STRUCTURAL MODELING ON PSIOS

Thesis submitted in partial fulfillment of the requirements for the award of degree of

Master of Engineering

in

Software Engineering

Submitted By

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Certificate

I hereby certify that the work which is being presented in the thesis entitled, "*Structural Modeling on PSiOS*", in partial fulfillment of the requirements for the award of degree of Master of Engineering in *Software Engineering* submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of *Mr. Ashish Aggarwal* and refers other researcher's work which are duly listed in the reference section.

The matter presented in the thesis has not been submitted for award of any other degree of this or any other University.

(Jay Patel)

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

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Abstract

In this thesis, an integrated system model is germinated for the structure of the privacy and security of iOS (PSiOS) devices with the help of the Matrix Algebra and Graph Theory to compare the Graphs. Firstly, the structure of the PSiOS is sculptural using Graph Theory, secondly using Variable Adjacency Matrix and last by a polynomial which is known as Permanent Function. In terms of Storage Optimization and execution time of a program, the Permanent Function provides a chance to effectuate the structural Analysis of PSiOS by comparing the properties of PSiOS with it. To germinate the Graph Model, Matrix Model and a polynomial permanent model, antithetic structural attributes of the PSiOS are identified. For the complete analysis of PSiOS system, top-down approach is also exemplified.

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First of all I would like to thank the Almighty, who has always guided me to work on the right path of the life. It is a great privilege to express my gratitude and admiration towards my respected supervisor **Mr. Ashish Aggarwal,** Assistant Professor, Computer Science & Engineering Department, Thapar University, Patiala. He has been an esteemed guide and great support behind achieving this task. This work would not have been possible without the encouragement and able guidance of him. I also thank my supervisor for his time, patience, discussions and valuable comments. His enthusiasm and optimism made this experience both rewarding and enjoyable. I am truly grateful to him for extending his total co-operation and understanding whenever I needed help and guidance from him. I am also heartily thankful to **Dr. Deepak Garg**, Associate Professor and Head, Computer Science & Engineering Department and **Dr. Rupali Bhardwaj**, PG coordinator, for motivation and providing uncanny guidance and support throughout the preparation of the thesis report.

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Jay Patel

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Chapter 1: Introduction

1.1 IOS

IOS is an operating system in use on iPhone, iPad, iPod [1] touch mobile devices as well as second generation Apple TV [2]. IOS is derived from OS X, and makes use of existing frameworks. IOS supports the development of two types of application.

1) Native Application->Objective C
2) Web Application->HTML, JavaScript and Cascading Style Sheet (CSS).

1.1.1 Native Application

For a particular device or platform, an application program has been developed known as Native Application [3]. Objective C is an object-oriented superset of the C programming language [4]. It adds syntax to declare and define classes and instantiate them as objects. Classes contain properties (data members) and methods.

1.1.2 Web Application

An application that is distributed all over internet through browser interface and stored on the remote servers [3]. It includes major terms like HTML, JavaScript and Cascading Style Sheet (CSS). HTML full form is Hyper Text Markup Language which is used for developing the web pages [5]. JavaScript is a lightweight programming language used for designing the network-centric application [6, 7]. CSS full form is Cascading Style Sheet that describes the presentation of the HTML (or XML) pages [8].

1.2 Tools By Apple

Some of the tools described below:

1.2.1 Xcode IDE

Xcode is an integrated development environment or IDE created by Apple [9, 10]. It contains a suite of software development tools used for developing OSX and iOS software. It was first introduced in 2003. It includes editor's compliers and other

necessary tools required to facilitate the development it supports development or Apple's devices including Macs, iPhones and iPads. Project builder IDE was rewritten for a while it was called PBX. Xcode is designed to operate best as a single window interface and it is a rich and powerful environment for developing code to use some Macs and Apple mobile environments [11]. Xcode compelled universal binaries which allow software to run on both PowerPC and Intel based platforms and that can include both 32 bit and 64 bit code.

1.2.2 Interface Builder

For Apple's Mac OS X operating system, it is a software development application [10]. Using a Graphical user interface, it allows carbon and Cocoa Developer to develop interface for applications. It is a part of Xcode. File format like .nib file and .xib file is used to store the result of interface.

1.2.3 IOS Simulator

It provides a way to debug and test iOS apps on the simulator entirely from Visual Studio on Windows [10].

1.2.4 Git or SVN for Version Control

A version Control is system that let you track changes in your source code by checking in your code into that system. Subversion is a free/open source version control system (VCS). It manages changes made to files and directories and allows checking the history of data changing and recovers the older version of data. Git is a distributed version control system created by linus tovald, creator of Linux, to replace BitKeeper as the VCS used for maintaining the Linux Kernel [12].

1.3 Architecture of IOS

Architecture of IOS [13] contains four layers which are described as follows:

1.3.1 Cocoa Touch

- Primarily Objective-C.

- Based off the Mac OS X Cocoa API.
- Frameworks
    - UIKit- UI Elements, Life cycle Management, touch, Gestures.
    - Address Book UI- Contacts, adding, editing.
    - Event Kit UI-Calendar events.
    - Game Kit Framework- P2P networking, Game Center.
    - IAd-Apple's advertising platform.
    - Map Kit-Google maps.
    - Message UI-Email and SMS.

1.3.2 Media

- Frameworks
    - Assets Library-Photos and Videos on devices.
    - AV Foundation-Advanced audio and videos.
    - Core Audio-Low Level Audio.
    - Core Graphics-2D Drawing, Quartz.
    - Core Text-Advanced text layout and fonts.
    - Image I/O-Importing/exporting images.
    - Media Player-Simple audio/video playback.
    - OpenGl ES- 2D and 3D drawing.
    - Quartz Core-Animations.

Figure 1.1 IOS Architecture [13]

1.3.3 Core Services

- Frameworks
    - Address Book-Lower layer contacts.
    - CFNetwork-Socket level networking.
    - Core Data-Data model for MVC.
    - Core Location- GPS, cell or Wi-Fi based location services.
    - Core Media-Low level media used by AV.
    - Core Telephony-Phone interface.
    - Event Kit-Low level calendar events.
    - Foundation-Objective C wrapped core foundation.
    - Mobile Core Services-Uniform type identifier support.
    - Quick Look – Previewing Files.
    - Store Kit-In App Purchases.

1.3.4 Core OS

- Frameworks
    - Accelerate-Big Number and DSP Calculation.
    - External Accessory-Communicate with hardware accessories.
    - Security-Certificates and cryptography.
    - System-Low Level operating system methods.

1.4 PIOS

PIOS (Privacy for iOS devices) is an automated tool has been developed to analyze the iOS application that can identify the gap of privacy [14]. Its main function is to detect the privacy leak coded in iOS application.

Privacy leak is an event in which without the user authorizations, the iOS application reads the data and send to the third party. It is a direct violation of the iPhone developer program license agreement [15], which authorizes that without user permission no sensitive data may be transmitted.

1.5 PSIOS

Now a day, Runtime attacks on the iOS is major problem for strengthening security and preventing privacy leaks. Therefore a tool has been developed known as PSiOS (Privacy and Security for iOS devices) that features framework for novel policy enforcement [16]. Without requiring access to the application code, it provides sandboxing for each third-party application. A mechanism in which arbitrary guest code executed in confined environment by host software system is known as sandbox. For many purpose sandboxing is used, such as safely extending operating system kernels [17, 18], running untrusted web applets within a browser [19] and limiting potential damage caused by compromised applications [20-23].

1.6 Structural Modeling

Structural Modeling shows that how the things are related to each other and concerned with describing the things [78]. A "thing" is part of the system which can be a class, object, package etc. It works throughout the entire system of development life cycle therefore it is very important process [79].

Different Undirected graph of the original system can be germinated using the Structural Modeling. Structural Modeling is used to examine the connectivity or interaction of the modules within the system. Another advantage of the using the Structural Modeling is to provide the different diagram for exemplifying the views of the system. Structural Modeling is done using the Graph Theory, Variable Adjacency Matrix and Permanent Function. Work related to the Structural Modeling and Analysis of Test Generation System for database application, Architecture of Privacy and Security to iOS devices (PSiOS), Structural Modeling and Analysis of FRP Composite Product Subsystems-A Systems Approach and Structural Modeling, Characterization and Integrative Analysis of EDM System are also described in this section.

2.1 Architecture of PSiOS system

The Architecture of PSiOS is delineated in figure 2.1. Design is trifid into distinct phases. (1) Static analysis (offline), (2) Binary Rewriting at load-time and (3) Runtime Control Flow Integrity and Policy Enforcement at execution-time [16]. Only once Static Analysis phase is performed and whenever the Application is plunged by the user, the binary rewriting and runtime enforcement phases are performed. The wide spread workflow is as follows: To derive the application structure, firstly they revert engineer the application binary with the help of automated tool. For deriving the control flow application with the help of MOCFI [24], there is a requirement to obtain the execution path which are relevant (step 1) to utilize the static Objective–C analyzer which regains the method of existing architecture like PiOS and they analyze the existing classes and method of Objective-C with the help of Objective-C helper scripts [25] (step 2). For prolonging these tools they need to use all calls to system call wrapper. After application is plunged by user, firstly re-execute binary rewriting into the binary (step 3) to unite the control flow constraints. When the application access the Public Frameworks, System call wrapper and Objective-C runtime, checkpoints will be reached this is inserted by the Binary rewriting (step 4). During execution-time, with the help of Objective-C analyzer,

they extracted relevant information and confront the incompleteness of the static analysis (step 5). The control flow of the application, which follows the valid path, is secured by the Control-flow integrity (step 6). For accessing all the request of Policy enforcement, System call wrapper and Objective-C environment, when the accessing request follow the given policy rules (step 7).

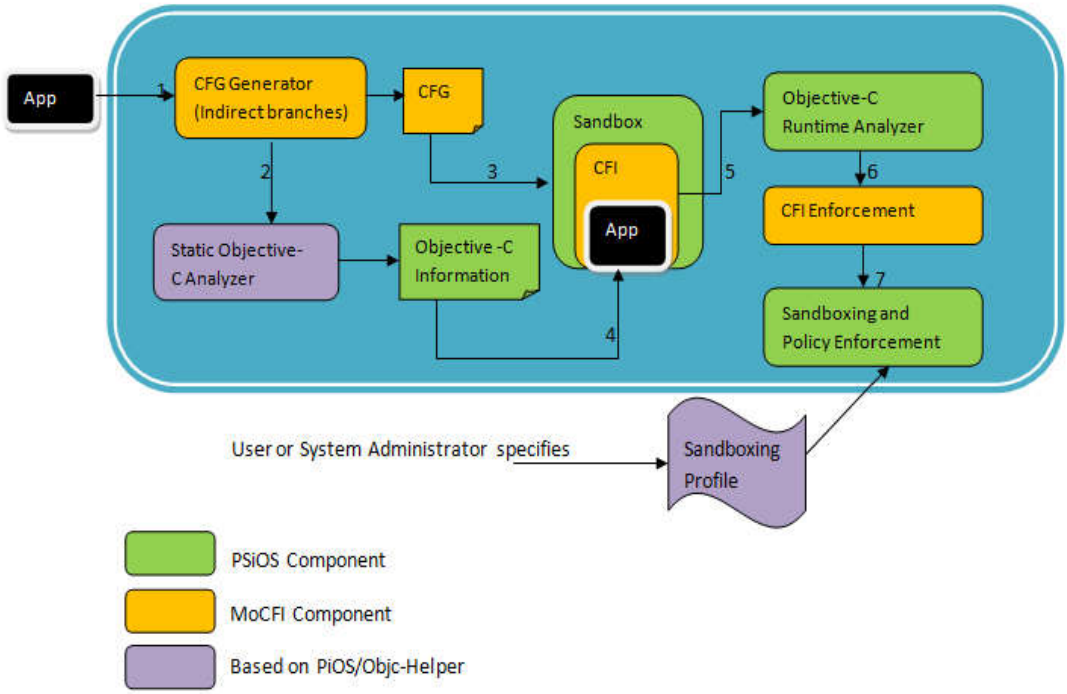

Figure 2.1 Architecture of PSiOS [16]

2.1.1 Static Analyzer

By default, the iOS applications are in encrypted form. With the help of process dumping [26] technique, they can obtain the decrypted form of iOS Binary. After that with the help of MoCFI they designed CFG to resolve the target of indirect branches. Using PiOS they can resolve the Objective-C calls in innovative design of MoCFI. On experimental results shows that Objective-C structure is not always fetched by the PiOS when the static analysis is performed on it. Hence for identifying all important classes, inheritance relationship and methods within Objective-C structure, they proposed a novel static Objective-C analyzer.

2.1.2 Binary Rewriting and Runtime Enforcement

After the iOS application loader has insured the application signature, they use Binary Rewriting to prolong the application signature. For this PSiOS work on the rewriting-engine to check all the indirect branch instruction with the control flow. Moreover, PSiOS re-scripts all access requests to insert checkpoints at the Objective-C runtime. Whenever the execution of an application starts and the checkpoints has been reached, PSiOS ensures that valid CFG path has been followed by the call and gibe to the given sandboxing profile.

2.1.3 Enforcement Policies

There are three different types of Enforcement policies; Log, Exit and Replace. All the policy violation is recorded by System is ensured by the log option. This option helps system administrator for the identification of required Objective-C calls which are performed by application. Whenever the policy is violated, the current process is terminated instantly with the help of Exit Option. Replace option allows the application to run at execution time that replaces the values of Objective-C runtime by shadow data. If the Policy violation had occurred, the sandboxing profile disallows the address book and returns the fake data or an empty data set.

2.2 Structural Modeling and Analysis of Test Generation System for Database Application

Now days, Database Application [27] is found everywhere, but there is a problem that how to examine the program whether they are correct or not. Because the database state, as well as the user's input, determine what the program does, such program present new problem for software tester. For this problem, GLOBECONDBUNIT, a Test Generator for Database Application has been germinated [28].

2.2.1 Architecture of the GLOBECONDBUNIT Tool Set

Input is taken in the form of Database Schema of the Database on which the application execute, Application source code and "sample values files", which contain some values of attributes. The programmer provides data about the behavior of the test cases by selecting the test heuristics. With the help of this data, GLOBECONDBUNIT germinates inputs to the application and start execution on those inputs. Category-Partition method [29] is applied in which values of attributes is suggested by the user and divided into groups, known as data groups. Sample-values files contain that data group. Combination of these values is produced by the tool to fulfill the database tables and provides as an input to an application. Tool provides test templates representing the test cases with the help of heuristics selected by the user and data groups.

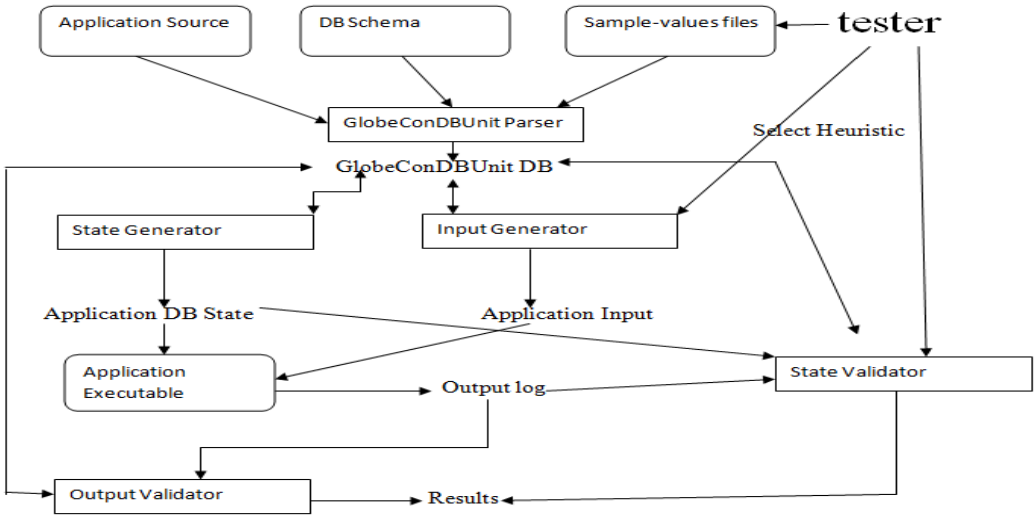

Figure 2.2 Architecture of the GLOBECONDBUNIT Tool [28]

GLOBECONDBUNIT consists of the five components interacting with each other.

- GLOBECONDBUNIT PARSER:-It is used to extract the information from Application Queries, Application's Database Schema and Sample-values files. Extracted information is stored in the internal database which is known as GlobeConDBUnit DB.
- State Generator: - It is used to extract the information from the GlobeConDBUnit DB about the sample data, table and attributes of application. It germinates the initial DB State for application knows as the Application DB state.

- Input Generator: - With the help of information germinated by GlobeConDBUnit Parser and State Generator the data is created that is used as an input to the Application.
- State Validator: - During the execution of a test, it checks how the database states of application changes.
- Output Validator: - It catches the output of the application and checks them with the query post- conditions and pre-conditions that are germinated by the user suppler and by the tool.

Now GlobeConDBUnit architecture is converted into the system representation (Graph Theoretic Representation). After that the System Representation has been converted into directed and undirected Graph. Now undirected graph is represented into matrix from to evaluate the Permanent Function of the GlobeConDBUnit which contain each term as a separate diagram. Firstly, undirected graph is converted into a canonical from matrix A. Secondly, Matrix B is generated by equation [B= (P*I)-A]. After that Variable Characteristics Matrix and Variable Permanent Matrix is germinated. By calculating the determinant of the Variable Permanent Matrix, Permanent function is determined [30].

2.3 Structural Modeling and Analysis of FRP Composite Produce Subsystems-A Systems Approach

For Advanced Engineering structure, Fiber reinforced polymer composites are used. Composite of Fiber reinforced polymer is used in the range from ships and boats to sport goods, helicopter and aircraft to offshore platform, civil infrastructure and automobiles where ever they can super cede the conventional materials. More and more use of FRP composites in the existing markets like sports, civil structure and biomedical devices, helps to grow at an efficacious rate. Day to day increase in composite application is the creation of the new FRP materials. It includes performance increase in the nanoparticles and nanotubes, a new style of reinforcement and also increase in the resin systems [31]. Good understanding between the relationships of structure and composition, behavior and properties are some of the major factor required for developing the FRP composites. Major Factor are explained in the literature survey like the role of resin system [32, 33],

coupling agent [37, 38] the sizing ingredients [34-37] for fiber and its importance, binder [39], architecture on final properties [40] and antistatic agent [41]. On out coming performance, there is an importance of process equipment selection because Liquid composite molding process manufactures the FRP composites [33]. A significant role is being played by the selection of proper tooling [42, 43] for the manufacture process and has an importance on the properties of product. For the high performance and better development of the composite product, product design is an important activity [44-46]. Less number of publication focuses on significance of binder/resin [39], tooling/product design [50], interactions between fiber/matrix [47, 48] and process equipment/tooling design [49]. Therefore for analyzing a composite product system, a mathematical tool is developed based on matrix algebra and graph theory. Various Engineering applications such as automobile vehicle design and analysis [51], failure cause effect analysis [52], failure cause analysis [53] and wear analysis [54] etc, include the Graph Theoretic methodology. In this article, for the development of Permanent Function, the system like reinforcement, resin tooling product design and process equipment systems are considered separately and interaction between the various subsystems provide us the five Permanent Functions, which is used to create the complete Permanent Function of the FRP system.

2.3.1 Hierarchical Tree Structure of Fiber- reinforced polymer composite product system

To define the elements of FRP composite product, the structure is divided into system and subsystem at each level. Four level of tree structure is shown in Figure 2.3. In level 1: the whole FRP composite product system, level 2: Subsystem, level 3: Sub-subsystem, level 4: Sub-sub-subsystem. After that the graph approach is used on the FRP system which is shown in Figure 2.4 to evaluate the further process like variable adjacency matrix and permanent function.

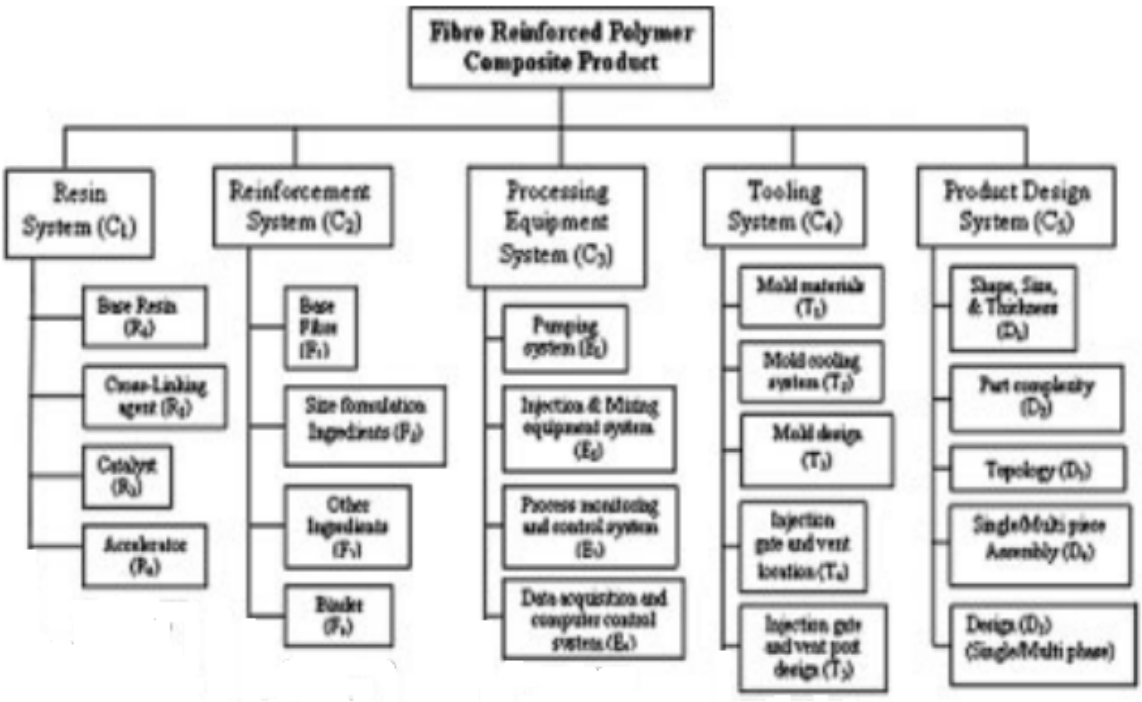

Figure 2.3 Hierarchical tree structure of an FRP composite product system [30]

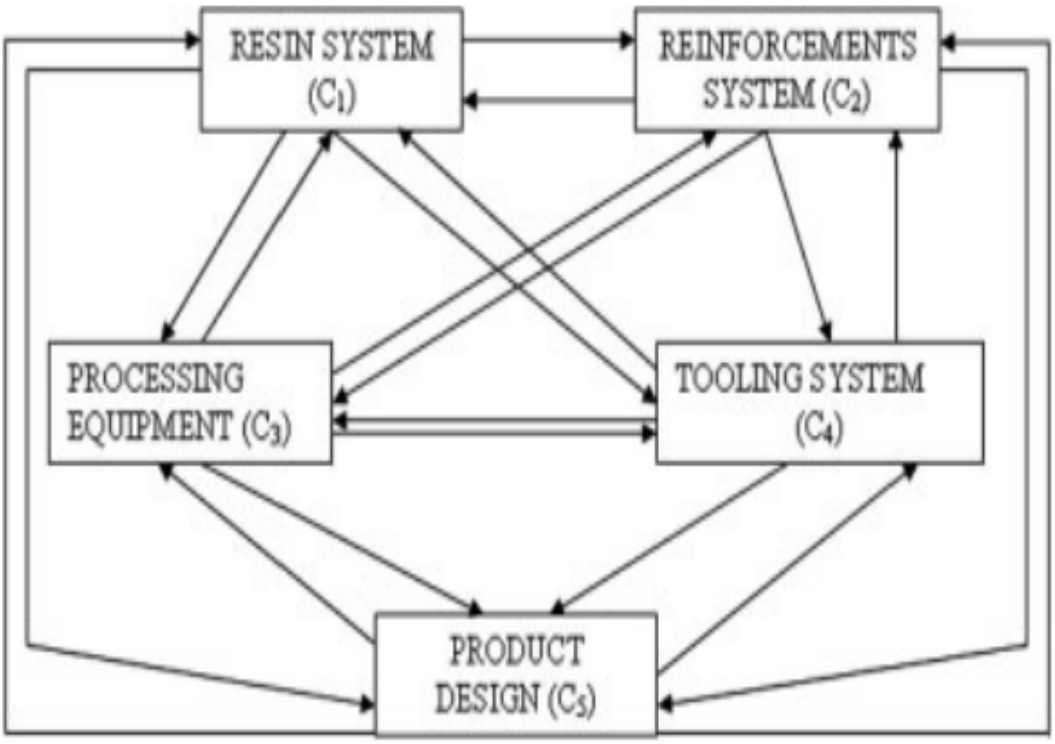

Figure 2.4 System Representation of Fiber-reinforced polymer [30]

2.4 Structural Modeling, Characterization and Integrative Analysis of EDM System

Electric Discharge Machining is complex metal-removal mechanism with a thermal process. Complex metal removal mechanism contains the manufacture of plasma channel between work piece and tool. By conventional methods, some of the electrically conductive materials are very difficult to machine such as space-age alloys. Some of the metals like hardened stainless steel, high strength steel alloys, tungsten etc require special technique [55] and can't be machined by conventional method. Rather having the advancement, the conventional methods are not suitable to machine. In 1940s, a technique has been developed to remove the material from a part by mean of a series of repeated electrical discharge between electrodes and work piece in the presence of a dielectric fluid [56]. Electric Discharge Machining system consists of a number of appurtenances. These appurtenances are from different back ground therefore they have different functionalities and interaction exits between these appurtenances. These appurtenances are linked together in such a way that electrical energy is converted into thermal energy and material is extracted [56]. The performance of the system depends upon the appurtenances and the interaction between these appurtenances [57]. Functions of Electric Discharge Machining system are performed by each of these appurtenances. Therefore, compatibility and integration among the appurtenances also affect the performance, quality and functionality of an EDM system. So a methodology is proposed for the structural analysis of EDM system. Identification of the appurtenances and their connectivity is represented by graph theory. Capabilities of manufacturing system have been recognized in various ways such as combination sets of subsystems and structural patterns [57]. In 2006 Garg et al. germinated a deterministic quantitative model which is used to compare the technical and economical features of hydro, thermal power plants and winds based on graph theoretical approach. It is used rank and evaluates the power plants in descending and ascending order with respect to the value of their index [58]. A prototype model has been developed for the structure of the composite product system by Prabhakaran et al. (2006) in the term of its appurtenances and the interaction between appurtenances and curing kinetics molding process etc. Firstly, the structure of the EDM

is sculptural using Graph Theory, secondly using Variable Adjacency Matrix and last by a polynomial which is known as Permanent Function [59]. To develop a high quality product, a methodology is presented by Kiran et al. (2011). This methodology provides a solution for Mechatronic industry by the combination of all the design aspects of product together to create a form.Very less work has been done to analyze the appurtenances of the EDM system. Therefore a mathematical model is developed to analysis the EDM system using the graph theory and matrix algebra.

2.4.1 Hierarchical Tree Structure of Electric Discharge machining system

To define the elements of EDM system, the structure is divided into system, subsystem and sub subsystem at each level. Three level of tree structure is shown in Figure 2.5.

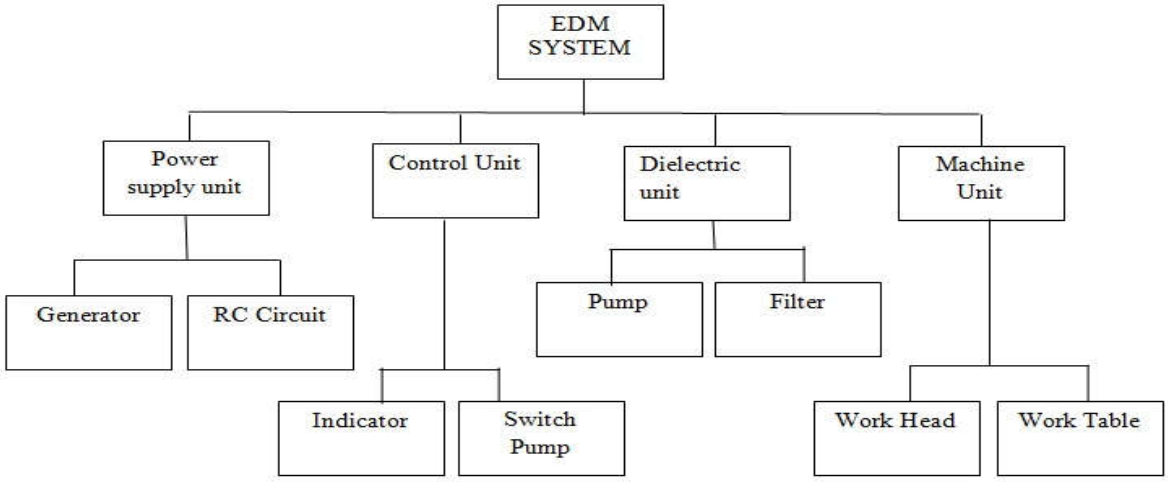

Figure 2.5 Hierarchical tree structure of EDM system [76]

At level 0: the whole EDM system, level 1: Sub systems are Power Supply Unit, Control Unit, Dielectric Unit and Machine Test, level 2: Sub subsystem are Generator, resistance capacitance relaxation circuit, push button, indicator lamps, pump, Filter, Work Head and Work Table [76]. After that the graph approach is used on the EDM system which is shown in Figure 2.6 to evaluate the further process like variable adjacency matrix and permanent function.

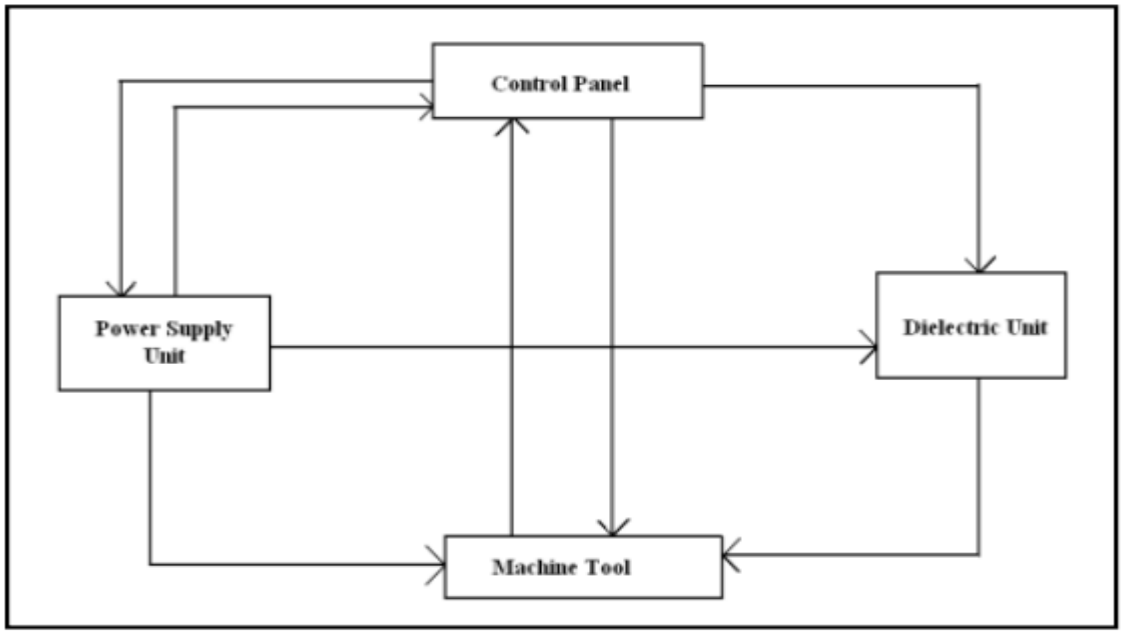

Figure 2.6 System Representation of EDM system [76]

2.5 Structural Modeling and integrative analysis of Manufacturing systems using graph theoretic approach

The importance of the Manufacturing system management is has already been defined in 1960 at the corporate level and it is a competitive weapon [61, 62]. Analysis of the broader system wide effects cannot be done and decisions are taken in the sporadic way in the existing model of manufacturing system [63]. Without the use of a broad perspective of system wide effects the performance of system is measured [64]. Now days, the increase in the competition and rapid changes in market condition has made more severe [65, 66, 67]. The primary challenge for the researcher was to increase the comprehensiveness of the manufacturing system model [68, 69, 70]. To measure the accuracy of the manufacturing system with respect to the parameter like average inventory, average lead time, production rate etc most of the models have been germinated. As there are large number of constraints and variable, the analysis of the manufacturing system cannot be performed due to some limitation [71]. The interactive role to measure the performance has been investigated by the Bourne et al. [72]. Lack in the performance measure of the manufacturing system is also pointed out by the Gomes

et al. [73]. To analysis the manufacturing system, there are various limitations in existing model. Fault tree methods, Markov model, event tree etc are structure based and interaction of the system, but are limited to first neighbor connection only [74]. To avoid this gap, a prototype model is germinated based on the graph theory approach with the help of variable adjacency matrix and permanent function and it can include the interaction of the subsystem [59]. The prototype tool will be used for designing, evaluating and analyzing the manufacturing system at the conceptual stage. To stream line the process of manufacturing system, the prototype tool can be used for sustainable production [75].

2.5.1 Hierarchical Tree Structure of Manufacturing system

To define the elements of manufacturing system, the structure is divided into system, subsystem and sub subsystem at each level. Four level of tree structure is shown in Figure 2.7.

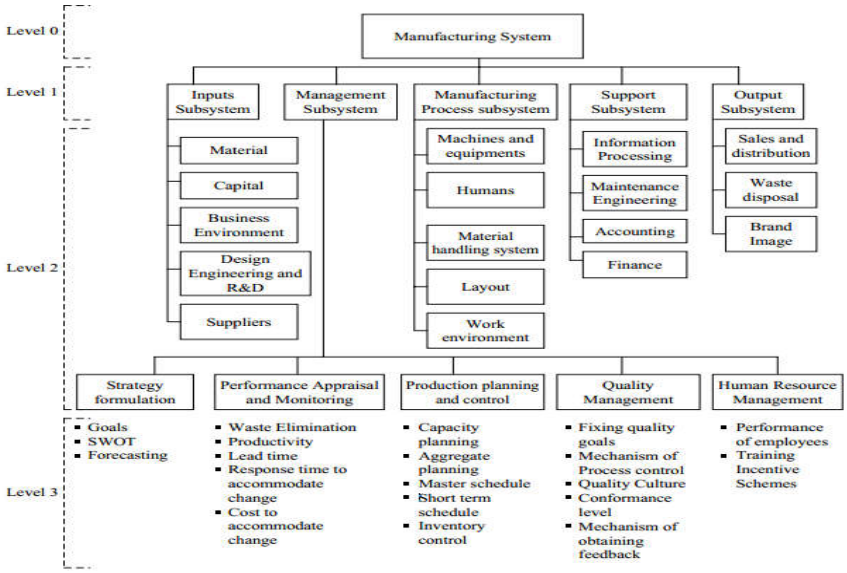

Figure 2.7 Hierarchical tree structure of Manufacturing system [77]

At level 0: the whole Manufacturing system, level 1: Sub systems are Input, Management, Manufacturing process, Support and output, level 2: Sub subsystem are Material, Capital, Business Environment, Design Engineering and R & D, suppliers, Strategy formulation Performance Appraisal and Monitoring, Production planning and

control, Quality management, Human Resource management etc, level 3: Goal, Forecasting, Waste Elimination, productivity, Lead Time, Capacity planning, Aggregate planning, Fixing Quality goals, Mechanism of Process control, Performance of employees, Training incentive Schemes [77]. After that the graph approach is used on the Manufacturing system which is shown in Figure 2.8 to evaluate the further process like variable adjacency matrix and permanent function.

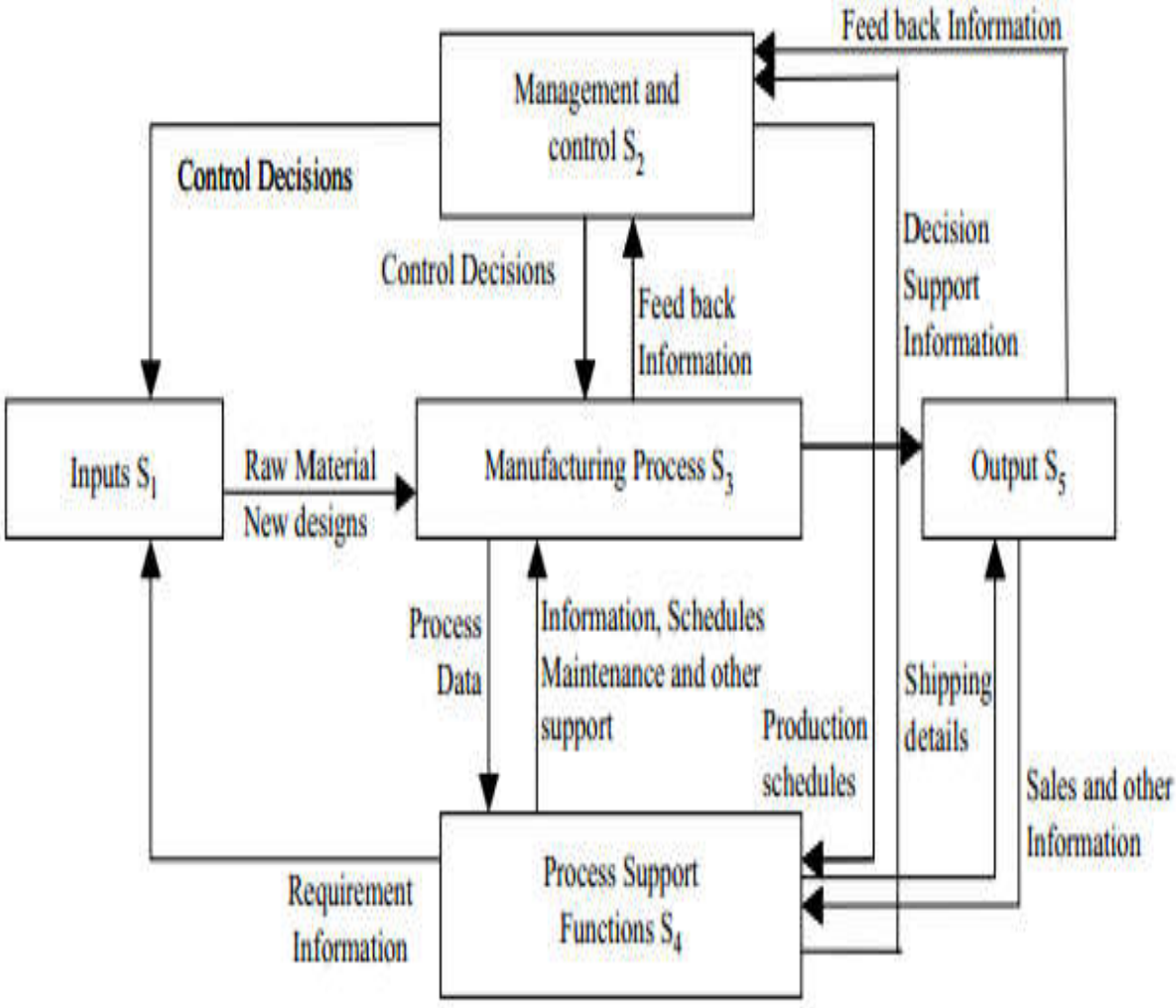

Figure 2.8 System Representation of Manufacturing system [77]

Chapter 3: Gap Analysis and Problem Statement

This chapter analyzes the previous work done in the field of privacy and security to iOS devices, gathers the research gaps and exemplifies it.

3.1 Gap Analysis

Following gaps have been identified based on literature review of privacy and security to iOS devices.

- At present, only Sandboxing profile is considered for the privacy and security to iOS devices.
- No Algorithm is used to check or verify the interconnection or connectivity between the components of the PSiOS devices.

3.2 Problem Statement

In PSiOS system, if its architecture is compromised then there is the possibility that the sensitive information of the user is corrupted or stolen. In PSiOS system there is a module known as CFG Generator, which checks the control flow graph of the application. If this modules is hacked or compromised and the control flow graph of the application is changed without any authorization then PSiOS architecture is damaged, means the connectivity of the modules is been changed. Therefore by using Structural Modeling for analysis and check the connectivity or interaction of the between the modules.

Chapter 4: Methodology

How structural Modeling is used in PSiOS system is illustrated in this chapter.

4.1 Methodology for the analysis the system

Step 1:- Consider the system. Examine the complete system and its subsystems, and also their interaction between the subsystems.

Step 2:- Germinate a block diagram of the system, considering its subsystem and interactions along with assumption, if any.

Step 3:- Germinate a systems graph of the system with its subsystems as nodes/vertices and edges for interconnection and connectivity between the nodes/vertices.

Step 4:- Germinate the matrix and multinomial representations of the system.

Step 5:- Evaluate functions/values of diagonal element from the permanent functions of distinct subsystems of the System and repeat steps 2-4 for each subsystem.

Step 6:- Identify the functions/values of diagonal elements at antithetic levels of hierarchy of the system.

4.2 Methodology is fully summarized in this section

4.2.1 Consider the PSiOS system; examine system and subsystem with their interaction.

The complete Architecture of PSiOS system shown in Figure 2.1 is studied and examined first, how the systems and subsystems are interacting with each other.

4.2.2 Germinate the block diagram of the PSiOS architecture with the proper connectivity of between the modules.

The appurtenances are linked together through different forms of bonding and interaction. These appurtenances and interaction forming a PSiOS system are shown in Figure 4.1. With the help schematic diagram, slabs shows appurtenance, line show connectivity/interaction. However, schematic diagram is a keen representation of PSiOS system for amended understanding of its structure but it is not mathematical entity. Hence

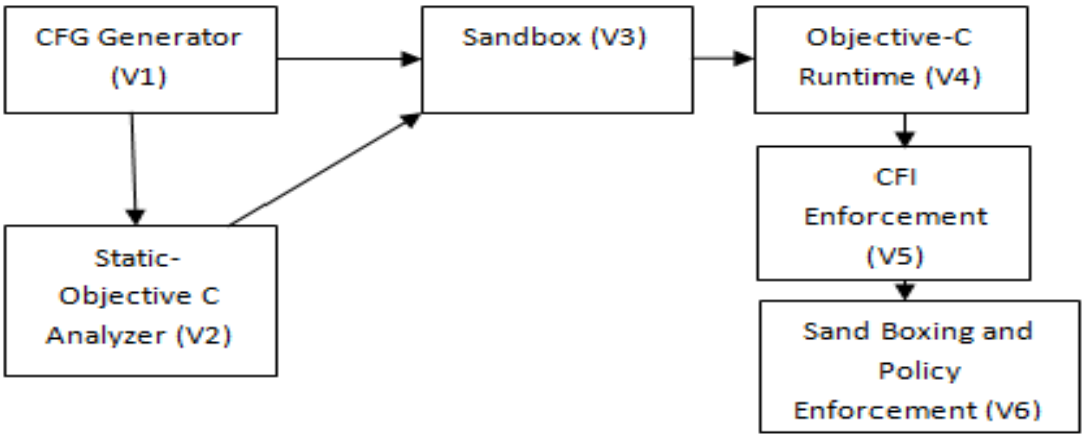

Figure 4.1 System Representation of PSiOS

it is impossible to gain antithetic result as no mathematical operation can be carried out. Schematic diagram is proposed to introduce a mathematical representation of PSiOS system in an endeavour to develop a system model for analysis and synthesis of the PSiOS system which will be profitable to carryout analysis of an existing product for the rectification and cost reduction. A graph G is an ordered pair G= (V, E) where 'V' is a finite set of element and 'E' is a set of 2-subsets of 'V'. For representing a PSiOS system, assuming the appurtenance of this system denoted by means of the Vertex set {V} of the graph and interaction among different appurtenance is denoted by Edge set {E}. By converting Directed edges into Undirected Edges by means of directional properties that represent the interaction between the edges.

There are six appurtenance (A1,A2,A3,A4,A5,A6) forming a PSiOS system shown Figure 4.1 and these are shown by six vertices (V1,V2,V3,V4,V5,V6) i.e. the appurtenance Ai is shown by the vertex Vi for germinating an algorithm.

The edge e_{ij} is used between the appurtenance A_i and A_j (between V_i and V_j) for the connection. With the help of $e_{ij}!=e_{ji}$, the PSiOS system has a graph theoretic representation because by assuming that all the six appurtenance are interacting with each other. The $e_{ij}! =e_{ji}$ means that their influences are not equal to each other. In case of $e_{ij}=e_{ji}$, while direction is not substantial, then used undirected graph of PSiOS system for the representation.

A PSiOS system consists of six subsystems i.e. CFG Generator, Static-Objective C Analyzer, Sandbox, Objective-C Runtime Analyzer, CFI Enforcement and Sandboxing and policy enforcement. The effect of one subsystem on another subsystem is also shown in Figure 4.1. By showing a numerical entity known as PSiOS system which is previously a non-numerical entity shown in Figure 4.2.

4.2.3 Germinate the Directed and Undirected Graph of the System Representation of PSiOS system.

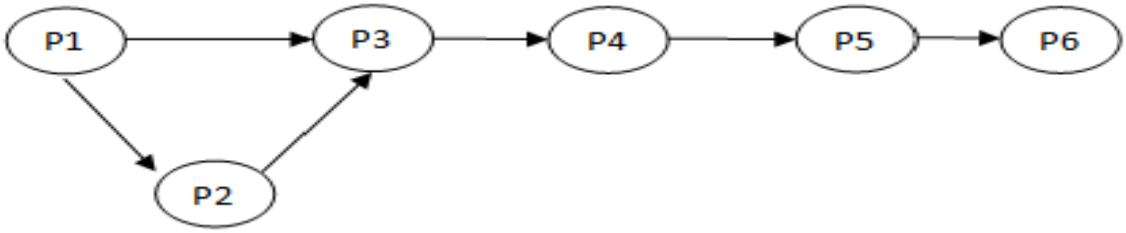

Figure 4.2 Directed Graph of PSiOS

Assuming that if not including the directional interaction i.e. $p_{ij}=p_{ji}$, then PSiOS system is represented by an undirected graph shown in Figure 4.3.

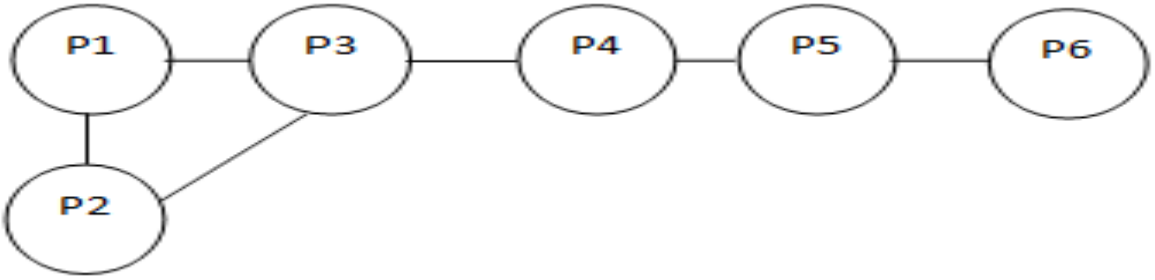

Figure 4.3 Undirected Graph of PSiOS

4.2.4 Germinate the Matrices and Multinomial representation of PSiOS

Steps to develop different matrices are as follows:

4.2.4.1 Develop a Matrix from Undirected Graph

Let us consider a matrix A= $[p_{ij}]$ where rows and columns are represented by the vertices or nodes of diagraph i.e. the p_{ij} represent the connectivity of one vertex to another vertex.

P_{ij} = {1, if one vertex is connected to another vertex

0, otherwise}

Equation 1

The diagraph shown in Figure 4.3 representing the matrix form of PSiOS system which is written as:

$$A = \begin{pmatrix} 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$

In the above matrix A, the value of p_{ij} i.e. p14, p15, p16, p24, p25, p26, p35, p36, p41, p42, p46, p51, p52, p53, p61, p62, p63, p64 are zero because there is no connectivity with each other and there is no dependency or interaction of the vertices itself therefore the diagonal element are zero. A characteristic matrix is defined, to characterize the PSiOS system.

4.2.4.2 Develop PSiOS Characteristics Matrix

Equation 2

Let consider 'P' as a variable representing the appurtenance of the PSiOS system and Identity matrix 'I'.

$$\text{Identity matrix, } I = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

The characteristics matrix B of the PSiOS system from the diagraph represent in Figure 4.3 is determined with the help of equation [(P *I)-A] where the value of 'A' is taken from Equation 1. PSiOS characteristics matrix, B= [(P*I)-A]

$$B = P * \begin{pmatrix} 1&0&0&0&0&0 \\ 0&1&0&0&0&0 \\ 0&0&1&0&0&0 \\ 0&0&0&1&0&0 \\ 0&0&0&0&1&0 \\ 0&0&0&0&0&1 \end{pmatrix} - \begin{pmatrix} 0&1&1&0&0&0 \\ 1&0&1&0&0&0 \\ 1&1&0&1&0&0 \\ 0&0&1&0&1&0 \\ 0&0&0&1&0&1 \\ 0&0&0&0&1&0 \end{pmatrix}$$

$$B = \begin{pmatrix} P&0&0&0&0&0 \\ 0&P&0&0&0&0 \\ 0&0&P&0&0&0 \\ 0&0&0&P&0&0 \\ 0&0&0&0&P&0 \\ 0&0&0&0&0&P \end{pmatrix} - \begin{pmatrix} 0&1&1&0&0&0 \\ 1&0&1&0&0&0 \\ 1&1&0&1&0&0 \\ 0&0&1&0&1&0 \\ 0&0&0&1&0&1 \\ 0&0&0&0&1&0 \end{pmatrix}$$

$$B = \begin{pmatrix} P&-1&-1&0&0&0 \\ -1&P&-1&0&0&0 \\ -1&-1&P&-1&0&0 \\ 0&0&-1&P&-1&0 \\ 0&0&0&-1&P&1 \\ 0&0&0&0&-1&P \end{pmatrix}$$

In above matrix B, all the diagonal elements values are same. The connectivity/interaction between the vertices/nodes have been assigned values of 0 and 1 depending on whether they are connected or not but it is not representing the varying degree of influence of one vertices/node over another vertices/node. To reckon this, PSiOS variable characteristics matrix is evaluated.

4.2.4.3 Develop PSiOS Variable Characteristics Matrix

Equation 3

Let consider a diagraph in Figure 4.3 for defining variable characteristics matrix of PSiOS system. Consider a square matrix C with off diagonal element from matrix A (Equation 1).

$$C = \begin{pmatrix} 0 & p12 & p13 & 0 & 0 & 0 \\ P21 & 0 & p23 & 0 & 0 & 0 \\ P31 & p32 & 0 & p34 & 0 & 0 \\ 0 & 0 & p43 & 0 & p45 & 0 \\ 0 & 0 & 0 & p54 & 0 & p56 \\ 0 & 0 & 0 & 0 & p65 & 0 \end{pmatrix}$$

P_{ij} represents the connectivity between the vertices/nodes of the diagraph. Assuming another matrix 'D' with only the diagonal element Pi where i=1, 2, 3, 4, 5, 6 representing the different subsystems.

$$D = \begin{pmatrix} P1 & 0 & 0 & 0 & 0 & 0 \\ 0 & P2 & 0 & 0 & 0 & 0 \\ 0 & 0 & P3 & 0 & 0 & 0 \\ 0 & 0 & 0 & P4 & 0 & 0 \\ 0 & 0 & 0 & 0 & P5 & 0 \\ 0 & 0 & 0 & 0 & 0 & P6 \end{pmatrix}$$

Considering Matrices 'C' and 'D' variable characteristics matrix of PSiOS system is expressed as H= [D-C].

$$H = \begin{pmatrix} P1 & -P12 & -P13 & 0 & 0 & 0 \\ -P21 & P2 & -P23 & 0 & 0 & 0 \\ -P31 & -P32 & P3 & -P34 & 0 & 0 \\ 0 & 0 & -P43 & P4 & -P45 & 0 \\ 0 & 0 & 0 & -P54 & P5 & -P56 \\ 0 & 0 & 0 & 0 & -P65 & P6 \end{pmatrix}$$

The complete information about all the six subsystem is authorized by the above matrix 'H'. For design, analysis and development, this data is efficacious for new PSiOS products for the purpose of optimization at different stages. The variable characteristics PSiOS polynomial is a matrix glut a regent tool through its determinant. It exemplifies the complete PSiOS system that shows the characteristics of the system by considering the interaction and effect of PSiOS subsystem.

The determinant of the matrix 'H', contains the negative and positive terms. The polynomial contains all the information of PSiOS system. Information will be lost, by replacing these terms with their mathematical values. Due to the additional and subtraction of mathematical values, the full information of the PSiOS system will get or will be lost by means of diagonal and off-diagonal elements. Thus, the matrix H, fails to provide the complete information under some certain condition. To avert the forfeit of structural information during the numerical process, another matrix is generated known as Variable Permanent Matrix.

4.2.4.4 Develop PSiOS Variable Permanent Matrix

Equation 4

Variable Permanent Matrix of PSiOS system is generated to avert the forfeit of structural information during the numerical process which is introduced from the Figure 4.1 and Figure 4.3. It is defined as

$$E=\begin{pmatrix} P1 & P12 & P13 & 0 & 0 & 0 \\ P21 & P2 & P23 & 0 & 0 & 0 \\ P31 & P32 & P3 & P34 & 0 & 0 \\ 0 & 0 & P43 & P4 & P45 & 0 \\ 0 & 0 & 0 & P54 & P5 & p56 \\ 0 & 0 & 0 & 0 & P65 & P6 \end{pmatrix}$$

In above Matrix E, the diagonal element exemplifies the six critical subsystems and the interaction between the subsystems is represented by the off-diagonal element.

4.2.4.5 Permanent Function Representation

These models can be changed by changing the name of nodes, therefore the representation of the matrix and diagraph are usual. A Permanent Function of the matrix is created to germinate a unique representation of PSiOS system. The process of the calculating the determinant and Permanent function from a matrix is same. The difference in Permanent Function and the determinant is that in Permanent Function; the negative sign is replaced by the positive sign but not in case of determinant. This mathematical process results in a multinomial (Equation 6), which has a physical significance of each and every terms of PSiOS system.

The Variable Permanent Function for PSiOS system is (Equation 5)

$$\begin{aligned}Per\ (p) = {} & ((((P_6*P_5-P_{65}*P_{56})*P_4+((-P_6*P_{54}+P_{64}*P_{56})*P_{45}+(P_{65}*P_{54}-P_{64}*P_5)*P_{46}))*P_3+(((-P_6*P_5+P_{65}*P_{56})*P_{43}+((P_6*P_{53}-P_{63}*P_{56})*P_{45}+(-P_{65}*P_{53}+P_{63}*P_5)*P_{46}))*P_{34}+(((P_6*P_{54}-P_{64}*P_{56})*P_{43}+((P_6*P_{53}+P_{63}*P_{56})*P_4+(P_{64}*P_{53}-P_{63}*P_{54})*P_{46}))*P_{35}+((P_{65}*P_{54}+P_{64}*P_5)*P_{43}+((P_{65}*P_{53}-P_{63}*P_5)*P_4+(-P_{64}*P_{53}+P_{63}*P_{54})*P_{45}))*P_{36})))*P_2+((((-P_6*P_5+P_{65}*P_{56})*P_4+((P_6*P_{54}-P_{64}*P_{56})*P_{45}+(-P_{65}*P_{54}+P_{64}*P_5)*P_{46}))*P_{32}+(((P_6*P_5-P_{65}*P_{56})*P_{42}+((-P_6*P_{52}+P_{62}*P_{56})*P_{45}+(P_{65}*P_{52}-P_{62}*P_5)*P_{46}))*P_{34}+(((-P_6*P_{54}+P_{64}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_4+(-P_{64}*P_{52}+P_{62}*P_{54})*P_{46}))*P_{35}+((P_{65}*P_{54}-P_{64}*P_5)*P_{42}+((-P_{65}*P_{52}+P_{62}*P_5)*P_4+(P_{64}*P_{52}-P_{62}*P_{54})*P_{45}))*P_{36})))*P_{23}+((((P_6*P_5-P_{65}*P_{56})*P_{43}+((-P_6*P_{53}+P_{63}*P_{56})*P_{45}+(P_{65}*P_{53}-P_{63}*P_5)*P_{46}))*P_{32}+((-P_6*P_5+P_{65}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_{45}+(-P_{65}*P_{52}+P_{62}*P_5)*P_{46}))*P_3+((P_6*P_{53}-P_{63}*P_{56})*P_{42}+((-P_6*P_{52}+P_{62}*P_{56})*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_{46}))*P_{35}+((-P_{65}*P_{53}+P_{63}*P_5)*P_{42}+((P_{65}*P_{52}-P_{62}*P_5)*P_{43}+(P_{63}*P_{52}+P_{62}*P_{53})*P_{45}))*P_{36}))*P_{24}+((((-P_6*P_{54}+P_{64}*P_{56})*P_{43}+((P_6*P_{53}-P_{63}*P_{56})*P_4+(-P_{64}*P_{53}+P_{63}*P_{54})*P_{46}))*P_{32}+(((P_6*P_{54}-P_{64}*P_{56})*P_{42}+((-P_6*P_{52}+P_{62}*P_{56})*P_4+(P_{64}*P_{52}-P_{62}*P_{54})*P_{46}))*P_3+(((-P_6*P_{53}+P_{63}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_{43}+(-P_{63}*P_{52}+P_{62}*P_{53})*P_{46}))*P_{34}+((P_{64}*P_{53}-P_{63}*P_{54})*P_{42}+((-P_{64}*P_{52}+P_{62}*P_{54})*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_4))*P_{36})))*P_{25}+(((P_{65}*P_{54}-P_{64}*P_5)*P_{43}+((-P_{65}*P_{53}+P_{63}*P_5)*P_4+(P_{64}*P_{53}-P_{63}*P_{54})*P_{45}))*P_{32}+(((-P_{65}*P_{54}+P_{64}*P_5)*P_{42}+((P_{65}*P_{52}-P_{62}*P_5)*P_4+(-P_{64}*P_{52}+P_{62}*P_{54})*P_{45}))*P_3+(((P_{65}*P_{53}-P_{63}*P_5)*P_{42}+((-P_{65}*P_{52}+P_{62}*P_5)*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_{45}))*P_{34}+((-P_{64}*P_{53}+P_{63}*P_{54})*P_{42}+((P_{64}*P_{52}-P_{62}*P_{54})*P_{43}+(-P_{63}*P_{52}+P_{62}*P_{53})*P_4))*P_{35})))*P_{26})))*P_1+((((-P_6*P_5+P_{65}*P_{56})*P_4+((P_6*P_{54}-P_{64}*P_{56})*P_{45}+(-P_{65}*P_{54}+P_{64}*P_5)*P_{46}))*P_3+(((P_6*P_5-P_{65}*P_{56})*P_{43}+((-P_6*P_{53}+P_{63}*P_{56})*P_{45}+(P_{65}*P_{53}-P_{63}*P_5)*P_{46}))*P_{34}+(((-P_6*P_{54}+P_{64}*P_{56})*P_{43}+((P_6*P_{53}-P_{63}*P_{56})\end{aligned}$$

$$*P_4+(-P_{64}*P_{53}+P_{63}*P_{54})*P_{46}))*P_{35}+((P_{65}*P_{54}-P_{64}*P_5)*P_{43}+((-P_{65}*P_{53}+P_{63}*P_5)*P_4+(P_{64}*P_{53}$$
$$-P_{63}*P_{54})*P_{45}))*P_{36})))*P_{21}+((((P_6*P_5-P_{65}*P_{56})*P_4+((-P_6*P_{54}+P_{64}*P_{56})*P_{45}+(P_{65}*P_{54}-P_{64}*$$
$$P_5)*P_{46}))*P_{31}+(((-P_6*P_5+P_{65}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_{45}+(-P_{65}*P_{51}+P_{61}*P_5)*P_{46})$$
$$)*P_{34}+(((P_6*P_{54}-P_{64}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_4+(P_{64}*P_{51}-P_{61}*P_{54})*P_{46}))*P_{35}+((-P_{65}*$$
$$P_{54}+P_{64}*P_5)*P_{41}+((P_{65}*P_{51}-P_{61}*P_5)*P_4+(-P_{64}*P_{51}+P_{61}*P_{54})*P_{45}))*P_{36})))*P_{23}+((((-P_6*P_5+$$
$$P_{65}*P_{56})*P_{43}+((P_6*P_{53}-P_{63}*P_{56})*P_{45}+(-P_{65}*P_{53}+P_{63}*P_5)*P_{46}))*P_{31}+(((P_6*P_5-P_{65}*P_{56})*P_{41}+$$
$$((-P_6*P_{51}+P_{61}*P_{56})*P_{45}+(P_{65}*P_{51}-P_{61}*P_5)*P_{46}))*P_3+(((-P_6*P_{53}+P_{63}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}$$
$$*P_{56})*P_{43}+(-P_{63}*P_{51}+P_{61}*P_{53})*P_{46}))*P_{35}+((P_{65}*P_{53}-P_{63}*P_5)*P_{41}+((-P_{65}*P_{51}+P_{61}*P_5)*P_{43}+$$
$$(P_{63}*P_{51}-P_{61}*P_{53})*P_{45}))*P_{36})))*P_{24}+((((P_6*P_{54}-P_{64}*P_{56})*P_{43}+((-P_6*P_{53}+P_{63}*P_{56})*P_4+(P_{64}*$$
$$P_{53}-P_{63}*P_{54})*P_{46}))*P_{31}+(((-P_6*P_{54}+P_{64}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_4+(-P_{64}*P_{51}+P_{61}*P_{54})$$
$$*P_{46}))*P_3+(((P_6*P_{53}-P_{63}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_{43}+(P_{63}*P_{51}-P_{61}*P_{53})*P_{46}))*P_{34}+((($$
$$-P_{64}*P_{53}+P_{63}*P_{54})*P_{41}+((P_{64}*P_{51}-P_{61}*P_{54})*P_{43}+(-P_{63}*P_{51}+P_{61}*P_{53})*P_4))*P_{36})))*P_{25}+(((-P_{65}$$
$$*P_{54}+P_{64}*P_5)*P_{43}+((P_{65}*P_{53}-P_{63}*P_5)*P_4+(-P_{64}*P_{53}+P_{63}*P_{54})*P_{45}))*P_{31}+(((P_{65}*P_{54}-P_{64}*P_5)$$
$$*P_{41}+((-P_{65}*P_{51}+P_{61}*P_5)*P_4+(P_{64}*P_{51}-P_{61}*P_{54})*P_{45}))*P_3+(((-P_{65}*P_{53}+P_{63}*P_5)*P_{41}+((P_{65}*$$
$$P_{51}-P_{61}*P_5)*P_{43}+(-P_{63}*P_{51}+P_{61}*P_{53})*P_{45}))*P_{34}+((P_{64}*P_{53}-P_{63}*P_{54})*P_{41}+((-P_{64}*P_{51}+P_{61}*P_{54}$$
$$)*P_{43}+(P_{63}*P_{51}-P_{61}*P_{53})*P_4))*P_{35})))*P_{26})))*P_{12}+((((P_6*P_5-P_{65}*P_{56})*P_4+((-P_6*P_{54}+P_{64}*P_{56}$$
$$)*P_{45}+(P_{65}*P_{54}-P_{64}*P_5)*P_{46}))*P_{32}+(((-P_6*P_5+P_{65}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_{45}+(-P_{65}*$$
$$P_{52}+P_{62}*P_5)*P_{46}))*P_{34}+(((P_6*P_{54}-P_{64}*P_{56})*P_{42}+((-P_6*P_{52}+P_{62}*P_{56})*P_4+(P_{64}*P_{52}-P_{62}*P_{54})*$$
$$P_{46}))*P_{35}+((-P_{65}*P_{54}+P_{64}*P_5)*P_{42}+((P_{65}*P_{52}-P_{62}*P_5)*P_4+(-P_{64}*P_{52}+P_{62}*P_{54})*P_{45}))*P_{36})))*$$
$$P_{21}+((((-P_6*P_5+P_{65}*P_{56})*P_4+((P_6*P_{54}-P_{64}*P_{56})*P_{45}+(-P_{65}*P_{54}+P_{64}*P_5)*P_{46}))*P_{31}+(((P_6*P_5$$
$$-P_{65}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_{45}+(P_{65}*P_{51}-P_{61}*P_5)*P_{46}))*P_{34}+(((-P_6*P_{54}+P_{64}*P_{56})*$$
$$P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_4+(-P_{64}*P_{51}+P_{61}*P_{54})*P_{46}))*P_{35}+((P_{65}*P_{54}-P_{64}*P_5)*P_{41}+((-P_{65}*P_{51}$$
$$+P_{61}*P_5)*P_4+(P_{64}*P_{51}-P_{61}*P_{54})*P_{45}))*P_{36})))*P_2+((((P_6*P_5-P_{65}*P_{56})*P_{42}+((-P_6*P_{52}+P_{62}*$$
$$P_{56})*P_{45}+(P_{65}*P_{52}-P_{62}*P_5)*P_{46}))*P_{31}+(((-P_6*P_5+P_{65}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_{45}+(-P_{65}$$
$$*P_{51}+P_{61}*P_5)*P_{46}))*P_{32}+(((P_6*P_{52}-P_{62}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52}$$
$$)*P_{46}))*P_{35}+((-P_{65}*P_{52}+P_{62}*P_5)*P_{41}+((P_{65}*P_{51}-P_{61}*P_5)*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_{45}))*P_{36})$$
$$))*P_{24}+((((-P_6*P_{54}+P_{64}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_4+(-P_{64}*P_{52}+P_{62}*P_{54})*P_{46}))*P_{31}+$$
$$(((P_6*P_{54}-P_{64}*P_{56})*P_{41}+((P_6*P_{51}+P_{61}*P_{56})*P_4+(P_{64}*P_{51}-P_{61}*P_{54})*P_{46}))*P_{32}+(((-P_6*P_{52}+P_{62}$$
$$*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_{46}))*P_{34}+((P_{64}*P_{52}-P_{62}*P_{54})*P_{41}+(($$
$$-P_{64}*P_{51}+P_{61}*P_{54})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_4))*P_{36})))*P_{25}+(((P_{65}*P_{54}-P_{64}*P_5)*P_{42}+((-P_{65}*$$

$P_{52}+P_{62}*P_5)*P_4+(P_{64}*P_{52}-P_{62}*P_{54})*P_{45}))*P_{31}+(((-P_{65}*P_{54}+P_{64}*P_5)*P_{41}+((P_{65}*P_{51}-P_{61}*P_5)*$
$P_4+(-P_{64}*P_{51}+P_{61}*P_{54})*P_{45}))*P_{32}+(((P_{65}*P_{52}-P_{62}*P_5)*P_{41}+((-P_{65}*P_{51}+P_{61}*P_5)*P_{42}+(P_{62}*$
$P_{51}-P_{61}*P_{52})*P_{45}))*P_{34}+((-P_{64}*P_{52}+P_{62}*P_{54})*P_{41}+((P_{64}*P_{51}-P_{61}*P_{54})*P_{42}+(-P_{62}*P_{51}+P_{61}*$
$P_{52})*P_4))*P_{35})))*P_{26})))*P_{13}+((((-P_6*P_5+P_{65}*P_{56})*P_{43}+((P_6*P_{53}-P_{63}*P_{56})*P_{45}+(-P_{65}*P_{53}+$
$P_{63}*P_5)*P_{46}))*P_{32}+(((P_6*P_5-P_{65}*P_{56})*P_{42}+((-P_6*P_{52}+P_{62}*P_{56})*P_{45}+(P_{65}*P_{52}-P_{62}*P_5)*P_{46}))*$
$P_3+(((-P_6*P_{53}+P_{63}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_{43}+(P_{63}*P_{52}+P_{62}*P_{53})*P_{46}))*P_{35}+((P_{65}*$
$P_{53}-P_{63}*P_5)*P_{42}+((-P_{65}*P_{52}+P_{62}*P_5)*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_{45}))*P_{36})))*P_{21}+((((P_6*P_5-P_{65}$
$*P_{56})*P_{43}+((-P_6*P_{53}+P_{63}*P_{56})*P_{45}+(P_{65}*P_{53}-P_{63}*P_5)*P_{46}))*P_{31}+(((-P_6*P_5+P_{65}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_{45}+(-P_{65}*P_{51}+P_{61}*P_5)*P_{46}))*P_3+(((P_6*P_{53}-P_{63}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_{43}+(P_{63}*P_{51}-P_{61}*P_{53})*P_{46}))*P_{35}+((-P_{65}*P_{53}+P_{63}*P_5)*P_{41}+((P_{65}*P_{51}-P_{61}*P_5)*P_{43}+(-P_{63}*P_{51}+P_{61}*P_{53})*P_{45}))*P_{36})))*P_2+((((-P_6*P_5+P_{65}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_{45}+(-P_{65}*P_{52}+P_{62}*P_5)*P_{46}))*P_{31}+(((P_6*P_5-P_{65}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_{45}+(P_{65}*P_{51}-P_{61}*P_5)*P_{46}))*P_{32}+(((-P_6*P_{52}+P_{62}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_{46}))*P_{35}+((P_{65}*P_{52}-P_{62}*P_5)*P_{41}+((-P_{65}*P_{51}+P_{61}*P_5)*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_{45}))*P_{36})))*P_{23}+((((P_6*P_{53}-P_{63}*P_{56})*P_{42}+((-P_6*P_{52}+P_{62}*P_{56})*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_{46}))*P_{31}+(((-P_6*P_{53}+P_{63}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_{43}+(P_{63}*P_{51}+P_{61}*P_{53})*P_{46}))*P_{32}+(((P_6*P_{52}-P_{62}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_{46}))*P_3+((-P_{63}*P_{52}+P_{62}*P_{53})*P_{41}+((P_{63}*P_{51}-P_{61}*P_{53})*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_{43}))*P_{36})))*P_{25}+(((-P_{65}*P_{53}+P_{63}*P_5)*P_{42}+((P_{65}*P_{52}-P_{62}*P_5)*P_{43}+(-P_{63}*P_{52}+P_{62}*P_{53})*P_{45}))*P_{31}+(((P_{65}*P_{53}-P_{63}*P_5)*P_{41}+((-P_{65}*P_{51}+P_{61}*P_5)*P_{43}+(P_{63}*P_{51}-P_{61}*P_{53})*P_{45}))*P_{32}+(((-P_{65}*P_{52}+P_{62}*P_5)*P_{41}+((P_{65}*P_{51}-P_{61}*P_5)*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_{45}))*P_3+((P_{63}*P_{52}-P_{62}*P_{53})*P_{41}+((-P_{63}*P_{51}+P_{61}*P_{53})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_{43}))*P_{35})))*P_{26})))*P_{14}+((((P_6*P_{54}-P_{64}*P_{56})*P_{43}+((-P_6*P_{53}+P_{63}*P_{56})*P_4+(P_{64}*P_{53}-P_{63}*P_{54})*P_{46}))*P_{32}+(((-P_6*P_{54}+P_{64}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_4+(-P_{64}*P_{52}+P_{62}*P_{54})*P_{46}))*P_3+(((P_6*P_{53}-P_{63}*P_{56})*P_{42}+((P_6*P_{52}+P_{62}*P_{56})*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_{46}))*P_{34}+((-P_{64}*P_{53}+P_{63}*P_{54})*P_{42}+((P_{64}*P_{52}-P_{62}*P_{54})*P_{43}+(-P_{63}*P_{52}+P_{62}*P_{53})*P_4))*P_{36})))*P_{21}+((((-P_6*P_{54}+P_{64}*P_{56})*P_{43}+((P_6*P_{53}-P_{63}*P_{56})*P_4+(-P_{64}*P_{53}+P_{63}*P_{54})*P_{46}))*P_{31}+(((P_6*P_{54}-P_{64}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_4+(P_{64}*P_{51}-P_{61}*P_{54})*P_{46}))*P_3+(((-P_6*P_{53}+P_{63}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_{43}+(-P_{63}*P_{51}+P_{61}*P_{53})*P_{46}))*P_{34}+((P_{64}*P_{53}-P_{63}*P_{54})*P_{41}+((-P_{64}*P_{51}+P_{61}*P_{54})*P_{43}+(P_{63}*P_{51}-P_{61}*P_{53})*P_4))*P_{36})))*P_2+((((P_6*P_{54}-P_{64}*P_{56})*P_{42}+((-P_6*P_{52}+P_{62}*P_{56})*P_4+(P_{64}*P_{52}-P_{62}*P_{54})*P_{46}))*P_{31}+(((-P_6*P_{54}+P_{64}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_4+(-P_{64}*P_{51}+P_{61}*P_{54})*P_{46}))*P_{32}+((

$(P_6*P_{52}-P_{62}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_{46}))*P_{34}+((-P_{64}*P_{52}+P_{62}*P_{54})*P_{41}+((P_{64}*P_{51}-P_{61}*P_{54})*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_4))*P_{36})))*P_{23}+((((-P_6*P_{53}+P_{63}*P_{56})*P_{42}+((P_6*P_{52}-P_{62}*P_{56})*P_{43}+(-P_{63}*P_{52}+P_{62}*P_{53})*P_{46}))*P_{31}+(((P_6*P_{53}P_{63}*P_{56})*P_{41}+((-P_6*P_{51}+P_{61}*P_{56})*P_{43}+(P_{63}*P_{51}-P_{61}*P_{53})*P_{46}))*P_{32}+(((-P_6*P_{52}+P_{62}*P_{56})*P_{41}+((P_6*P_{51}-P_{61}*P_{56})*P_{42}+(P_{62}*P_{51}+P_{61}*P_{52})*P_{46}))*P_3+((P_{63}*P_{52}-P_{62}*P_{53})*P_{41}+((-P_{63}*P_{51}+P_{61}*P_{53})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_{43}))*P_{36})))*P_{24}+(((P_{64}*P_{53}-P_{63}*P_{54})*P_{42}+((-P_{64}*P_{52}+P_{62}*P_{54})*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_4))*P_{31}+(((-P_{64}*P_{53}+P_{63}*P_{54})*P_{41}+((P_{64}*P_{51}-P_{61}*P_{54})*P_{43}+(-P_{63}*P_{51}+P_{61}*P_{53})*P_4))*P_{32}+(((P_{64}*P_{52}-P_{62}*P_{54})*P_{41}+((-P_{64}*P_{51}+P_{61}*P_{54})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_4))*P_3+((-P_{63}*P_{52}+P_{62}*P_{53})*P_{41}+((P_{63}*P_{51}-P_{61}*P_{53})*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_{43}))*P_{34})))*P_{26}))))*P_{15}+((((-P_{65}*P_{54}+P_{64}*P_5)*P_{43}+((P_{65}*P_{53}-P_{63}*P_5)*P_4+(-P_{64}*P_{53}+P_{63}*P_{54})*P_{45}))*P_{32}+(((P_{65}*P_{54}-P_{64}*P_5)*P_{42}+((-P_{65}*P_{52}+P_{62}*P_5)*P_4+(P_{64}*P_{52}-P_{62}*P_{54})*P_{45}))*P_3+(((-P_{65}*P_{53}+P_{63}*P_5)*P_{42}+((P_{65}*P_{52}-P_{62}*P_5)*P_{43}+(-P_{63}*P_{52}+P_{62}*P_{53})*P_{45}))*P_{34}+((P_{64}*P_{53}-P_{63}*P_{54})*P_{42}+((-P_{64}*P_{52}+P_{62}*P_{54})*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_4))*P_{35})))*P_{21}+((((P_{65}*P_{54}-P_{64}*P_5)*P_{43}+((-P_{65}*P_{53}+P_{63}*P_5)*P_4+(P_{64}*P_{53}-P_{63}*P_{54})*P_{45}))*P_{31}+(((-P_{65}*P_{54}+P_{64}*P_5)*P_{41}+((P_{65}*P_{51}-P_{61}*P_5)*P_4+(P_{64}*P_{51}+P_{61}*P_{54})*P_{45}))*P_3+(((P_{65}*P_{53}-P_{63}*P_5)*P_{41}+((-P_{65}*P_{51}+P_{61}*P_5)*P_{43}+(P_{63}*P_{51}-P_{61}*P_{53})*P_{45}))*P_{34}+((-P_{64}*P_{53}+P_{63}*P_{54})*P_{41}+((P_{64}*P_{51}-P_{61}*P_{54})*P_{43}+(-P_{63}*P_{51}+P_{61}*P_{53})*P_4))*P_{35})))*P_2+((((-P_{65}*P_{54}+P_{64}*P_5)*P_{42}+((P_{65}*P_{52}-P_{62}*P_5)*P_4+(-P_{64}*P_{52}+P_{62}*P_{54})*P_{45}))*P_{31}+(((P_{65}*P_{54}-P_{64}*P_5)*P_{41}+((-P_{65}*P_{51}+P_{61}*P_5)*P_4+(P_{64}*P_{51}-P_{61}*P_{54})*P_{45}))*P_{32}+(((-P_{65}*P_{52}+P_{62}*P_5)*P_{41}+((P_{65}*P_{51}-P_{61}*P_5)*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_{45}))*P_{34}+((P_{64}*P_{52}-P_{62}*P_{54})*P_{41}+((-P_{64}*P_{51}+P_{61}*P_{54})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_4))*P_{35})))*P_{23}+((((P_{65}*P_{53}-P_{63}*P_5)*P_{42}+((-P_{65}*P_{52}+P_{62}*P_5)*P_{43}+(P_{63}*P_{52}-P_{62}*P_{53})*P_{45}))*P_{31}+(((-P_{65}*P_{53}+P_{63}*P_5)*P_{41}+((P_{65}*P_{51}-P_{61}*P_5)*P_{43}+(-P_{63}*P_{51}+P_{61}*P_{53})*P_{45}))*P_{32}+(((P_{65}*P_{52}-P_{62}*P_5)*P_{41}+((-P_{65}*P_{51}+P_{61}*P_5)*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_{45}))*P_3+((-P_{63}*P_{52}+P_{62}*P_{53})*P_{41}+((P_{63}*P_{51}-P_{61}*P_{53})*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_{43}))*P_{35})))*P_{24}+(((-P_{64}*P_{53}+P_{63}*P_{54})*P_{42}+((P_{64}*P_{52}-P_{62}*P_{54})*P_{43}+(-P_{63}*P_{52}+P_{62}*P_{53})*P_4))*P_{31}+(((P_{64}*P_{53}-P_{63}*P_{54})*P_{41}+((-P_{64}*P_{51}+P_{61}*P_{54})*P_{43}+(P_{63}*P_{51}-P_{61}*P_{53})*P_4))*P_{32}+(((-P_{64}*P_{52}+P_{62}*P_{54})*P_{41}+((P_{64}*P_{51}-P_{61}*P_{54})*P_{42}+(-P_{62}*P_{51}+P_{61}*P_{52})*P_4))*P_3+((P_{63}*P_{52}-P_{62}*P_{53})*P_{41}+((-P_{63}*P_{51}+P_{61}*P_{53})*P_{42}+(P_{62}*P_{51}-P_{61}*P_{52})*P_{43}))*P_{34})))*P_{25})))*P_{16}$

The equation above is germinated for six subsystem of the PSiOS system which contain 720 terms. But it is reduced to minimum terms because the variables P_{35}, P_{36} ,P_{41} ,P_{42} ,$P_{46,}$

P_{51} ,P_{52} .P_{53} ,P_{61} ,P_{62} ,P_{63} ,P_{64} ,P_{14} ,P_{15} ,P_{16} ,P_{24} ,P_{25} and P_{26} are 0 which means that there is no connectivity or the interaction are missing.

The Variable Permanent Function for PSiOS system is (Equation 6)

Per (E) =$P_1*P_2*P_3*P_4*P_5*P_6-P_1*P_2*P_3*P_4*P^2_{56}-P_1*P_2*P_3*P^2_{45}*P_6+P_1*P_2*P^2_{34}*P^2_{56}-P_1*P_2*P^2_{34}*P_5*P_6+P_1*P^2_{23}*P_4*P^2_{56}-P_1*P^2_{23}*P_4*P_5*P_6-P_1*P^2_{23}*P^2_{45}*P_6+P^2_{12}*P_3*P_4*P^2_{56}-P^2_{12}*P_3*P_4*P_5*P_6+P^2_{12}*P_3*P^2_{54}*P_6+P^2_{12}*P^2_{34}*P_5*P_6-P^2_{12}*P^2_{34}*P^2_{56}+P_{12}*P_{23}*P_{31}*P_4*P_5*P_6-P_{12}*P_{23}*P_{31}*P_4*P^2_{56}-P_{12}*P_{23}*P_{31}*P^2_{45}*P_6+P_{13}*P_{21}*P_{32}*P_4*P_5*P_6-P_{13}*P_{21}*P_{34}*P_4*P^2_{56}-P_{13}*P_{21}*P_{32}*P^2_{54}*P_6 +P^2_{13}*P_2*P^2_{45}*P_6$

The above equation is unambiguously representing the PSiOS system. The standard form as (N+1) groups is written with the help of Permanent Function of Equation (6). The complete analysis of PSiOS system is done with the help of this multinomial at the different level. Among the various subsystems of the PSiOS, it helps in determining the design attributes, process parameter and different appurtenance.

Group 1:- It contain only 1 term of six vertices i.e. six subsystems are independent constituents.

Group 2:- Subsystem has no connectivity with itself therefore this group is empty.

Group 3:- Include 5 terms; each term has a set of two subsystems loop i.e. P_{ij}, P_{ji} and the three independent subsystems.

Group 4:- Include 2 terms; each term has a set of three-subsystem loop and three independent subsystems.

Group 5:- Include 7 terms; each term is a subset of two subsystem loops and two independent subsystems.

Group 6 has two subgroups:- Group 6(i) include 3 terms, each terms has a set of three-subsystem loop, two subsystem loop and one independent subsets while Group 6(ii) include only one term i.e. two-subsystem loop, connectivity of three subsystem and one independent subsystem.

Group 7:-Include only one term i.e. three subsystem loop and zero independent subsystems.

Generally, Permanent Function of Six subsystem will have !6 i.e. 720 terms arranged in (N+1) group.

Figure 4.4 gives the graphical representation for Equation 6 for improvement, analysis and Visual understanding of a PSiOS system.

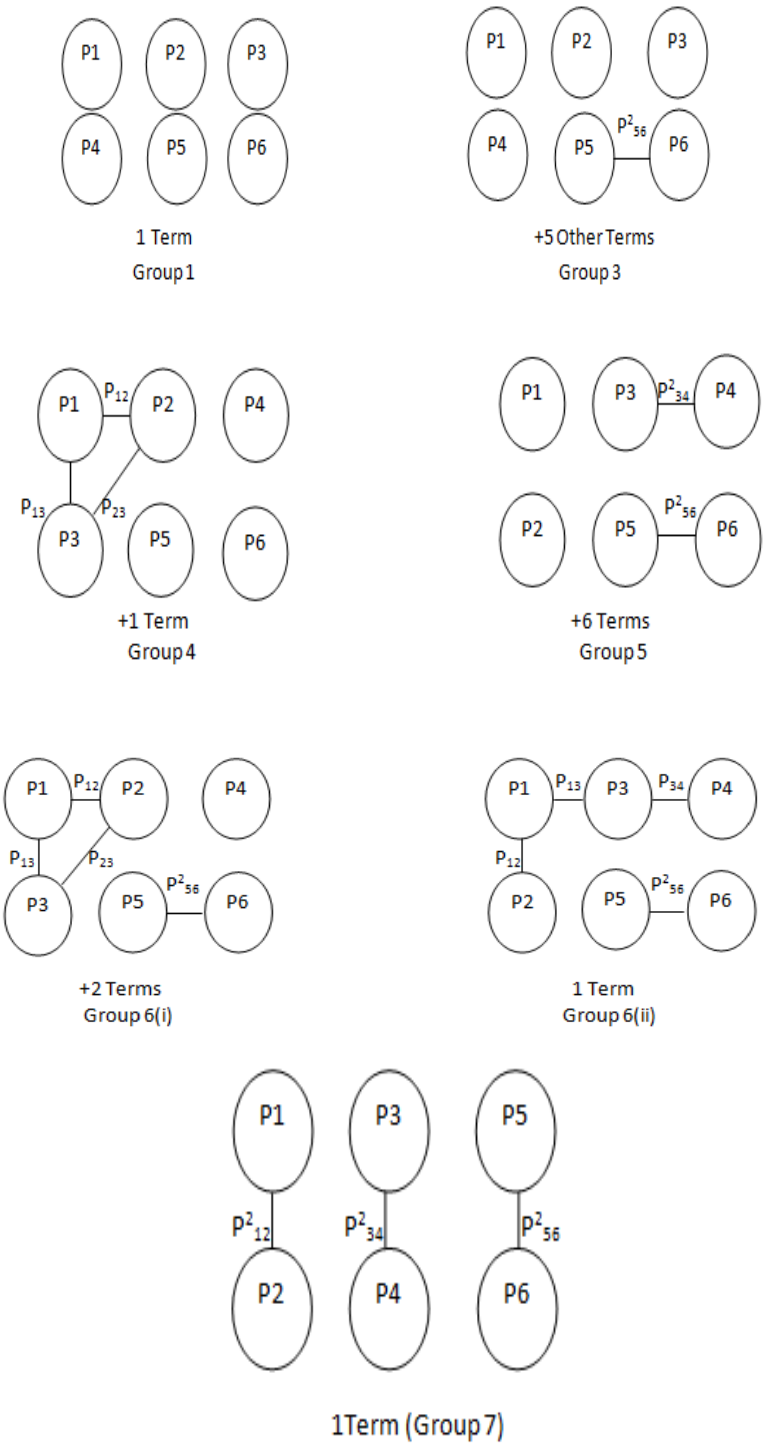

Figure 4.4 Undirected Sub-Graph groups of PSiOS

Now compare the generated undirected graph with the Original undirected graph of the system (PSiOS), means that the adding the graph of the groups with each other and then try to make the original graph and compare with the undirected original graph with respect to the nodes and edges.

Now consider the terms from different groups. Let take the term $p_1p_2p_3p_4p^2_{56}$ from group 3 (Figure 4.5) and the term $p_1p_2p^2_{34}p^2_{56}$ from group 5 (Figure 4.6) and add them. Graphical representations of these terms are given below.

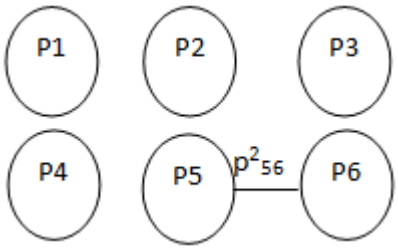

Figure 4.5 Undirected Sub Graph of term $p_1p_2p_3p_4p^2_{56}$

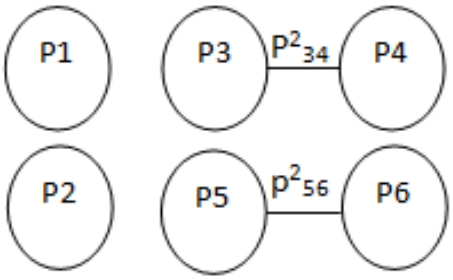

Figure 4.6 Undirected Sub Graph term $p_1p_2p^2_{34}p^2_{56}$

Adding these terms will generate a new graph for comparing with the original graph of the PSiOS system.

Generated New Graph ‘C1’ is

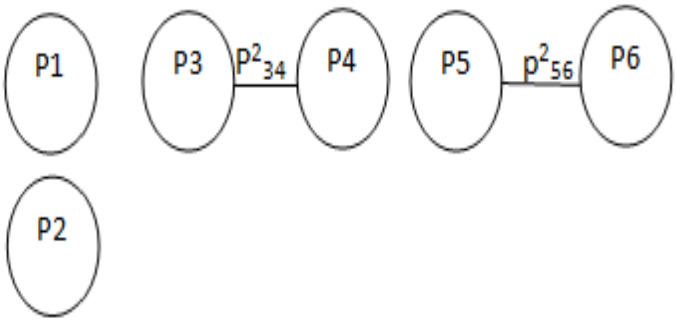

Figure 4.7 Undirected Graph ‘C1’

New Graph ‘C1’ is germinated with the help of 12 nodes and 6 edges. Now this new graph is compared with the original graph of the PSiOS system which is shown in Figure 4.3.

By comparing, new Graph ‘C1’ doesn’t match with the original graph. So the addition of term $p_1p_2p_3p_4p^2_{56}$ and term $p_1p_2p^2_{34}p^2_{56}$ doesn’t work. Now consider the other two terms from different groups; let consider the term $p_1p_2p^2_{34}p^2_{56}$ from group 5 (Figure 4.8) and term $p_{12}p_{31}p_{23}p^2_{45}p_6$ (Figure 4.9) from group 6(i) and add them.

Graphical Representation is of these terms are as below:

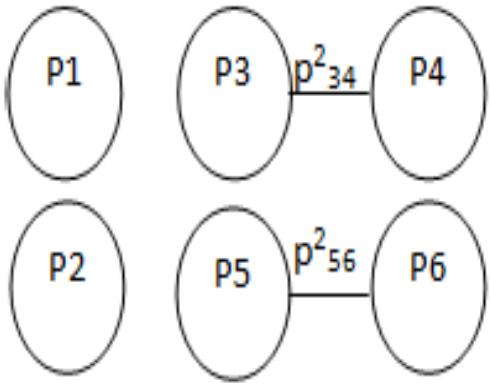

Figure 4.8 Undirected Sub Graph of term $p_1p_2p^2_{34}p^2_{56}$

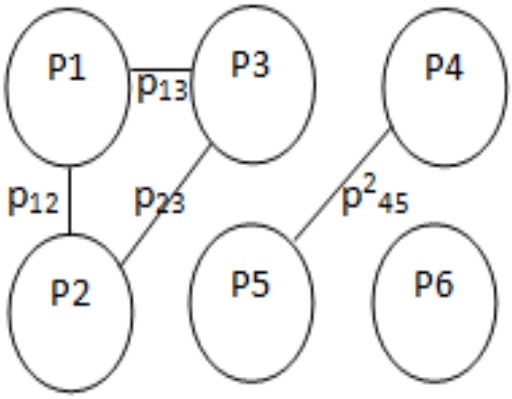

Figure 4.9 Undirected Sub Graph of term $p_{12}p_{31}p_{23}p^2_{45}p_6$

Adding these terms will generate a New Graph ‘C2’ for comparing with the original graph of the PSiOS system.

Generated New Graph ‘C2’ is

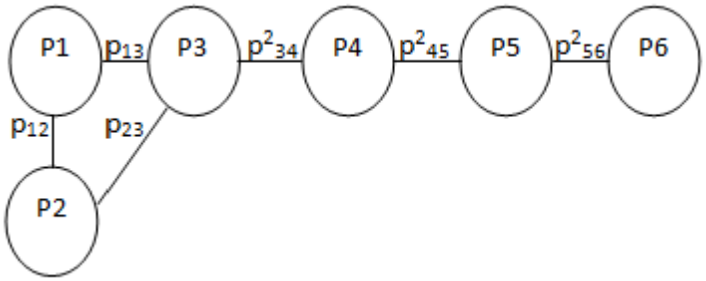

Figure 4.10 Undirected Graph ‘C2’

New Graph ‘C2’ is germinated with the help of 12 nodes and 9 edges. Now this new graph is compared with the original graph of the PSiOS system shown in Figure 4.3. By the Comparison, new Graph ‘C2’ matches with the original graph. So the addition of term $p_1p_2p^2_{34}p^2_{56}$ and term $p_{12}p_{31}p_{23}p^2_{45}p_6$ works. Let consider the addition of the three terms. Consider the term $p_1p_2p_3p^2_{45}p_6$ from group 3 (Figure 4.11), term $p_{13}p_{21}p_{32}p_4p_5p_6$ from group 4 (Figure 4.12) and term $p_{13}p_{21}p_{34}p_4p^2_{56}$ from group 6 (ii) (Figure 4.13).

Addition of these terms will give us a New Graph ‘D’ which will be compared to the original graph.

Graphical representation of these terms is given below:-

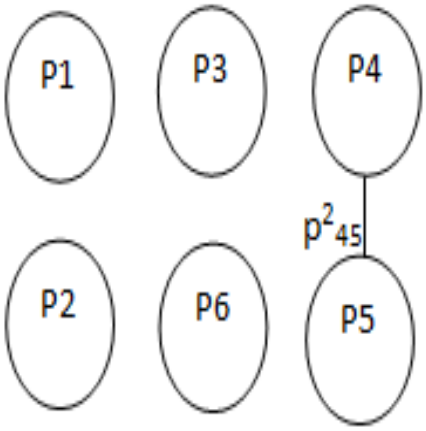

Figure 4.11 Undirected Sub Graph of term $p_1p_2p_3p^2_{45}p_6$

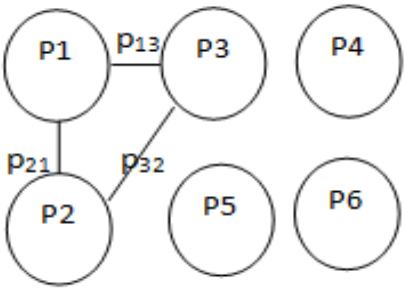

Figure 4.12 Undirected Sub Graph of term $p_{13}p_{21}p_{32}p_4p_5p_6$

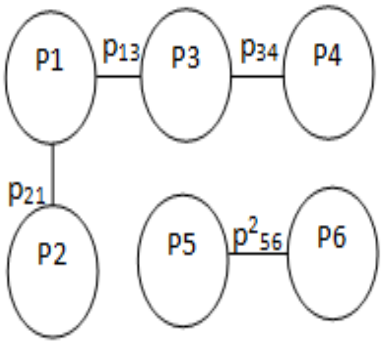

Figure 4.13 Undirected Sub Graph of term $p_{13}p_{21}p_{34}p_4p^2_{56}$

Generated New Graph 'D' is

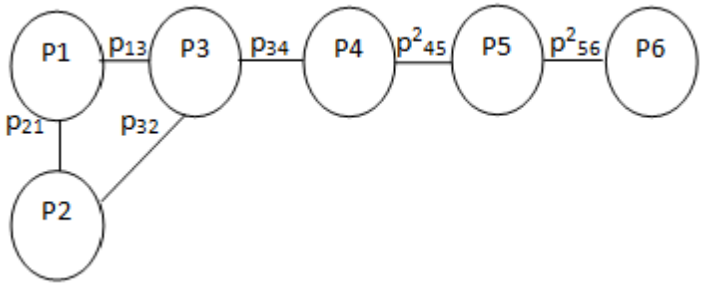

Figure 4.14 Undirected Graph 'D'

A New Graph 'D' is generated with the help of 18 Nodes and 10 Edges. Now this new graph is compared with the original graph of the PSiOS system shown in Figure 4.3. By comparison, conclusion is that the New Graph 'D' also matches with the Original graph of PSiOS system.

Chapter 5: Implementation Details

5.1 Installation

Following are the software that installs before begins:

5.1.1 Java and Net beans IDE Installation:

a. First downloaded Java and installed it in our system.

b. After Java installation, next step is to install Net beans IDE.

5.2 Algorithm for comparison of graphs as a Matrix

Step 1: Enter the Original Undirected Graph of the PSiOS system.

Step 2: Enter the number of sub graph and enter its values.

Step 3: Generate a new graph by adding the sub graphs.

Step 4: Compare the new graph with the original graph with the parameter like edges and nodes.

Step 5: Repeat step 2 to step 4.

5.3 Implementation

For Comparison, coding is done in net beans with the help of java. Graphs are compared on the basis of String matrices comparison. The original graph is entered in the matrix form with the number of nodes, number of edges and edges between the nodes. To display original graph matrix, a method matrixprint (parameter 1, ……) is created. The number of nodes decides the 2D array size and the edges between the nodes are represented by the value '1' inside the matrix and the value '0' indicate that no edge is connected to each other. After that a choice is given that how many graphs you want to add to compare to the original graph. Therefore methods like compare2 (parameter 1, ……) for adding two matrices to compare, compare3 (parameter 1, ……) for adding three matrices to compare, compare4 (parameter 1, ……) for adding four matrices to compare and the exit method to end the comparison. In the comparison method, a new matrix is created by adding the sub graph matrices and compare to the original graph matrix and provide us the result. The value of the sub graphs are terms from Figure 4.5.

Chapter 6: Testing and Results

An epitome tool is implemented using java as a language to show the comparison between graphs.

6.1 Output germinated by code

Results and output generated by the code is shown in this section.

6.1.1 Matrix form of Undirected Graph of PSiOS (Figure 4.4)

Output Matrix of the undirected graph of PSiOS is illustrated in Figure 6.1.

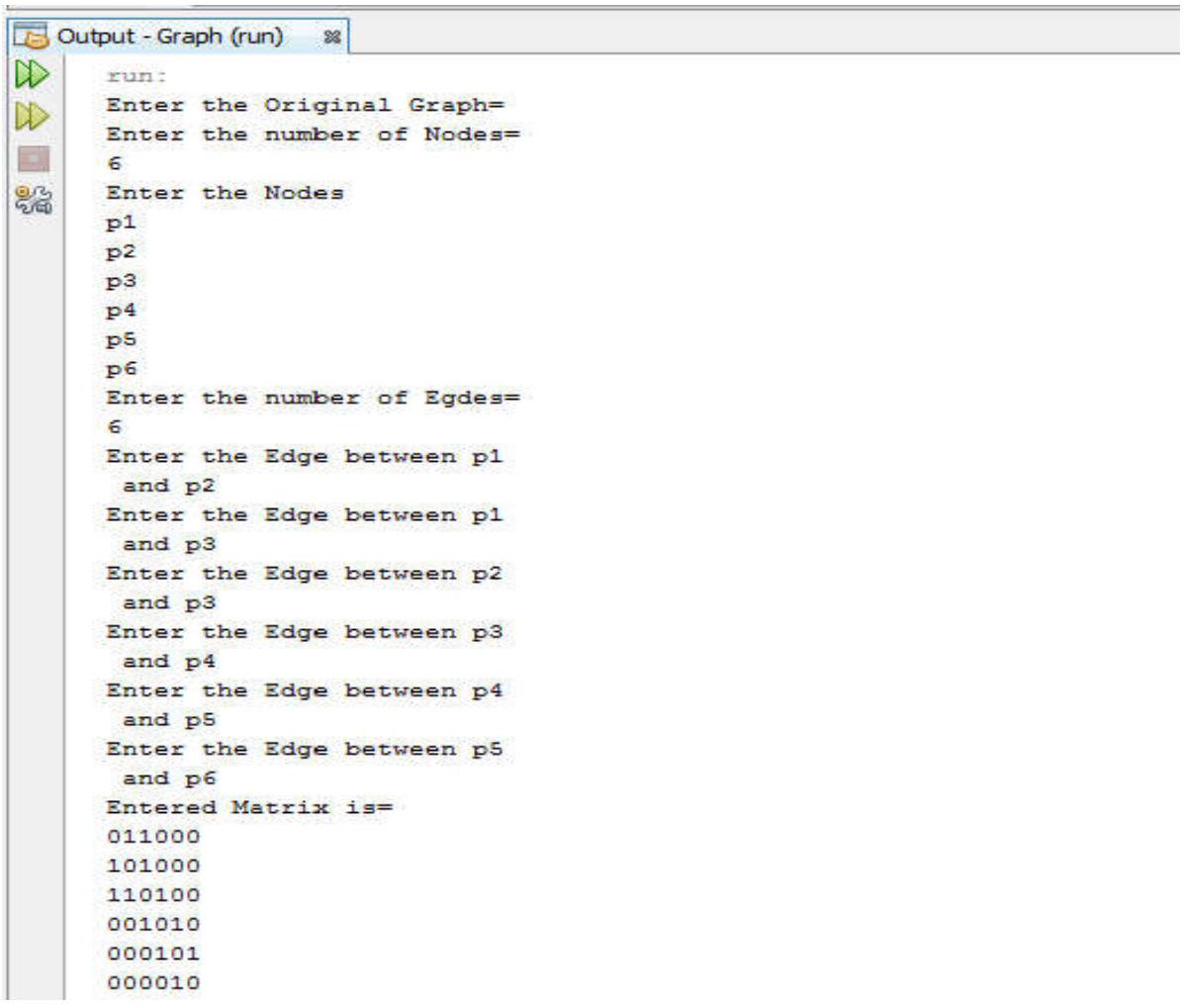

Figure 6.1 Output Matrix of the undirected graph of PSiOS

6.1.2 Enter the Sub graphs in the terms format and add them to compare to the Original graph of PSiOS

A) Comparison '1' shown in Figure 6.2; in which two Sub graphs are added to compare with the original Graph and provide results.

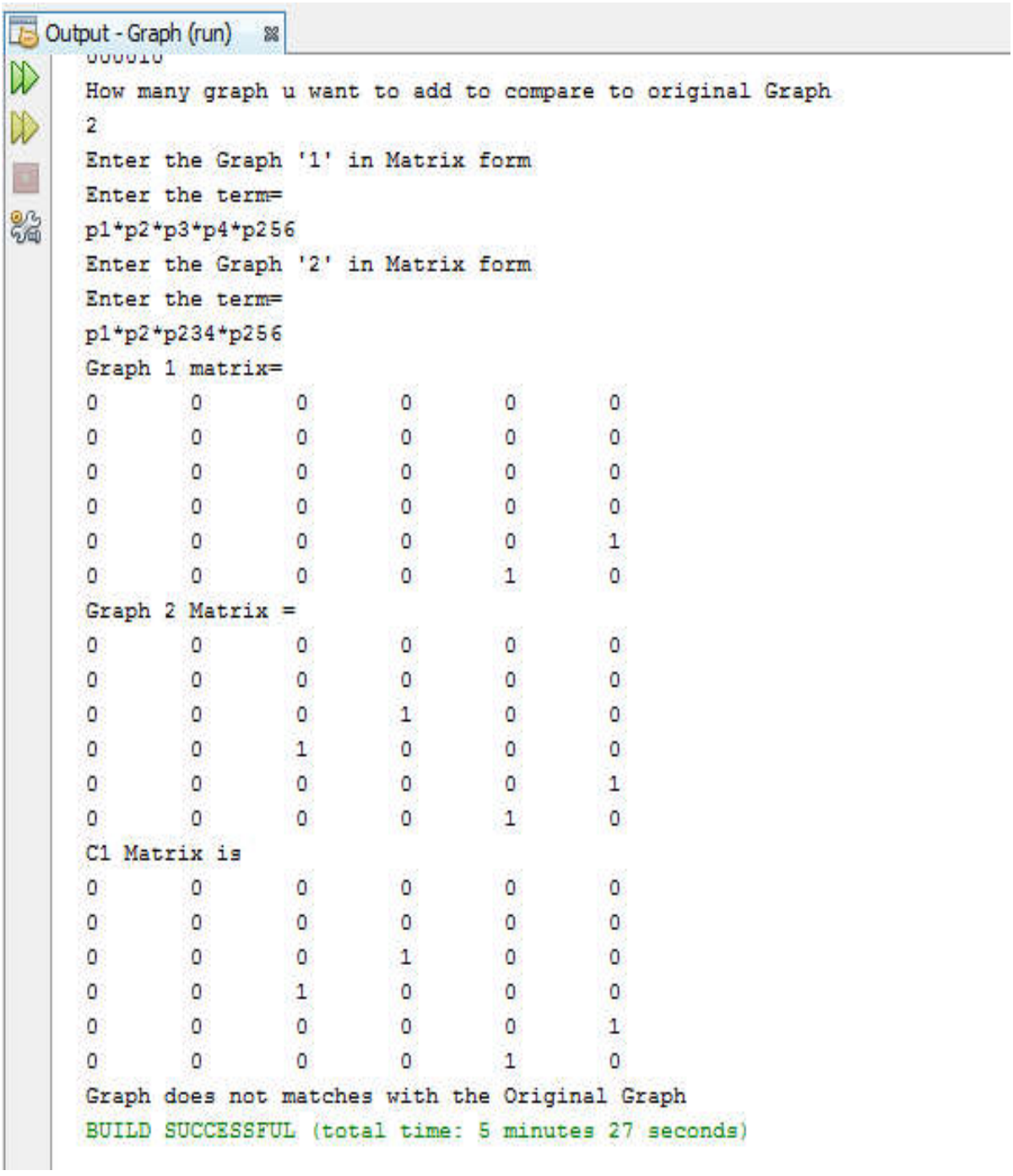

Figure 6.2 Comparison '1'

B) Comparison ‘2’ shown in Figure 6.3; in which also two graphs is added to compare to the original graph and provide result.

Figure 6.3 Comparison ‘2’

B) Comparison ‘3(i)’ and Comparison ‘3(ii)’ shown in Figure 6.4 and Figure 6.5 respectively in which three graphs is added to compare to the original graph and provide result.

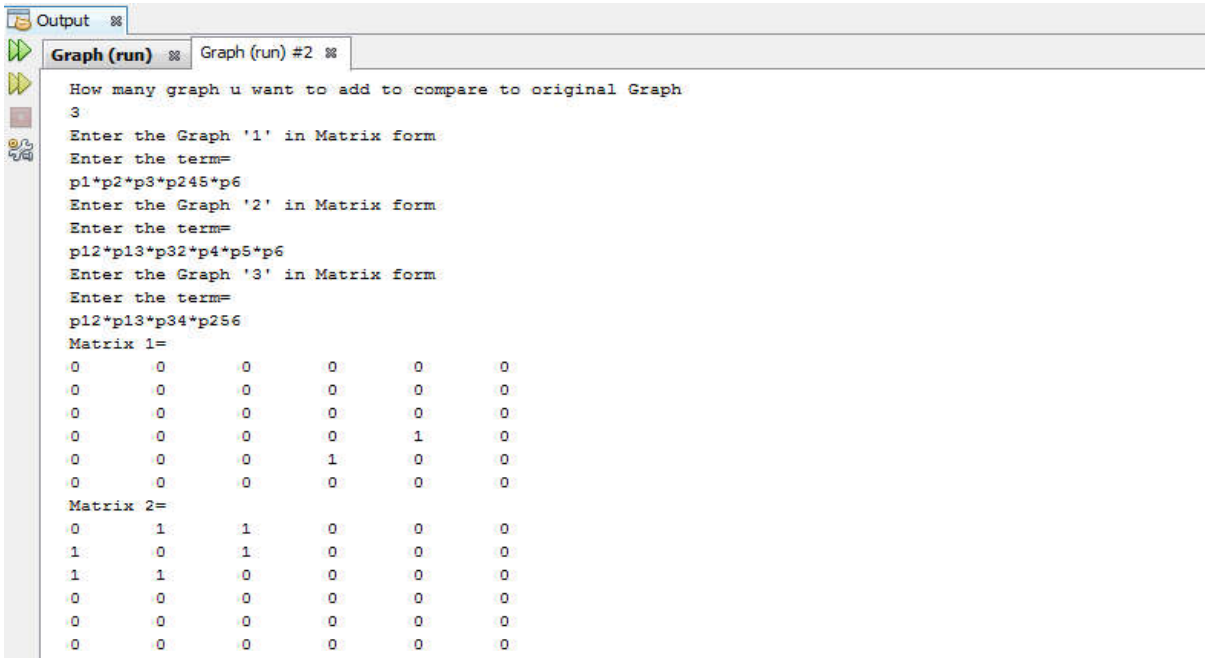

Figure 6.4 Comparison ‘3(i)’

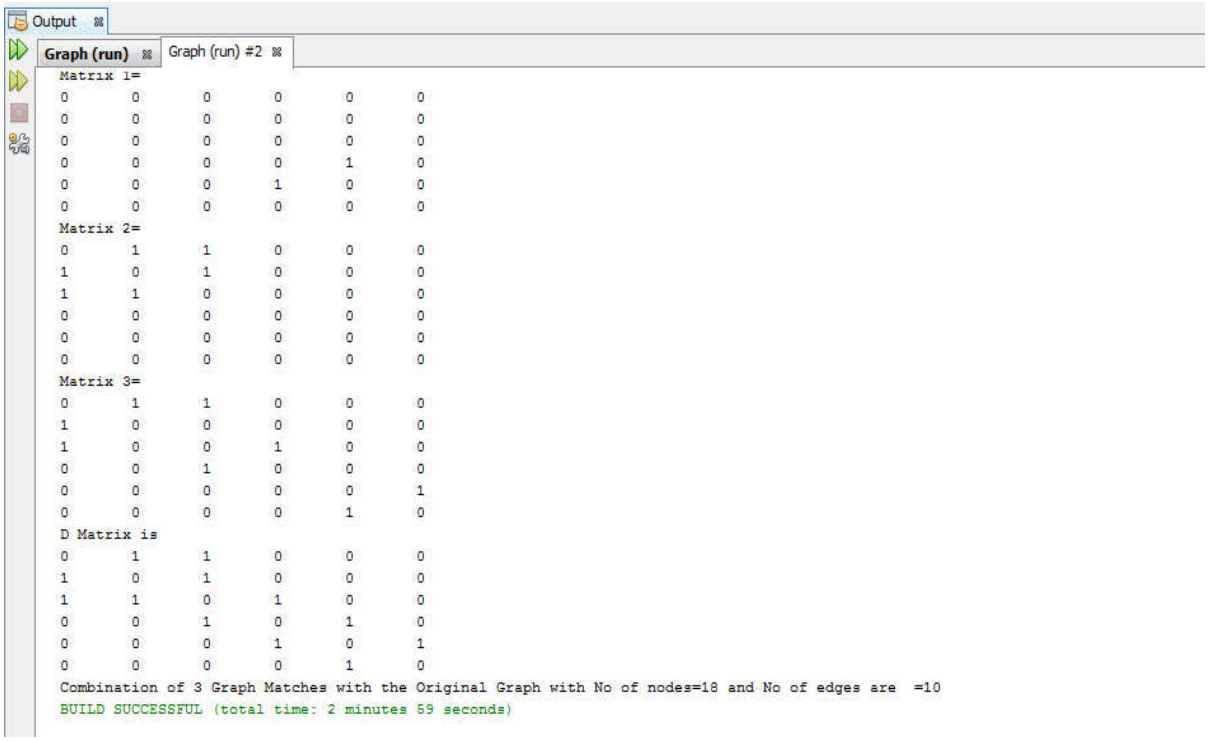

Figure 6.5 Comparison ‘3(ii)’

6.2 Result

Result are as follows:

6.2.1 Comparison Table

Comparison between Graph ‘C1’ and Graph ‘D’ with respect to the parameter; edges and nodes is shown in Table 6.1

Table 6.1 Comparison

Number of terms added	Graphs Generated	Number of Nodes	Number of Edges
2	C1	12	9
3	D	18	10

From the above comparison table, Graph ‘C1’ is better the Graph ‘D’ with respect to both edges and nodes as parameters in the manner of space reduction.

Chapter 7: Conclusion and Future Work

A proposed approach for comparing the graphs with the help of java code is concluded in this chapter. In Future there are some of the points that can be considered.

7.1 Conclusion

In this thesis, methodology used for germinating the system model by identifying all the attributes. Using matrix approach and diagraph these attributes are responsible for production, design and process parameter. This epitome tool exemplifies the interaction that affects the design, process parameter and production attributes. PSiOS system is currently working on six parameters. This system consists of diagraph, matrix, and Permanent function. This PSiOS digraph is a numerical representation of functional characteristics and their interdependency is gainful for modeling and analysis. The PSiOS matrix represents a very strong tool for storing and retrieval of data and also for numerical processing. A Multinomial model characterizing the structure of PSiOS system is the Permanent Function of PSiOS system. From the permanent function, each term uniquely represent the structure the PSiOS system.

7.2 Future Work

There are some of the points that can be explored further are as follows

a) To compare the graphs, Hash table and Array list can be used in java code.

b) Parameters like Space and Time complexity can also be considered for the future work.

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List of Publications

Accepted:

[1] Jay Patel, Ashish Aggarwal, "Structural Modeling on PSiOS," Journal of Basic and Applied Engineering Research (JBAER), volume 3, issue 6, April-June 2016.

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