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AMC 2016

THE ASIAN MATHEMATICAL CONFERENCE

Bali

Program & Abstracts

25 - 29 JULY 2016

Bali Nusa Dua Convention Center
Bali Indonesia

Hosted by:

IndoMS
Indonesian Mathematical Society

SEAMS
South East Asian Mathematical Society

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The Asian Mathematical Conference 2016

Program

Abstracts

July 25 – 29, 2016
BNDCC Nusa Dua, Bali, Indonesia

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SEAMS (Southeast Asian Mathematical Society)

Organized by : ITB (Institut Teknologi Bandung)
Unpad (Universitas Padjadjaran)
UGM (Universitas Gadjah Mada)
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Edy Tri BASKORO
Chair of Asian Mathematical
Conference (AMC) 2016

Budi Nurani RUCHJANA
President of Indonesian
Mathematical Society

This wonderful opportunity has finally come to Indonesia. The spirit of Mathematics is in the air. We are very proud to be able to hold this big event in the place where everyone would love to visit, Bali. Please accept our warm greetings to all of you! It is our great honor and pleasure to welcome all the participants of the Asian Mathematical Conference 2016 from July 25 to July 29 to Bali, Indonesia.

As one of the most prestigious gatherings of mathematicians in Asia, the Asian Mathematical Conference (AMC) has been conducted since 1990. This AMC2016 is the seventh one and hosted by the Indonesian Mathematical Society (IndoMS) and South East Asian Mathematical Society (SEAMS). We are very happy to have this great opportunity to hold such important event. This conference surely will give a very significant impact on promoting and enhancing mathematics in Indonesia as well as in the Asia region.

The program of this conference consists of plenary talks, special lectures, invited and contributed talks as well as posters and exhibitions. We are very grateful that more than 600 mathematicians from 33 countries attend this conference. In this conference, we also have a forum on the establishment of the Mathematical Union of Asia as well as a forum on Asian Women Mathematicians.

We would like to express our sincere gratitude to all the speakers, members of the steering, scientific, program and organizing committees of the AMC 2016 and Indonesian Mathematical Society, SEAMS council members, and distinguished guests from all mathematical societies in Asia. Special thanks go to the co-organizers: Institut Teknologi Bandung (ITB), Universitas Padjadjaran (Unpad), Universitas Gadjah Mada (UGM), Universitas Indonesia (UI) and Universitas Udayana (Unud). We also thank the Korean Mathematical Society (KMS), Mathematical Society of Japan (MSJ), Korea Institute for Advanced Studies (KIAS), International Mathematical Union (IMU), Commission of Women in Mathematics IMU, Centre International de Mathematiques Pures et Appliquees (CIMPA), the Ministry of Research Technology and Higher Education, the Ministry of Tourism, Badan Keamanan Laut (BAKAMLA), Persatuan Aktuaria Indonesia (PAI), PT Komatsu Indonesia for their invaluable supports.

Once again, welcome all of you, we hope all of you enjoy staying in the paradise island of Bali, Indonesia.

Words of Welcome

LING San
President, Southeast Asian Mathematical Society

On behalf of the Southeast Asian Mathematical Society (SEAMS), I welcome you warmly to the Asian Mathematical Conference 2016 (AMC 2016).

The AMC was inaugurated in 1990 in Hong Kong. Held on the average of every 4-5 years, the AMC has been held subsequently in Thailand (Nakhon Ratchasima), the Philippines (Manila), Singapore, Malaysia (Kuala Lumpur), and South Korea (Busan). AMC 2016 is the seventh conference in this series. We thank our colleagues in the Indonesian mathematical community for hosting and organizing this important event at this beautiful location of Bali.

Asia is a vast continent with countries and regions at very different stages of development in mathematics. Some are mathematically very advanced, and have produced many a renowned mathematician; some face major challenges even to produce enough university graduates in mathematics. However, what is important is that progress is constantly being made throughout the continent in both research and education in mathematics.

With speakers and participants hailing from all over the world, the AMC is a good platform to showcase mathematical research in Asia, to celebrate the achievements of mathematicians in this continent, to facilitate networking for mathematicians from Asia and beyond, and to advance the cause of mathematics together.

I am glad that you have chosen to participate in AMC 2016. I wish you a fruitful and enjoyable time here in Bali, Indonesia.

The Asian Mathematical Conference 2016

Program

S08. Combinatorics and Graph Theory

Invited Talks

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08.30 - 10.00 **The eccentric digraph of a graph**
Eka Ferawati*, Tri Atmojo Kusmayadi
Sebelas Maret University, Indonesia [S08-P-19, p.423]

08.30 - 10.00 **Signed product cordial labeling of flower graph $f_{n\times 4}$ with graph operations is duplicating all the edges**
Siti Julaeha*, Hadiati
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16.00 - 17.30 **A note on skew-checkered weighing matrices and association schemes**
Wai-Keong Kok*, Li-Yin Tan
Tunku Abdul Rahman University College, Malaysia [S08-P-22, p.424]

16.00 - 17.30 **On the rc and src of graphs containting joins with $\overline{K_n}$**
Fendy Septyanto*, Kiki Ariyanti Sugeng
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16.00 - 17.30 **The characteristic polynomials of the adjacency and anti-adjacency matrices of amalgamation of two complete graphs**
Diah Prastiwi*, Kiki Ariyanti Sugeng
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16.00 - 17.30 **The H-super(anti)magic decompositions of generalized toroidal prism and antiprism graphs**
Hendy*, Ahmad Dzulfikar
Universitas Pesantren Tinggi Darul 'Ulum, Indonesia [S08-P-25, p.426]

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Omar I. Cauntongan
Mindanao State University [S08-P-26, p.426]

16.00 - 17.30 **Totally irregular total labeling of some caterpillar graphs**
Diari Indriati*[1,2], Widodo[1], Indah E. Wijayanti[1], Kiki A. Sugeng[3]
[1]University of Gadjah Mada, Indonesia
[2]University of Sebelas Maret, Indonesia
[3]University of Indonesia, Indonesia [S08-P-27, p.427]

16.00 - 17.30 **On the distance two-dominating number of graphs resulting from graph operations**
Wicha Dwi Vikade[1], K. D. Purnomo[1], Slamin*[2]
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08.30 - 10.00	**Construction of super edge antimagicnes of disjoint union of any graph by using a graph coloring technique** A. I. Kristiana*, M. Mahmudah, Dafik, K. D. Purnomo University of Jember, Indonesia [S08-P-30, p.429]
08.30 - 10.00	**Super complete-antimagicness of amalgamation of complete graph** I. H. Agustin*, Dafik, M. D. Milasari University of Jember, Indonesia [S08-P-31, p.429]
08.30 - 10.00	**Super total antimagic d-face labeling from corona results of friendship graph with path graph** Vicardy Kempa, Darmaji Sepuluh Nopember Institute of Technology [S08-P-32, p.430]
08.30 - 10.00	**Bi-resolving graph of cycle-related graphs** Hazrul Iswadi Universitas Surabaya, Indonesia [S08-P-33, p.430]
08.30 - 10.00	**Local metric dimension of circulant graph** Ruzika Rimadhany*, Darmaji Institut Teknologi Sepuluh Nopember, Indonesia [S08-P-34, p.431]
08.30 - 10.00	**Fuzzy autocatalytic set (FACS) and first isomorphism theorem** Rossiana Edhelyn*, Tahir Ahmad Universiti Teknologi Malaysia [S08-P-35, p.431]
08.30 - 10.00	**The partition dimension of comb product graphs** Novi Mardiana*[1], Suhadi Wido Saputro[2], Faisal[3] [1]Kopertis Wilayah IV Bandung, Indonesia [2]Institut Teknologi Bandung, Indonesia [3]Bina Nusantara University, Indonesia [S08-P-36, p.432]

the same time.The total irregularity strength of a graph G is the minimum value k such that G has a totally irregular total k-labeling, denoted by $ts(G)$. This notion was introduced by Marzuki, Salman, and Miller. Observing the edge-weight set $W(E)$ and the vertex-weight set $W(V)$ of G which induced by $ts(G)$, it may be found that the intersection set $W(E) \cap W(V)$ is a nonempty set. Considering this property, Tilukay and Salman defined a new parameter called *a totally disjoint irregular total labeling* of a graph G as a total labeling $\lambda : V \cup E \to \{1, 2, \cdots, k\}$ which satisfies: (i) for any two vertices $x \neq y \in V$, $w(x) \neq w(y)$; (ii) for any two edges $x_1y_1 \neq x_2y_2 \in E$, $w(x_1y_1) \neq w(x_2y_2)$; (iii) $W(V) \cap W(E) = \emptyset$; where $w(x) \in W(V)$ is the sum of the label x and the labels of all edges incident to x and $w(x_1y_1) \in W(E)$ is the sum of the labels of x_i, y_i and x_1y_1. The minimum value k such that G has a totally disjoint irregular total labeling is called *the total disjoint irregularity strength* of G, denoted by $ds(G)$. Tilukay and Salman have determined the exact values ds of paths, cycles, stars, and complete graphs. This paper deals with the total disjoint irregularity strength of wheels and related graphs. We determine the exact values of the total disjoint irregularity strength of wheels, fans, friendships, gears, triangular books, and flowers.

2010 Mathematics Subject Classification: 05C78.
Keywords: total disjoint irregularity strength, total edge irregular labeling, total irregularity strength, total vertex irregular labeling.

CT-53. Constructions of encryption key by using a super H-antimagic total graph

A. C. Prihandoko*[1], Dafik[2], Slamin[1], A. I. Kristiana[2]
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The strength of cryptosystem relays on the management of encryption key. The key should be managed such that it is hard for any intruder to analyze the key. Thus, the main issue is how to make the relation between plaintext, ciphertext and the key is hidden. This paper will study the use of super (a, d)-H antimagic total graph in developing an encryption key to achieve the security. Let H be a simple, connected and undirected graph. A graph $G = (V, E)$ is said to be a super (a, d)-H-antimagic total graph if there exist a one-to-one map $f : V(G) \cup E(G) \to \{1, 2, \ldots, |V(G)| + |E(G)|\}$ such that for all subgraphs isomorphic to H, the total H-weights $w(H) = \sum_{v \in V(H)} f(v) + \sum_{e \in E(H)} f(e)$ form an arithmetic sequence $\{a, a + d, a + 2d, ..., a + (s - 1)d\}$, where a and d are positive integers and s is the number of all subgraphs isomorphic to H, and $f : V(G) \to \{1, 2, \ldots, |V(G)|\}$. The resulting super (a, d)-H antimagic total graph can potentially generates a complex key, thus by using such graph we can get a secure cryptosystem.

2010 Mathematics Subject Classification: 05C78.
Keywords: super H-antimagic total graph, cryptosystem, encryption.

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The construction of encryption key by using a super H-antimagic total graph

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Abstract

The strength of cryptosystem relays on the management of encryption key. The key should be managed such that it is hard for any intruder to analyze the key. Thus, the main issue is how to make the relation between plaintext, ciphertext and the key is hidden. This paper will study the use of super (a, d)-H antimagic total graph in developing an encryption key to achieve the security. Let H be a simple, connected and undirected graph. A graph $G = (V, E)$ is said to be a super (a, d)-H-antimagic total graph if there exist a one-to-one map $f : V(G) \cup E(G) \to \{1, 2, \ldots, |V(G)| + |E(G)|\}$ such that for all subgraphs isomorphic to H, the total H-weights $w(H) = \sum_{v \in V(H)} f(v) + \sum_{e \in E(H)} f(e)$ form an arithmetic sequence $\{a, a + d, a + 2d, ..., a + (s - 1)d\}$, where a and d are positive integers and s is the number of all subgraphs isomorphic to H, and $f : V(G) \to \{1, 2, \ldots, |V(G)|\}$. The resulting super (a, d)-H antimagic total graph can potentially generates a complex key, thus by using such graph we can get a secure cryptosystem.

2010 Mathematics Subject Classification: *05C78*
Keywords: *Super H-antimagic total graph, Cryptosystem, Encryption*

Section: *SS-08*

1 Introduction

Encryption is a popular approach for secure information or digital content distributed over the Internet. Some encryption implementation scenarios for such security purposes can be cited in [6, 7, 8]. The strength of these security systems relays on the management of the encryption key. The key must be secret and inaccessible to unauthorized users, as finding the key would allow someone to decrypt and access the content or information without restriction. Indeed, keeping the key from being accessible to the users is a major challenge for any cryptosystem.

We focus on a block cipher. This type of cipher supports a polyalphabetic cryptosystem. In this cipher, plaintext is divided into blocks with the same length. Each block is encrypted using a sequence of keys. By this algorithm, the same alphabets in different positions could be encrypted by different keys. In an ordinary block cipher, all blocks are encrypted using the same sequence of keys. Suppose we work on 26 English alphabets and the plaintext is divided into blocks of length b, so a cryptanalyst can compute the block key in 26^b ways. To make the key harder to analyze, we employ a a super H-antimagic total graph labeling to construct the block keys. By this labeling, the different blocks could be encrypted using the different sequences of keys. It will be harder for an intruder to break the system as he has to analyze the keys for every single block.

A *shackle* of graph H, denoted by $G = shack(H, v, n)$, is a graph G constructed by non-trivial graphs $H_1, H_2, \ldots, H_n$ such that, for every $1 \leq s, t \leq n$, H_s and H_t have no a common vertex with $|s-t| \geq 2$ and for every $1 \leq i \leq n-1$, H_i and H_{i+1} share exactly one common vertex v, called *connecting vertex*, and those $k-1$ connecting vertices are all distinct. By a *generalized shackle* of graph, we mean the graph $G = shack(H, v, n)$ by replacing the connecting vertex by any subgraph $K \subset H$ and we denote such a graph as $G = gshack(H, K \subset H, n)$.

A graph G is said to be an (a, d)-H-antimagic total graph if there exist a bijective function $f : V(G) \cup E(G) \rightarrow \{1, 2, \ldots, |V(G)| + |E(G)|\}$ such that for all subgraphs of G isomorphic to H, the total H-weights $w(H) = \sum_{v \in V(H)} f(v) + \sum_{e \in E(H)} f(e)$ form an arithmetic sequence $\{a, a+d, a+2d, ..., a+(n-1)d\}$, where a and d are positive integers and n is the number of all subgraphs of G isomorphic to H. If such a function exist then f is called an (a, d)-H-antimagic total labeling of G. An (a, d)-H-antimagic total labeling f is called super if $f : V(G) \rightarrow \{1, 2, \ldots, |V(G)|\}$.

There many articles have been published in many journals, some of them can be cited in [2, 3, 5]. Inayah *et al.* in [5] proved that, for H is a non-trivial connected graph and $k \geq 2$ is an integer, $shack(H, v, k)$ which contains exactly k subgraphs isomorphic to H is H-super antimagic. They only covered a connected version of shackle of graph when a vertex as a connector, and their paper did not cover all feasible d. Our paper attempt to determine the existence of a super (a, d)-H antimagic total labeling of connected or disconnected generalized shackle of graphs H, K when $H = \digamma_{2,m}$ and $K = e$, denoted by $G = \text{gshack}(\digamma_{2,m}, e, n)$, as well as to study its application to the construction of cryptosystem encryption key.

2 A Useful Lemma and Corollary

A generalized shackle of prism graph $G = \text{gshack}(H, P_2, n)$ is a connected graph with vertex set $V_1(\text{gshack}(H, P_2, n)) = \{x_{i,j}; 1 \leq i \leq 2, 1 \leq j \leq n+1\}$, $V_2(\text{gshack}(H, P_2, n)) = \{y_{i,j}; 1 \leq i \leq p_H - 4, 1 \leq j \leq n\}$ and edge set $E_1(\text{gshack}(H, P_2, n)) = \{x_{1,j}x_{2,j}; 1 \leq j \leq n+1\}$, $E_2(\text{gshack}(H, P_2, n)) = \{e_{l,j}; 1 \leq l \leq p_H - 2, 1 \leq j \leq n\}$. Thus $p_G = |V(G)| = |V_1| + |V_2| = n(p_H - 2) + 2$ and $q_G = |E(G)| = |E_1| + |E_2| = n(q_H - 1) + 1$.

A disjoint union of generalized shackle of prism graph $G = s\text{gshack}(H, P_2, n)$ is a disconnected graph with vertex set $V_1(\text{gshack}(H, P_2, n)) = \{x^k_{i,j}; 1 \leq i \leq 2, 1 \leq j \leq n+1, 1 \leq k \leq s\}$, $V_2(\text{gshack}(H, P_2, n)) = \{y^k_{i,j}; 1 \leq i \leq p_H - 4, 1 \leq j \leq n, 1 \leq k \leq s\}$ and edge set $E_1(\text{gshack}(H, P_2, n)) = \{x^k_{1,j}x^k_{2,j}; 1 \leq j \leq n+1, 1 \leq k \leq s\}$, $E_2(\text{gshack}(H, P_2, n)) = \{e^k_{l,j}; 1 \leq l \leq p_H - 2, 1 \leq j \leq n, 1 \leq k \leq s\}$. Thus $p_G = |V(G)| = |V_1| + |V_2| = ns(p_H - 2) + 2s$ and $q_G = |E(G)| = |E_1| + |E_2| = ns(q_H - 1) + s$.

The upper bound of feasible d for $G = \text{gshack}(H, P_2, n)$ and $G = s\text{gshack}(H, P_2, n)$ to be a super (a, d)-H-antimagic total labeling follows the following lemma [2].

Lemma 1. *[2] Let G be a simple graph of order p and size q. If G is super (a, d)-H-antimagic total labeling then $d \leq \frac{(p_G - p_H)p_H + (q_G - q_H)q_H}{n-1}$, for $p_G = |V(G)|$, $q_G = |E(G)|$, $p_H = |V(H)|$, $q_H = |E(H)|$, and $n = |H_j|$.*

Thus, for $p_G = n(p_H - 2) + 2$ and $q_G = n(q_H - 1) + 1$, we have the following corollary.

Corollary 1. *For $m \geq 2$, if the graph $G = \text{gshack}(H, P_2, n)$ admits super (a, d)-H-antimagic total labeling then $d \leq p_H^2 + q_H^2 - 2p_H - q_H$.*

Thus for $p_G = ns(p_H - 2) + 2s$ and $q_G = ns(q_H - 1) + s$, we have the following corollary.

Corollary 2. *For $n \geq 2$ and odd $s \geq 3$, if the disconnected graph $G = s\text{gshack}(H, P_2, n)$ admits super (a, d)-H-antimagic total labeling then $d \leq p_H^2 + q_H^2 - 2p_H - q_H + \frac{(s-1)(2p_H + q_H)}{(ns-1)}$.*

We recall a partition $\mathcal{P}^n_{m,d}(i, j)$ introduced in [4]. We will use the partition for a linear combination in developing a bijection of vertex and edge label of the main theorem.

Lemma 2. *[4] Let n and m be positive integers. The sum of $\mathcal{P}^n_{m,d}(i, j) = \{(i-1)n + j,\ \ 1 \leq i \leq m\}$ and $\mathcal{P}^n_{m,d}(i, j) = \{(j-1)m + i;\ \ 1 \leq i \leq m\}$ form an aritmatic sequence of difference $d \in \{m, m^2\}$, respectively.*

Lemma 3. *Let n and m be positive integers. For $1 \leq j \leq n$,the sum of $\mathcal{P}^n_{m,d}(i, j) = \{mn + i - mj; 1 \leq i \leq m; 1 \leq j \leq n\}$ and $\mathcal{P}^n_{m,d}(i, j) = \{1 + ni - j; 1 \leq i \leq m; 1 \leq j \leq n\}$ form an arithmetic sequence of differences of $d \in \{-m^2, -m\}$.*

Lemma 4. *Let n , m and s be positive integers $1 \leq j \leq n; 1 \leq k \leq s$, the sum of $\mathcal{P}^{n,s}_{m,d_7}(i,j,k) = \{(k-1)m + i + (j-1)ms; 1 \leq i \leq m; 1 \leq j \leq n; 3 \leq k \leq s\}$ and the sum of $\mathcal{P}^{n,s}_{m,d_8}(i,j,k) = \{(j-1)s + i + k + (i-1)ns; 1 \leq i \leq m\}$ form an arithmetic sequence of differences $d_5 = m^2$ and $d_6 = m$.*

3 The Results

To show the existence of super (a,d)-H antimagic total labeling of $G = \text{gshack}(F_{2,m}, e, n)$ and $G = s\text{gshack}(F_{2,m}, e, n)$, we will use *an integer set partition technique* introduced by [1, 3]. This technique used in determining the feasible difference d. Let n, m, d and k be positive integers. We consider the partition $\mathcal{P}^n_{m,d}(i,j)$ of the set $\{1, 2, \dots, mn\}$ into n columns, $n \geq 2$, m-rows such that the difference between the sum of the numbers in the $(j+1)$th m-rows and the sum of the numbers in the jth m-rows is always equal to the constant d, where $j = 1, 2, \dots, n-1$. Thus these sums form an arithmetic sequence with the difference d. By the symbol $\mathcal{P}^n_{m,d}(i,j)$ we denote the jth m-rows in the partition with the difference d, where $j = 1, 2, \dots, n$. Let $\sum \mathcal{P}^n_{m,d}(i,j)$ be the sum of the numbers in $\mathcal{P}^n_{m,d}(i,j)$, thus $d = \sum \mathcal{P}^n_{m,d}(j+1) - \sum \mathcal{P}^n_{m,d}(j)$.

3.1 Super (a,d)-H antimagic total labeling (SHATL)

The following three lemmas are useful for studying the existence of super (a,d)-H antimagic total labeling of $G = \text{gshack}(F_{2,m}, e, n)$. These lemmas are related to the developing of the partition $\mathcal{P}^n_{m,d}(i,j)$.

Lemma 5. *Let n and m be positive integers. For $1 \leq j \leq n$, the sum of*

$$\mathcal{P}^n_{m,d}(i,j) = \begin{cases} ni - j & ;\text{i} \equiv 1(\text{mod}3), 1 \leq i \leq m, 1 \leq j \leq n-1 \\ ni & ;\text{i} \equiv 1(\text{mod}3), 1 \leq \text{i} \leq \text{m}, \text{j} = \text{n} \\ ni - n + j + 1 & ;\text{i} \equiv 2(\text{mod}3), 1 \leq \text{i} \leq \text{m}, 1 \leq \text{j} \leq \text{n} - 1 \\ 1 + ni - n & ;\text{i} \equiv 2(\text{mod}3), 1 \leq \text{i} \leq \text{m}, \text{j} = \text{n} \\ ni - n + j & ;\text{i} \equiv 3(\text{mod}3), 1 \leq \text{i} \leq \text{m}, 1 \leq \text{j} \leq \text{n} \end{cases}$$

and

$$\mathcal{P}^n_{m,d}(i,j) = \begin{cases} ni - 2j + 2 & ;\text{i} \equiv 1(\text{mod}3), 1 \leq i \leq m, 1 \leq j \leq n-1 \\ ni - 1 & ;\text{i} \equiv 1(\text{mod}3), 1 \leq \text{i} \leq \text{m}, \text{j} = \text{n} \\ ni - n + 2j - 1 & ;\text{i} \equiv 2(\text{mod}3), 1 \leq \text{i} \leq \text{m}, 1 \leq \text{j} \leq \text{n} - 1 \\ ni - n + 2 & ;\text{i} \equiv 2(\text{mod}3), 1 \leq \text{i} \leq \text{m}, \text{j} = \text{n} \\ ni - j + 1 & ;\text{i} \equiv 3(\text{mod}3), 1 \leq \text{i} \leq \text{m}, 1 \leq \text{j} \leq \text{n} \end{cases}$$

form an arithmetic sequence of differences of $d \in \{\frac{m}{3}, \frac{-m}{3}\}$.

Now we are ready to present the main theorem related to the existence of super $(a,d) - H$ antimagicness of the connected graph $G = \text{gamal}(H, K \subseteq H, n)$, in the following theorem.

Teorema 1. *For $m, n \geq 3$, the graph $G = \text{gshack}(H, P_2, n)$ admits a super $(a, d) - H$ antimagic total labeling with feasible d is* $d = \frac{m_1}{3} - \frac{m_2}{3} + m_3^2 - m_4^2 + m_5 - m_6 + \frac{r_1}{3} - \frac{r_2}{3} + r_3^2 - r_4^2 + r_5 - r_6 + 10$.

3.2 Building encryption keys

Now, we will show how to construct encryption keys by using super $(a, d) - H$ antimagic total labeling of the graph $G = \text{gshack}(F_{2,m}, e, n)$. Suppose we work on 26 English alphabets. The keys construction is undertaken through the following algorithm.

Algorithm 1. SHATL Algorithm for constructing encryption keys

```
1. Assign f as label of the graph elements
2. If f is bijection, do 3, otherwise back to 1
    3. Take a certain d for super (a,d)-HATL
    4. Take z= sum of the number of vertices and 26
    5. Draw the layered diagram by ignoring all labels greater than z
    6. Place all edge labels in sequence from left to right
       and start from the top to the bottom layer.
7. Use the sequence of labels as the encryption keys
```

For clarity, we need to have an illustration of $f(x_{i,j}), 1 \leq i \leq 2, 1 \leq j \leq 5$, $f(y_{i,j}), 1 \leq i \leq 5, 1 \leq j \leq 4$, $f(x_{1,j}x_{2,j}), 1 \leq j \leq 5$, $f(e_{l,j}), 1 \leq i \leq 11, 1 \leq j \leq 5$, through the following figure.

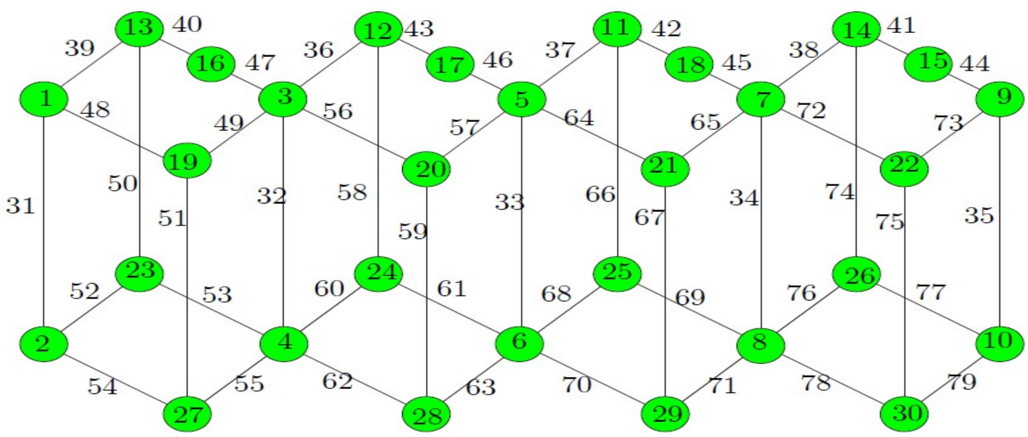

Figure 1: Super $(a, 12) - H$ ATL of the graph $G = \text{gshack}(F_{2,4}, e, 4)$.

Figure 1 indicates that the vertex labels start from 1 to 30 and the edge labels start from 31 to 79. We then draw a layered diagram rooted at label 1 of super $(a, 74) - H$ antimagic total labeling of the graph $G = \text{gshack}(F_{2,4}, e, 4)$, by ignoring the labels which start from $57, 58 \ldots, 79$. The obtained layered diagram is shown in Figure 2. Thus, the sequence of encryption keys (through the order of alphabets A to Z in the Figure) is 31, 39, 48, 52, 54, 40, 50, 49, 51, 53, 55, 47, 32, 36, 56, 43, 46, 33, 37, 42, 45, 34, 38, 41, 44, 35, or (in its equivalence modulo 26) 5, 13, 22, 0, 2, 14, 24, 23, 25, 1, 3, 21, 6, 10, 4, 17, 20, 7, 11, 16, 19, 8, 12, 15, 18, 9.

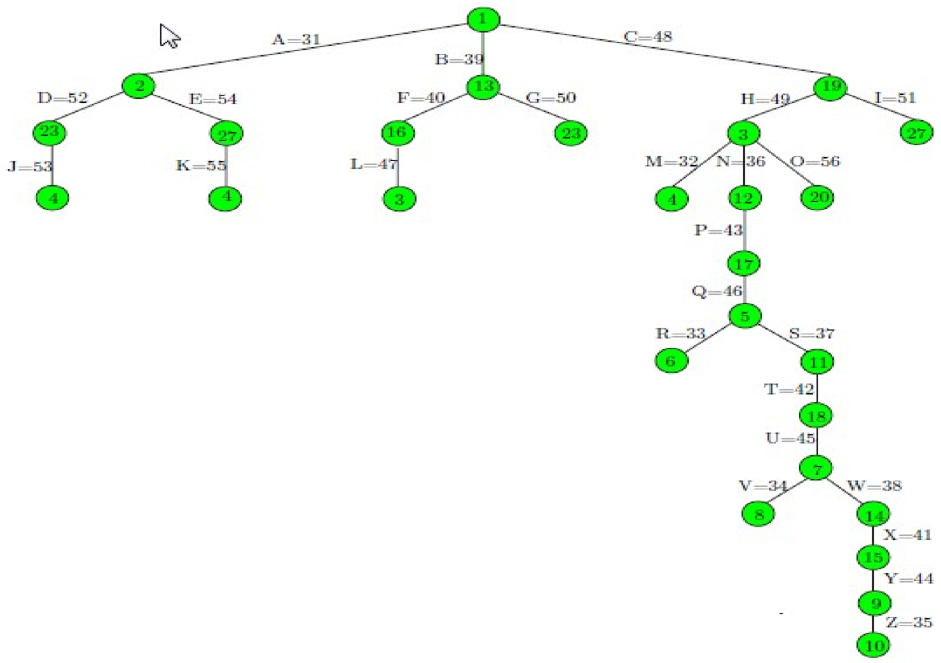

Figure 2: The layered diagram rooted at label 1

3.3 Encryption Algorithm

We apply the sequence of keys produced by the algorithm 1 to a block cipher in the mode of Cipher Block Chaining (CBC). In this system, a plaintext P is divided into blocks as well as the keys sequence K. Encryption process is undertaken using algorithm 2.

Algorithm 2. Encryption using CBC Mode

1. *Let the plaintext* $P = (p_i), 1 \leq i \leq h$
2. *Let the keys sequence* $K = (k_i), 1 \leq i \leq m$
   (a) *If* $m < h$, K *is repeated fully or partially, such that* $|K| = |P|$.
   (b) *If* $m > h$, $K = K - \{k_{h+1}, ..., k_m\}$
3. *Divide* P *into blocks of the length* b.
4. *Divide* K *into blocks of the length* b.
5. *For* $i = 1$ *to* $\lceil \frac{h}{b} \rceil$, *compute the ciphertext blocks using equation 1.*

$$C_i = C_{i-1} + P_i + K_i \bmod 26 \tag{1}$$

where P_i, K_i, and C_i are the i-th block of plaintext, key sequence, and ciphertext, respectively. For $i = 1$, C_{i-1} is a null vector.

We express our cryptosystem using triple: $(G = \text{gshack}(H, P_2, n), CBC, b)$. It means that the encryption keys are generated using *SHATL* on a *shackle* graph G and encryption process is undertaken block by block of the length b each in the mode Cipher Block Chaining. Table 1 shows how the keys sequence obtained from the layered diagram in Figure 2 is applied to encrypt the plaintext "asianmathematicalconference" and yields the ciphertext "FFEADFDUGUUYTYALDCXDJPFQIUY". The decryption process can be done in the reverse direction.

Table 1: Example of Encryption Process.

plaintext	a	s	i	a	n	m	a	t	h	e	m	a	t	i	c
P_i	0	18	8	0	13	12	0	19	7	4	12	0	19	8	2
C_{i-1}	0	0	0	0	0	5	5	4	0	15	5	3	20	6	20
P'_i	0	18	8	0	13	17	5	23	7	19	17	3	13	14	22
K_i	5	13	22	0	2	14	24	23	25	1	3	21	6	10	4
C_i	5	5	4	0	15	5	3	20	6	20	20	24	19	24	0
ciphertext	F	F	E	A	P	F	D	U	G	U	U	Y	T	Y	A
plaintext	a	l	c	o	n	f	e	r	e	n	c	e			
P_i	0	11	2	14	13	5	4	17	4	13	2	4			
C_{i-1}	20	24	19	24	0	11	3	2	23	3	9	15			
P'_i	20	9	21	12	13	16	7	19	1	16	11	19			
K_i	17	20	7	11	16	19	8	12	15	18	9	5			
C_i	11	3	2	23	3	9	15	5	16	8	20	24			
ciphertext	L	D	C	X	D	J	P	F	Q	I	U	Y			

3.4 Security Analysis

We combine SHATL and CBC to develop a cryptosystem scheme. SHATL is utilized to construct a keys sequence, while CBC is to encrypt the plaintext. This combination is aimed to make the relation between plaintext, ciphertext and the key is hidden (*confusion principle*) and to spread the effect of a bit plaintext or key to as many as possible the ciphertext (*diffusion principle*). These two principles are utilized to strengthen block cipher. To analyze security of the scheme, we simulate four main possible attack models.

Ciphertext Only Attack

In this attack, an intruder knows the ciphertext only. The intruder applies as many as possible keys to the known ciphertext to determine which key that yields a meaningful plaintext. As the plaintext is divided into blocks of the length b, there are 26^b possible keys for a block. Since there exists $\lceil \frac{h}{b} \rceil$ blocks and different blocks are encrypted by different keys, there are 26^h, where h is the length of the plaintext. Furthermore, by CBC mode, the keys for the 2nd to $\lceil \frac{h}{b} \rceil$-*th* blocks are confused by previous cipher blocks.

Known Plaintext Attack

This attack assumes that an intruder has a part of the ciphertext and its correspondent plaintext. In ordinary block cipher, once the intruder get a pair of ciphertext and plaintext in a block, he can decrypt the whole message. In our scheme, having only a part of the ciphertext and its correspondent plaintext is not adequate to decrypt the whole message, since the different blocks are encrypted using different sequence of keys.

Chosen Plaintext/Ciphertext Attack

In these attack models, an intruder is assumed having a temporary access to the encryption/decryption machine. He attempts to encrypt a number of plaintext/ciphertext and use the results to derive the encryption/decryption keys. In our scheme, a new keys sequence can be generated using SHATL everytime an encryption process is started. Therefore, a temporary access to the encryption/decryption machine is not sufficient to break the system, since at the subsequent times, the machine uses new SHATL-generated keys.

Based on the previous analysis, our block cipher scheme achieve a good security. This scheme is harder to break by all possible attacks, compared to the ordinary block cipher.

Concluding Remarks

We have shown the existence of super antimagicness of generalized shackle of graph $G = \text{gshack}(H, P_2, n)$, and the use of this graph in constructing an encryption key of polyalphabetic cipher. The result shows that the resulting super (a, d)-H antimagic total graph can potentially generates different keys sequence for different blocks in a block cipher and thus, make the cipher harder to analyzed. However, the keys of each block are independent each other. For future research we still propose the following open problems.

Open Problem 1. *Can super (a, d)-H antimagic total graph generate keys for a stream* *cipher, where a keys sequence of a block is generated from the keys sequences of previous blocks?*

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