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IRREGULARITY INVESTIGATION OF CERTAIN COMPUTER NETWORKS EMPOWERED SECURITY

KHALID HAMID*
PhD Scholar, Department of Computer Science, Superior University Lahore, Pakistan. Lecturer Computer Science at NCBA & E East Canal Campus Lahore. Corresponding Author Email: Khalid6140@gmail.com

MUHAMMAD WASEEM IQBAL
PhD, Associate Professor Department of Software Engineering, Superior University Lahore, Pakistan. Email: Waseem.iqbal@superior.edu.pk

SALMAN UBAID BHATTI
MPhil, Department of Computer Science, University of Lahore, Pakistan. Lecturer Computer Science at SABAC College Lahore. Email: salman.bhatti51@gmail.com

NAZIM HUSSAIN
Lecturer, Computer Science Department, Government College University, Lahore, Pakistan.
Email: nhussain@live.com

MADIHA FATIMA
Lecturer, Superior University Lahore, Pakistan. Department of Computer Science, COMSATS University Islamabad, Sahiwal Campus, Sahiwal, Pakistan. Email: phcs-f21-006@superior.edu.pk

SABA RAMZAN
PhD Scholar, Superior University Lahore, Pakistan. Sharif College of Engineering and Technology, Lahore, Pakistan. Email: sabaramzan@sharif.edu.pk

Abstract

Security is a prime issue in today's world due to the increase in the number of devices and dependencies on the internet. This paper discusses and investigates the irregularities found in different networks which are one of the causes of loopholes in the security of networks. Any number that can be uniquely determined by a graph is called a graph invariant. During the last twenty years' countless mathematical graph invariants have been characterized and utilized for correlation analysis. The study investigates cloud networks, hierarchical hypercube networks, and block shift networks with the help of the Irregularity sombor index (ISO) which has good potential of prediction to discover irregularities of networks or structure in the field of computer science, mathematics, chemistry, pharmacy, informatics and biology in context with physical and chemical structures. After finding irregularities in the networks, further, the network is solved by K banhatti redefined zagreb indices for the modeling purpose of enhanced networks with best characteristics. These deduced results can be used for the modeling of computer networks like Local area networks (LAN), Metropolitan area networks (MAN), and Wide area networks (WAN), the backbone of the internet and other networks/structures of computers, power generation, bio-informatics and chemical compounds synthesis.

Keywords: Bridge Networks; Invariants; K-Banhatti; Sombor Indices; Maple; Network Graph; Molecular Graph

1. INTRODUCTION

Gutman in 2021, define the idea of sombor indices. A new vertex degree-based invariant graph named Sombor Index is used to capture the sharp lower and upper bounds of the

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connected network and the characteristics of the network reaching the boundaries [1]. There are two variants of k-banhatti sombor indices, the first one is k-banhatti sombor index and the second is its reduced version [2]. A K-Banhatti Sombor Index is a topological index that is a number associated with a network graph that captures the symmetry of the network structure and provides a scientific language for predicting the characteristics of the network. V. R. Kulli derived a new irregularity index by taking an idea from sombor indices called the Irregularity sombor (ISO) index that has the quality to predict irregularities present in computer networks.

The delay in communication in the network may cause serious security issues. The study solves certain computer network topologies by mapping through the graph to find the irregularities present in the networks used in different products like memory interconnection networks, processor interconnection networks, ICs, power generation networks and some chemical constructs, etc. Because Irregularities in the networks may cause delays or low performance which leads to security violations. For the formal reason, the study discusses and solves the topology of certain computer networks with the help of graph theory numerically.

As another arising science is developed with the help of computer sciences, mathematics and chemistry called cheminformatics, whose significant segments incorporate Quantitative structure-activity relationship (QSAR) and Quantitative structure-property relationships (QSPR) and the segments can add to the examination of physicochemical characteristics of synthetic mixtures. QSAR is a modeling tool used to solve the topology of networks or structures of compounds and model the efficient and best performer networks or structures. QSPR is also a modeling tool that correlates the properties of a network structure with the help of mathematical equations or expressions. It also provides the quantitative relationship between the properties of networks or chemical structures. Angles of topology in the form of numeric values can be portrayed with the help of a graph because of invariance. It is done due to the auto morphism property of the graph. In the fields of computer sciences and chemistry, there are a lot of applications of graph theory. These topological indices or invariants are also numeric values related to computer networks, their interconnections and their properties, etc. This examination gives a basis to understand the profound topologies of some important bridge networks and how these networks can be developed based on the best topological properties. This feature also gives potential assistance to scholars to contemplate network characteristics better. For additional work, if the related networks are replaced by different networks, this study can also calculate and get the comparing formulas [3].

A topological index is planned by transforming a network structure into a number. Originally, we aim to introduce new computer architectures and networks that profit from both efficiencies and advance with the assistance of topological indices. An interconnection network’s structure can be mathematically demonstrated by a graph. The geography of a graph decides the way where vertices are associated by edges. From the geography of a network, certain properties can easily be resolved. Maximum distance is resolved between any two hubs in the network. The level of the hub is identified by the

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number of connections attached to it. Computer networks from intranet to worldwide networks, electric power interconnection, social networks, sexual sickness of networks of transmission, and genome networks are comparable with graph theory with the help of complex network analysis apparatus. All these networks are at a peak level of their use and are diversified. In this load of cases, this study can compute boundaries called Topological invariants (TIs) that mathematically depicted the connectedness designs (structure) between the hubs or entertainers in a network. So this study can construct a brain-shocking network of general sets of laws partner laws (hubs) that direct typical organic subjects for instance. QSAR and QSPR are providing the foundation for these models. A final remark is that the utilization of the measurement in the network plane facilitates a quantitative evaluation of various geography-safeguarding mapping algorithms [4].

This paper first introduces the problem statement with certain computer network graph and irregularity sombor index, secondly review the literature, thirdly discuss objectives, significance, research gap and method in the research methodology section, in the fourth section analyze data and in the last section write results by finding irregularities from certain computer networks if any exist then solved with the help of k-banhatti redefined zagreb indices and conclude the research. The study has implications in the fields of computer science, physics, chemistry, mathematics and bioinformatics for modeling purposes of networks, network interconnections, power generation interconnection networks and chemical compounds. ISO and KBRZ invariant allows us to accumulate information about algebraic structures and mathematically predict hidden properties of various structures such as certain computer networks.

2. LITERATURE REVIEW

The calculation of the irregularity indices of honeycomb networks, hexagonal networks, oxide networks, and silicate networks is done. The results are very helpful in understanding the behavior of different computer networks and chemical networks. After understanding these formulas different researchers can construct their own best networks in chemistry and computer also [5]. Further, the study elaborates that graph theory is a field through which they calculate topological indices for finding the properties of different chemicals without performing any types of experiments on them. It may be understanding only mathematical formulas or equations which are deduced for them. It also calculates topological indices for m-polynomial block shift networks which are a part of different chemical compounds with the help of the division of edge [6].

Another study told that topological indices and network polynomials are invariants of molecular graphs. Expected properties of structures of molecules can be studied with the help of invariants. In benzene networks, honeycomb networks are significantly used. In the current article, new topological portrayals of honeycomb networks are given as degree-based descriptors. They, for the first time, used some consistency indices and a few co-indices identified with this network without line graph and complement also [7]. These indices of honeycomb networks are very much effective to understand the

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physiochemical properties of chemicals. These realities might be valuable for individuals working in software engineering and science who experience honeycomb networks. An ideal level of a specific index can be acquired by putting a limitation on n [8].

According to the readings explanation that another arising science is cheminformatics which is a combination of chemistry, mathematics and computer science. It is the main concern and constituent part is QSAR and QSPR which mainly explore the physicochemical properties of chemicals and their structures. This paper tended to the OTIS traded networks and bi-swapped networks and investigated their topological indices. They decided the overall randi ć, general aggregate availability, first and second zagreb, first and second multiple zagreb, hyper zagreb molecule bond and mathematical indices for both the group of networks by considering the premise network as way Pn and k-customary graph Rk. They likewise gave express formulae for ABC4 and GA5 indices of these networks with the premise Rk network [9] [10].

Another study conveyed that since computer tools are used in the world as a source of information, they increasing in numbers numerously. To such an extent, today, it is hard to track down any space, logical or other, which is not dependent on their application. Indeed, even general sets of laws have been affected by novel processing and data strategies. A considerable lot of these QSAR procedures depend on the utilization of structural boundaries, which are a mathematical arrangement that classify helpful structural data and empathy relationships among structure and natural properties [11].

In every one of these cases, they can compute boundaries called TIs that mathematically depicted the connectedness designs between the nodes or entertainers in a network. Thus, TIs are helpful as contributions to QSPR models at all structural levels. Indeed, even general sets of laws might be moved toward utilizing figuring and data strategies like networks. So they can develop an unpredictable network of overall sets of laws associating laws (nodes) that manage basic organic points for example. Then again, a systematic judicial framework is expected to give proper and pertinent direction to addressing different registering procedures as applied to logical research [12].

The research study told that graphs are considered a stunning modeling apparatus that can be utilized to show and clarify diverse sorts of relations between actual issues. A lot of issues and issues can be investigated exhaustively with the assistance of graph theory. In this paper, scientists concentrated on various types of issues identified with graph theory and their executions and suggestions in the field of software engineering to exhibit the adequacy of graph theory. These applications are acquainted especially with stretch-out graph theory and display its objective and significance in software engineering designing. This paper is planned to benefit the investigations of software engineering to get significant data on graph theory and its significance with different subjects like working frameworks, networks, databases, programming, etc. this paper focused on the various uses of huge graph theory that have congruity to the field of software engineering and applications [13] [14].

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The hypothetical thoughts of the graph are especially utilized by software engineering applications. Especially in research spaces of software engineering such as information mining, picture division, grouping, picture catching, networking, etc. For example, an information design can be arranged as a tree which hence utilized vertices and edges. Additionally, modeling of network geographies ought to be conceivable using graph thoughts. Also, the fundamental thought of graph concealing is utilized in asset distribution and booking. Furthermore, ways, walks and circuits in graph theory are used in enormous applications say versatile deals issues, information base arrangement thoughts, and resource networking. This prompts the headway of new estimations and new hypotheses that can be used in gigantic applications. It has been parceled into two regions. The first region gives a certain establishment of graph theory and a couple of uses in the booking. The second region underlines how graph theory is utilized in various PC applications [15].

The research material of this paper explains that the field of math accepts a vital part in various fields. The most important piece of science is graph theory and it is utilized in structural modeling. They give an audit of graph theory used in PC sciences. The outline involves a portrayal of explicit subjects from the theory of graph of the spaces of Computer science wherein they are used. Regardless, for each portrayed theory they show the fields wherein it is used. It tends to be utilized in multiprocessor frameworks, factual information bases, the information mining field, web looking and arranging, in acknowledgment of examples and in PC vision too. This paper gives a diagram of the uses of graph theory in heterogeneous fields to some degree yet basically software engineering is the field around which graph theory thoughts work. Graph theory has found expansive applications in different fields. Thusly, these fields have fortified the improvement of various new chart hypothetical thoughts and incited many testing graph theory issues. They can expect that the proceeded exchange between graph theory and various spaces of use will provoke critical new developments. The critical occupation of graph theory in PC applications is the improvement of graph estimations [16] [17] [18] [19][20][21] [22].

Topological invariants enable us to gather data about logarithmic designs and give us a numerical strategy to figure out the secret properties of various designs [23]. Various strategies are available in history to check the nature of a topological index [24]. There are two principal conflicts of topological indices, first one is the degree based topological and the below average is known as distance-based topological indices. There are hundreds of such invariants are present in history [25]. ISO index has good potential for prediction in the field of computer science, mathematics, chemistry, pharmacy, informatics and biology in context with physical and chemical structures and networks [26].

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3. RESEARCH METHODOLOGY

3.1 Objectives

The main objective of this study is to investigate the topological invariants of certain computer networks for security concerns. The study finds out the intensity of seriousness of topological indices in certain networks like computer networks, interconnection networks of processors, power interconnection networks and chemical structures, etc. This paper, the study explains the ISO index and its benefits. Its prime objective is to develop formulas so that it can check the topology, irregularity, and performance of certain networks without doing/performing experiments and find irregularities in certain computer networks. The work deduced some results which are used in the modeling of certain computer networks [27].

3.2 Significance

The study is very significant these days because it creates awareness about the topological invariants of certain networks. It is also discovering new and significant solutions or formulas for modeling secure certain networks because no adequate solution has been found till now due to its incremental and fast nature.

3.3 Method

This systematic study, will take an existing certain computer network, associate it with a graph and solve the topology of the graph with the help of the ISO index. Then draw and optimize the results graphically. If irregularities are found from a certain network, they will be solved with the help of newly presented invariants called K banhatti redefined zagreb invariants. The concerning results in the form of formulas will compare with existing results. These deduced results will apply to many other networks in the fields of certain computer networks afterward. This model is very concerning as it solved the topology of a certain network like cloud networks, block shift networks and hierarchical hypercube networks in numeric and graphical forms. It gives accurate irregularity and modeling results. After analysis, a simulation tool maple is used for the verification and validation of results [28-35].

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Figure 1: Method for the study of certain networks through ISO and KBRZ invariants

4. EXPERIMENTAL RESULTS

A bridge graph is a graph obtained from the number of graphs G_1, G_2, G_3,...G_m by associating the vertices v_i and v_{i+1} by an edge∀, i = 1,2,..., m − 1 [36-38].

$$ISO(G) = \sum_{ue} \sqrt{|d_u^2 - d_v^2|} \quad (1)$$

Eq. (1) shows the ISO index which will be used for the solution of certain computer networks like cloud, block shift and hierarchical hypercube networks mentioned in Fig. 2, Fig. 4, Fig. 6, Fig. 8 and Fig. 10.

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Table 1: Edge partition of Cloud Network

E	ε (du , dv)	De	ε(du , de)	Recurrence
ε_1	ε(n-1, n-1)	2n-4	ε(n-1, 2n-4)	(m(n-1)(n-2))/2
ε_2	ε(n-1, m+n-2)	m+2n-5	ε(n-1, m+2n-5)	m(n-1)
ε_3	ε(m+n-2, m+n-2)	2m+2n-6	ε(m+n-2, 2m+2n-6)	M(n-1)/2

$$de = du + dv - 2$$

Tab. 1 describes the edge partitions of the graph of the cloud computing network $Q_{m, n}$ given in Fig. 2. Where 'ε' represents the edge, d_u and d_v are showing edge partitions and 'u' and 'v' are the vertices of a graph $Q_{m, n}$ under discussion. Recurrence means the number of edges attached to a particular vertex also called frequency.

4.1 Main Results of Cloud Computing Graph

The graph Q(m, n) is gotten from Km and m duplicates of Kn by distinguishing each vertex of Km with a vertex of one Kn. Here we figure out the ISO index of the graph Q(m, n) and infer their decreased and other topological structures from it.

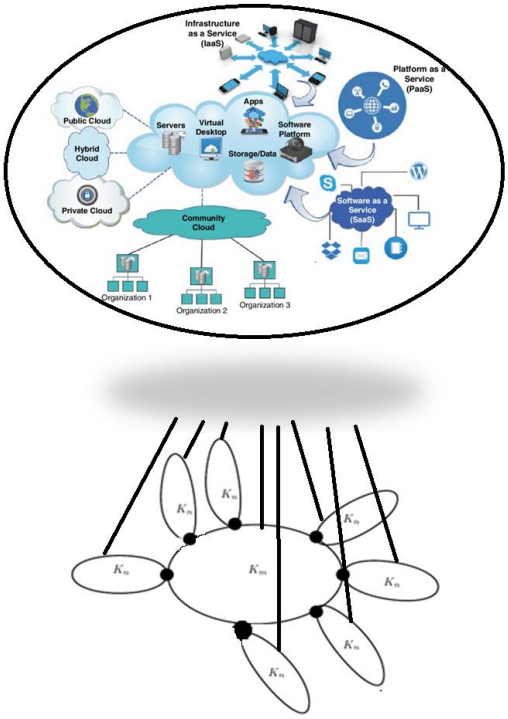

Figure 2: A cloud graph is extracted from a piece of cloud computing network

Fig. 2. Showing a cloud computing network in which different clouds are involved from which extraction of cloud graph is carried out. A bigger centralized cloud is represented by K_m and smaller clouds attached to a bigger one are represented by K_n.

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4.2 Cloud Computing Graph

Let $Q_{m,n} = G$ be a graph of the cloud computing network with edge partitions mentioned in Tab. 1.

4.3 Theorem 8

Let $Q_{m,n} = G$ be a graph of the cloud computing network, then, after investigation of $Q_{m,n}$ of the cloud computing network graph by ISO index

$$ISO(G) = \sqrt{|-(n-1)^2+(m+n-2)^2|}\, m(n-1) \quad (2)$$

Eq. (2) represents the proven results of the graph of $Q_{m,n}$ of the cloud computing network mentioned in Fig. 3.

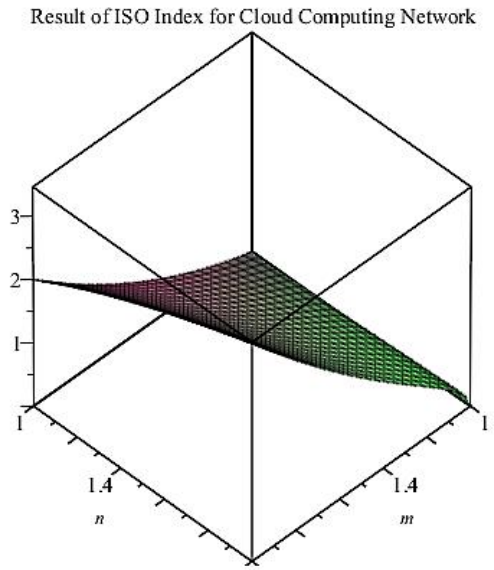

Figure 3: Result of ISO index for cloud network

Fig 3. Shows that the graph is not straighter having irregularities in the network. Now it would be solved by newly prepared invariants having the best prediction qualities for modeling concern. The deduced results from solving K banhatti redefined zagreb indices can be used for the modeling of enhanced networks with advanced and secure characteristics.

$$KBRZ1(Q_{m,n}) = \frac{1}{2}\frac{(3n-5)m(n-2)}{2n-4} + \frac{(3n-6+m)m}{m+2n-5} + \frac{\frac{1}{2}(3m+3n-8)m(n-1)}{(m+n-2)(m+2n-6)} \quad (3)$$

$$KBRZ2(Q_{m,n}) = \frac{1}{2}\frac{(n-1)^2(2n-4)m(n-2)}{3n-5} + \frac{(n-1)^2(m+2n-5)m}{m+3n-6} + \frac{\frac{1}{2}(m+n-2)(2m+2n-6)m(n-1)}{(2m+3n-8)} \quad (4)$$

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$$KBRZ3\ (Q_{m,n}) = \frac{\frac{1}{2}(n-1)^2(2n-4)m(n-2)(3n-5)m(n-2)}{1} + \frac{(n-1)^2(m+3n-6)(m+2n-5)m}{1} + \frac{\frac{1}{2}(3m+3n-8)(m+n-2)(m+2n-6)m(n-1)}{1} \quad (5)$$

These equations will be used for modeling of secure and enhanced cloud computing network with the best characteristics.

Table 2: Edge partition of BSCN-1 (3x3)

E	ε (du, dv)	De	ε(du , de)	Recurrence
ε_1	ε(3 ,3)	1	ε(3 ,4)	24a^2 – 10
ε_2	ε(2 ,3)	2	ε(2 ,3)	8

de = du + dv – 2

Tab. 2 describes the edge partitions of graph G of the BSCN-1 graph given in Fig.4.

4.4 Main Results

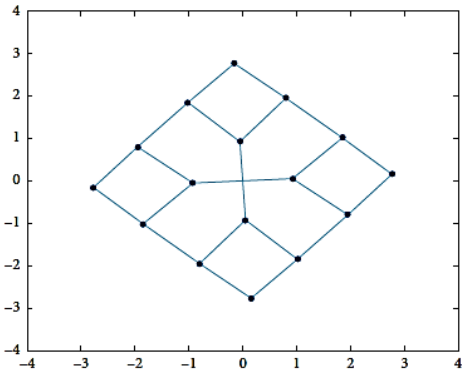

Figure 4: BSCN-1 (3x3)

Fig. 4 shows a BSCN with dimension (3x3).

4.5 Block Shift Computer Network Graph

If E(G) represents the edge set. Fig. 3 shows that there are two distinct kinds of edges present in the graph of BSCN-1. Tab. 2, explains in detail the edges partition.

4.6 Theorem 9

Let G be a graph of BSCN-1, then, after investigation of BSCN-1 graphs by ISO index

$$ISO\ (BSCN\text{-}1) = \sqrt{7}\,(24a^2 - 10) + 8\sqrt{5} \quad (6)$$

Eq. (6) represents the proven results of the graph of BSCN-1 mentioned in Fig. 5.

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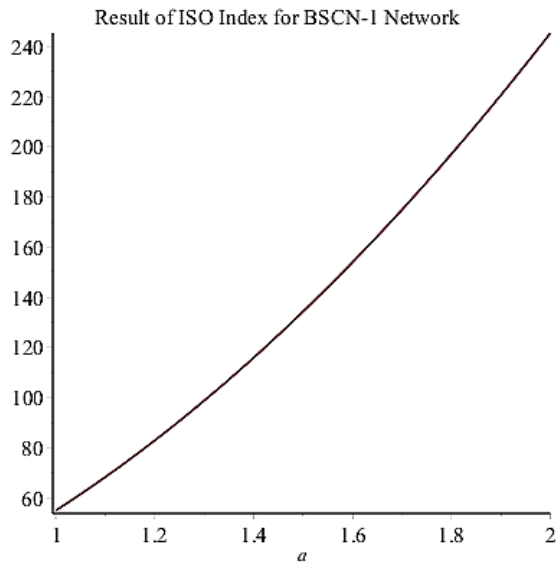

Figure 5: Result of ISO index for BSCN-1 network

Fig 5. the graph shows a few irregularities in the network as the graph is not fully straight. Now it would be solved by newly prepared invariants having the best prediction qualities for modeling concern. The deduced results from solving K banhatti redefined zagreb indices can be used for the modeling of secure and enhanced networks with advanced characteristics.

$$\text{KBRZ1 (BSCN-1)} = 14a^2 + \frac{5}{6} \quad (7)$$

$$\text{KBRZ2 (BSCN-1)} = \frac{288}{7}a^2 - \frac{264}{35} \quad (8)$$

$$\text{KBRZ3 (BSCN-1)} = 2016a^2 - 600 \quad (9)$$

These equations will be used for modeling secure and enhanced block shift computer network-1 with the best characteristics.

Table 3: Edge partition of BSCN-2

ε	ε (du , dv)	De	ε(du , de)	Recurrence
ε1	ε(4, 4)	6	ε(4, 6)	32a^2-14
ε2	ε(3 ,4)	5	ε(3, 5)	12

Tab. 3 describes the edge partitions of graph G of the BSCN-2 graph given in Fig. 6 with frequencies.

4.7 Main Results Block Shift Computer Network-2 Graph

If E(G) represents the edge set. Fig. 5 shows that there are two distinct kinds of edges present in the graph of BSCN-2. Tab. 3, explains in detail the edges partition.

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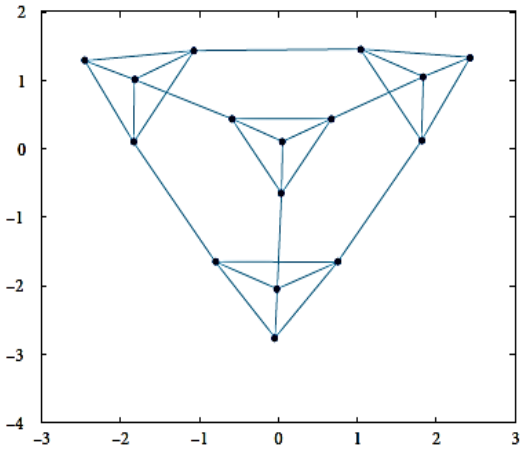

Figure 6: BSCN-2 (1x1)

Fig. 6 shows the Block shift computer network 2 (BSCN-2)

4.8 Theorem 10

Let G be a graph of BSCN-2 then, after investigation of BSCN-2 graphs by ISO index

$$\text{ISO (BSCN-2)} = 2\sqrt{5}(24a^2 - 10) + 32 \qquad (10)$$

Eq. (10) represents the proven results of the graph of BSCN-2 mentioned in Fig. 7.

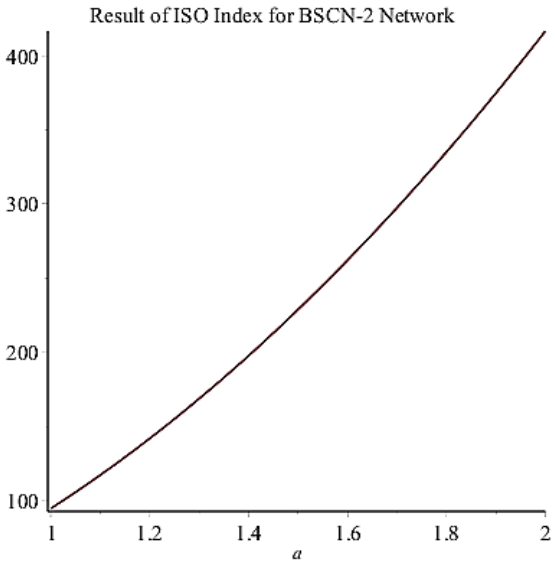

Figure 7: Result of ISO index for BSCN-2 network

Fig 7. graph shows a few irregularities in the block shift computer network-2 as the graph is not fully straight. Now it would be solved by newly prepared invariants having the best prediction qualities for modeling concern. The deduced results from solving K

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banhatti redefined zagreb indices can be used for the modeling of secure and enhanced networks with advanced characteristics.

$$\text{KBRZ1 (BSCN-2)} = \frac{40}{3}a^2 + \frac{17}{13} \quad (11)$$

$$\text{KBRZ2 (BSCN-2)} = \frac{384}{5}a^2 - \frac{111}{10} \quad (12)$$

$$\text{KBRZ3 (BSCN-2)} = 7680a^2 - 1920 \quad (13)$$

These equations will be used for modeling secure and enhanced block shift computer network-2 with the best characteristics.

Table 4: Edge partition of HHC-1

E	ε (du , dv)	De	ε(du , de)	Recurrence
ε_1	ε(3 ,3)	1	ε(3 ,4)	24a+4
ε_2	ε(2 ,3)	2	ε(2 ,3)	16

Tab. 4 describes the edge partitions of graph G of the HHC-1 graph given in Fig. 8 with several occurrences.

4.9 Main Results

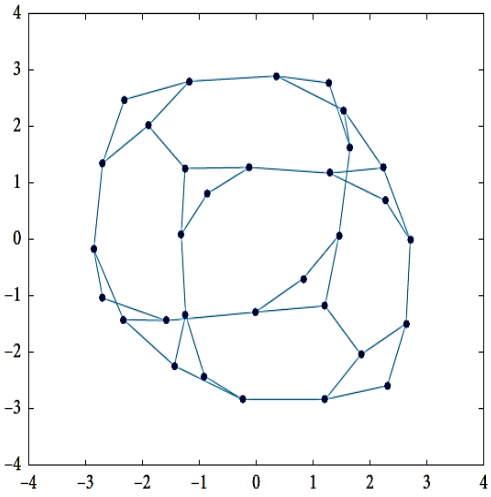

Figure 8: HHC-1 (1x1)

Fig. 8 shows the Hierarchical hypercube network used in the field of computer engineering.

4.10 Hierarchical Hypercube-1 Graph G

If E (G) shows the edge set, figure 7 shows the HHC graph G of the HHC-1 network. The HHC-1 graph of the network graph has two different edges. Tab. 4 provides a detailed description of the edge set.

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4.11 Theorem 11

Let G be a graph of the HHC-1 network. then, after investigation of HHC-1 graphs by ISO index

$$\text{ISO (HHC-1)} = \sqrt{7}\,(24a + 4) + 16\sqrt{5} \qquad (14)$$

Eq. (14) represents the proven results of the graph of HHC-1 mentioned in Fig. 9.

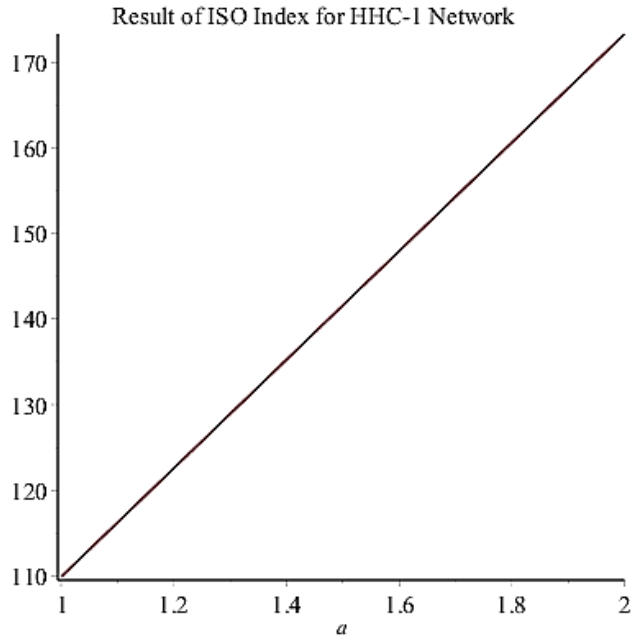

Figure 9: Result of ISO index for HHC-1 network

Fig 9. graph shows no irregularities in the network as the graph is fully straight. Its upper and lower bounds are looking sharp.

4.12 Main Results

Table 5: Edge partition of HHC-2

E	ε (du , dv)	De	ε(du , de)	Recurrence
ε_1	ε(4 ,4)	1	ε(4 ,6)	32a+4
ε_2	ε(3 ,4)	2	ε(3 ,5)	24

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Tab. 2 describes the edge partitions of graph G of the HHC-2 graph given in Fig.10.

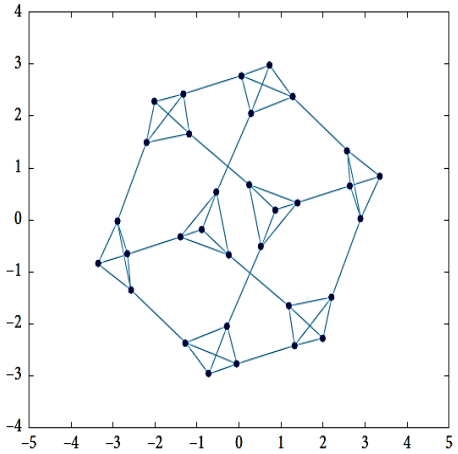

Figure 10: HHC-2 (1x1)

Fig. 10 shows hierarchical hypercube network-2 with dimensions 1x1

4.13 Hierarchical Hypercube-2 Graph G

If E (G) shows the edge set, figure 10 shows the HHC graph G of the HHC-2 network. The HHC-2 graph of the network graph has two different edges. Tab. 5 provides a detailed description of the edge set.

4.14 Theorem 12

Let G be a graph of the HHC-1 network. then, after investigation of HHC-1 graphs by ISO index

$$\text{ISO (HHC-2)} = 2\sqrt{5}\,(32a + 4) + 96 \qquad (15)$$

Eq. (15) represents the proven results of the graph of HHC-2 mentioned in Fig. 11.

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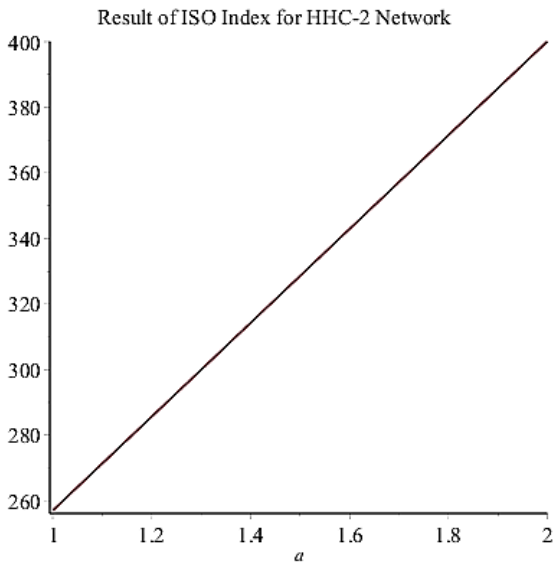

Figure 11: Result of ISO index for HHC-2 network

Fig 11. the graph shows no irregularities in the hierarchical hypercube network-2 as the graph is fully straight. Its upper and lower bounds are looking sharp.

5. CONCLUSION

TIs have lots of uses and implementations in many fields of computer science, chemistry, biology, informatics, arithmetic, material sciences, and many more. But the utmost significant application is in the non-exact QSPR and QSAR. TIs are associated with the structure of networks, the backbone of the internet, local area networks and chemical structure. But the present article discusses the ISO index which is freshly presented and have numerous prediction quality for different certain computer graphs or networks, i.e. $Q_{m, n}$, BSCN-1, BSCN-2, HHC-1 and HHC-2 networks. Cloud computing networks, BSCN-1 and BSCN-2 are showing irregularities when solved through ISO which may cause compromised security. The solution for these networks is developed through k-banhatti redefined zagreb indices. These deduced results will be used for the modeling of certain computer networks used in LAN, MAN, WAN, cloud computing and the backbone of the internet, power generation interconnection networks, memory interconnection networks, processor interconnection networks, chemical structures, image processing, bio-informatics, etc.

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