Diagrams:** Activity diagrams will show the flow of work and information between activities performed by users and system or its parts. They elaborate the use cases.

**Sequence Diagrams:** Sequence diagrams will show the sequence of interactions between users and system or its parts. This will help in realizing the structural organization of objects that communicate within a system. **(Kennesaw 2001)**

**Class Diagrams:** UML class diagrams will be used to provide an implementation-independent description of the objects that are used in the system and passed between its components. The design then can be implemented on any platform using any development environment.

**Design patterns:** Patterns are reusable solutions to problems that recur in many applications. A pattern serves as a guide for creating a “good” design. Patterns are based on sound common sense and the application of fundamental design principles. These are created by people who spot repeating themes across designs. The pattern solutions are typically described in terms of class and interaction diagrams, the developer has used **Iterator pattern**

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**Traceability Matrix between Analysis and Design**

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement Analysis** | **Design** | | |
| **Use Case** | **Activity Diagram** | **Sequence Diagram** |
| **Design Route Map** | **UC-01** | **AD-01** |  |
| **Plan Route** | **UC-02** | **AD-02** |  |
| **XML Connection** | **UC-03** | **AD-03** |  |
| **Manage Loading** | **UC-04** | **AD-04** |  |
| **View Loading** | **UC-05** | **AD-05** |  |
| **Change Language** | **UC-06** | **AD-06** |  |
| **Reports** | **UC-07** | **AD-07** |  |
| **Lock** |  |  |  |
| **Image Download** |  |  |  |
| **Save/ View** |  |  |  |

### 5.1 Use Cases

With the help of use case diagrams, the developer wishes to discuss and communicate:

* The scenarios in which Beacon will function as a product.
* The goals that it helps those actors achieve.
* The scope/limitations of Beacon.

The use case diagrams will not in any circumstance show the detail of any functionality: it will only summarize some of the relationships between use cases, actors, and systems. In particular, the diagram will not show the order in which steps are performed to achieve the goals of each use case.

**The developer’s approach:**

For the benefit of the reader’s the developer has prepared a high-level use-case context diagram with all specifications. After that for each context a full formed use-case is prepared along with any **assumptions, pre-conditions, post-conditions, happy-path, alternate-paths (if any), and exception-pathways**.

### Along with the use cases activity diagrams and sequence diagrams are also provided wherever relevant and deemed necessary.

### 5.1.1 Use Case Context Diagram

|  |
| --- |
| C:\Users\r0G3R b1NNy\Desktop\Diagrams\USE CASES\1.Use Case Context Diagram.jpg |
|  |

**5.1.1.1 Actor List**

|  |  |
| --- | --- |
| **Actor** | **Description** |
| **User** | Any user who wants to use Beacon for finding shortest path, container loading or Consignment management. |

**5.1.1.2 Use – Case List**

|  |  |  |
| --- | --- | --- |
| **ID** | **Use Case Name** | **Description** |
| UC-01 | **Design Route Map** | Designer for the route map |
| UC-02 | **Plan Route** | Algorithms behind the route and customized output |
| UC-03 | **XML-Connection** | Read /Write to XML file |
| UC-04 | **Manage Loading** | Get elements and helps in choosing best algorithm |
| UC-05 | **View Loading** | View Loading plan in the Graph form |
| UC-06 | **Change Language** | Language Changer |
| UC-07 | **Reports** | Previously Saved Solution Reports |
|  |  |  |

### 5.1.2 Use Case Specification ( Design Route Map)

|  |  |
| --- | --- |
| Name ID | |
| **Description:** |  |
| **Goal:** |  |
| **Actor(s):** |  |
| **Assumption(s):** |  |
| **Pre-condition(s):** |  |
| **Post-condition(s):** |  |
| **Primary (Happy) Path:** | |
|  | |
| **Alternate Pathway(s):** | |
|  | |
| **Exception Pathway(s):** | |
|  | |

Use Case Diagram

|  |
| --- |
|  |
| C:\Users\r0G3R b1NNy\Desktop\Diagrams\USE CASES\3 .Design Route MAp - use case diagram.jpg |
|  |

|  |
| --- |
| Activity Diagram |
| C:\Users\r0G3R b1NNy\Desktop\Diagrams\Activity Diagram\3.Design Route Map -activity Diagram.jpg |
|  |

### Use Case (Plan Route )

|  |  |
| --- | --- |
| Name ID | |
| **Description:** |  |
| **Goal:** |  |
| **Actor(s):** |  |
| **Assumption(s):** |  |
| **Pre-condition(s):** |  |
| **Post-condition(s):** |  |
| **Primary (Happy) Path:** | |
|  | |
| **Alternate Pathway(s):** | |
|  | |
| **Exception Pathway(s):** | |
|  | |

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| **C:\Users\r0G3R b1NNy\Desktop\Diagrams\USE CASES\4. Plan Route Map -use case diagram.jpg** |
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| **C:\Users\r0G3R b1NNy\Desktop\Diagrams\Activity Diagram\4.Plan Route Map - activity Diagram.jpg** |
|  |

Use Case ( XML Editor)

|  |  |
| --- | --- |
| Name ID | |
| **Description:** |  |
| **Goal:** |  |
| **Actor(s):** |  |
| **Assumption(s):** |  |
| **Pre-condition(s):** |  |
| **Post-condition(s):** |  |
| **Primary (Happy) Path:** | |
|  | |
| **Alternate Pathway(s):** | |
|  | |
| **Exception Pathway(s):** | |
|  | |

|  |
| --- |
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| C:\Users\r0G3R b1NNy\Desktop\Diagrams\USE CASES\4.1 XML editor.jpg |
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| --- |
|  |
| C:\Users\r0G3R b1NNy\Desktop\Diagrams\Activity Diagram\4.1 XML activity.jpg |
|  |

Use Case (Manage Loading)

|  |  |
| --- | --- |
| Name ID | |
| **Description:** |  |
| **Goal:** |  |
| **Actor(s):** |  |
| **Assumption(s):** |  |
| **Pre-condition(s):** |  |
| **Post-condition(s):** |  |
| **Primary (Happy) Path:** | |
|  | |
| **Alternate Pathway(s):** | |
|  | |
| **Exception Pathway(s):** | |
|  | |

|  |
| --- |
| Manage loading |
| C:\Users\r0G3R b1NNy\Desktop\Diagrams\USE CASES\6 .Manage Loading use case diagram.jpg |
|  |

|  |
| --- |
| Activity Diagram ( Manage Loading) |
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# Chapter 7: Implementation

This chapter describes the core, enhanced and special functionalities of the Beacon. Design are clearly explains these implementation through designs.

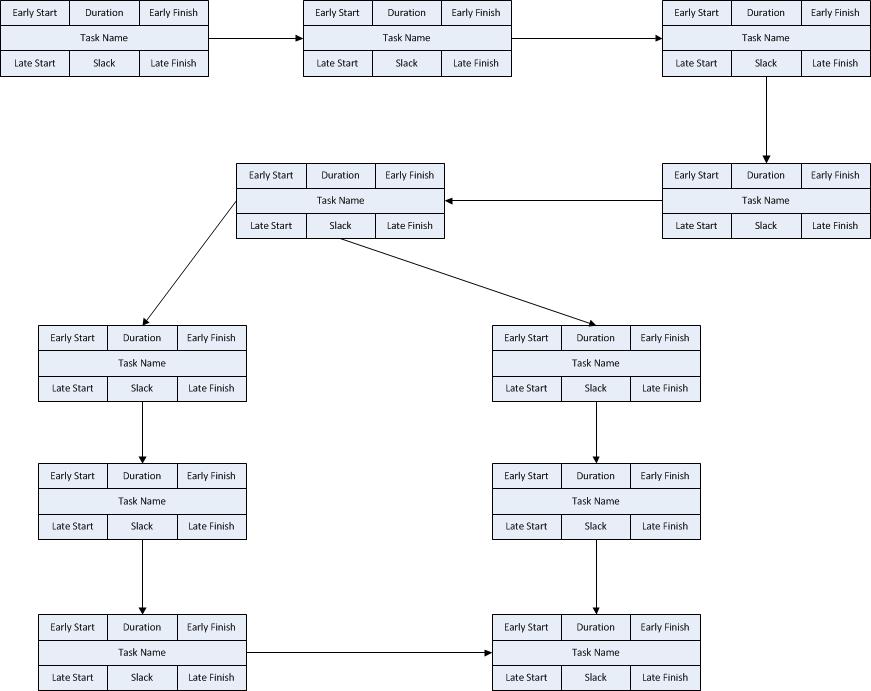
## 7.1 Tools used for Implementation

|  |  |  |
| --- | --- | --- |
| No. | Case Tools/ Development Tool/ Others | Purpose |
| 1 | Microsoft Visio 2007 | To draw all the UML diagrams. |
| 2. | Microsoft Project | To draw Project Gantt chart |
| 3. | Visual Paradigm UML | To draw UML Diagrams |
| 4. | Microsoft Visual Studio 2010 | Used as a primary IDE for functionality, testing. |
| 5. | SQL Server Management Studio | Used as the backend database. |
| 6. | Windows 7 Home Premium | Used as the primary OS to publish software and testing. |
| 7. | .NET Framework version 4 | Framework of development |
| 8. | Microsoft Word 2010 | To document the report. |
| 9. | Microsoft PowerPoint 2010 | To prepare presentation slides. |
| 10. | MS Paint | For image and logo creation. |
| Table 22 : Tools Used | | |

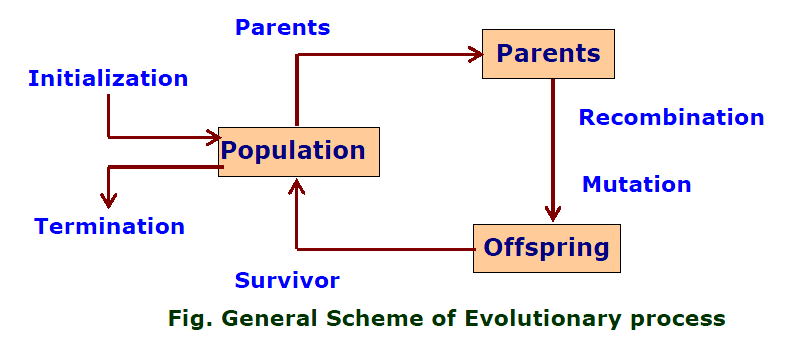
### 7.1.1 Implementation Plan

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Task ID** | **A1** | **A2** | **A3** | **A4** | **A5** | **A6** |
| **Task Details** | Implementation Plan | CF-1 | CF-2 | CF-3 | CF-4 | CF-5 |
| **Task ID** | **A7** | **A8** | **A9** | **A12** | **A13** | **A14** |
| **Task Details** | EF-1 | EF-2 | EF-3 | SF-1 | SF-2 | Handover |

|  |  |  |
| --- | --- | --- |
| **Abbreviations** | | |
| **CF-Core Functionality** | **EF-Enhanced Functionality** | **SF-Special Functionality** |

7.2 Implementing Complex Modules

The following sections describe how each module was implemented. In addition to that, each part explains the problems encountered and how they were tackled by the developer. Implementation phase of the entire system was divided as follows for easier and better implementation and maintenance.



### 7.2.1 Create Random Population (TSP)

Initialization of population is probably the last of application issues to be solved, thus is not also easy to decide. In TSP, the population is randomly initialized and mixed, but the initialization of population could be more sophisticated task to do and think about. The initial population is base for all further population growth and development, so if the population is initialized incorrectly, e.g. not enough randomized for TSP, then the whole computation is going in wrong way.

### 7.2.1.1 Objective

GA is applied to the certain number of population that includes random cost and constraints to deal with. Mating and crossover is done to the specific chromosomes based on their cost. Tours are the individuals here.

* Create the initial set of random tours of the same cities.
* Choosing a starting point of the tour.
* Prefer choosing a city, the logic is not up to now, but it should be near enough to be chosen.
* Connect the last two cities

### 7.2.1.2 Description: This module basically covers the following subparts:

To begin a GA, we define an initial population of chromosomes. A matrix represents the population with each row in the matrix being a 1 \* array (chromosome) of continuous values.

If initial look at this problem with N =13 cities with the fixed starting and ending points, there are a total of  **= 3.1135 \*** possible combinations can be generated. In the Implementation, developer has provided indefinite number of cities to select for and this results in a very large number of possible and unexpected tours.

### 7.2.1.3 Flow of the module:

**Step 1**: Population class inherits the Generic list of Tour that is strongly typed list of objects can be used to sort, search and manipulate. Tour consists the link to the cities in particular order and sub function to use the tour for crossover. Best Available Tour is null during the initiation of population.

|  |  |
| --- | --- |
| Pseudo code | Packages |
| Step1. START  Step2. CREATE Class population  Step 3. Inherit arrayList of tour  Step 4. SAVE private bestTour as NULL  Step 5 GET/SET bestTour to public function  Step 6. Generate Random Population  Step 7. UPDATE bestTour  Step 8. STOP | using System;  using System.Collections;  using System.Collections.Generic;  using System.Text; |

**Step 2**: Random generation of population is done by using three parameters, population size, city list and chance to choose closet city. New tour object is created by counting the total number of cities in the tour array. After this starting and ending point of tour is randomly selected (refer to TSP definition 3.3.1) A random tour is generated using random method and closet city parameters and last tour is first to create a cyclic map.

Then the function determines the Tour Fitness by using tour object. Fitness is the total distance of the tour. Add tour into the population array. If the Tour found has the best fitness, save it as best Tour

|  |  |
| --- | --- |
| Pseudo code | External Class and function used |
| Step 1. START  Step 2. CREATE object of tour of length of city list  Step 3. Randomly select first city  Step 4. FOR EACH city  Step 4.1. DO  Step 4.2. IF new next city , ADD in array  Step 4.3 ELSE ADD random next city  Step 4.4 .END WHILE when next city is last city  Step 4.5 END FOR  Step 5 Connect last two cities using  Step 6 Determine tour fitness  Step 7. ADD tour in the Population  Step 8. IF tour fitness is smaller than best tour fitness  Step 9. REPLACE best tour with tour  Step 10. STOP | **Object**  Tour object is created of size city list  **Function**  Tour.nextCity  Tour.firstCity  Tour.determineFitness  CityList.CloseCities  Rand.next |

## 7.2.2. Crossover (TSP)

Crossover comes after the generation of initial population the GA flowchart. Crossover is done to the parents to create new offspring of better and hybrid cost.

### 7.2.2.1 Objective:

* Perform the crossover operation on two parent tours to create new child tour
* Total of two children will be created so twice execution of the function
* Count links of the cities using iteration
* Take all the common links from both parents and put them in child, this will inherit parent’s traits into child tours.
* Randomly assign remaining links as parent’s link cause multiple disconnected loops in the tour

**7.2.2.2 Description:** The crossover technique used here is much similar as PMX (partially mapped Crossover (**Goldberg, 1985**). A better crossover should introduce new edges to the children and common edges must be inherited. Common edges preserve parent’s traits and new edges provide diversity and escape from local optima.

|  |  |
| --- | --- |
|  |  |
| **1. Decide two crossover points** | **2. Copy path between two crossover point** |
|  |  |
| **3. Copy path of another parent if possible** | **4. Copy remaining path with correspondence** |
|  |  |
| **5. Copy remaining path with correspondance** | **6. Result of PMX** |
| REF : IBA LAB (laboratory Tokoyo ) http://www.iba.t.u-tokyo.ac.jp/ 09-11-2010 | |

### 7.2.2.3 Flow of the Module:

**Step 1**: The Shared crossover modules in the Tour have three parameters parent1, parent2 and city list. Basically the module is mathematical selection and manipulation of the link of the city. Tour object is created of size city list to maintain new tour. Calculation of the city link is done through iteration of city list array.

**Step 2**: Parent’s traits are saved as the link that are common to both the parents is also saved in child. To implement this, developer has used iteration of city and then if connection of links of parents are same, save it for next city. Since there are 2 parents and 2 connections, a total of checking will happen. Two offspring are their so, it require to execute this step twice.

**Step 3:** Since parents would cause multiple disconnected loops in the tour. To fill those loops random links are connected to the loops to join cities. Next city will be random city until the flow finds a new city to link to.

|  |
| --- |
| Pseudo code |
| Step 1. START  Step 2. Take parameters as Parent1 , Parent2 and city list  Step 3. CREATE object of Tour  Step 4. FOR EACH city  Step 4.1. SAVE cityusage  Step 4.2. END FOR  Step 5. FOR EACH city  Step 6. IF parent1 connection 1 is EQUALS parent2 connection 1  Step 7. join cities in child connection to next city  Step 8. REPEAT step 6 7 times again  Step 9. FOR EACH city  STEP 9.1. WHILE cityusage is smaller than 2  STEP 9.2. next city EQUALS random city  STEP 10. RETURN child  STEP 11. STOP |

### 7.2.3 Map Editor - GUI Drawing (TSP)

Map Editor Module is the used to showcase the route and the working of algorithm at runtime.

**7.2.3.1 Objective:**

* To Display the cities in the Picture Box of the graph
* Display the routes within the city and algorithm is finding the solution
* Enable to create cities at the mouse click at any co-ordinates.
* Load co-ordinates from XML file
* Can be saved in the image format to be saved in the database

**7.2.3.3 Description:** Map editor is basically a picture box in the system that works on various events. Graphical properties of Picture Box are used to create the map editor.

**7.2.3.4 Flow of the Module:**

**Step 1:** The Map editor start with the loading of picture box. When mouse down events is initiated, the map looks for drawCityList function, City list are created by taking the co-ordinates of picture box in consideration. Also city list can be shown in map by loading it through XML file.

|  |  |
| --- | --- |
| Pseudo Code | Libraries |
| Step 1. START  Step 2. CREATE cityimage EQUALS picturebox  Step 3. DECLARE graphics for cityImage  Step 4. FOR EACH city in citylisy  Step 4.1. DRAW small rectangle  Step 4.2 END FOR  Step 5. RETURN cityimage  Step6. UPDATE city count  Step 7. STOP | using System;  using System.Collections.Generic;  using System.ComponentModel;  using System.Data;  using System.Drawing;  using System.Text;  using System.Windows.Forms;  using System.Threading;  using System.IO;  using System.Globalization; |
| XML file based loading |
| Step 1. START  Step 2. TRIGGER event  Step 3. OPEN file Dialog  Step 4. Filter.xml file  Step 5. IF GET File name  Step 6. OPEN city list from file  Step 7. ELSE  Step 8. PRINT error file not found  Step 9. END IF  Step 10. STOP |

**Step 2:** After loading the city list, next task is to apply algorithm to generate best possible tour. Developers approaches to show the working of algorithm with the TSP Events. Every New tour in the process is reflected into the map with total distance and routes.

|  |
| --- |
| Pseudo code |
| Step 1 .START  Step 2. GET last best fitness value  Step 3. GET last iteration value  Step 4. next city EQUALS best tour connection1  Step 5. FOR EACH city in city list  Step 5.1. DRAW rectangle for city  Step 5.2. DRAW the line connecting city  Step 5.4. IF last city EQUALS NOT best city connection 1  Step 5.5. next city EQUALS best tour connection 1  Step 5.6. ELSE next city EQUALS best tour connection 2  Step 5.7. END FOR  Step 5.8. RETURN city image  Step 6. STOP |
|  |

## 7.2.4 Container loading Algorithm – Bin Packing Algorithm

Bin Packing is a mathematical way to deal with efficiently fitting Elements into Bins. The hitch is that Bin packing problem is classified as the NP-complete problem. Basically means that there’s no way of being guaranteed the best solution without checking every possible solution

**7.2.4.1 Objective**

* To take the elements as the length of the container
* Apply approach of solving through first fit, next fit, best fit, and worst fit.
* Bin height can be increased and decreased during the execution

**7.2.4.2 Description**

The goal of every Bin Packing algorithm is to use the least amount of Bins to hold the required number of Elements

* **Bin**: The fixed size container that can hold the Elements
* **Bin Height**: The specified amount that each Bin can hold.
* **Element**: An item that is to be placed in a Bin having a certain Element Height
* **Element Height**: The amount of Bin space the Element will take up if placed in that Bin.

**7.2.4.4 Flow of the Module:**

**Step 1**: The first step includes getting the elements from the field and the choice of algorithm to choose for when the event triggered. The decreasing check box apply this algorithm in the decreasing order of array.

|  |  |
| --- | --- |
| Libraries | Pseudo code |
| using System;  using System.Collections.Generic;  using System.ComponentModel;  using System.Data;  using System.Drawing;  using System.Text;  using System.Windows.Forms;  using System.Threading;  using System.IO;  using System.Globalization;  using System.Data.SqlClient; | Step 1: START  Step 2. IF decreasing equals TRUE  Step 2.1. SORT elements  Step 2.2. REVERSE array  Step 2.3. END IF  Step 3 STOP |

**Step 2: Next-Fit Algorithm** - This algorithm starts at the beginning of the Elements array and steps through each one. Once Bin 1 is full, it moves on and starts placing elements into Bin 2, never looking back to see if an Element in the future may fit inside Bin 1.

**Step 3: First-Fit Algorithm**: It steps through the Elements sticking them into the first Bin it can, if there aren't any Bins that it will fit into, a new Bin is added. It is more efficient than Next Fit Algorithm.

**Step 4: Worst-Fit Algorithm:** It comes with some extra processing though (on small data sets it doesn't really matter). The only difference between the two algorithms is that Worst Fit picks the Bin with the most amount of free space (or creates a new Bin if no existing one can fit the Element) instead of just picking the first Bin available.

**Step 5: Best-Fit Algorithm:** Instead of picking a Bin with the most amount of free space, this algorithm picks the Bin with the least amount of free space in it that can still hold the current Element. The results you obtain by using this algorithm are not always the same as the Worst Fit, sometimes it is slightly better, other times it is not. It depends on the nature of the data supplied.

|  |
| --- |
| Pseudo Code |
| Step 1. START  Step 2. IF elements equals NULL  Step 2.1. EXIT  Step 3. Declare elements copy, Bin number, Bin Element, Bin count as integer  Step 4. Declare best bin , bin amount ,i , j ,k as integer  Step 5. COPY of array  Step 6. SORT array in descending order  Step 7. FOR EACH element  Step 7.1 best bin and best bin amount EQUALS -1  Step 7.1.1 FOR EACH bin number  Step 7.1.2 bin element =bin(j)  Step 7.1.3 COUNT amount in bin  Step 7.1.4 END FOR  Step 7.2 FIND the most full bin  Step 7.3 RETURN best bin  Step 7.4 END FOR  Step 8. IF best bin equals -1 THEN  Step 9. CREATE new bin  Step 10. Initialise first element to new bin  Step 11. ELSE  Step 12 Place element in the best bin  Step 12 END FOR  Step 13 REMOVE unused elements  Step 14 STOP |
|  |
|  |

## 7.3 Problems (Hardest Task)

### 7.3.1 Problem 1: (Mapping TSP with GA and approach of solving)

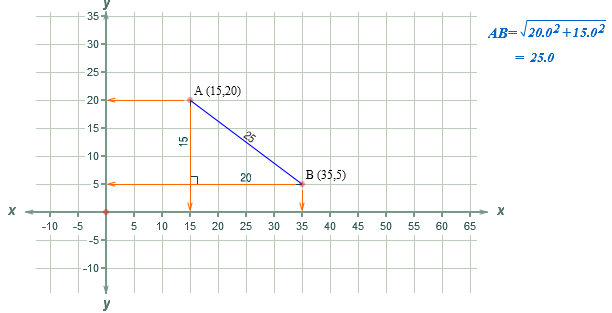
For solving the route planner problem the developer had to do the following task on the single action

1. Identifying the cost function for the TSP
2. Find the closet city with minimum distance logic
3. Code the chromosome ( as in Genetic Algorithm) of the TSP using data structure.
4. Define fitness function that decide the overall rank of a tour
5. Generate Genetic Algorithm engine for population control and filtering
6. Mating algorithm that do crossover between two parents and generate new offspring.
7. Implement Mutation to reallocate the population from any local extrema
8. Apply right initial parameters.

(Ray, Bandyopadhyay, & Pal, 2004)

**Solution**

1. **Cost Function:** The cost function id determined by the public sub procedures in Cities class. It is basically derived from the Pythagoras Theorem of calculation that is



<http://www.mathopenref.com/coorddist.html>

The City distances are calculated for all the cities and further the distance are added to the array list for processing.

1. **Closet city with minimum distance logic:** When creating the initial population of tours, this is a greater chance that a nearby city will be chosen for a link. This is the number of cities that will be considered close

|  |
| --- |
|  |
| 1.START  2. FOR EACH i  2.1 FOR EACH cityNum  2.1.1 IF distance of cityNim is smaller then shortest distance THEN  2.1.2 shortest distance EQUALS distance of cityNum  2.1.3 shortest city is cityNum  2.1.4 END IF  2.2 END FOR  2.3 ADD shortest city of closecities array  2.4 END FOR |

The final array include the array of the shortest distance to the next city of the all the distances of that city to all other cities. The final values stored in the process are the cities that have the shortest distance.

1. **Map the Chromosomes of TSP for GA**

The chromosome is set of ordered indexes of cities, through which the traveller goes. The TSP is coded into data structure, which can be handed like a chromosome. The array index is our route order, the contents of each array elements is a city number. Hence, if developer wrote the following pseudo code:

A[ ] = { 5 ,64, 23 ,8 , 32 …….. }

It would mean that the visit of city 5 is the starting point followed by city 64, 23, 8, 32 and so on. This is how ‘chromosomes’ or trial solutions is encoded in genetic algorithm. In the code, tour class represents the order of cities linked together and object of the tour class is used to find fitness and other processing in GA.

1. **Fitness Function**

The fitness is calculated for each chromosome that further mates to create new offspring. Fitness is the criteria of ranking the tours. TSP determines fitness as the total distance of a Tour, The higher the distance, lower is the fitness.

Root Mean Square (RMS) value is used to determine fitness from the cost function.

|  |
| --- |
|  |
| Public Sub DetermineFitness(ByVal cities As Cities)  Fitness = 0  Dim lastCity As Integer = 0  Dim nextCity As Integer = Me(0).Connection1  For Each link As Link In Me  Fitness += cities(lastCity).Distances(nextCity)  If lastCity <> Me(nextCity).Connection1 Then  lastCity = nextCity  nextCity = Me(nextCity).Connection1  Else  lastCity = nextCity  nextCity = Me(nextCity).Connection2  End If  Next  End Sub |
|  |

1. **Genetic Algorithm Engine for Population control and Filtering**

Select genetic algorithm engine care about the population, its growth, filtering, selecting and sorting individuals and random mutations of chromosomes. It also handles all the computation process and optionally enables multi-threading processing of the problem.

**Description of Population Generation (Refer to 7.2.1.2)**

**Pseudo code of Population Generation (Refer to 7.2.1.3)**

1. **Mating Algorithm Crossover**

Mating algorithm is very important way, how to create offspring (child) from the parent chromosomes. The task of the mating is to create new offspring, which has characteristics from both parent and improves the quality returned by fitness function. Developer recognises this task as the most difficult and most important as it decides, how well and how fast will the population improve.

**Description of Crossover in GA (Refer to 7.2.2.2)**

**Pseudo code of Crossover in GA (Refer to 7.2.2.3)**

|  |
| --- |
|  |
|  |

1. **Implement Random Mutation**

Enable the mating algorithm for moving the population from local extrema. It could happen that the computation is in such a state locked in non-optimal position and needs external (random impulse to break the disability apart a start again moving ahead. The critical factor is that if there is too much of random process into computation, the result will never be the most optimal.

1. **Apply the right initial parameters**

The initial parameter includes parameters like population size, size, mutation ratio, population growth. These parameters are relevant to used algorithm, and can influence the computation process a lot.

### 7.3.2 Problem 2 (Generating the Graph of Loading)

The main problem is this to generate the graph on the change event of elements and algorithm selected. The graph of loading is made and control using user control feature of Visual Basic by which custom graphical interfaces can be created and reused. User control is creates by combining controls and components into a user control container and further properties of graph and custom functionality of changes graph are added to extend the functionality of binpackingGraph

<http://msdn.microsoft.com/en-us/library/c316f119%28v=vs.71%29.aspx>

## 7.4 Technical Quality

### 7.4.1 Memory Utilization

|  |  |
| --- | --- |
|  |  |

List represents a strongly typed list of objects that can be accessed by index. Provides methods to search, sort, and manipulate lists. For utilizing less memory the developer has used ArrayList as it utilizes the memory as required(Dynamically) instead of array that uses fix amount of memory whether that is usable or not.

### 7.4.2 Performance

The application performance is measured in terms of the speed, and time taken to solve the problem, generally termed as the time complexity of algorithm. For upto 100 cities in the tour , application takes less than 30 seconds to approach to the best possible solution in TSP. In loading the output is instant solves and generated graph under a second.

### 7.4.3 User Interface

* User Interface is based on the Human Computer Interaction and Usability Concepts.
* Metaphors are used to increase the usability and understanding.
* Graph are made is very decent way that show each path and route.
* Zoom capability, Co-ordinates can be used to view it in proper way.

### 7.4.4 Short-Cut Keys

For Help F1 , Exit – Alt+f4 key and other set of keys are provided to use so that Beacon can be used as frequently and effectively as user want.

### 7.4.5 Naming Convention

|  |  |
| --- | --- |
| Naming Convention for Class | Naming Convention for Variables |
| Public Class Cities  Inherits List(Of City) | Private bmpGraph As Bitmap  Private DrawingTextBrush As New SolidBrush(Me.ForeColor) |
| Starts with Capital letter | Bmp for bitmap graph |

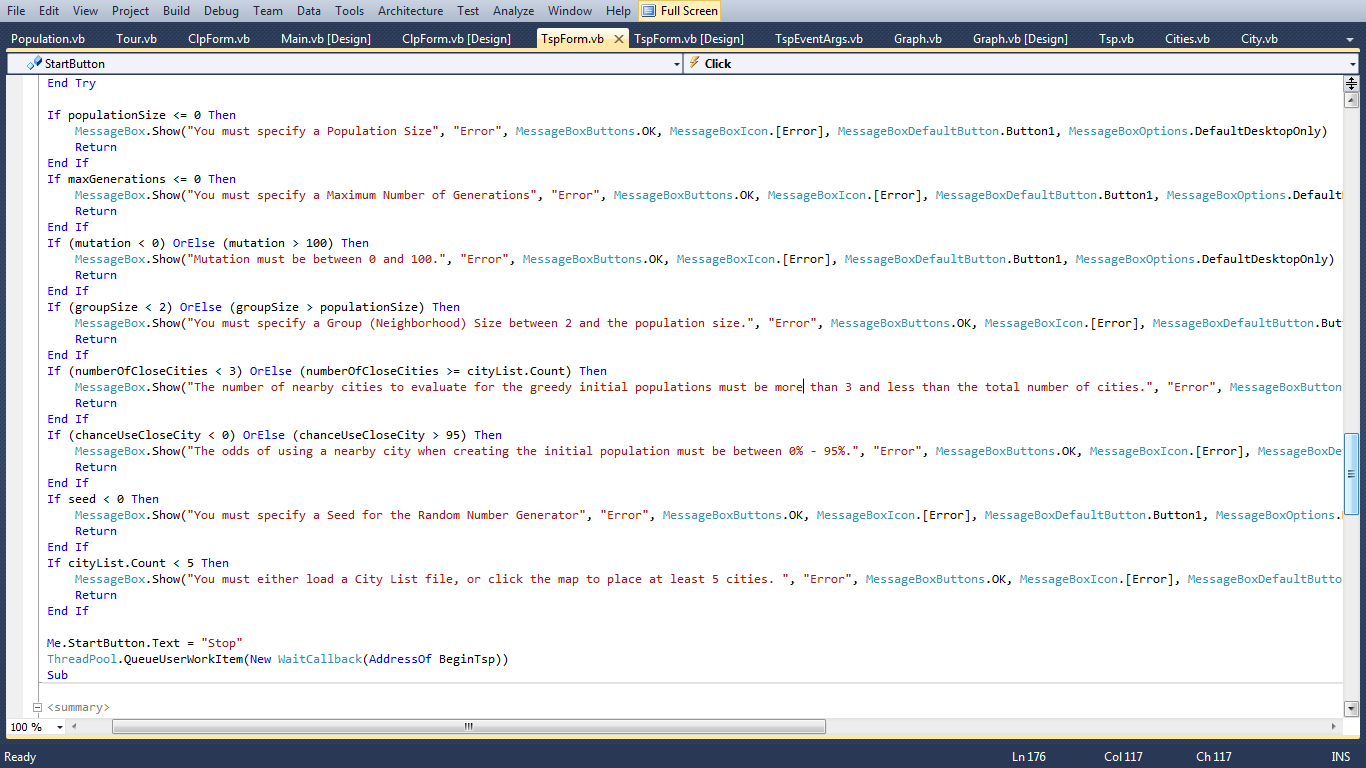
### 7.4.6 Comments

Relevant Comments are provided for better understating of codes and flow within the code

|  |
| --- |
| ''' <summary>  ''' Create the initial set of random tours.  ''' </summary>  ''' <param name="populationSize">Number of tours to create.</param>sn  ''' <param name="cityList">The list of cities in this tour.</param>  ''' <param name="rand">Random number generator. We pass around the same random number generator, so that results between runs are consistent.</param>  ''' <param name="chanceToUseCloseCity">The odds (out of 100) that a city that is known to be close will be used in any given link.</param> |

### 7.4.7 Validations

|  |
| --- |
|  |
|  |



### 7.4.8 User Manual

### 7.4.9 Technical Manual

# Chapter 8 Testing

”... we have as many testers as we have developers. And testers spend all their time testing, and developers spend half their time testing. We're more of a testing, a quality software organization than we're a software organization.” – Bill Gates

(Information Week 2002)

Testing is the process of exercising software with the intent of finding and correcting errors. The objective of the testing is to uncover different classes of errors and to do so with a minimum amount of time and effort. In order to provide highly acceptable and error free system, the system should have to face the testing procedure and evaluation of each and every module and functionality.

Testing is the process of executing a program with the intent of finding errors. Once the system is developed, testing will be performed according to test plan. The result of the testing is used for enhancement and correction of the system in the next iteration.

The highlights of this chapter include:

* The different types of testing done.
* The duration taken to test.
* The person(s) involved.
* The reported errors.
* The measures taken.

## Test Plan

|  |  |  |
| --- | --- | --- |
| No. | Method | Details |
| 1. | Unit Testing | In this testing activity the developer tested each functionality separately in an isolated manner from the rest of the application |
| 2. | System Testing | Here the developer performed testing on the complete, integrated system. All modules were combined and tested together to evaluate the system’s compliance with the specified requirements. |
| 3. | Compatibility Testing | Developer has tested the application in different windows platform. |
| 4. | User Acceptance Testing | The system was given to a user and he was asked to test the system to check whether the system fulfills the requirement. |

Assumptions: The Complete Testing process is performed by Developer.

## Test Duration

|  |  |  |
| --- | --- | --- |
| **Test Strategy** | **Start Date** | **End Date** |
| **Unit Testing** | 01 April 2013 | 09th April 2013 |
| **System Testing** | 15th April 2013 | 21th April 2013 |
| **Compatibility Testing** | 22 April 2013 | 23rd April 2013 |
| **User Acceptance Testing** | 23th April 2013 | 25th April 2013 |

## 8.3 Unit Testing

In order to test each small part of the developed system individual test cases were developed. Unit testing was very helpful as it helped the developer to test individual units of source code.

Two Flavours of unit testing was basically conducted, namely black box (also called functional testing) and white box (also called logical testing).

### 8.3.1 Black Box Testing

|  |  |  |  |
| --- | --- | --- | --- |
| **Project Title** | Beacon 1.0 | **Testing Date** |  |
| **Test Name** | **Beacon Design Route Map** | | |
| **Test ID** | **Beacon-UT-BlackBox-1** | | |
| **Conducted By** | Binit Kumar | | |
| **Description** | Validates the Design and Process of Designing | | |

|  |  |  |  |
| --- | --- | --- | --- |
| Beacon-UT1 -Test Case #1 | | | |
| Function to Test: | Provide blank field notification during user login. | | |
| Execution Steps: |  | | |
| Expected Result Actual Result Status(Pass/Fail) | | | |
| An error alert box should appear indicating the user that both fields are mandatory. | | Alert box shown. | Pass |
| Remarks | | Nil | |

|  |  |
| --- | --- |
| **Conclusion** | |
| **Errors Detected:** | 1 |
| **Measures Taken:** | The code was modified as required and the expected result was achieved. |

Reference :

REF : http://cgi.csc.liv.ac.uk/~epa/ Efficient Algorithms for 2-D Rectangle packing

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http://www.cs.ucsb.edu/~suri/cs130b/BinPacking.txt

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<http://www.ams.org/samplings/feature-column/fcarc-bins1>

<http://users.cs.cf.ac.uk/C.L.Mumford/heidi/BinPacking.html>

<http://cgi.csc.liv.ac.uk/~epa/references.html>

<http://codeincomplete.com/posts/2011/5/7/bin_packing/example/>