

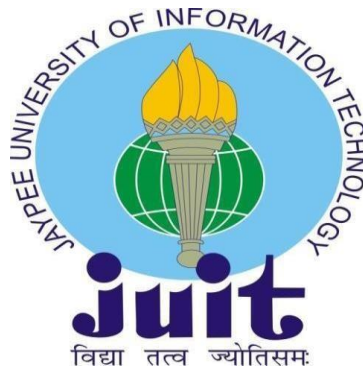
**PROCURING PERFORMANCE TESTING SOLUTIONS
WITH JAVA & LOADRUNNER EXPENDING NON-
FUNCTIONAL TESTING AND ANALYTICAL TOOLS**

*Project report submitted in partial fulfilment of the requirement for the
degree of*

**BACHELOR OF TECHNOLOGY
IN
COMPUTER SCIENCE AND ENGINEERING**

By
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**UNDER THE GUIDANCE OF
Mr. Satyajit Deb**



**JAYPEE UNIVERSITY OF INFORMATION
TECHNOLOGY, WAKNAGHAT**

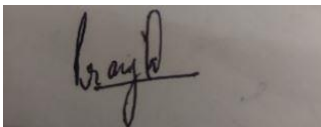
May-2021

Certificate

Candidate's Declaration

I decree hereby that the work presented in this report entitled **“Procuring performance testing solutions with Java and Loadrunner expending non-functional testing and analytical tools”** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering / Information Technology submitted in the department of Computer Science & Engineering and Information Technology, Jaypee University of Information Technology Waknaghat is a real record of our own work carried out over a period from February 2021 to May 2021 under the supervision of Mr. Satyajit Deb (Coach, Cognizant).

The matter embodied in the report has not been submitted for the award of any other degree or diploma.



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This is to certify that the above statement made by the candidate is true to the best of my knowledge.

(Supervisor Signature)

Mr. Satyajit Deb Coach
at Cognizant
Dated:



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at Juit

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LIST OF ABBREVIATIONS

Acronym	Description
SQL	Structured Query Language
CLI	Command Line Interface
UNIX	UNiplexed Information and Computing Service
DBMS	Database Management System
RDBMS	Relational Database Management System
E-R	Entity-Relationship
GNU	GNU's Not UNIX
DDL	Data Definition Language
DML	Data Manipulation Language
DCL	Data Control Language
TCL	Transaction control Language
JVM	Java Virtual Machine
API	Application Program Interface
JDBC	Java Database Connectivity
ODBC	Open Database Connectivity
OS	Operating System
JSON	JavaScript Object Notation
XML	eXtensible Markup Language
SDK	Software Development Kit
VuGen	Virtual User Generator

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- 25.** Architecture of Loadrunner
- 26.** Creating a scenario on Loadrunner Controller
- 27.** Goal Oriented Scenario
- 28.** Launching of Loadrunner Controller
- 29.** Controller Configuration
- 30.** Runtime Settings
- 31.** Complete Designed Scenario
- 32.** Graph Showing Avg Response Time
- 33.** Graph showing the Hits Per Second
- 34.** Graph showing the throughput amount
- 35.** Transactions per second
- 36.** CPU Utilization
- 37.** Merging of Hits per second graph and the Transaction response time graph

ABSTRACT

Many apps fail when it matters most to produce strong results. For example, when everyone goes lock-in and begins to use Netflix during the eCommerce sales season. Such high load symptoms could have significant business consequences if not diagnosed. The aim of performance testing is not to find bugs but to remove performance buggies and to check whether the system is capable of maintaining continuous planned load (though you would be surprised to find them).

When done correctly and introduced into the implementation of software early enough, the company receives important details about the application, which affects the business.

As you cannot calculate something you cannot see, the signs of performance issues must be discovered and addressed, and their root cause digested. Quality tests are also necessary and ensure consistency and progress for the company an hence are the need of the hour.

Chapter-1

INTRODUCTION

1.1 What is Software Testing?

Software testing is the method of checking and validating that a software or service is bug-free, meets the technical specifications as guided by its architecture and development, and meets the user requirements successfully and efficiently when addressing both extraordinary and boundary scenarios.

The aim of software testing is not only to locate flaws in current software, but also to find ways to increase the software's performance, precision, and usability. Its primary goal is to evaluate the design, features, and performance of a software program or application.

Testing should start as soon as possible to reduce the cost and the time of reworking and producing software that has no bug to send to the customer. However, testing will begin from the requirements collection process of the Software Development Life Cycle (SDLC) and continue until the software is available in production. It also relies on the model of construction used. In the Waterfall model, for example, the evaluation begins with a test step that is very lower than in the tree but is carried out parallel to the growth phase in the V-model.

Below mentioned are the general Principles of Testing: -

- (i) All tests must follow the customer's specifications.
- (ii) (To make our software testing more effective, we can hire a third party.
- (iii) It is impossible to do exhaustive testing. We require the optimum amount of testing depending on the application's risk evaluation.
- (iv) Many of the tests that will be carried out should be prepared before they are carried out.
- (v) It adheres to the Pareto principle (80/20 rule), which says that 80% of software

failures are caused by 20% of program components.

- (vi) Start with small pieces and work your way up to larger ones.

1.2 Software Testing Importance and Advantages

Software Testing is important since any errors or bugs can be detected early and resolved prior to release of the software if any flaw or mistake occurs in the software. The software product is properly evaluated for usability, safety and high performance, which further saves time, costs and customer loyalty.

Testing is significant because technological glitches can be costly or risky. Below are some reasons which help us understand the importance of Software Testing –

1. To identify faults and errors during development, software testing is really needed.
2. It is essential because it ensures that the consumer considers the company trustworthy and that the application maintains its satisfaction.
3. The quality of the commodity is also critical. The quality product supplied to the customers contributes to their trust.
4. For successful software application or product performance, testing is needed.
5. It is necessary to ensure that application doesn't fail because the fixing may be very costly in future or at subsequent periods of production since revision, re-implementation and re-testing of the application may be necessary.

Below are some advantages of Quality Assurance (QA) or Software Testing –

1. Software development is expensive. And the longer one can't see a flaw in their app, the harder and more costly it is to patch it.
2. QA Prevents Disasters in Corporate. The stakes are much higher for enterprise technology.
3. By making the testing of software a clear priority for software development, one gives their customers a message that they want their apps to work as successfully as possible.

1.3 Types of Software Testing

The testing of software is commonly grouped into two major diverse categories: functional and non-functional. Another general test form is also known as maintenance testing.

1.3.1 Functional Testing

It is a sort of system testing used to check the software application's features whether the feature works according to the requirement. Each function evaluated with the value, the performance determination, and the real output verification with the intended value in functional testing. Functional tests conducted as black-box tests, showing that an application or device functionality is as expected. It is done to check the application's features.

Functional testing is often referred to as black box testing because it relies instead of the real code on program specifications. Tester just has to evaluate the software instead of the system.

The testing professionally follows the following steps:

- In the program framework, Tester verifies the requirement specification.
- Following research, the test driver will make a plan.
- The tester designs the test case after the experiments have been planned.
- After the test has been designed, the case tester can provide a traceability matrix paper.
- The test case construction is performed by the tester.
- Coverage analysis to analyze the application's protected research area.
- Management of defects should be done to resolve defects.

The primary purpose of functional testing is to monitor software system functionality. It's just about:

- Basic usability: Functional testing requires device compatibility testing. It checks whether a user can easily move through the screens without any problems.

- Accessibility: Functional testing to assess the function's accessibility.
- Core functioning: It depends on the main feature checking.
- Error state: The error condition is tested using functional testing. It verifies that the error message appears.

Various functional testing forms are available such as:

- Unit testing
- Integration testing
- End-to-end testing
- Smoke testing
- Sanity testing
- Regression testing
- Acceptance testing
- White box testing
- Black box testing
- Interface testing

Both manually and by automation tools, functional tests are conducted. Manual testing is simple for this type of testing, but you can use tools if needed.

Micro Focus UFT (formerly QTP and UFT stands for Unified Functional Test), Selenium, JUnit, soapUI, Watir, etc. are some methods that can be used for functional testing.

1.3.2 Non-Functional Testing

Non-function testing is a method of software testing for non-functional criteria such as

software stability, load testing, software efficiency and software responsibility. The primary aim of non-functional research is to measure the program system's reading speed according to non-functional parameters. Until operational testing, the conditions of non-functional testing are never checked.

Non-functional tests are often very important since they perform and they play a key role in satisfying customers. For newly designed applications, functional and non-functional testing is needed. Functional tests monitor the correctness and the ability to perform within an external context is monitored by non-functional research. It provides the way for installing, configuring and running applications. Metrics are compiled and developed under non-functional tests for internal research and development. Detailed understanding of product actions and technology was provided by non-functional trials. It contributes to reducing the manufacturing risk and related software costs.



Figure 1 Parameters in Non-Functional Testing

Normally, non-functional testing is not performed manually. Actually, this kind of testing is difficult to do manually. Via instruments these measurements are normally performed.

There are various kinds of non-functional tests, for example:

- Performance testing
- Security testing
- Load testing
- Failover testing
- Compatibility testing
- Usability testing
- Scalability testing
- Volume testing
- Stress testing
- Maintainability testing
- Compliance testing
- Efficiency testing
- Reliability testing
- Endurance testing
- Disaster recovery testing
- Localization testing
- Internationalization testing

CHAPTER 2

ORACLE MYSQL RDBMS

It is the plan of decrees with which all ventures and customers get to data. Application activities and instruments consistently license customers without using clearly, anyway therefore ought to use when executing the customer's sales.

2.1 Introduction to Database

Database is an efficient assemblage of information. Databases support repository and handling of data. Databases make data supervision effortless. A Database would obviously be used in an online-telephone directory store information concerning people, their contact numbers, other details, etc. Electricity utilities provider most certainly has adopted a Data base to manage the invoices, client complaints, handling faults etc. Let us ponder over Facebook. With basic demands of storing, influencing & presenting data related to members, their companions, member activeness, messages, promotional features with a lot of other options. There may be incalculable number of examples for usage of databases.

Flat File Model

	Route No.	Miles	Activity
Record 1	I-95	12	Overlay
Record 2	I-495	05	Patching
Record 3	SR-301	33	Crack seal

Figure 2 A flat file model database

2.2 About Relational Databases

All parties have intelligence and data that needs to be stored and handled to get an inch closer to its desires. An example would be, that a large organization should gather and maintain human resources records for all its employees. These statistics should be accessible by the users.

An **information system** is a formal structure which stores and processes evidence. This system could be anything, like a list of pulpwood boxes consisting of fawn files along with guidelines in order to save and salvage files. Nowadays, organizations prefer using databases to fully automate their information structures. Database is a well-oriented cluster of information which is considered as a unit. Its purpose is to compile, save and recover associated knowledge for usage by catalogue applications.

Database Management System

Database management system is a software that commands the loading, union, and recovery of information. DBMS consists of the following components:

Kernel code

Handling of the memory and storage is done by this code.

Repository of metadata

This depository is generally labelled as data dictionary.

Query language

Accessing of data by the tenders is done by this language.

2.3 Relational Database Management System

This model is the reason for a social database the executives framework. A RDBMS transfers material into a databank, stocks up the material recovering it with a goal of enabling the applications to send it. Several setups can be distinguished: -

Logical operations

Material which is required is been classified out here for instance a device or company requires is listed out to help ease through the problems.

Physical operations

In this condition, it oversees the working and completion of the activity. An example, the moment after the demand for a table is made by the application, the database can make use of a record to locate referenced lines, read the information into memory, and play out various strolls just before it restores an outcome for the client. It can stock up and guarantee information with the target that physical activities are obvious to database tenders.

Table 1 Difference between DBMS & RDBMS

DBMS	RDBMS
Data is kept in file	data is horizontally stored
Exclusive access needed	At single instance more than one data pieces.
No link between data to be made.	Data stacked over one another to make the better use of memory
No standardization is there	Presence of standardization
Absence of support for dissemination.	Dissemination is easily handled.
Hierarchical form and course plotting is preferred method	pillar names used for heads and analogous values for rows.
Data handled is very puny compared to other	Capable of handling large amount
Idle state can be seen frequently.	Duplication avoided by key and pairs

Deals in small body and handles less data.	Vast amount of data is covered.
Manipulation of data restricted only to lower levels	Safekeeping of data is ensured through its arrangement.
Software with low requirement and lower rations being addressed	High requirement for data in software and more rationing.
Examples include access by Microsoft	Includes sql, postgresql, etc

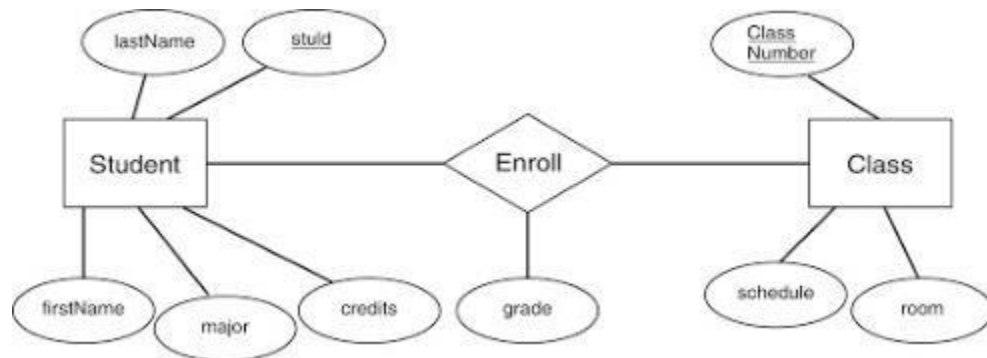


Figure 3 E-R Model in RDBMS

2.4 Working of SQL

The métiers of SQL give advantages to a wide range of clients, including delicate software engineers, database regulators, administrators, and end clients. In fact, speaking, SQL is an information sublanguage. The industriousness of SQL is to give a limit to an intuitive database, for example, Oracle Database, and all SQL explanations are rules to the database. In this SQL

contrasts from universally useful programming dialects like C and BASIC.

Among the highlights of SQL are the accompanying:

- It forms sets of information as gatherings instead of as particular units.
- It gives careless route to the information.

SQL lets you work with information at the coherent level. You should be worrisome with the execution subtleties just when you need to impact the information. For instance, to repossess a lot of lines from a table, you characterize a condition used to channel the lines. All lines fulfilling the state are recovered in a solitary advance client, to another SQL articulation.

You need not manage the columns individually, nor do you need to stress over how they are genuinely put away or recovered. All SQL proclamations utilize the analyzer, a piece of Oracle Database that decides the most proficient methods for getting to the predefined information. Prophet likewise gives exhibitions that you can use to make the streamlining agent play out its activity better.

SQL gives explanations to an assortment of undertakings, including:

- Questioning information
- Infusing, refreshing, and erasing columns in a table
- Shaping, supplanting, adjusting, and dropping articles
- Controlling articles
- Affirming equity and honesty

binds together entirety of the previous assignments in one predictable colloquial.

2.5 The Main Features of MySQL

This segment articulates a portion of the basic appearances. In many regards, the guide identifies with all records.

Internals and Portability

Meant to be completely multithreaded utilizing portion strings, to Systems extremely wanton B-tree plate slows down (MyISAM) with file pressure. Planned to make it generally simple to include other capacity motors.

Data Types

MySQL underpins SQL information types in a few kinds: numeric sorts, sorts, and the JSON information type. This part gives a diagram and increasingly thorough portrayal of the properties of the sorts in every classification, and an outline of the information type stockpiling prerequisites. The underlying diagrams are purposefully short. Counsel the more point-by-point depictions for extra proof about specific information types, for example, the average organizations wherein you can indicate values.

Numeric

MySQL holds up complete typical SQL numeric data types. They consolidate particular numericdata variant, similarly as the ballpark numeric datatypes. Watchword INT subs for integer, and catchphrases like “DEC” and “FIXED” are substitutes for DECIMAL. Its rarities as a replacement for Dp . Also in like manner, it views REAL as an elective word for d Precis, aside from if the REAL_AS_FLOAT SQL mode is empowered.

The watchword INT subs for Whole number, and the catchphrases DEC and FIXED are substitutes for deci MySQL rarities Fill in as a trade for Twofold Exactness (a nonstandard turn of events).

MySQL in like way believes Genuine to be an elective word for Twofold Exactness (a nonstandard strategy), near if the REAL_AS_FLOAT SQL mode is enabled. The BIT information type stores bit respects and is buttressed for MyISAM, MEMORY, InnoDB, and NDB tables.

accommodates SQL std. number sorts INTEGER and SMALLINT. Further enhancing the std, it furthermore facilitates number sorts “TINYINT”, “MEDIUMINT”, “BIGINT”. Going with table demonstrates essential amassing and spectrum for entire number sort

Type	Storage (Bytes)	Minimum Value Signed	Minimum Value Unsigned	Maximum Value Signed	Maximum Value Unsigned
TINYINT	1	-128	0	127	255
SMALLINT	2	-32768	0	32767	65535
MEDIUMINT	3	-8388608	0	8388607	16777215
INT	4	-2147483648	0	2147483647	4294967295
BIGINT	8	-2^{63}	0	$2^{63}-1$	$2^{64}-1$

Figure 4 the approved size

Datetime

The date and time information types for showing running qualities are DATE, TIME, DATETIME, TIMESTAMP, and YEAR. For DATE and DATETIME extend accounts, implies that albeit prior qualities may work, there is no word.

Licenses fragmentary seconds for TIME and TIMESTAMP convictions, reaching micro seconds exactness. Characterizing section incorporating partial seconds part, utilize linguistic structure type_name(fsp) where type_name is TIME, DATETIME, or TIMESTAMP, and fsp is the fragmentary seconds exactitude.

2.6 DDL, DML & DCL

SQL orders are shared into four subsections, DDL, DML, DCL, and TCL.

- CREATE - to make a database and its things like (table, list, sees, store procedure, limit, and triggers)
- ALTER - modifies the present database
- DROP - eradicate objects
- TRUNCATE - expel all records, including all spaces dispensed for depletion of records.
- COMMENT - comments added to the word reference
- RENAME - article renaming
- LOCK TABLE - synchronization Control

DCL: DCL is short name of Information Control Language which handles orders, for instance,

Award and all things considered stressed over rights, OKs and various controls of the database structure.

- Award - grant customers get to inclinations to the database.
- Repudiate - attract customers get to benefits given by using the Respect command.

TCL: TCL is short name of Exchange Control Language which deals with a trade inside a database.

- Submit - presents an Exchange
- ROLLBACK - rollback a trade if there ought to be an event of any foul up occurs
- SAVEPOINT - to roll back the trade making centers inside parties
- SET Exchange - show characteristics of the trade

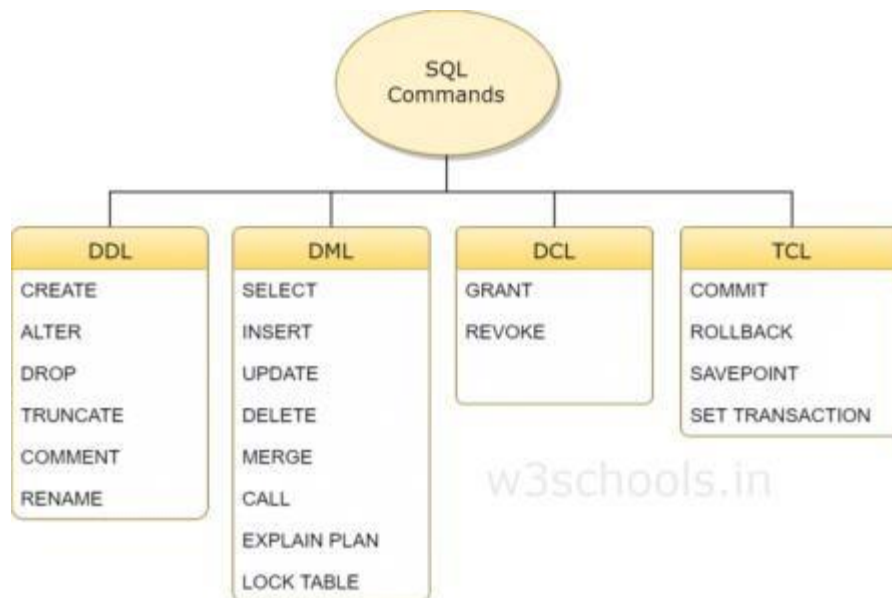


Figure 5 Various SQL Guidelines (source:w3schools.in)

2.7 Joins in SQL

SQL JOINS are utilized to question information from at least two tables, in view of a relationship concerning certain segments in these tables. Utilizing JOINS, you can get

effectively the information you need. Various retailers permit fluctuating quantities of tables to participate in a solitary join activity.

Types of joins: Right, Left, Inner, Cross & Self.

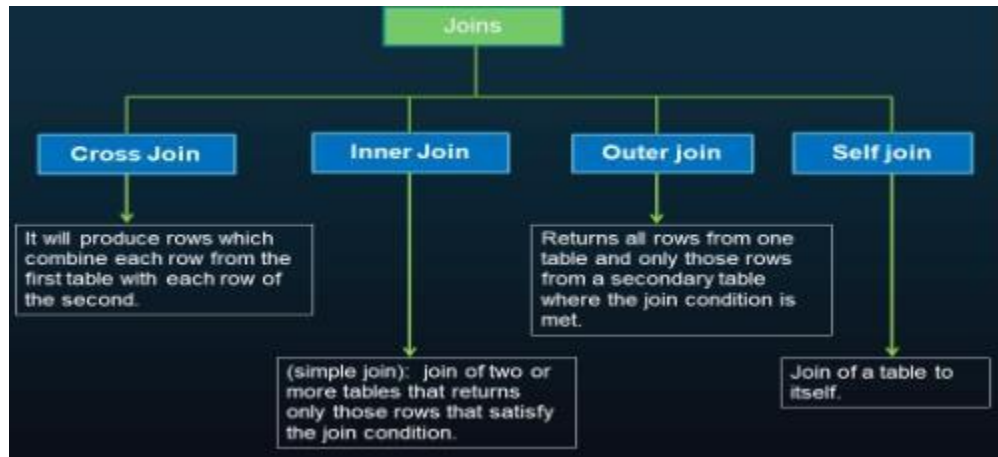


Figure 6 Joins in Sql

CHAPTER 3

CORE JAVA

3.1 About Java Technology

Java has been developed to be a simultaneous, class-based, object-orientated programming language and is also a computer platform first published by Sun Microsystems in 1995. If you have Java enabled and more is developed every day, a huge number of apps and websites will not run. The denial of Java is like refusing you access to a technical infrastructure. Java's efficiency, protection and reliability is highly regarded.

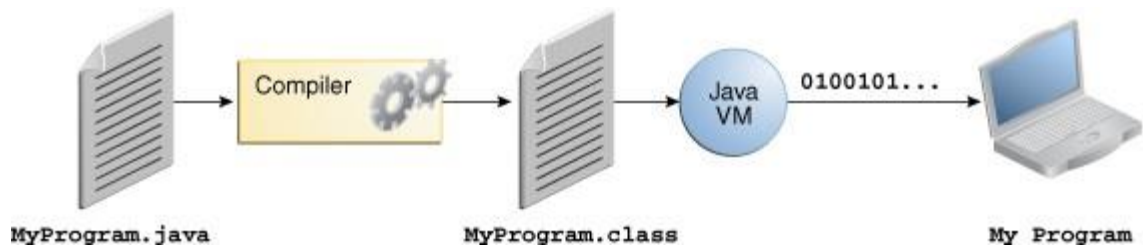


Figure 7 processes involved in Software development

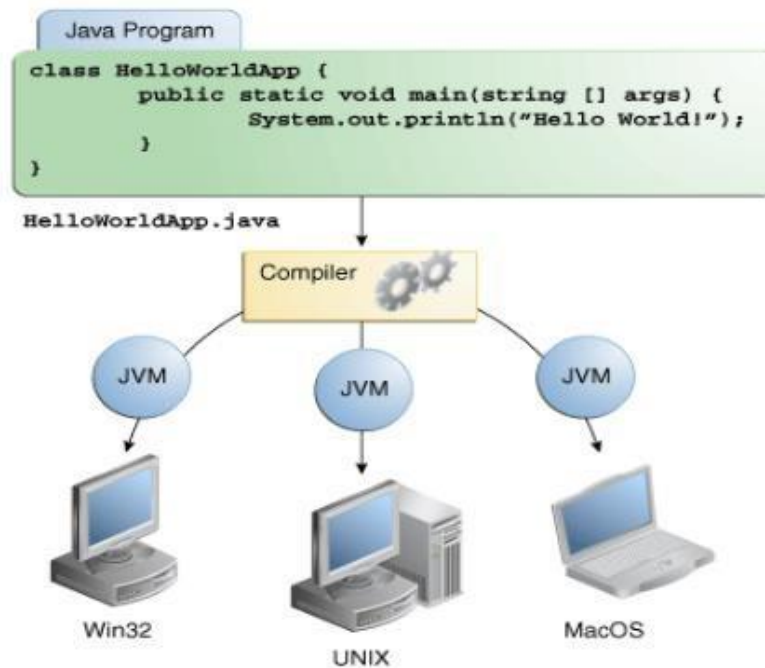


Figure 8 the same application is capable of on multiple platforms on multiple scale

3.2 Characteristics of Java

object-oriented: a totally object-arranged language. As in other item arranged dialects, for example, C++, Java contains classes, objects, functions, Inheritance and polymorphism.

Java is straightforward: The sentence structure of Java programming language is gotten from C/C++, which numerous software engineers as of now use. The Java programming language gives its own garbage assortment, which is without a doubt exceptionally charming to the certified software engineers.

Furthermore, the Java language discards pointers, which are frequently a wellspring of program memory outpourings and can cause program blunders that are extremely difficult to fix. These two highlights, intensified with the way that the class libraries included with the Java language are greatly diminished than in a language like VC++, makes the language a lot cooler to learn.

Not at all like the compiler of a C++ program that produces machine guidelines, the Java compiler staples byte code that are then executed by a Java Virtual Machine. The JVM incorporates a translator that peruses the Java byte codes and consequently makes an interpretation of the advices into local machine code. Java programs have the additional progression of deciphering and making an interpretation of the byte codes into machine rules before executing. This can deliver a recognizable distinction in stage execution speed.

Java is Platform Independent: Java programs, not at all like those in other programming dialects, are stage autonomous. This permits Java applets and applications to be run on fluctuating presentation place without recompiling the source code. This component is acknowledged on the grounds that, as was talked about in the past area, Java is a deciphered language. The hindrance of byte codes is execution speed. Compact: You can make and incorporate a Java application program and discharge the byte code to a wide assortment of stages without changes. This incorporates diverse equipment and working framework arrangements. Along these lines, Java is a fantastic language for creating Internet and Intranet applets, just as corporate-wide applications that must run a wide assortment of framework arrangements.

Multithreaded: One of the significant advantages of the Java programming language is that it has joined help for multithreading. At the end of the day, you can make Java programs with various strings of execution, subsequently permitting you to execute a few assignments simultaneously.

3.3 Datatypes

variable information type decides the qualities it might contain, in addition to the activities that might be cultivated on it. Notwithstanding influence language bolsters seven other crude information types. A crude sort is predefined by the language and is named by a reserved catchphrase. Crude qualities don't impart state to other early-stage esteems. The eight crude information types upheld by the software are mentioned.

byte: information type is a 8-piece marked two's supplement whole number. It has a base estimation of - 128 and a most extreme estimation of 127(inclusive). The byte information type can be helpful for saving memory in huge bunches, where the memory speculation reserves truly matters. They can similarly be used rather than int where their limits help to clarify your code; the truth that a variable's range is compelled can fill in as a sort of documentation.

short: is a 16-piece denoted two's enhancement entire number. It has a base estimation of - 32,768 and a most outrageous estimation of 32,767 comprehensive). Additionally, likewise with byte, comparative standard

int: datatype which us used for integers.

long: datatypes used for addressing unsigned integers who are not addressed by int and can store big numbers.

float: The float data type is a single precision 32-piece IEEE 754 coasting point. Its extent of characteristics is past the degree of this discussion, assortments of drifting point numbers. This information type should never be used for precise characteristics, for instance, cash.

double: The twofold information type is a twofold exactness 64-piece. Its scope of qualities is past the extent of this conversation, but is determined in the Floating-Point Types, Formats, and Values area of the Java Language Specification. For decimal qualities, this information

type is generally the default decision.

boolean: The boolean information type has just two potential values: true and false. Utilize this information type for basic banners that track true/bogus conditions. This information type speaks to the slightest bit of data, yet its "size" isn't something that is absolutely characterized.

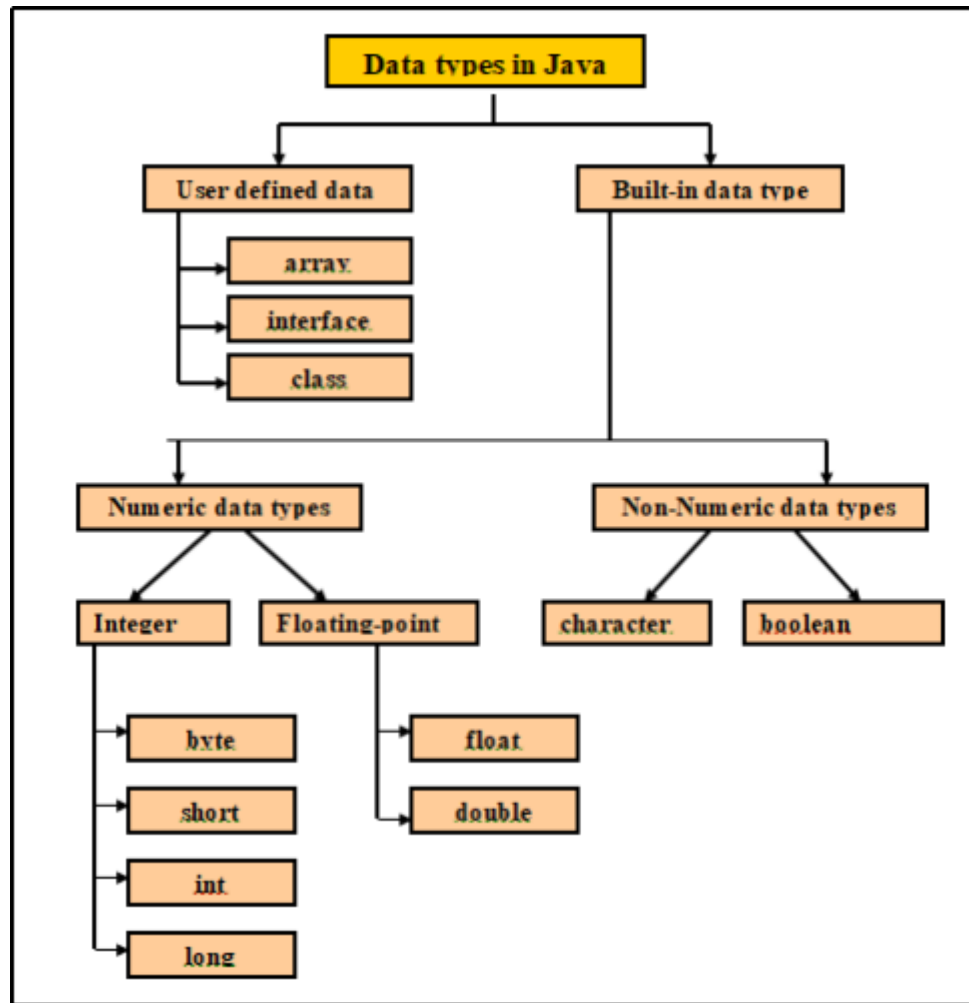


Figure 9 Data types in Java

3.4 Arrays

It is a holder object that holds a number which is fixed consisting of estimations of a solitary kind. Range length is built up when the cluster is made. After structure, we get a fixed size.

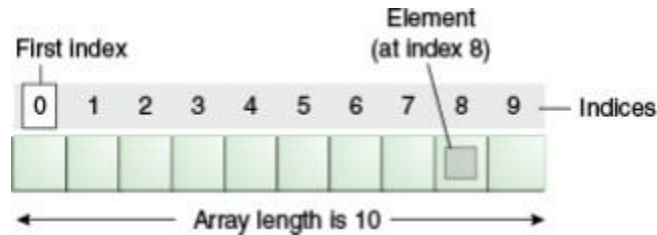


Figure 10 Demo of array

Everything in a array is called a component, and every component is perused by its numerical list. As appeared in the first delineation, numbering starts with 0. The ninth component, for instance, would accordingly be recovered at file 8. In a certifiable encoding circumstance, you would presumably utilize one of the bolstered circling develops to emphasize through every component of the exhibit, instead of compose each line only as in the first model.

Notwithstanding, the model unmistakably delineates the cluster punctuation. Pronouncing a Variable to Refer to an Array: Like assertions for factors of different sorts, a cluster announcement has two segments: the exhibit's sort and the exhibit's name. A array's sort is composed as `type[]`, where `type` is the information kind of the contained components; the sections are unique images indicating that this variable holds an exhibit. The size of the exhibit isn't a piece of its sort (which is the reason the sections are unfilled). An array's name can be anything you need, given that it keeps the standards and shows as recently examined in the naming area. As through factors of different kinds, the assertion doesn't really make an exhibit; it basically tells the compiler that this variable will hold a variety of the ordered sort.

Exhibit Manipulations: Arrays are an incredible and valuable idea utilized in programming. Java SE gives strategies to execute probably the most widely recognized controls identified with exhibits. For example, the `ArrayCopyDemo` model uses the `arraycopy` strategy for the `System` class rather than physically emphasizing through the components of the source cluster and putting every one into the reason exhibit. This is performed in the background, empowering the designer to utilize only one line of code to call the technique. For availability, Java SE gives a few strategies to performing cluster jobs (basic undertakings, for example, replicating, arranging and looking through exhibits) in the `java.util.Arrays` class. For example, the past model can be changed to utilize the `copyOfRange` strategy for the `java.util.Arrays`

class, as should be obvious in the `ArrayCopyOfDemo` case. The thing that matters is that utilizing the `copyOfRange` doesn't expect you to make the objective exhibit before calling the daily schedule, in light of the fact that the reason cluster is returned by the technique. Some other helpful undertakings given by techniques in the `java.util.Arrays` class, are:

- Sharp a cluster for a particular incentive to get the file at which it is put (the `binarySearch` strategy).
- Likening two exhibits to decide whether they are equivalent or not (the `isEquivalent` technique).
- Dull an exhibit to put a particular incentive at each file (the `fill` technique).

Arranging an exhibit into rising request. This should be possible either serially, utilizing the `sort` strategy, or simultaneously, utilizing the `parallelSort` technique facilitated in Java SE 8. Equal arranging of large clusters on multiprocessor frameworks is quicker than dynamic array arranging.

3.5 Operators

They are unique images that total unequivocal procedure on one, two, or three operands, and afterward return an outcome. The administrators in the accompanying table are recorded by supremacy request. The closer to the highest point of the table an administrator shows up, the higher its precedence. Operators with higher priority are determined before administrators with moderately lower priority. Operators on a similar line have equivalent priority. At the point when administrators of equivalent prevalence show up in a similar disposition, a standard must administer which is evaluated first. Every parallel administrator with the exception of the task administrators is assessed from left to right; task administrators are gauged option to left.

Operators	Precedence
postfix	expr++ expr--
unary	++expr --expr +expr -expr ~ !
multiplicative	* / %
additive	+ -
shift	<< >> >>>
relational	< > <= >= instanceof
equality	== !=
bitwise AND	&
bitwise exclusive OR	^
bitwise inclusive OR	
logical AND	&&
logical OR	
ternary	? :
assignment	= += -= *= /= %= &= ^= = <<= >>= >>>=

Figure 11 Operator Precedence

When all is said and done reason programming, certain administrators will in general look more intermittently than others; for instance, the commitment administrator "=" is undeniably more typical than the unsigned right move administrator ">>>". In light of that, the accompanying conversation applications first on the administrators that you're well on the way to use all the time, and finishes concentrating on those that are less conjoint.

3.6 OOPS Concepts

Item Oriented Programming Concepts are indispensable in lieu of programming. Without having a thought regarding OOPS models, you won't have the option to conspire frameworks in the item situated programming model. The object-arranged programming model spins around the idea of Objects. An article is a solicitation of a Class. It contains properties and capacities. They resemble genuine items. For instance, your vehicle, house, PC, and so forth are generally questions. They have some particular properties and strategies to play out some activity. The Class characterizes the plan of Objects. They express the properties and functionalities of the items. For instance, Laptop is a class and your PC is an example of it.

3.6.1 Abstraction

The inward treating of the strategy is escaped the external world. There are numerous approaches to accomplish develop in object-situated programming, for example, epitome and legacy. A Java program is likewise an incredible model of reflection. Here java deals with changing basic proclamations to machine language and conceals the internal usage subtleties from the external world.

3.6.2 Encapsulation

Embodiment is the procedure used to contraption in object-situated programming.

Access modifier catchphrases are used for embodiment in object situated programming. For instance, embodiment in java is succeeded to expensing private, ensured and open watchwords which can be significant for the information wrapping.

3.6.3 Polymorphism

Polymorphism is where an article works conversely in various areas. Polymorphism can be classified into, gather time polymorphism and runtime polymorphism. The first type, is accomplished by technique over-burdening. Compiler have option to recognize the way to summon at assemble time, alas an accumulation is obtained in form of run-time polymorphism. The second might be affected when an "IS-An" association between things. In totality is called a technique overruling in importance of fact that the subclass needs to go past the superclass strategy for runtime. On the off chance that we are working as far as the superclass, the genuine completing class is chosen at runtime. The compiler can't choose which class technique will be conjured. This choice is done at runtime, henceforth the name as runtime polymorphism or dynamic strategy dispatch.

3.6.4 Inheritance

Legacy is the article arranged programming origination where an item depends on another article. Legacy is the device of code reuse. The article that is getting genetic is known as the superclass and the item that gets the superclass is known as a subclass. We use outspreads watchword in java to machine legacy.


```

package com.journaldev.java.examples1;

class SuperClassA {

    public void foo(){
        System.out.println("SuperClassA");
    }

}

class SubClassB extends SuperClassA{

    public void bar(){
        System.out.println("SubClassB");
    }

}

public class Test {
    public static void main(String args[]){
        SubClassB a = new SubClassB();

        a.foo();
        a.bar();
    }
}

```

Figure 12 Inheritance in Use

3.7 Functions

Practical interfaces give target types to lambda articulations and plan places. Each practical edge has a solitary theoretical technique, called the utilitarian strategy for that useful interface, to which the lambda articulation's thought and return types are coordinated or adjusted. Functional interfaces can give an objective sort in different settings, for example, task setting, strategy summon, or cast setting. Very much planned interfaces frequently speak to digest ideas like capacities, activities, or predicates. In reporting practical interfaces, or alluding to factors composed as proficient interfaces, it isn't unexpected to allude legitimately to those theoretical ideas, for instance utilizing "this capacity" rather than "the capacity spoke to by this item". At the point when an API strategy is said to acknowledge or restore a utilitarian limit thusly, for example, "applies the gave work to...", this is comprehended to mean a non-invalid reference to an article utilizing the suitable useful interface, except if potential nullity is expressly

determined. An inherent capacity is an indication wherein a SQL catchphrase or extraordinary administrator executes some activity. Worked in capacities use watchwords or exceptional implicit administrators. Assembled ins are SQL92 Identifiers and are case-inhumane. Note that darted capacities like `TIMESTAMPADD` and `TIMESTAMPDIFF` are just reasonable utilizing the JDBC get away from utility sentence structure, and can be found in JDBC spray punctuation.

3.8 Exception Handling

We couldn't care less for unique cases yet we for the most part need to oversee them, unprecedented news is that Exception dealing with in Java is directing and easy to cognize and use. Uncommon cases in java can rise up out of balanced kind of conditions, for instance, wrong data entered by customer, gear frustration, arrange affiliation disillusionment, Database server down, etc. Around there, we will make sense of how exclusions are moved in java. Java being a thing orchestrated programming language, each time a misstep occurs while executing a declaration, makes an exception article and a short time later the conventional movement of the pack closures and JRE strives to find someone that can manage the raised unique case. The exception object contains a lot of investigating information, for instance, technique chain of significance, line number where the extraordinary case occurred, sort of uncommon case, etc. Right when the unique case occurs in a method, the path toward making the exclusion thing and giving it over to runtime condition is characterized "hurling the exceptional case". Note that Java Exception dealing with is a framework that is used to manage runtime botches simply, request time goofs are not dealt with by extraordinary case dealing with in java. We use keywords in java program to put forth an exceptional defense handler square.

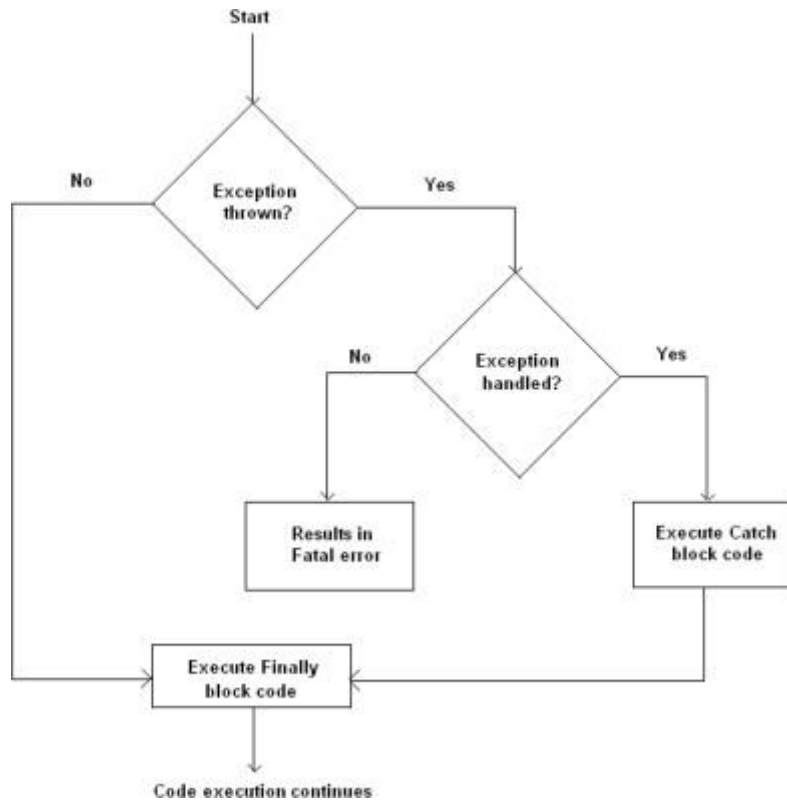


Figure 13 Flow Chart of Exception Handling

3.9 Mapping in Java

A Map is an interface that maps keys to values. A map can't contain duplicate keys: Each key can map to all things considered one worth. It displays the numerical capacity reflection. The Map interface incorporates strategies for essential activities, (for example, put, get, expel, containsKey, containsValue, size, and void), mass tasks, (for example, putAll and clear), and assortment sees, (for example, keySet, entrySet, and values).

The Java stage contains three universally useful Map executions: HashMap, TreeMap, and LinkedHashMap. Their conduct and show are unequivocally comparable to HashSet, TreeSet, and LinkedHashSet.

3.10 JDBC

- **The JDBC API:** API provides automatic access to social information from the language. Utilizing this, sales can execute SQL articulations, retrieve results, engender modifications to a information birthplace which is hidden. Can also associate to a

variety information disseminated by a source, assorted environment. It is a piece of Java stage, making the stand version and the enterprise version. It is separated to 2 bundles: java.sql and javax.sql.

- **JDBC Driver Manager:** Characterizes objects that might interface Java applications to JDBC driver. DriverManager customarily been the foundation of the JDBC engineering. Very little and simple, std addition bundles “javax.naming” and “javax.sql” to utilize a datasource object enrolled with Java Naming and Directory Interface™ (JNDI) assistance set up an association with an information source. You can utilize either interfacing instrument, however utilizing a DataSource object is suggested at whatever point conceivable.
- **JDBC Test Suite:** Results in discovering that drivers are going to process the program. The tests done neither extensive nor comprehensive, yet practice a considerable lot of the primary highlights in API.
- **JDBC-ODBC Bridge** — The Java Software connect gives JDBC get to through ODBC drivers. Keeping in mind we have to stack ODBC double code on every customer machine utilizing driver. Subsequently, is generally fitting on formal system, customer placing in not a significant issue, development level which is three levelled.

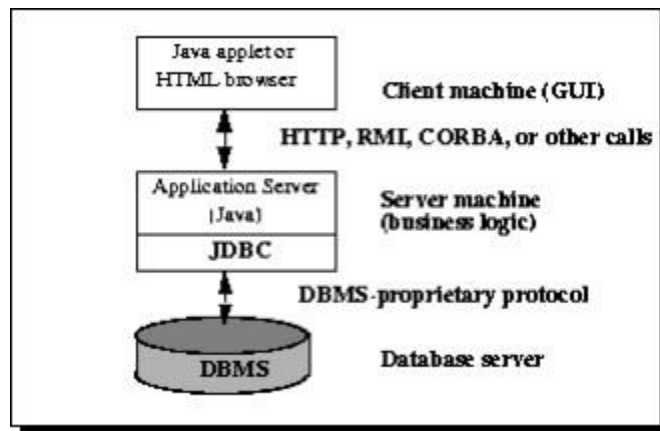


Figure 14 Three tier architecture

Chapter 4

LOADRUNNER FOR PERFORMANCE TESTING

Loadrunner is an industry grade software for non-functional testing product created by Hewlett-Packard. It tests the performance of the application by simulating the load as it would be in real world.

While doing non-functional testing loadrunner can create thousands of virtual users and gather information from the infrastructure of the application like database servers and web servers. The performance can be analyzed in the detailed report generated by loadrunner to see the behavior of application under given environment.

Taking example of website blazedemo.com which is a flight booking website. At a time, there can be hundreds of customers using the site to book their tickets. Each request will be hitting the database to fetch information required. During vacations there can be a huge load expected on the website. So, to simulate those condition to see how the application will behave under those scenarios we can generate a script to create exact steps and replay them. If a problem is detected, the concerned team can rectify the problem and can again play the same script to check whether the problem is fixed or not.

Loadrunner software consists of three components. They are as follows:

1. Virtual User Generator
2. Controller
3. Analysis



Figure 15 Loadrunner Components

4.1 Virtual User Generator

It is the first component of the Loadrunner. It helps the tester to create the actions one virtual user would perform while accessing the application. In Vugen one can create scripts that consists of various actions that the virtual user will perform. These actions include opening the application, login, logout, selecting search results, searching etc.

One can also put text checks, image checks to see whether the particular text or image is present in application or not and various other functionalities.

4.1.1 Phases of generation of Vugen Script:

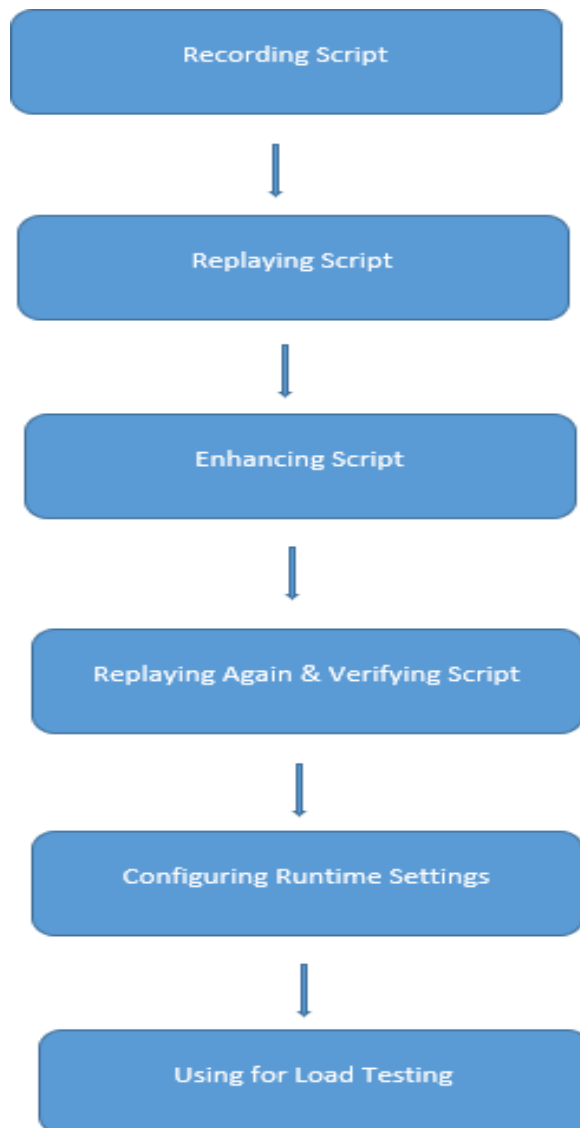


Figure 16 Phases of Vugen Script

4.1.2 Steps to create a Vugen Script:

1. Open Vugen

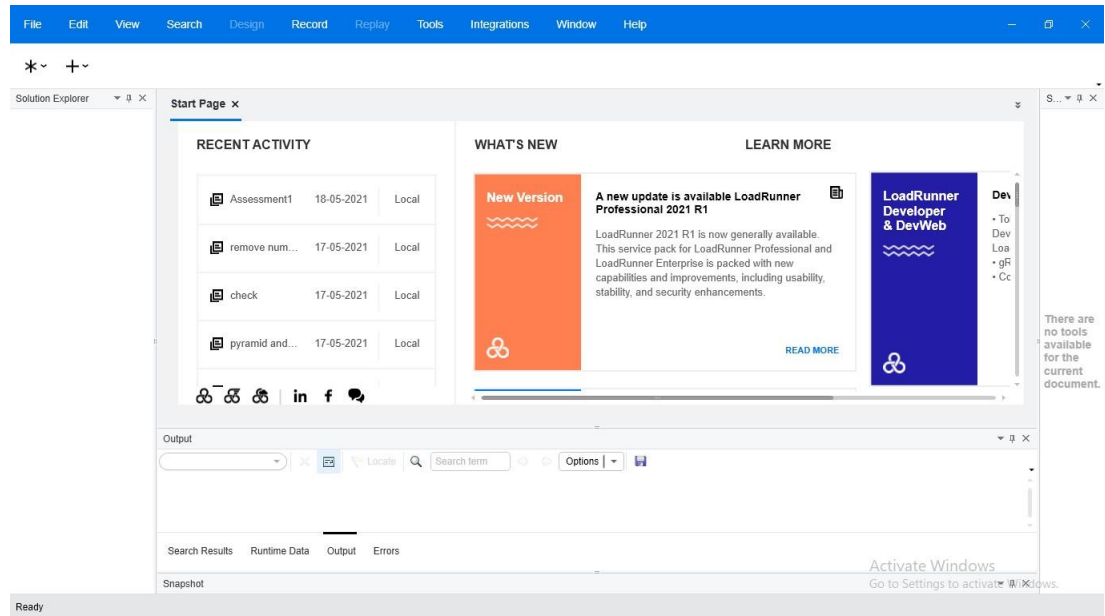


Figure 17 Vugen Dashboard

2. Create New Script

3. Select Protocol

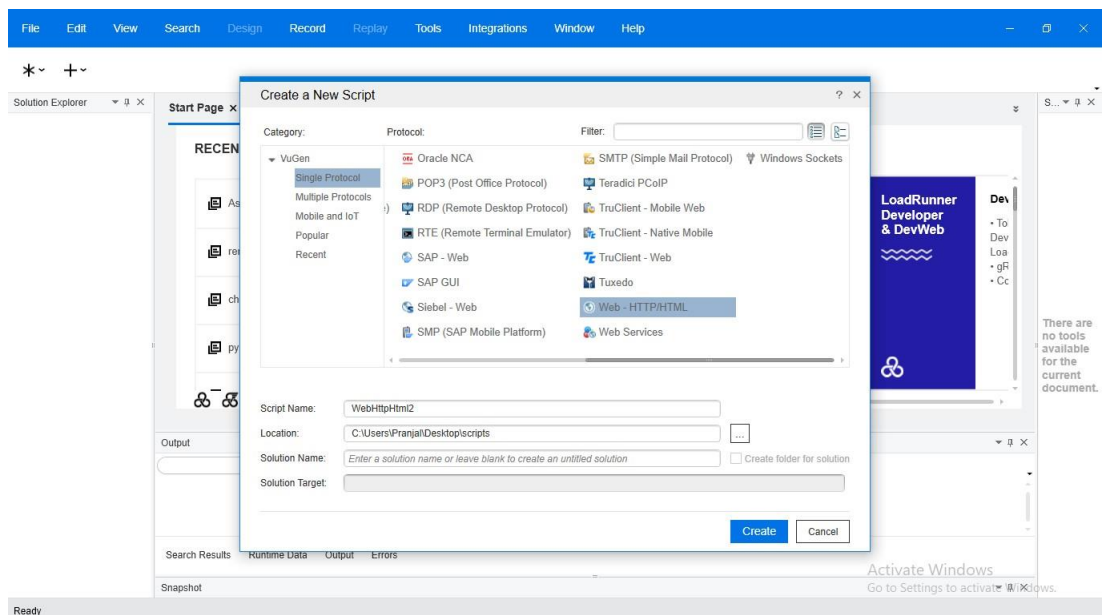


Figure 18 Vugen Protocols

4. Start Recording

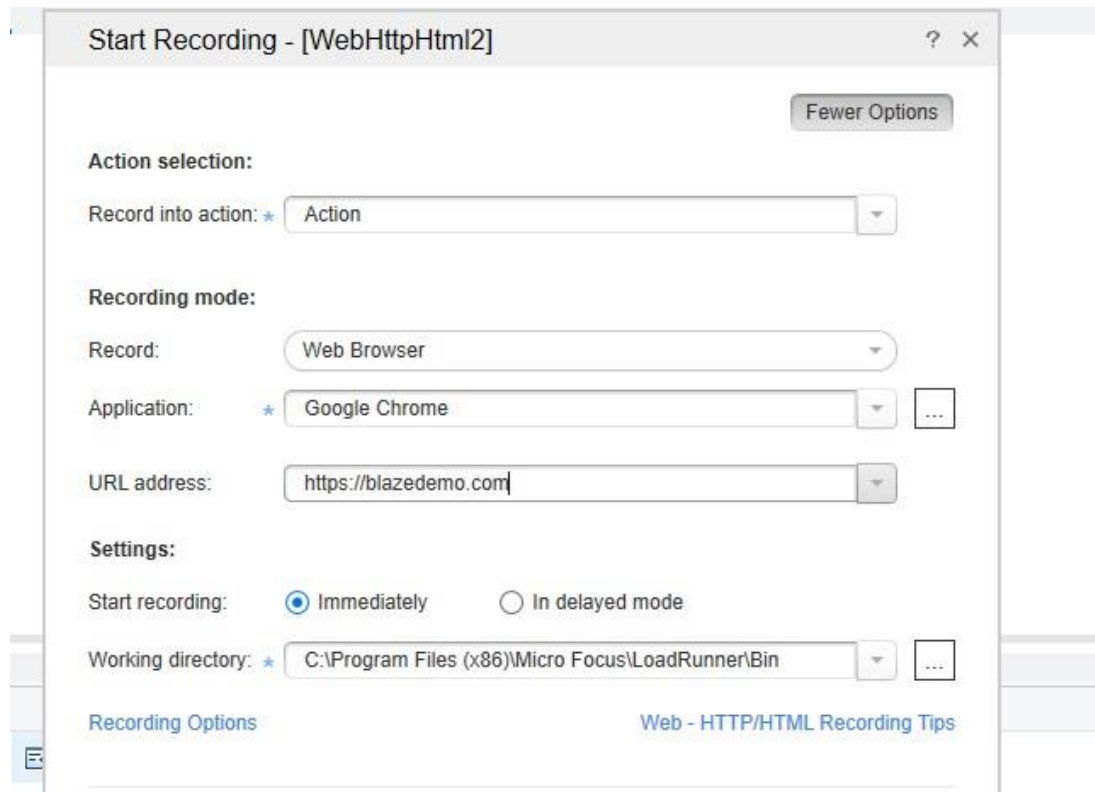


Figure 19 Recording Script in Vugen

5. Website opens select Departure City

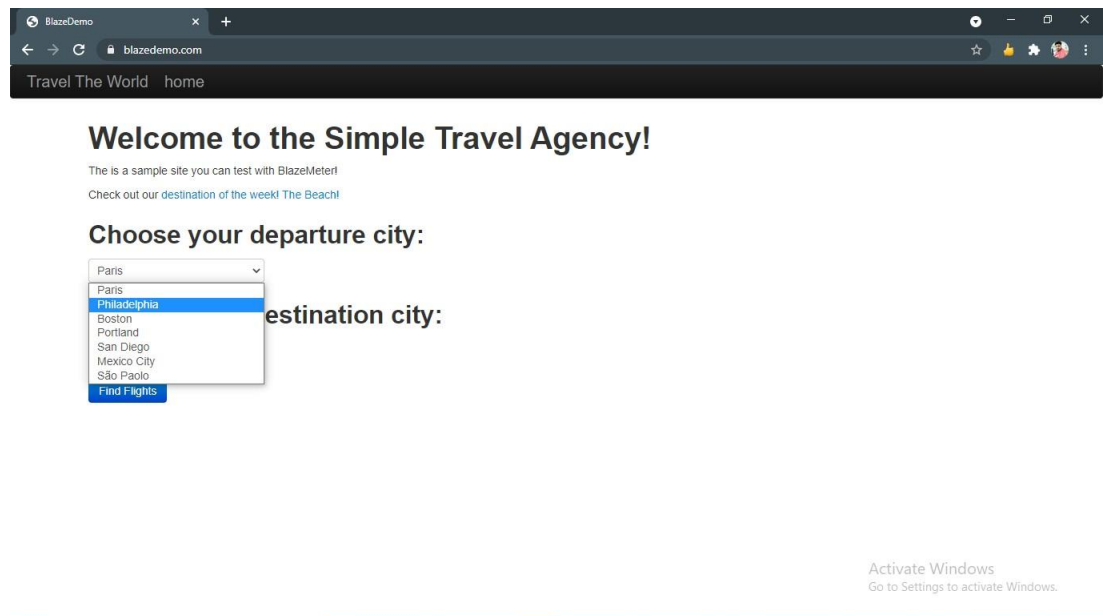


Figure 20 Recording www.blazedemo.com

6. Select Destination City
7. Choose Flight

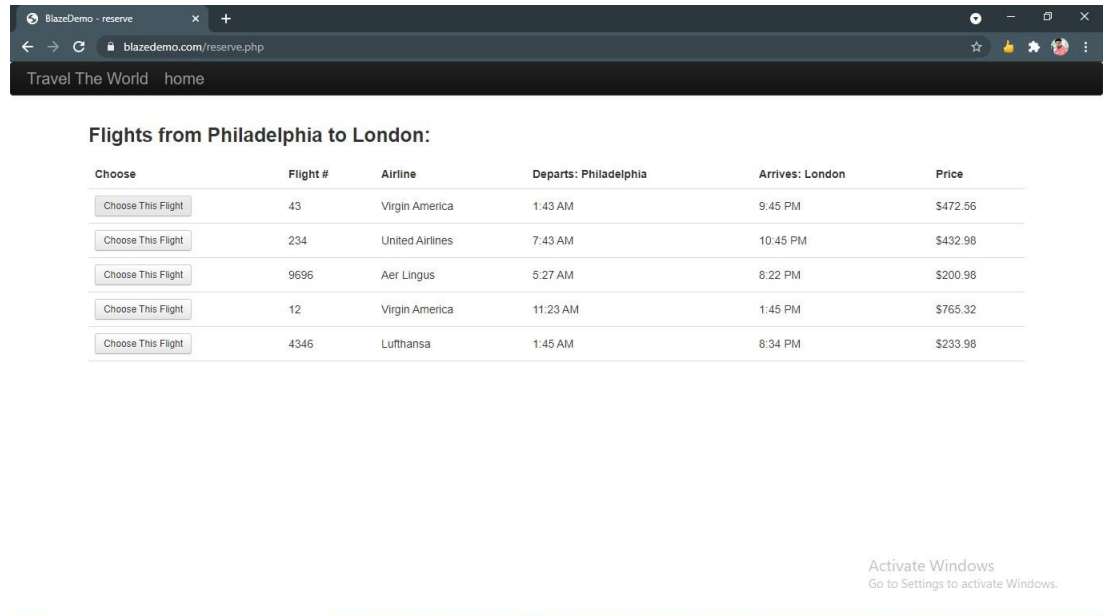


Figure 21 Select flight on www.blazedemo.com

8. Enter Details on the following page
9. Confirmation Page

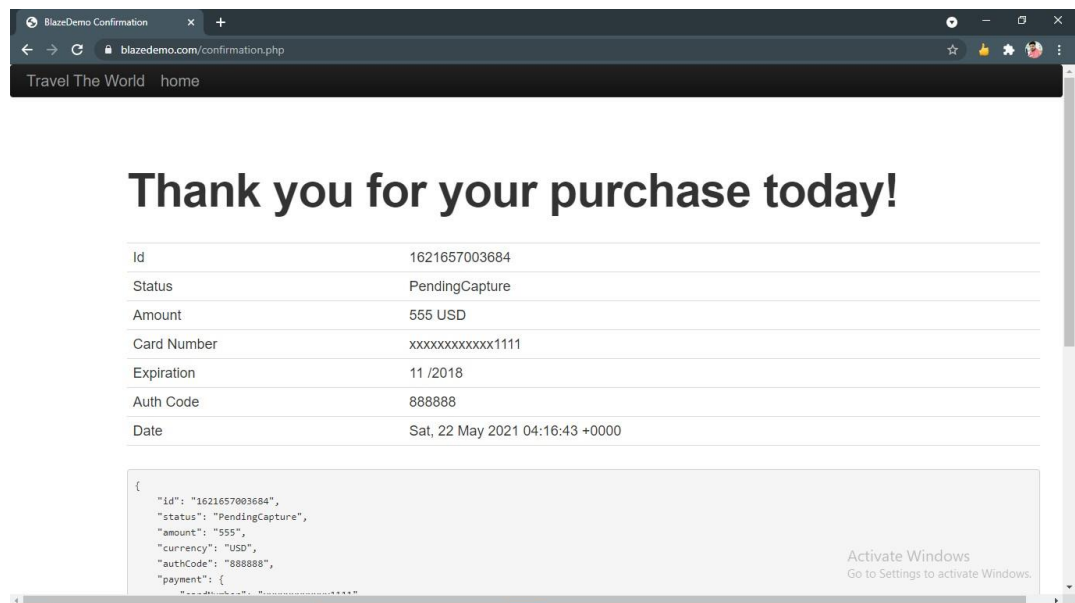


Figure 22 Confirmation Page www.blazedemo.com

10. Script Generated

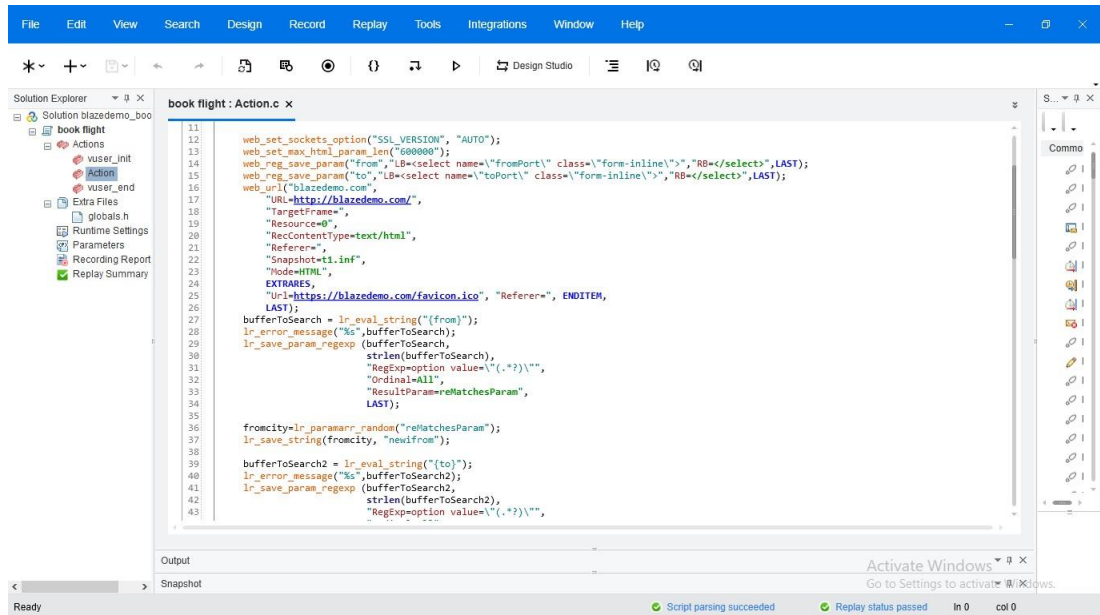


Figure 23 Generated Script on Vugen

11. Add functions, correlate values and tokens then replay the Script to check for output and errors.

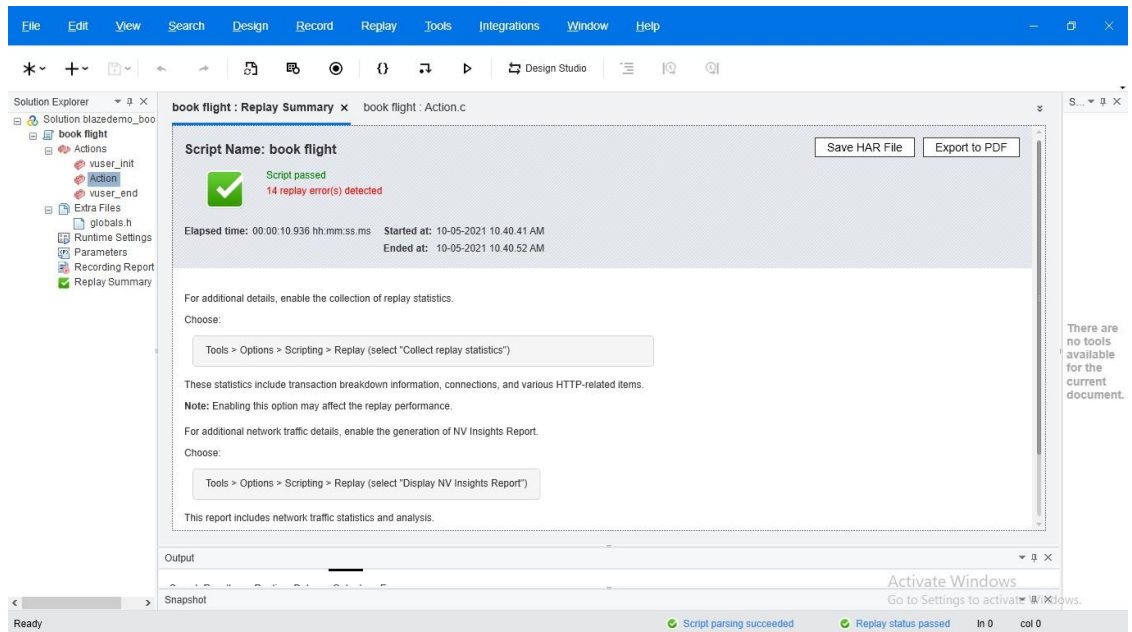


Figure 24 Successfully created and replayed Vugen Script

4.2 LoadRunner Controller:

The controller is one of the most important components in the LoadRunner workflow because it allows us to create and test scenarios. Scenarios may consist of a single script or a series of scripts. The test period, how the virtual users can execute and simulate, how the various tests/actions should be executed, and the virtual machine should build or produce the load are all discussed in a scenario.

To put it another way, a LoadRunner Controller is a program that "controls" total load checks. It allows one to change runtime configurations, permit or disable think time, add rendezvous points, and monitor the number of virtual users that each virtual machine can create. It generates a dump of execution outcomes and provides a summary of the "initial situation" of the load test.

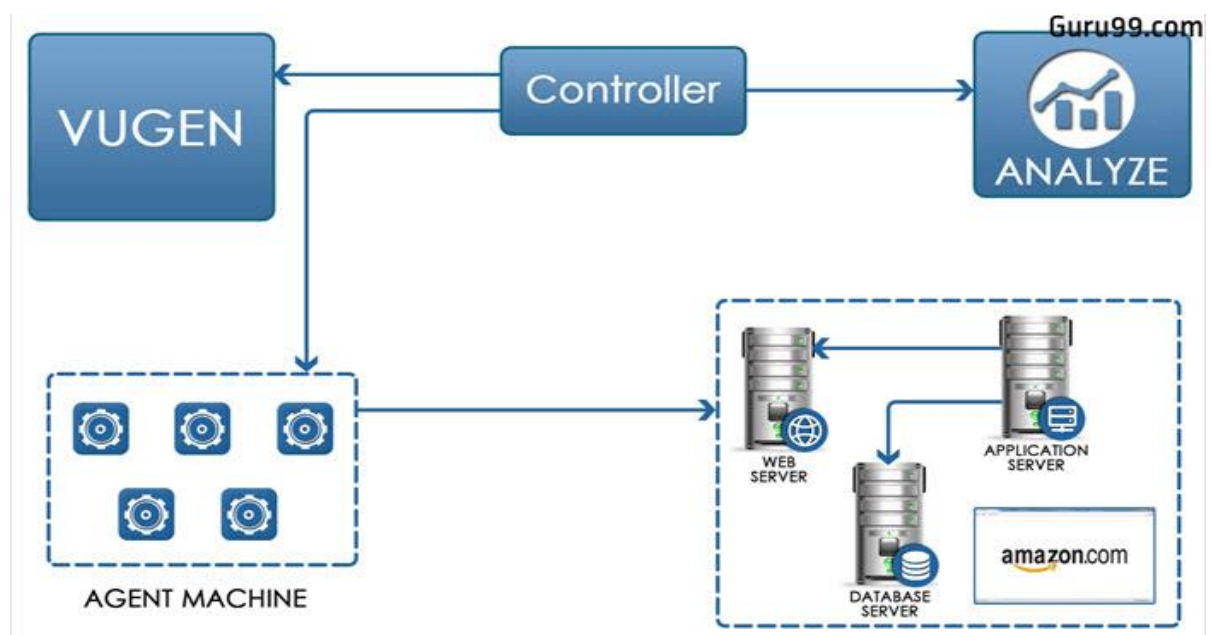


Figure 25 Architecture of Loadrunner

We can define the following fields while making the scenarios in MicroFocus LoadRunner Controller:

- Scenario Type
- Scripts
- Vusers
- Machine
- Load Pattern
- Graphs to monitor

While creating the scenario we can see that there are two types of scenarios:

1. **Manual Scenario**
2. **Goal-Oriented Scenario**

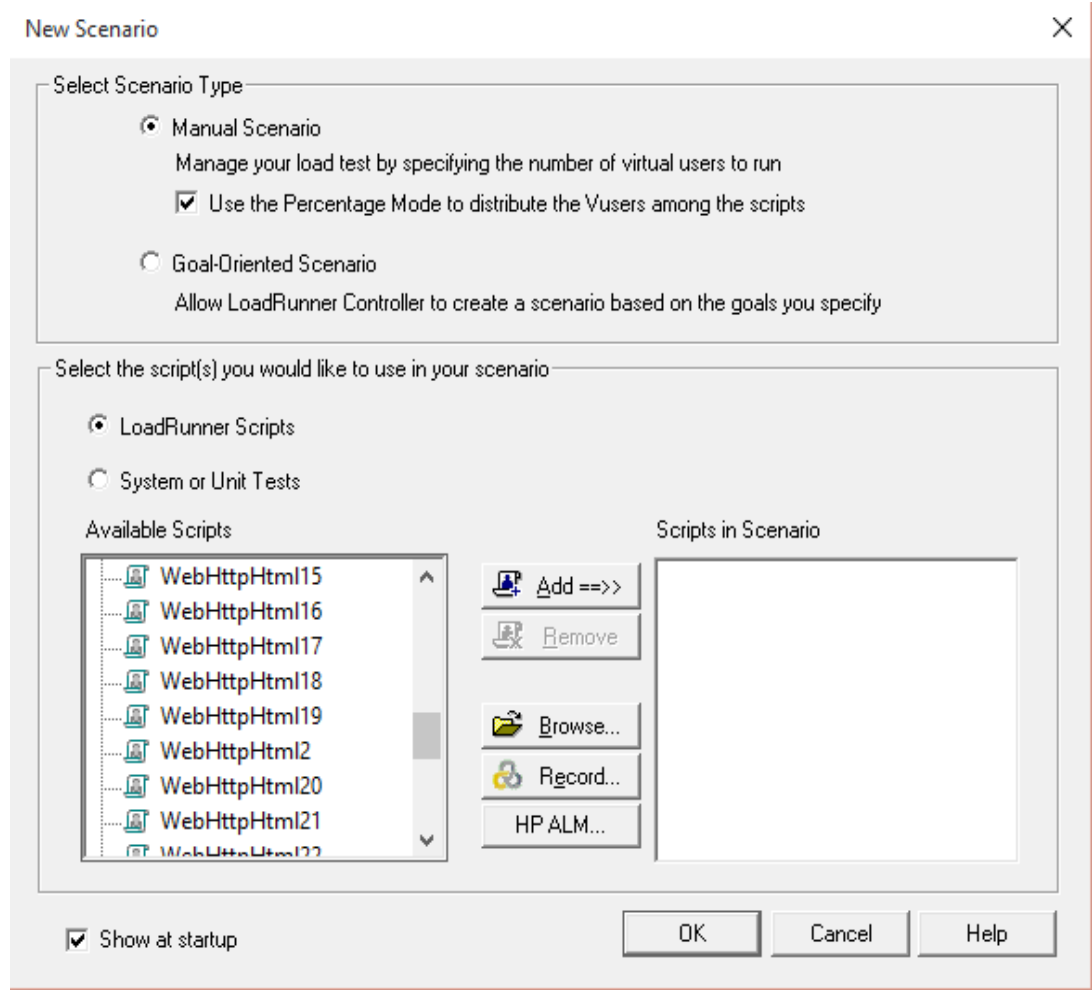


Figure 26 Creating a scenario on Loadrunner Controller

4.2.1 Simulating a Manual Scenario

Through listing Virtual Users or VUsers, load generators, and the load pattern, a manual scenario aids in the creation of a scenario. The following modes can be used to construct a manual scenario: Vuser party and percentage group.

- **Vuser group mode-** This mode assists us in defining the scenario by allowing us to join the number of Vusers for each script category.

- **Percentage mode-** This mode helps one to assign virtual users according to the percentage of virtual users allotted to each script.

4.2.2 Simulating a Goal-Oriented Scenario

Goal oriented scenario assists us to define our goals in which the LoadRunner automatically builds a scenario. For Example: If the user wants to inject 50 hits per seconds, then the following can be done.

The screenshot shows the 'Edit Scenario Goal' window. At the top, 'Goal Profile Name' is set to '50 Hits per Second'. Below this, the 'Define Scenario Goal' section contains a target icon, 'Goal Type' set to 'Hits per Second', 'Reach goal of' set to '50.00' hits per second, and 'Using a minimum of' 10 and 'and a maximum of' 25 Vusers.

Figure 27 Goal Oriented Scenario

Below are the Goal-Oriented scenarios that can be generated in Loadrunner Controller.

- Virtual Users
- Pages per minute
- Hits per second
- Transaction per second
- Transaction response time.

4.2.3 Creating a loadrunner scenario:

Following is the step-by-step instructions by which we can design a scenario and test it,

1. Launch the LoadRunner Controller and select the script that needs to be tested. Select the type of scenario to design as per the requirement. Click the **Add button** and then click **OK** as shown under.

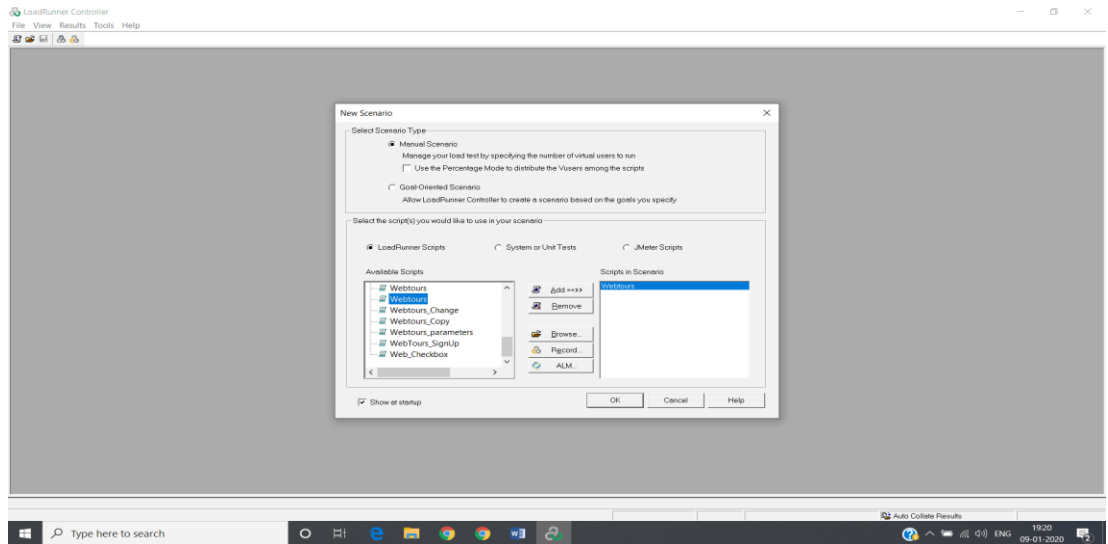


Figure 28 Launching of Loadrunner Controller

2. Select the **Number of Vusers**, that you want for the load test and select the ramp-up time for the Vusers.

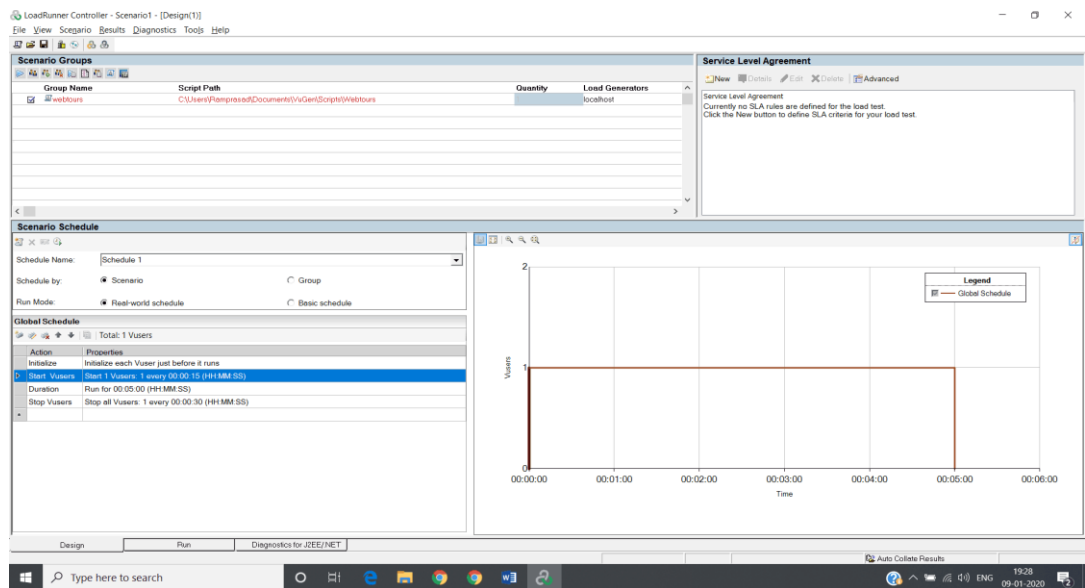


Figure 29 Controller Configuration

3. Set the **Duration time** for the test, the time for which you want the application to be in a steady state.
4. Set the **Ramp-down duration** for users.

- Different **Run-Time** settings like **pacing, think time, network, browser** etc can be setup, to emulate the user activity.

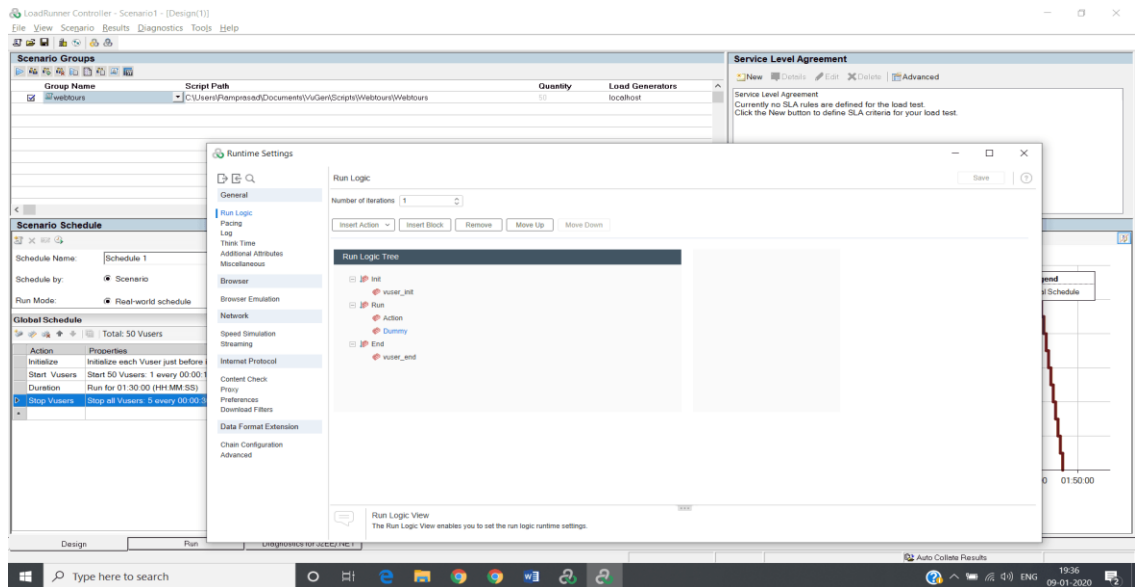


Figure 30 Runtime Settings

- After designing the complete scenario as per the requirements, Click the **Run** tab.

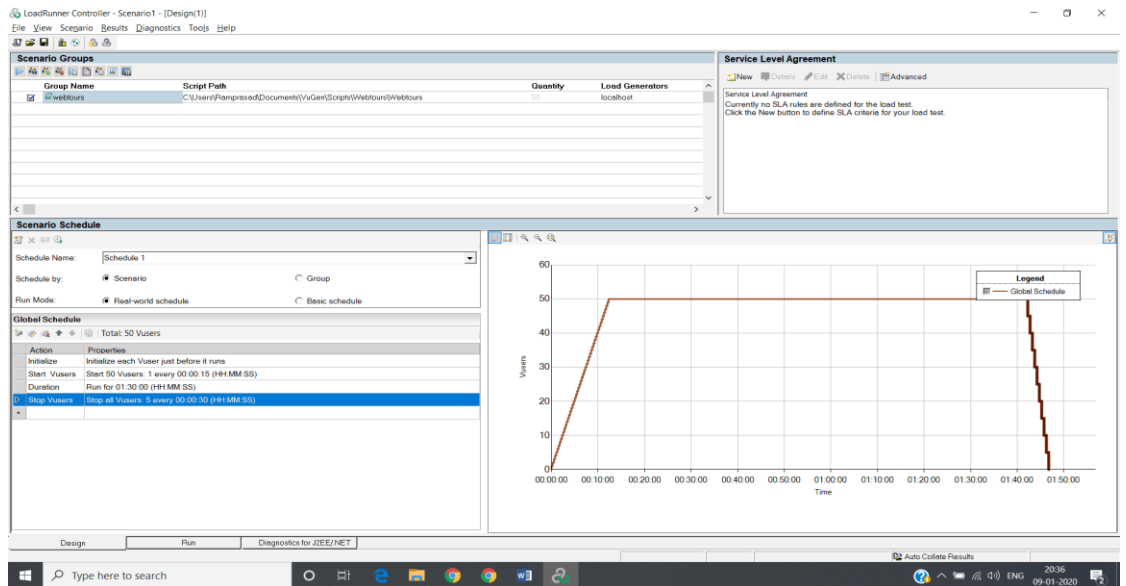


Figure 31 Complete Designed Scenario

4.3 LoadRunner Analysis

After the script has been documented and the scenarios have been developed, Loadrunner Analysis is a method that conducts a thorough analysis of the application. During the execution of the load test, Loadrunner Analysis searches for the dump provided by the Controller. The dump contains all information about the test application in raw format, which Loadrunner Analysis parses to produce different graphs.

4.3.1 LoadRunner Analysis Summary Report

Once we are done with the operations and load the analysis, we can see the window which gives the complete information about the scenarios in the Analysis Session. Also, we can see the test duration for which the scenario was executed to get these results.

4.3.2 Analysis Graphs

- **Average Response Time Graph:** This graph shows, for how many times the hits were made on the web server by the VUsers(Virtual Users) during each second of the load test.

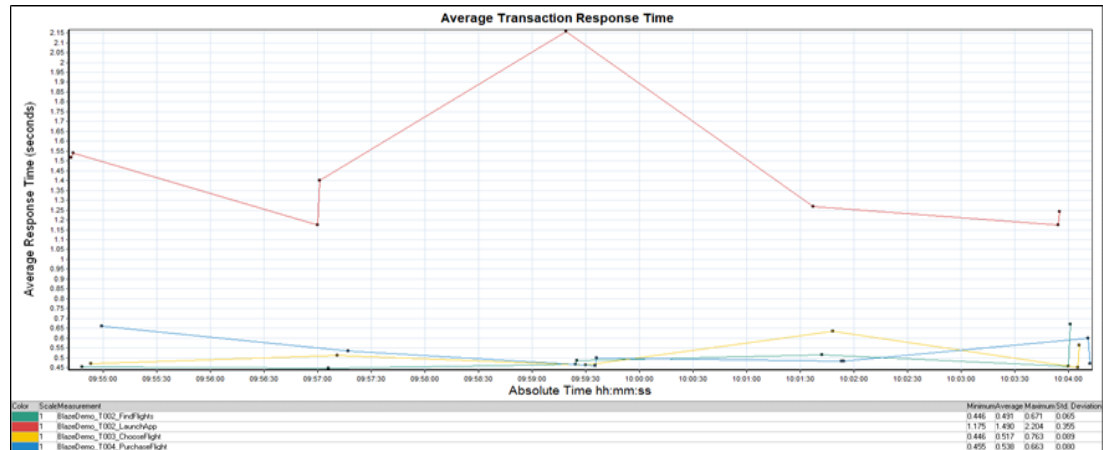


Figure 32 Graph Showing Avg Response Time

- **Hits per Second Graph:** This graph shows the hits quantity i.e., the number of hits by the VUser(Virtual User) during each second of the load test.

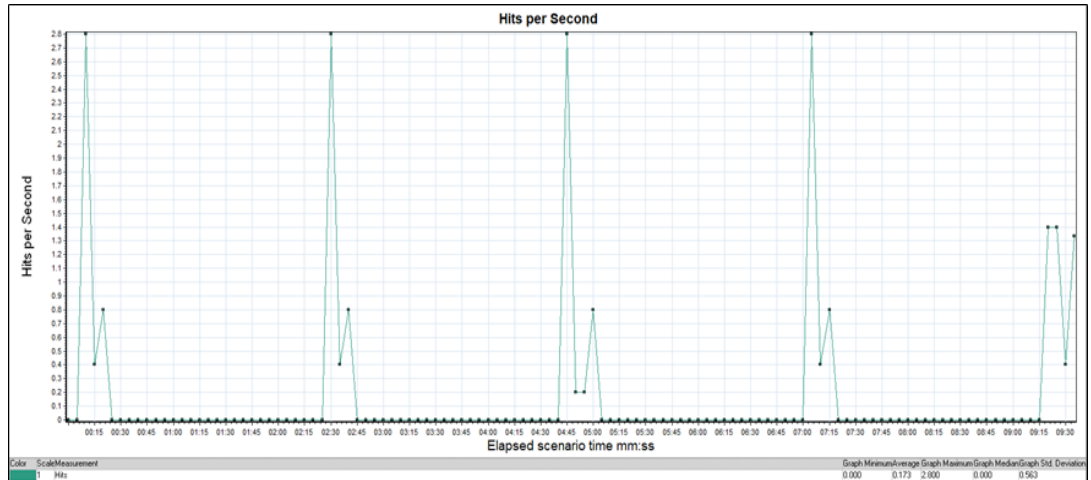


Figure 33 Graph showing the Hits Per Second

- Throughput Graph:** The sum of throughput (in bytes) on the web server during the test is seen here. It reflects the sum of data received from the cloud by the virtual user at any given time.

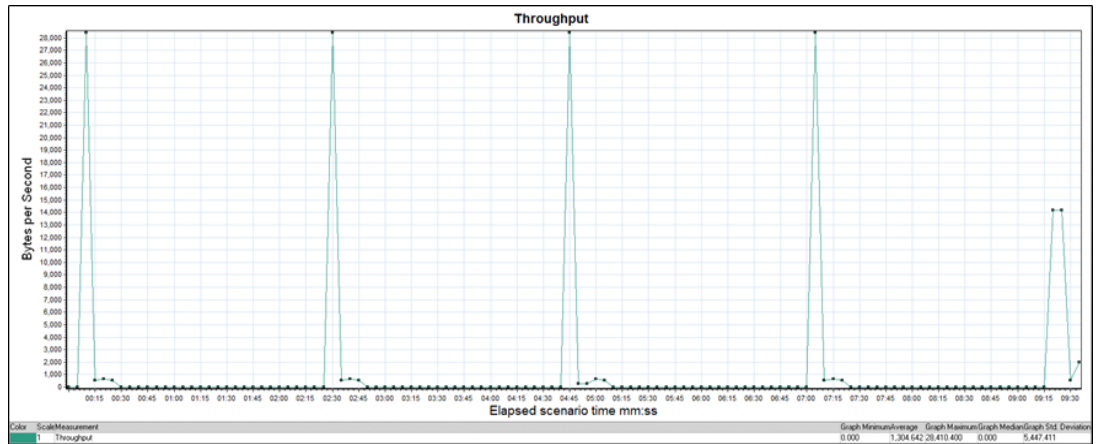


Figure 34 Graph showing the throughput amount

- Transaction Per Seconds Graphs:** This graph shows the quantity of completed transactions (effective and non-effective) performed during each second of the test. This helps us to decide the actual transaction load on the system at any particular moment.

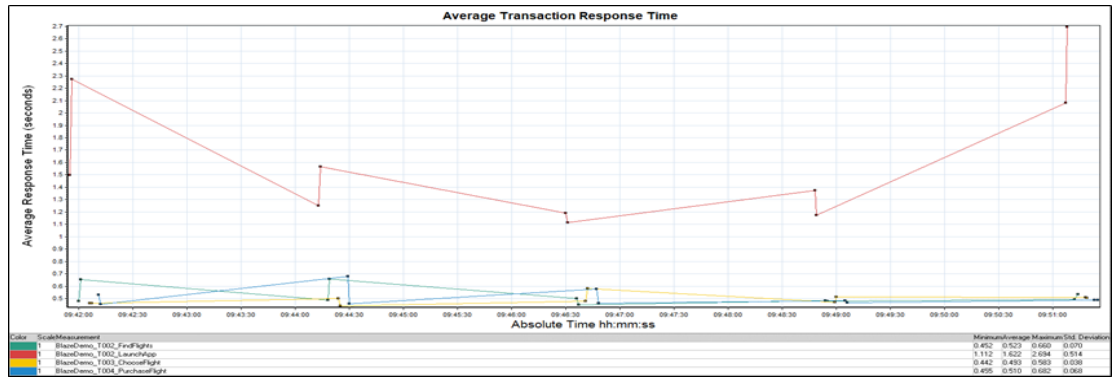


Figure 35 Transactions per second

- **Memory utilization Graph:** This Chart shows how the machine memory is utilized while performing the load test.

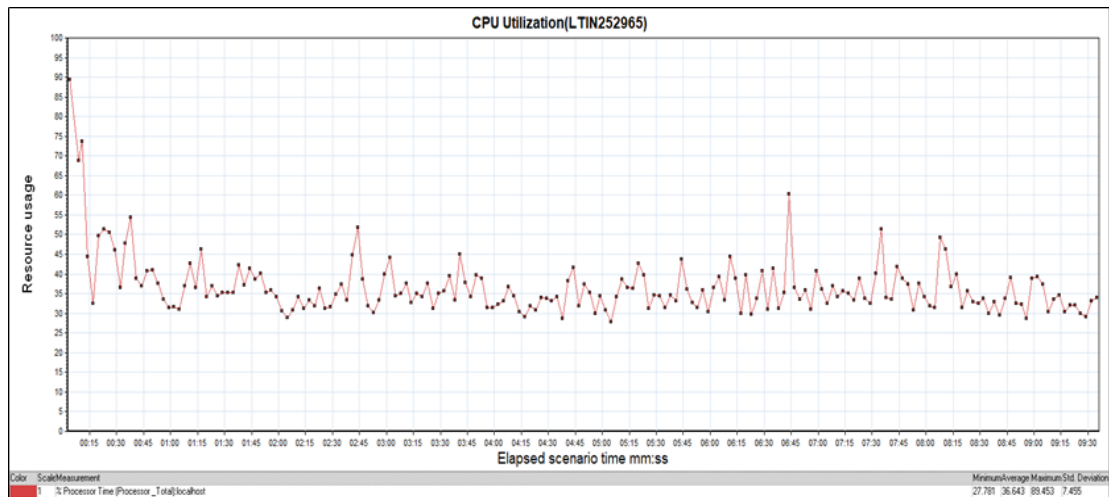


Figure 36 CPU Utilization

Merging of Graph

To get the meaningful information from the graphs, we need to merge two or more graphs. Before merging the two graphs we need to ensure that one of the graphs is already opened and we need to merge another graph over it.

To merge the graph, we need to open the graph window, go to the View menu and then click on merge graph. After that we can see the graphs that can be merged on the previous graph.

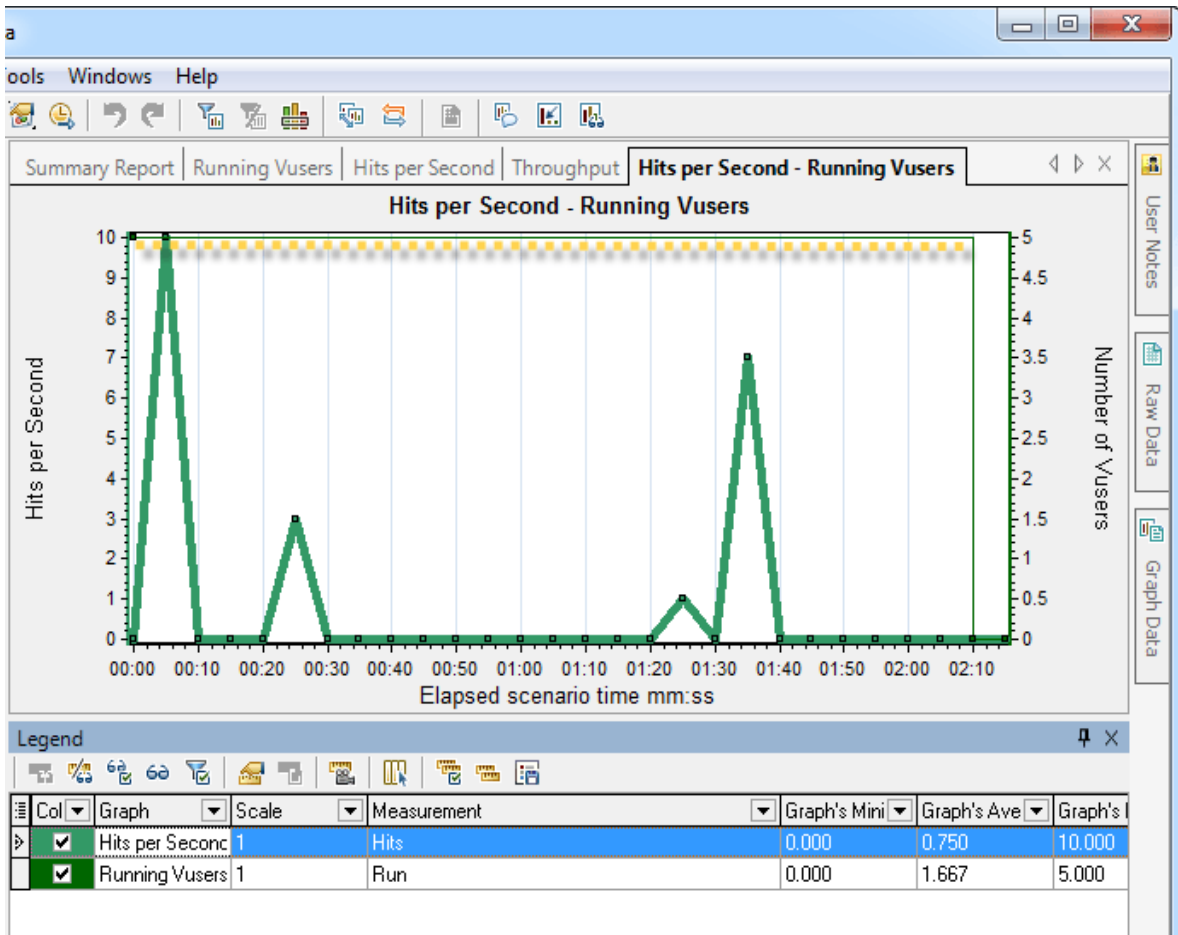


Figure 37 Merging of Hits per second graph and the Transaction response time graph

By the study of different graphs, we can easily find the performance of the test application as per the different scenarios and measures.

CONCLUSION

A performance test is often the last thing to be considered in IT programs. This is a blunder! Users are dissatisfied because their systems perform poorly. The most important aspect of any go-live experience is ensuring that your device or program is ready and capable of performing well under load (i.e. under the pressure of multiple users). You will guarantee that the device or program, no matter how basic or complicated, is ready to go-live by performing performance testing with LoadRunner and the assistance of an expert performance engineer.

Using LoadRunner, we can simulate user traffic from the user's point of view. It enables us to generate load and volume based on the business operations that customers run, allowing us to see how the device can cope. It is extremely effective in its ability to emulate user traffic and compare related metrics (system infrastructure, web servers, network, and so on). It's the closest thing to a crystal ball in IT, allowing you to foresee what will happen within your device before it goes live and impacts your customers.

This needs a thorough scientific knowledge of the environment as well as the LoadRunner results. It is important to be able to integrate output test execution with in-depth technical analysis in order to obtain useful outcomes.

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