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# An Efficient Encryption Process with Graceful Labeling – A Hybrid Approach

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**Abstract.** In this paper, an efficient encryption process using Trifid Cipher accompanied with Graceful Labeling is elaborated. The Trifid Cipher is a trigraphic cipher which uses a 3x3x3 key cube for plaintext encryption and combines the concepts of Substitution cipher along with Transposition and Fractionation techniques making it highly resistant to frequency attacks. An innovative means of presenting the resulting Ciphertext in the form of Cryptographic writing subject to Graceful labeling in which the labels are represented in the form of codes instead of formal integers in a hybrid approach is implemented. To facilitate this Tom - Tom Code is adopted and these codes provides the Graph labeling clue which paves way for corresponding decryption of the Ciphertext. This work thus brings about a new dimension in the field of cryptographic encryption by merging codes with Graph labeling.

## INTRODUCTION

The practice of making use of codes and symbols for secure transmission of information had been in vogue since time immemorial. Many research works, advancements and inventions have been developed in this field since then. Cryptography is the Science that specializes in secret message transmission and it has set its foot on many branches of science including Mathematics, Computer Science, and Engineering. Graph Labeling is the process of assigning integer values to the edges or vertices or both subject to set of conditions or regulations. Research Topics in the combination of these two wonderful subjects have been developed and many are in progress. Here we elaborate on the encryption of secret message using Trifid Cipher and the resulting Ciphertext is passed onto the receiver in the form of Cipher Graph. We introduce a novel methodology of presenting the Cipher Graph with coded vertices instead of formal integers. Application of Graph Labeling techniques to these Codes proves to be even more efficient for secure message transmission as it is difficult for anyone other than the intended person to perceive or process the Cipher Graph further. In this work we make use of Tom - Tom Codes for vertex representation of Cipher Graph in hand with Graceful Labeling for efficient encryption.

## LITERATURE REVIEW

For basic definition and notions in Graph Labeling and Cryptography we refer J.A. Gallian [1] and F. Harary [3]. From R.C. Read [2] ideas on the application of Graph Theory associated with Cryptography has been derived. G. Suzan and Ch. Krishna[4] and Sumathi.R and N.R.Raajan[5] showcases encryption techniques of multilevel cryptosystems making use of Trifid Cipher. J.Jeba Jesintha and Ezhilarasi Hilda Stanley[6] explores graceful labeling of Bow graphs and Shell - Flower Graphs. R. Uma and N. Murugesan [7] discusses some results on graceful labeling of graphs and their sub graphs.[8, 9, 10 &11] elaborates on the concept of transmission of secret messages through graph labeling techniques. Encouraged by these we carry some research in this area with

slight variations and the current work on encryption using Trifid Cipher together with Graph Labeling is a reflection of it.

## PRELIMINARIES

### Definitions

#### *Tom –Tom Code*

A Code language consisting of a combination of oblique bars (/) and (\) to represent each alphabet.

#### *Superstar Tree*

A tree which consists of several stars connected to a single star is called a Superstar Tree.

#### *Bow Graph*

A Shell graph denoted as  $C(n, n-3)$  is a cycle  $C_n$  with  $(n-3)$  chords sharing a common end point called the apex. Two disjoint shells with a common apex is termed as a Double Shell whereas a collection of edge disjoint shells with a common apex is a Multiple Shell. A bow graph is a double shelled graph where each shell can maintain any order

### Graceful Labeling

Let  $G$  be a graph with  $n$  edges. A bijection  $g:V(T) \rightarrow \{0,1,2,\dots, n\}$  such that when each edge is assigned the label  $|g(u) - g(v)|$  the edge label sets is equal to  $\{1,2,3,\dots,n\}$  is called a graceful labeling of  $G$ .

#### *Plaintext*

The original message from the sender to the receiver which undergoes encryption and the encrypted plaintext is called the Ciphertext.

### Cipher Graph

Cipher Graph is the Graph structure forwarded to the receiver which on application of Graph labeling technique yields back the Ciphertext.

#### *Cryptographic Writing*

The process of presenting the Cipher graph along with the Cipher clue to the receiver for identification of the ciphertext is termed as cryptographic writing.

## PLAN OF WORK

The plan of work is depicted below. The plaintext from the sender undergoes trifid cipher encryption and the ciphertext as cryptographic writing is passed over to the receiver. Application of Graceful Labeling and corresponding decryption yields the plaintext back.

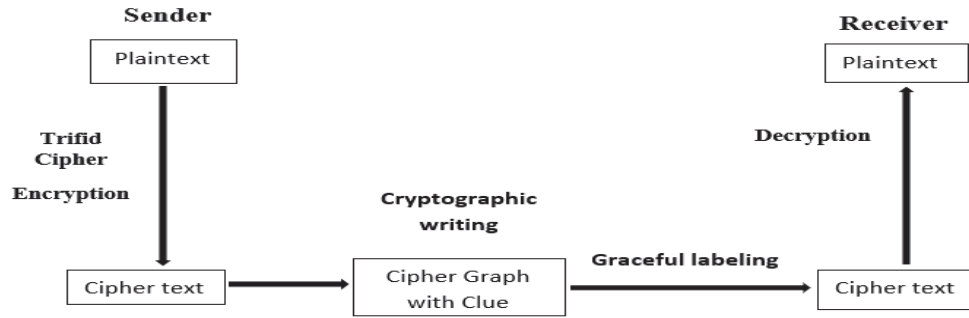


FIGURE 1. Plan of Work

## TRIFID CIPHER

The Trifid Cipher invented by Felix Delastelle is a classic example of combination ciphers in which the encryption process is a sequence of several techniques which combines the process of Substitution with Fractionation and Transposition. It is an extension of 5x5x5 Bifid Cipher. The trifid cipher is a symmetric key cipher which makes use of same key for both encryption and decryption and each letter of the cipher text depends on 3 letters of the plaintext called the trigram. Each trigram consists of block number, row number and column number respectively. The Trifid Cipher comprises of three blocks where Block 1 consists of key letters at the beginning followed by Block 2 and Block 3 containing remaining alphabets in the regular ordering and the last cell is filled with any convenient symbol.

### Trifid Encryption

To encrypt a message, we translate each plaintext letter into a 3- digit trigram using the 3x3x3 grid where the digits represent block number, the row number and then the column number respectively. The encryption is done by reading off the plaintext by rows taken three at a time and noting down its corresponding letter from the 3x3x3 grid. The decryption is done by simply reversing the encryption process.

### *Tom - Tom Code with Numbering of Alphabets*

The Tom - Tom Code is code language which uses a combination of forward and backward slashes i.e., (/) and (\) invented by Hayden as an alternative of English alphabets.

TABLE 1. Tom-Tom Code with Numbering of Alphabets from A to Z

<b>Regular Numbering</b>	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<b>Characters</b>	0	a	b	c	d	e	f	g	h	i	j	k	l	m	n
<b>Tom -Tom Code</b>	Δ	/	//	///	////	∧	∧∧	∧∧∧	∧∧∧	∧∧∧	∨	∨∨	∨∨∨	∨∨	∨∨∨

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
o	P	q	r	s	t	u	v	w	x	y	z	.	?	,	&
∨	//∨	∧∨	∧∨∨	∨	∨∨	∨∧	∨∧∧	//∨	∨∨	∨∨	∧∧	*	<	>	#

Here numbers are assigned to each alphabetic character in a two-way fashion. One is regular numbering from 1 to 30 for the characters and the other is by using Tom -Tom code for characters from a to z. The characters from a to z are numbered from 1 to 26 whereas characters 0, (.), (,), (?) and (&) are assigned special symbols of our choice. We can also increase the special characters count to extend the numbering depending on the Cipher graph and the labeling adopted.

## Cryptographic Writing

The art of writing or solving codes is termed as cryptography and the presentation of such codes in some unintelligible form is termed as cryptographic writing. Cryptographic writing is said to draw its origin from the Hieroglyphic writing of ancient Greek and Roman Empire dating back around 5,200 years ago. Hieroglyphic writing employs writing in the form of pictures whereas Cryptographic writing comprises of a combination of special symbols, code and letters in jumbled form. Hieroglyphic script is considered as the language of Gods whereas Cryptographic writing can be considered as the language of Cryptographers. Because of their pictorial form, hieroglyphs were difficult to write and were used only for monument inscriptions and are no longer used. The work aims at expressing encrypted messages for secure communication through such cryptographic writing in the modern digital era as it was used during ancient period.

### *Pre - Requisites Handed to the Receiver*

1. Cipher clue embedded in the Cryptographic writing to perceive the ciphertext from the Cipher Graph.
2. Decryption Key to decrypt the ciphertext from Cipher Graph yielding plaintext back.
3. The numbering of alphabets and the code language along with knowledge of cryptography and Graph Labeling is necessary.

### *Algorithm for Trifid encryption using Tom -Tom Code- A Hybrid Approach*

The algorithm details the steps to be performed for Trifid Cipher encryption using Tom -Tom Code.

*Step 1:* Process the given Plaintext through Trifid Cipher.

*Step 2:* The ciphertext thus determined is passed over to the receiver as a Cipher graph with Cipher clue which constitutes our cryptographic writing.

*Step 3:* Identification of Ciphertext through Cipher clue.

*Step 4:* Decryption of Ciphertext using Tom -Tom Code retrieves our plaintext.

## ILLUSTRATION 1

### Trifid Encryption

Let the plaintext be: **mary had a little lamb** and keyword: **white as snow**. We now detail the steps of Trifid Encryption. Ignoring blank spaces and repeated letters of the keyword the 3x3x3 grid representing the key words is shown in "Table 2" and the trigraphic representation of the plaintext block, row and column wise is depicted in "Table 3".

**TABLE 2.** 3x3x3 Grid Representing Key Word for Encryption

Block 1	Block 2	Block 3																																																
<table border="1" style="border-collapse: collapse; width: 100%; text-align: left;"> <tr><td></td><td><b>1</b></td><td><b>2</b></td><td><b>3</b></td></tr> <tr><td><b>1</b></td><td>w</td><td>h</td><td>i</td></tr> <tr><td><b>2</b></td><td>t</td><td>e</td><td>a</td></tr> <tr><td><b>3</b></td><td>s</td><td>n</td><td>o</td></tr> </table>		<b>1</b>	<b>2</b>	<b>3</b>	<b>1</b>	w	h	i	<b>2</b>	t	e	a	<b>3</b>	s	n	o	<table border="1" style="border-collapse: collapse; width: 100%; text-align: left;"> <tr><td></td><td><b>1</b></td><td><b>2</b></td><td><b>3</b></td></tr> <tr><td><b>1</b></td><td>b</td><td>c</td><td>d</td></tr> <tr><td><b>2</b></td><td>f</td><td>g</td><td>j</td></tr> <tr><td><b>3</b></td><td>k</td><td>l</td><td>m</td></tr> </table>		<b>1</b>	<b>2</b>	<b>3</b>	<b>1</b>	b	c	d	<b>2</b>	f	g	j	<b>3</b>	k	l	m	<table border="1" style="border-collapse: collapse; width: 100%; text-align: left;"> <tr><td></td><td><b>1</b></td><td><b>2</b></td><td><b>3</b></td></tr> <tr><td><b>1</b></td><td>p</td><td>q</td><td>r</td></tr> <tr><td><b>2</b></td><td>u</td><td>v</td><td>x</td></tr> <tr><td><b>3</b></td><td>y</td><td>z</td><td>.</td></tr> </table>		<b>1</b>	<b>2</b>	<b>3</b>	<b>1</b>	p	q	r	<b>2</b>	u	v	x	<b>3</b>	y	z	.
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This Cipher clue with Cipher graph constitutes our cryptographic writing from which the receiver identifies the Ciphertext by applying Graceful labeling to the clue. Here our Cipher graph is Superstar graph as depicted in “Fig.2”.

### IDENTIFICATION OF CIPHERTEXT USING CIPHER CLUE

**Stylish Tag for Tom:**  $SS^{///, \wedge}$   $SS^{/, \wedge}$   $SS^{///, //}$   $SS^{\Delta, //}$   $SS^{///, //}$   $SS^{\wedge, \vee}$   $SS^{\Delta, \vee}$

$SS^{/, \wedge}$   $SS^{\wedge, //}$   $SS^{\wedge, \vee}$   $SS^{\Delta, \vee}$   $SS^{//, \vee}$   $SS^{\Delta, *}$   $SS^{\wedge, //}$   $SS^{\Delta, \wedge}$   $SS^{/, \wedge}$   $SS^{///, \vee}$   $SS^{\Delta, \vee}$

The clue **Stylish Tag for Tom** discloses the labeling as Graceful for the Superstar Graph bestowed with Tom - Tom Code and  $SS^{i,j}$  refers to the edge label connecting (i, j). From “Table.1” using Graceful labeling  $SS^{///, \wedge}$  is identified as  $SS^{4,8}$  and applying graceful labeling we get  $|4 - 8| = 4$ . Also,  $SS^{/, \wedge}$  is identified as  $SS^{1,17}$  which gives  $|1 - 17| = 16$ . Similarly, the other edge labels obtained 4,16,3,23,3,5,21,17,1,5,24,11,27,1,26,16,7,25 yields the character sequence as **dpcwceuqaexk.azpgy** from “Table1”.

“Fig.3” shows the Cipher graph - Super Star tree displaying vertex and edge labels with integer values using Graceful labeling for Tom -Tom Code from “Table1”.

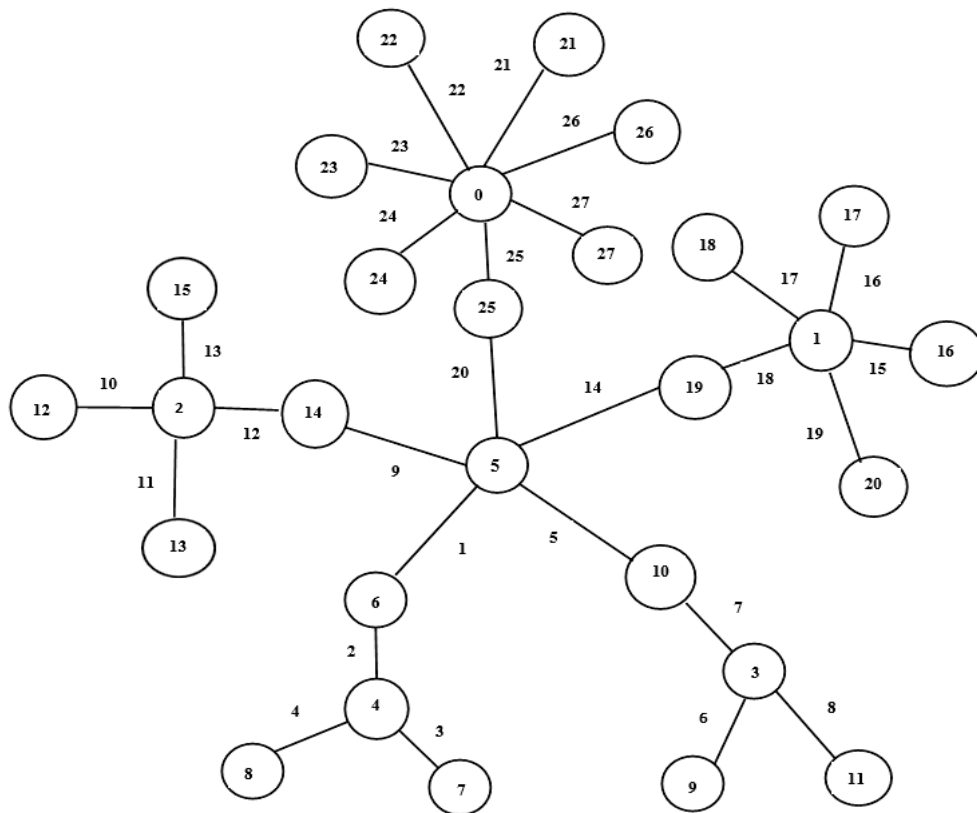


FIGURE 3. Superstar Tree with Edge Labels Using Graceful Labeling

## DECRYPTING THE CIPHERTEXT USING TRIFID CIPHER

The decryption key is: **white as snow** and the corresponding 3x3x3 Grid for decryption is shown in “Table 4”.

TABLE 4. 3x3x3 Grid for Decryption

<b>Block 1</b>	<b>Block 2</b>	<b>Block 3</b>																																																
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<b>3</b>	y	z	.																																															

Decryption of ciphertext: **dpcwceuqaexk.azpgy** with trigram 213, 311, 212, 111, 212, 122, 321, 312, 123, 122, 323, 231, 333, 123, 332, 311, 222, 331 is by splitting the Ciphertext into three equal rows one below the other and reading off by columns. Reading “Table 5” column wise we get 233, 123, 313, 331, 112, 123, 213, 123, 232, 113, 121, 121, 232, 123, 233, 211 yielding the required plaintext: **mary had a little lamb**

TABLE 5. Trigraphic Decryption of the Ciphertext

Block	2	1	3	3	1	1	2	1	2	1	1	2	1	2	1	2	2	
Row	3	2	1	3	1	2	1	2	3	1	2	2	3	2	3	2	3	1
Column	3	3	3	1	2	3	3	3	2	3	1	1	2	2	2	3	3	1
Plaintext	<b>m</b>	<b>a</b>	<b>r</b>	<b>y</b>	<b>h</b>	<b>a</b>	<b>d</b>	<b>a</b>	<b>l</b>	<b>i</b>	<b>t</b>	<b>t</b>	<b>l</b>	<b>e</b>	<b>l</b>	<b>a</b>	<b>m</b>	<b>b</b>

## ILLUSTRATION 2

Let our plaintext for Trifid Encryption be: **sell the golden ring** and let the key word: **to agent ten**. “Table 6” shows the 3x3x3 Grid for the keyword and Trigraphic representation of the plaintext.

TABLE 6. 3x3x3 Grid and Trigraphic Representation of the Plaintext

<b>Block 1</b>	<b>Block 2</b>	<b>Block 3</b>																																																
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Plaintext	<b>s</b>	<b>e</b>	<b>l</b>	<b>l</b>	<b>t</b>	<b>h</b>	<b>e</b>	<b>g</b>	<b>o</b>	<b>l</b>	<b>d</b>	<b>e</b>	<b>n</b>	<b>r</b>	<b>i</b>	<b>n</b>	<b>g</b>
Block	3	1	2	2	1	2	1	1	1	2	1	1	1	3	2	1	1
Row	1	2	2	2	1	1	2	2	1	2	3	2	2	1	1	2	2
Column	2	2	3	3	1	2	2	1	2	3	3	2	3	1	3	3	1



Reading off the plaintext in rows the trigrams are 312, 212, 111, 211, 132, 111, 222, 112, 212, 322, 112, 222, 331, 221, 233, 231, 331 producing the ciphertext: **shtfctkohwojyqmy** forwarded to the receiver. Here the Cipher graph considered is a bow graph shown in “Figure 4”.

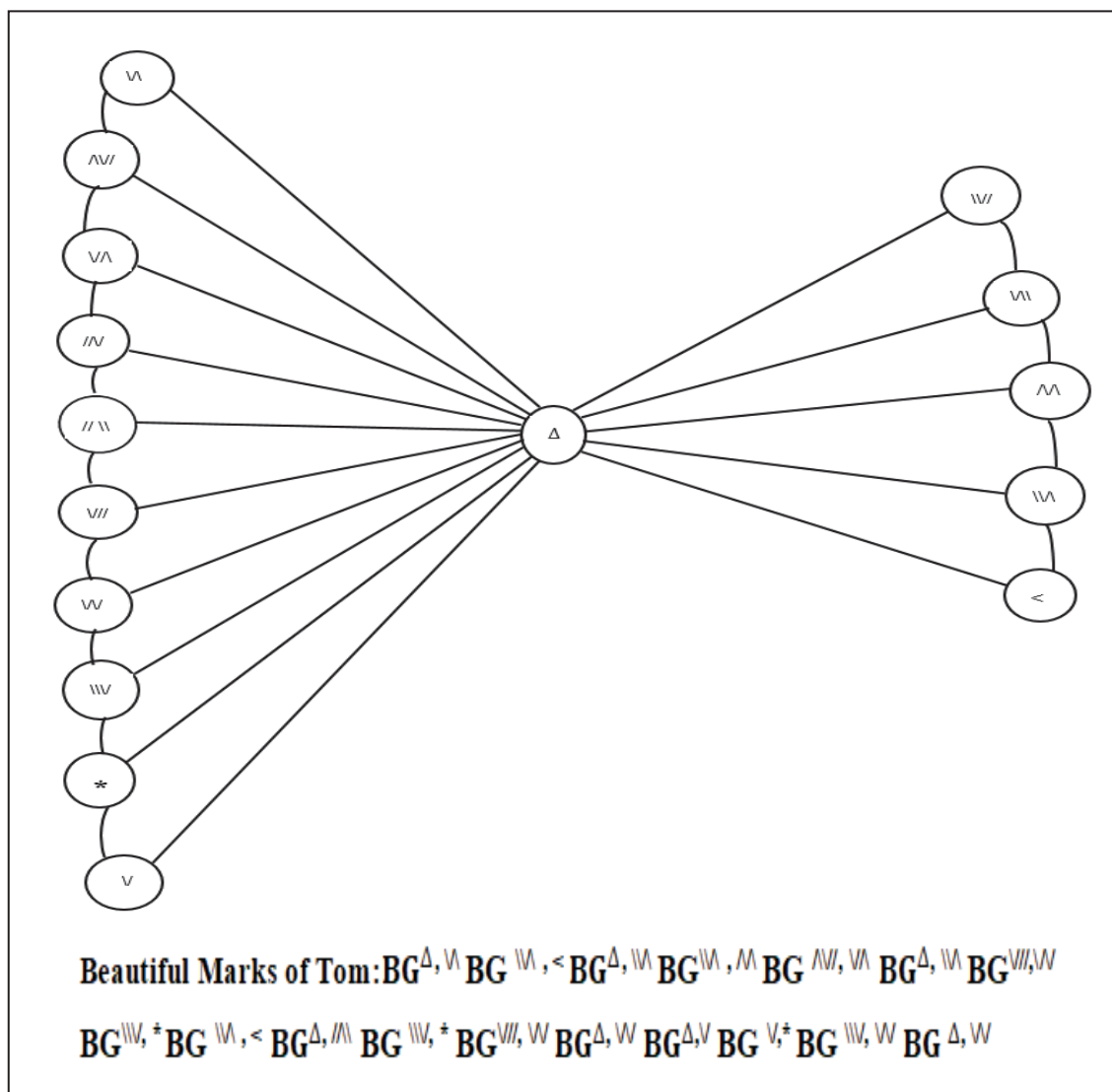


FIGURE 4. Cryptographic Writing to the Receiver - Bow Graph

### CIPHER CLUE

Proceeding as in Illustration 1, the clue **Beautiful Marks of Tom** discloses the labeling as Graceful for the Bow Graph bestowed with Tom-Tom Code and the corresponding edge labels sequence is 19,8,20,6,3,20,11,15,8,23,15,11,25,10,17,13,25 yielding the ciphertext sequence **asshtfctkohwojyqmy**.

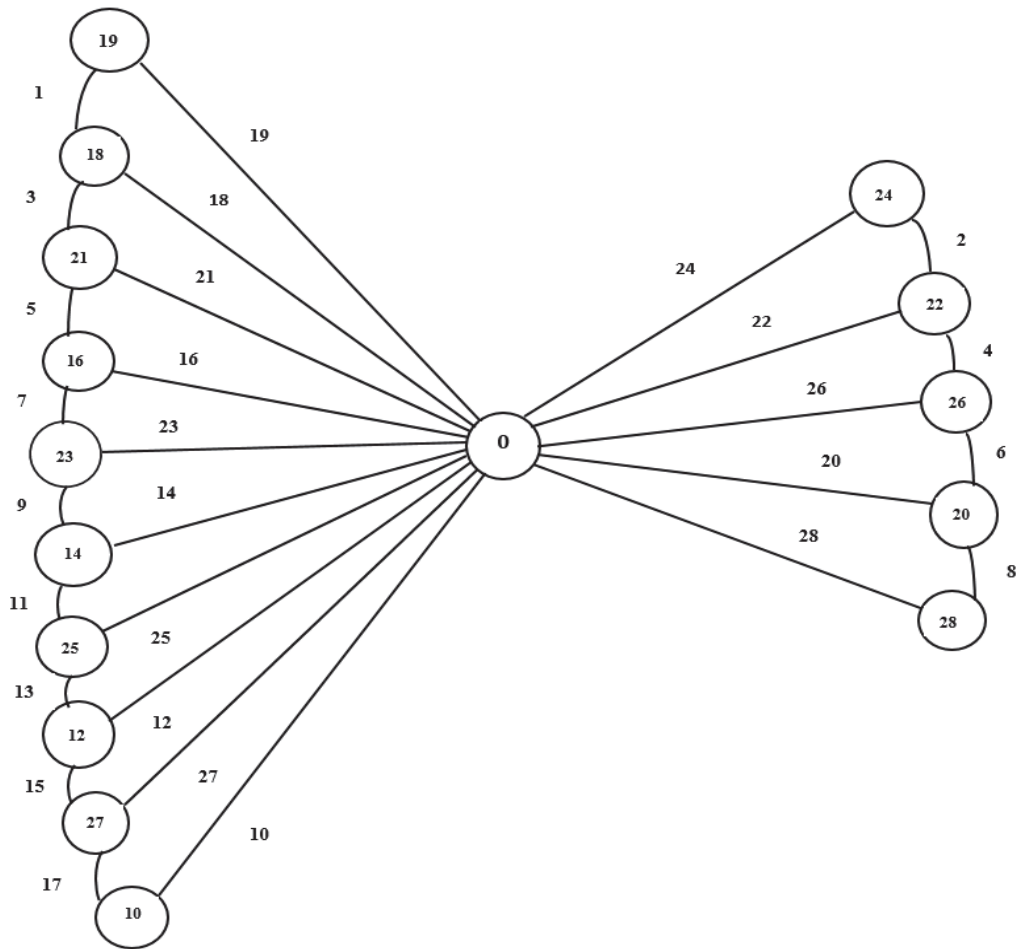


FIGURE 5. Bow Graph Showing the Edge Labels Using Graceful Labeling

### DECRYPTING THE CIPHERTEXT USING TRIFID CIPHER

Let the decryption Key be: **to agent ten**. Again, by “Table.6” for ciphertext: **shtfctkohwokyjqmy** reading off columnwise we get 312, 122, 223, 223, 111, 212, 122, 121, 112, 223, 133, 122, 123, 311, 213, 123, 121 yielding back the plaintext: **sell the golden ring**.

TABLE 7. Trigraphic Decryption of the Ciphertext

Block	3	1	2	2	1	2	1	1	1	2	1	1	1	3	2	1	1
Row	1	2	2	2	1	1	2	2	1	2	3	2	2	1	1	2	2
Column	2	2	3	3	1	2	2	1	2	3	3	2	3	1	3	3	1
Plaintext	s	e	l	l	t	h	e	g	o	l	d	e	n	r	i	n	g

## CONCLUSION

We have thus implemented an effective encryption technique using Trifid Cipher together with Graph Labeling as a hybrid approach. The methodology can be tried upon for a variety of labeling technique and code languages on different combinations of Cipher graphs structures thereby making transmission of secret message more secure and confidential.

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