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SDC Labeling On Path Union Of Special Graphs

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Abstract:
A sum divisor cordial labeling of a graph G with vertex set V(G) is a bijection f from V(G) to {1, 2 ,3, …, |V(G)|} such that an edge u v is assigned the label 0 if 2 divides f(u)+f(v) and 1 otherwise; and if it satisfies the condition $|e_f(0) - e_f(1)| \leq 1$, then the graph with a sum divisor cordial labeling is called a sum divisor cordial graph. In this paper we apply the concept of the sum divisor cordial labeling of path union of some special graphs.
Keywords: *Sunflower graph, flower graph, jelly fish graph, crown graph, sub division of star graph, cordial graphs, Sum divisor cordial graphs.*

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I. Introduction:

A graph labeling of a graph is a mapping that connects the graph elements to the numbers set. If the domain is a collection of nodes the labeling is called node labeling. If the domain is the collection of edges, then we called edge labeling. If the labels are given to both nodes and edges then the labeling is called total labeling. Graph labeling is an energetic region that belongs to research in graph theory. The concept of graph labeling was introduced by Rosa [1]. There are many labelings in graph theory, some of them are graceful labeling, edge labeling, radio labeling, Magic labeling, prime labeling and many others. One of the labelings is sum divisor cordial labeling. The idea of sum divisor cordial labeling was initiated with the aid of Lourdusamy st Xavier & Patrick St Xavier [7].

II. Preliminaries:

Definition 2.1

A wheel graph is a graph which is formed by cycle and a vertex at the center which connects to all vertices of the cycle. Let W_n be a wheel with x_0 as the nodes of its cycle. The sunflower graph G is formed by adding new vertices $y_1, y_2, \ldots, y_n$ such that y_i is connected to x_i, x_{i+1}, (mod n) (Ponraj et al.,2015)

Definition 2.2

The helm H_n is the graph obtained from a wheel by attaching a pendant edge to each rim vertex.

Definition 2.3

The crown $C_n \odot K_1$ is the graph obtained from a cycle by attaching a pendant edge to each vertex of the cycle.

Definition 2.4

The jelly fish graph, $J_{m,n}$ is obtained from a 4-cycle with vertices x, y, u, v, by joining x and y with a prime edge and appending m pendent edges to u and n pendent edges to v. The prime edge in jelly fish graph is defined to be the edge joining the vertices x and y.

Definition 2.5

The subdivision of star S $(K_{1,n})$ is the graph obtained from $K_{1,n}$ by attaching a pendant edge to each vertex of $K_{1,n}$ except root vertex.

Definition 2.6

The path union of a graph G is the graph obtained by adding an edge between corresponding vertices of G_i to G_{i+1}, $1 \leq i \leq n-1$, Where $G_1, G_2, G_3, \ldots, G_n$ $(n \geq 2)$ are n copies of G

Definition 2.7

A graph labeling is the assignment of unique identifiers to the edges and vertices of a graph.

Definition 2.8
The flower Fl_n is the graph obtained from a helm by attaching each pendant vertex to the apex of the helm.

Definition 2.9
A cordial labeling is a binary vertex labeling of a graph that satisfies certain conditions $|v_f(0) - v_f(1)| \leq 1$ and $|e_f(0) - e_f(1)| \leq 1$. $v_f(0)$ and $v_f(1)$ are the number of vertices in G with label 0 and label 1 under f respectively. $e_f(0)$ and $e_f(1)$ are the number of edges in G with label 0 and label 1 under f respectively.

Definition: 2.10
Let $G = (V(G), E(G))$ be a simple graph and $f: V(G) \rightarrow \{1, 2, ..., |V(G)|\}$ be the bijection. For each edge uv, assaign the label 0. If 2/f(u)+f(v) and the label 1 otherwise. The function f is a sum divisor cordial (SDC) labeling if $|e_f(0) - e_f(1)| \leq 1$. A graph which admits sum divisor cordial (SDC)labeling is calling a sum divisor cordial (SDC) Graph.

III. Main Results

SDC Labeling On Path Union Of Some Graphs
In this section, SDC labeling is obtained for different classes of graphs and path.

Theorem 3.1
The path union graph P (2. SF_n) is a SDC graph for all n ≥ 3

Proof: Let G = P (2. SF_n)
Let V (P (2. SF_n)) = $\{u_{1,0}, u_{1,j}, v_{1,j}, u_{2,0}, u_{2,j}, v_{2,j} : 1 \leq j \leq n\}$
and E (P (2. SF_n)) = $\{u_{1,0} u_{1,j}, u_{2,0} u_{2,j} : 1 \leq j \leq n;$
$u_{1,j} v_{1,j}, u_{2,j} v_{2,j} : 1 \leq j \leq n;$
$v_{1,j} v_{1,j+1}, v_{2,j} v_{2,j+1} : 1 \leq j \leq n-1;$
$v_{1,j} u_{1,j+1}, v_{2,j} u_{2,j+1} : 1 \leq j \leq n-1;$
$u_{1,1} v_{1,n}, u_{2,1} v_{2,n}, v_{1,1} v_{1,n}, v_{2,1} v_{2,n}, u_{1,0} u_{2,0}\}$
Then the order and size of the graph G are
| V(G) | = 4n+2 and | E(G) | = (8n+1) respectively.
Define g: V(G) → {1, 2, 3, …, 4n+1, 4n+3} by
$g(u_{1,0}) = 1$, $g(u_{1,j}) = 2j+1$, $1 \leq j \leq n$, $g(v_{1,j}) = 2j$, $1 \leq j \leq n$;
$g(u_{2,0}) = 2n+3$, $g(u_{2,j-(n+1)}) = 2j+1$, $n+2 \leq j \leq 2n+1$
$g(v_{2,j-(n)}) = 2j$, $n+1 \leq j \leq 2n$
Then the induced edge labeling as follows g*: E(G) → {0,1}
$g^*(u_{1,0} u_{1,j}) = 0$, $1 \leq j \leq n$;
$g^*(u_{1,j} v_{1,j}) = 1$, $1 \leq j \leq n$;
$g^*(v_{1,j} u_{1,j+1}) = 1$, $1 \leq j \leq n-1$;
$g^*(v_{1,j} u_{1,j+1}) = 0$, $1 \leq j \leq n-1$;
$g^*(u_{1,1} v_{1,n}) = 1$;
$g^*(v_{1,1} v_{1,n}) = 0$;
$g^*(u_{2,0} u_{2,j}) = 0$, $1 \leq j \leq n$;
$g^*(u_{2,j} v_{2,j}) = 1$, $1 \leq j \leq n$;
$g^*(v_{2,j} u_{2,j+1}) = 1$, $1 \leq j \leq n-1$;
$g^*(v_{2,j} u_{2,j+1}) = 0$, $1 \leq j \leq n-1$;
$g^*(u_{2,1} v_{2,n}) = 1$;
$g^*(v_{2,1} v_{2,n}) = 0$;
$g^*(u_{1,1} u_{2,1}) = 1$;
We notice that, $|e_{g^*}(0)| = 4n+1$ and $|e_{g^*}(1)| = 4n$
thus $|e_{g^*}(0) - e_{g^*}(1)| \leq 1$
Hence, path union graph P (2. SF_n) is a SDC graph for all n ≥ 3. □

Example 3.2:
The graph P (2. SF_n) Where n=3 is shown in figure 1
Let G = P (2. SF_3)
Then the order and size of the graph G are
| V(G) | =14 and | E(G) | = 25 respectively.
Define g: V(G) → {1, 2, 3, …, 13, 15} then the edge function is

g*: E(G) → {0,1}
We notice that, $|e_{g^*}(0)|$ =13 and $|e_{g^*}(1)|$ =12
From figure 1 $|\ e_{g^*}(0) - e_{g^*}(1)\ | = |\ 13\text{-}12| \le 1$
Hence, path union of Sunflower graph P (2. SF_3) is a SDC graph.

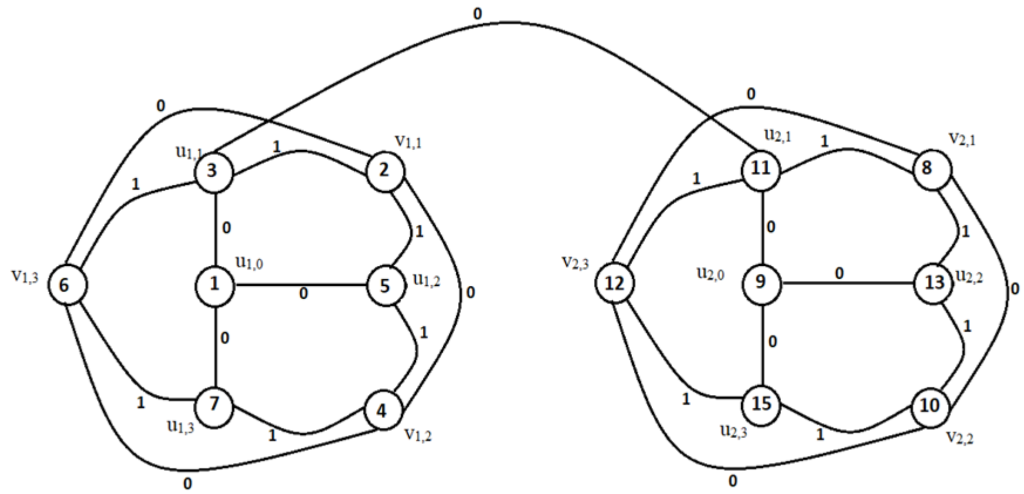

Figure 1: SDC labeling on **P (2. (SF_3))**

Example 3.3:
The graph P (2. SF_n) Where n=4 is shown in figure 2
Let G = P (2. SF_4)
Then the order and size of the graph G are
| V(G) | =18 and | E(G) | = 33 respectively.
Define g: V(G) → {1, 2, 3, …, 17, 19} then the edge function is
g*: E(G) → {0,1}
We notice that, $|e_{g^*}(0)|$ =17 and $|e_{g^*}(1)|$ =16
From figure 1 $|\ e_{g^*}(0) - e_{g^*}(1)\ | = |\ 17\text{-}16| \le 1$
Hence, path union of Sunflower graph P (2. SF_4) is a SDC graph.

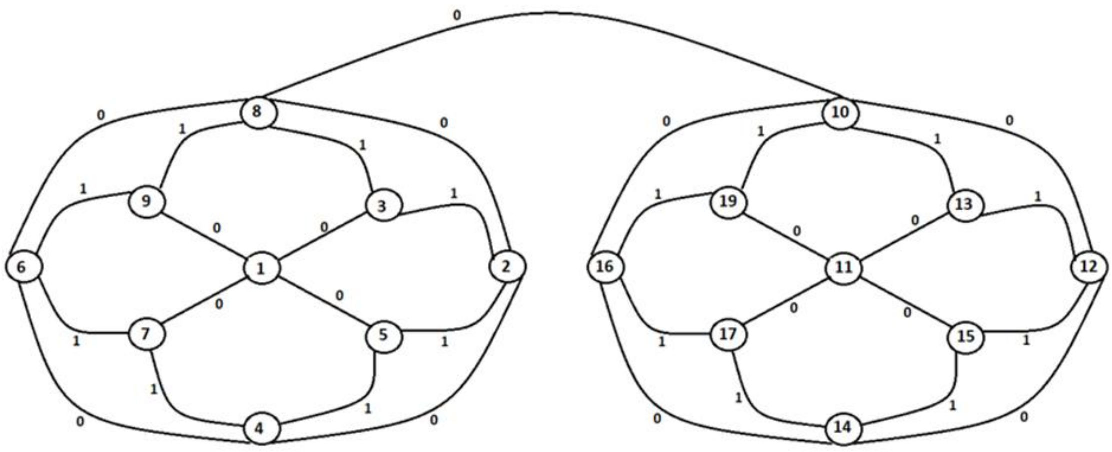

Figure 2: SDC labeling on **P (2. SF_4)**

Theorem 3.4
The path union of flower graph P (2.Fl_n) is a sum divisor cordial graph.
Proof:
Let G = P (2.Fl_n)
Let Vertex set and edge set of G are

$V(G) = \{v_{1,0}, v_{1,i}, u_{1,i}, v_{2,0}, v_{2,i}, u_{2,i}: 1 \le i \le n\}$ and
$E(G)= \{v_{1,0} v_{1,i}, v_{1,i} u_{1,i}, v_{1,0} u_{1,i}: 1 \le i \le n;$
$v_{1,n} v_{1,1}: v_{1,i} v_{1,i+1}: 1 \le i \le n-1;$
$v_{2,0} v_{2,i}, v_{2,i} u_{2,i}, v_{2,0} u_{2,i}: 1 \le i \le n;$
$v_{2,n} v_{2,1}: v_{2,i} v_{2,i+1}: 1 \le i \le n-1;$
$v_{1,1} v_{2,1}\}$
Then G is of order $|V(G)| = 4n+2$ and size $|E(G)| = 8n+1$
Define $g: V(G) \to \{1, 2, 3, \ldots, 4n, 4n+1, 4n+3\}$ as follows.
$g(v_{1,0}) = 1;$
$g(v_{1,i}) = 2i;\ 1 \le i \le n$
$g(u_{1,i}) = 2i+1;\ 1 \le i \le n$
$g(v_{2,0}) = 2n+3;$
$g(v_{2,i-n}) = 2i;\ n+1 \le i \le 2n$
$g(u_{2,i-n-1}) = 2i+1;\ n+2 \le i \le 2n+1$
Then the induced edge labeling as follows $g^*: E(G) \to \{0,1\}$.
$g^*(v_{1,0}\, v_{1,i}) = 1; 1 \le i \le n$
$g^*(v_{1,0}\, u_{1,i}) = 0; 1 \le i \le n$
$g^*(v_{1,i}\, u_{1,i}) = 1; 1 \le i \le n$
$g^*(v_{1,i}\, v_{1,i+1}) = 0; 1 \le i \le n-1$
$g^*(v_{1,1}\, v_{2,1}) = 0;$
$g^*(v_{2,0}\, v_{2,i}) = 1; 1 \le i \le n$
$g^*(v_{2,0}\, u_{2,i}) = 0; 1 \le i \le n$
$g^*(v_{2,i}\, u_{2,i}) = 1; 1 \le i \le n$
$g^*(v_{2,i}\, v_{2,i+1}) = 0; 1 \le i \le n-1$
$g^*(v_{2,n}\, v_{2,1}) = 0;$
$g^*(v_{1,1}\, v_{2,1}) = 0;$
We observe that $|e_{g^*}(0)| = 4n+1$ and $|e_{g^*}(1)| = 4n$
thus $|\ e_{g^*}(0) - e_{g^*}(1)| \le 1$
Hence path union of flower graph P $(2.Fl_n)$ is a sum divisor cordial graph. □

Example 3.5:
Let $G = P(2.Fl_4)$
Then G is of order $|V(G)| = 18$ and size $|E(G)| = 33$
Define $g: V(G) \to \{1, 2, 3, \ldots, 16, 17, 19\}$ as follows
Then the induced edge labeling as follows $g^*: E(G) \to \{0,1\}$.

The graph P $(2.\ Fl_4)$ where n=4 is shown in figure 3
From figure 3 We observe that $|e_{g^*}(0)| = 17$ and $|e_{g^*}(1)| = 16$
$|\ e_{g^*}(0) - e_{g^*}(1)| = |17-16| \le 1$
thus $|\ e_{g^*}(0) - e_{g^*}(1)| \le 1$
Hence path union of flower graph P $(2.Fl_n)$ is a sum divisor cordial graph. □

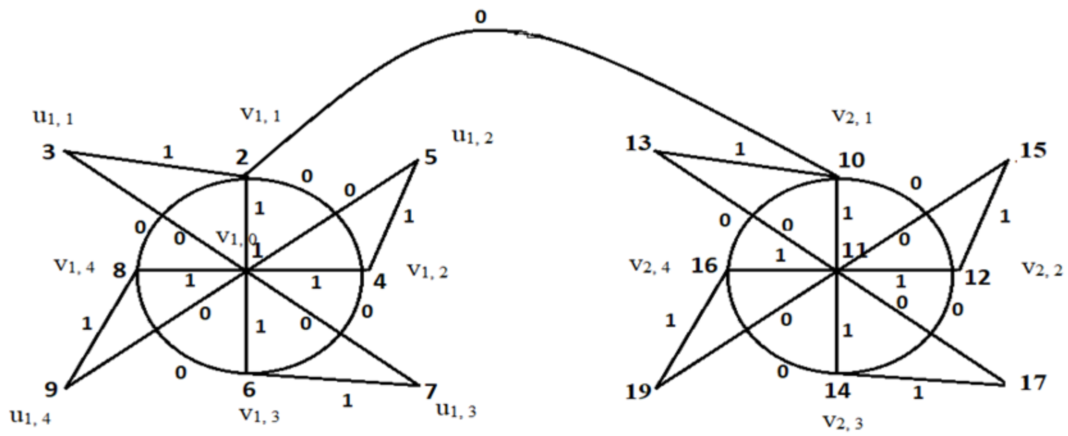

figure 3: SDC labeling on **P (2.FL_4)**

Theorem 3.6: The path union of Jellyfish graph P (2. J (m, m)) admits a SDC labeling. Where m is odd and m $greaterthan\ 0r\ equal\ to\ one$
Proof: Let G = P (2. J (m, m))
Let V(G) = {u_i, v_i , u, v, x, y, u_i^1, v_i^1, u^1 , v^1, x^1, y^1} be the vertex set of the graph G.
Let E(G) = {uu_i, vv_i, u x, u y, v x, v y, u v, $u^1u_i^1$, $v^1v_i^1$, u^1x^1, u^1y^1, v^1x^1, v^1y^1, u^1v^1, xx^1}
Then | V(G) | = 4m+8 vertices and
| E(G) | = 4m+13 edges
Define an injective function
g: v→ {1, 2, 3, …, 4m+8} such that
g(u) = 1
g(v) = 2
g(x) = 3
g(y) = 4
g ($u_{1,\,i}$) = 4+i; $1 \le i \le m$
g ($v_{1,\,i}$) = 4+m+i; $1 \le i \le m$
g(u^1) = 2m+5
g(v^1) = 2m+6
g(x^1) = 2m+7
g(y^1) = 2m+8
g ($u_{2,\,i}$) = 2m+8+i; $1 \le i \le m$
g ($v_{2,\,i}$) = 3m+8+i; $1 \le i \le m$
and an induced edge labeling function is defined as
g^*: E(G) → {0, 1} such that
$g^*(u\, u_{1,\,2i-1}) = 0;\ 1 \le i \le \left\lceil \frac{m}{2} \right\rceil$
$g^*(u\, u_{1,\,2i}) = 1;\ 1 \le i \le \left\lfloor \frac{m}{2} \right\rfloor$
$g^*(v\, v_{1,\,2i-1}) = 1;\ 1 \le i \le \left\lceil \frac{m}{2} \right\rceil$
$g^*(v\, v_{1,\,2i}) = 0;\ 1 \le i \le \left\lfloor \frac{m}{2} \right\rfloor$
$g^*(u^1u_{2,\,2i-1})) = 0;\ 1 \le i \le \left\lceil \frac{m}{2} \right\rceil$
$g^*(u^1u_{2,\,2i})) = 1;\ 1 \le i \le \left\lfloor \frac{m}{2} \right\rfloor$
$g^*(v^1v_{2,\,2i-1}) = 1;\ 1 \le i \le \left\lceil \frac{m}{2} \right\rceil$
$g^*(v^1v_{2,\,2i}) = 0;\ 1 \le i \le \left\lfloor \frac{m}{2} \right\rfloor$
$g^*(x\, y) = f^*(x^1y^1) = 1$
$g^*(u\, x) = f^*(u^1x^1) = 0$
$g^*(xv) = f^*(x^1v^1) = 1$
$g^*(y\, v) = f^*(y^1v^1) = 0$
$g^*(u\, y) = f^*(u^1y^1) = 1$
$g^*(u^1v^1) = f^*(u\, v) = 1$
$g^*(x\, x^1) = 0$
We observe that $|e_{g^*}(0)|$ = 2(m+3) +1 and
$|e_{g^*}(1)|$ = 2(m+3)
Thus $| e_{g^*}(0) - e_{g^*}(1) | \le 1$
Hence P (2. J (m, n)) is a sum divisor cordial graph.
Corollary 3.7:
let P (2. J (m, n)), m and n are not equal then also it is a SDC graph.
□

Example 3.8:
Let G = P (2. J (5, 5))
Then | V(G) | = 28 vertices and
| E(G) | = 33 edges
Define an injective function
g: v→ {1, 2, 3, …, 28} such that
g^*: E(G) → {0, 1} such that, from figure 4
We observe that $|e_{g^*}(0)|$ = 17 and $|e_{g^*}(1)|$ = 16

Thus $|e_{g^*}(0) - e_{g^*}(1)| \leq 1$
Hence the path union of jelly fish graph P (2. J (5, 5)) is a sum divisor cordial graph.

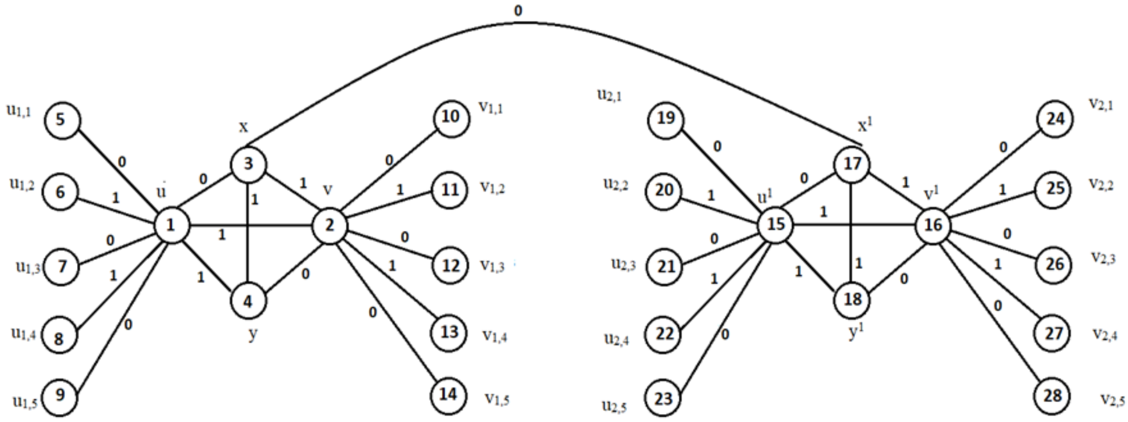

figure 4: SDC labeling on **P (2.J(5,5)))**

Theorem 3.9
The path union of crown graph P (2. ($C_n \odot K_1$)) is a sum divisor cordial graph.
Proof:
Let G = P (2. ($C_n \odot K_1$))
Let V(G) = {$u_{1,i}$, $u_{2,i}$, $v_{1,i}$, $v_{2,i}$: $1 \leq i \leq n$} and
Let E(G) = {$u_{1,i} u_{1,i+1}$: $1 \leq i \leq n-1$; $u_{1,n} u_{1,1}$;
$u_{1,i} v_{1,i}$:$1 \leq i \leq n$;
$u_{2,i} u_{2,i+1}$: $1 \leq i \leq n-1$; $u_{2,n} u_{2,1}$;
$u_{2,i} v_{2,i}$:$1 \leq i \leq n$;
$u_{1,1} u_{2,1}$}
Then G is of order 4n and size 4n+1.
Define g: V(G)→1, 2, 3, …, 4n} as follows:
g ($u_{1,i}$) =2i; $1 \leq i \leq n$
g ($v_{1,i}$) =2i-1; $1 \leq i \leq n$
g ($u_{2,i-n}$) =2i; $n+1 \leq i \leq 2n$
g ($v_{2,i-n}$) =2i-1; $n+1 \leq i \leq 2n$
Then the induced edge labels are.
$g^*(u_{1,i} u_{1,i+1}) = 0; 1 \leq i \leq n-1$
$g^*(u_{1,n} u_{1,1}) = 0$;
$g^*(u_{1,i} v_{1,i}) = 1; 1 \leq i \leq n$
$g^*(u_{2,i} u_{2,i+1}) = 0; 1 \leq i \leq n-1$
$g^*(u_{2,n} u_{2,1}) = 0$;
$g^*(u_{2,i} v_{2,i}) = 1; 1 \leq i \leq n$
$g^*(u_{1,1} u_{2,1}) = 0$
We observe that, $|e_{g^*}(0)| = 2n+1$, $|e_{g^*}(1)| = 2n$
Thus $|e_{g^*}(0) - e_{g^*}(1)| \leq 1$
Hence P (2. ($C_n \odot K_1$)) is a sum divisor cordial graph. □

Example 3.10:
A sum divisor cordial labeling of P (2. ($C_6 \odot K_1$)) is shown in figure 5.
Let G = P (2. ($C_6 \odot K_1$))
Then the order and size of the graph G are
| V(G) | =24 and | E(G) | = 25 respectively.
Define g: V(G) → {1, 2, 3, …, 23, 24} then the edge function is
g*: E(G) → {0,1}
We notice that, $|e_{g^*}(0)| = 13$ and $|e_{g^*}(1)| = 12$
From figure 1 $|e_{g^*}(0) - e_{g^*}(1)| = |13-12| \leq 1$
Hence, The path union of crown graph P (2. ($C_6 \odot K_1$)) is a SDC graph.

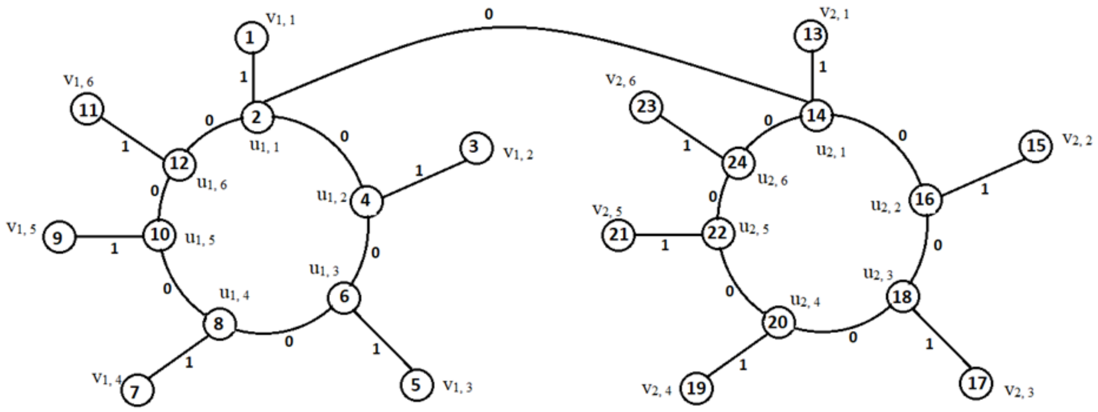

figure 5: SDC labeling on **P (2. ($C_6 \odot K_1$))**

Theorem 3.11: The path union of subdivision of star graph P (2. S ($K_{1,n}$)) is a sum divisor cordial graph.

Proof: Let G = P (2. S ($K_{1,n}$))
Let V(G) = $\{v_{1,0}, v_{1,i}, u_{1,i}, v_{2,0}, v_{2,i}, u_{2,i} : 1 \leq i \leq n\}$
And E(G) = $\{v_{1,0}v_{1,i}, v_{1,i}u_{1,i}, v_{2,0}v_{2,i}, v_{2,i}u_{2,i}, v_{1,0}v_{2,0} : 1 \leq i \leq n\}$.
The G is of order 4n+2 and size 4n+1.
Define g: V(G) $\rightarrow$ {1, 2, …, 4n+2} as follows
g ($v_{1,0}$) = 1;
g ($v_{1,i}$) = 2i+1; $1 \leq i \leq n$
g ($u_{1,p}$) = 2i; $1 \leq i \leq n$
g ($v_{2,0}$) = 2n+3;
g ($v_{2,i}$) = 2i+1; $n+2 \leq i \leq 2n+1$
g ($u_{2,i}$) = 2i; $n+1 \leq i \leq 2n$
g ($v_{1,0}v_{2,0}$) = 0;
$|e_{g^*}(0)|$=2n+1 and $|e_{g^*}(1)|$=2n
We observe that $|e_{g^*}(0) - e_{g^*}(1)| = |(2n+1) - 2n| = 1 \leq 1$
Hence P (2. S ($K_{1,n}$)) is a sum divisor cordial graph. □

Example 3.12:
P (2. S ($K_{1,5}$)) admits the sum divisor cordial labeling is given in figure 6.
Let G = P (2. S ($K_{1,5}$))
Then the order and size of the graph G are
| V(G) | =22 and | E(G) | = 21 respectively.
Define the vertex labeling function g: V(G) $\rightarrow$ {1, 2, 3, …, 21, 22} then,
the edge labeling function is g*: E(G) $\rightarrow$ {0,1}
We notice that, $|e_{g^*}(0)|$ =11 and $|e_{g^*}(1)|$ =10
From figure 6 $|e_{g^*}(0) - e_{g^*}(1)| = |11-10| \leq 1$
Hence, The path union of subdivision of star graph P (2. S ($K_{1,5}$)) is a SDC graph.

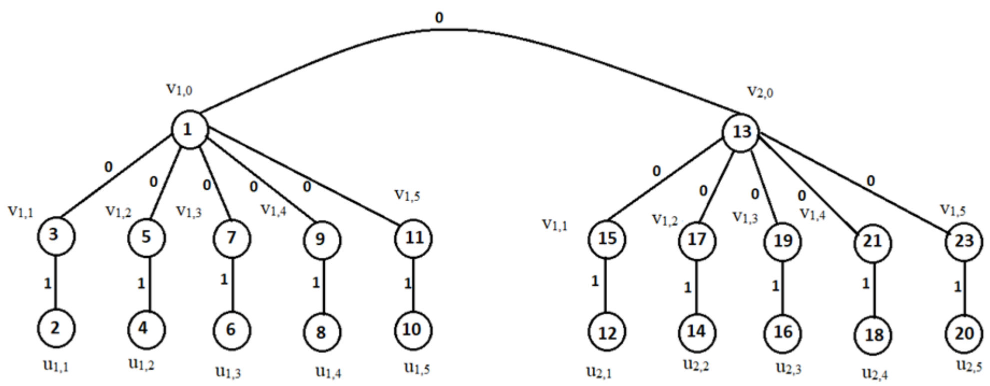

figure 6: SDC labeling on **P (2. S ($K_{1,5}$))**

corollary3.13:
The path union of m subdivision of star graph P (m. S ($K_{1, n}$)) does not admit the SDC labeling for all m > 2. □
Example 3.14:
Let G = P (3. S ($K_{1, 5}$))
Then the order and size of the graph G are
| V(G) | =33 and | E(G) | = 32 respectively.
Define the vertex labeling function g: V(G) → {1, 2, 3, …, 32, 33} then,
the edge labeling function is g*: E(G) → {0,1}
We notice that, $|e_{g^*}(0)|$ =17 and $|e_{g^*}(1)|$ =15 from figure 7
From figure 6 | $e_{g^*}(0) - e_{g^*}(1)$ | = | 17-15| $\nleq$ 1
Hence, The path union of three, subdivision of star graph P (3. S ($K_{1, 5}$)) does not admit the SDC labeling.

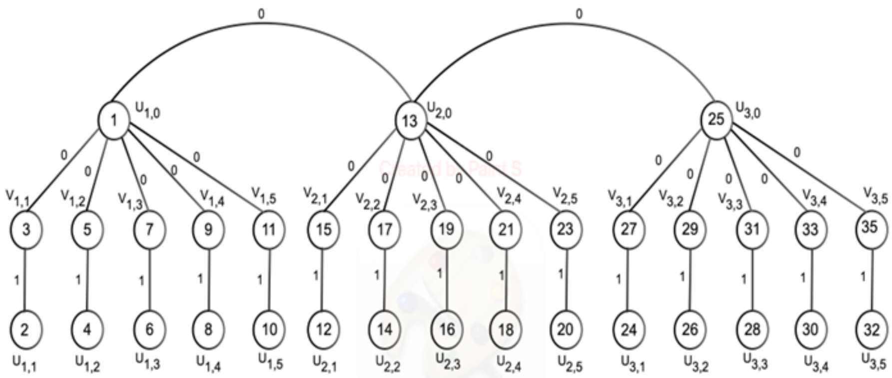

figure 7: SDC labeling on **P (3. S ($K_{1, 5}$))**

IV. Conclusion

The path union graphs
- P (r. SF_n), n ≥ 3, r=2 is a SDC graph if r>2 does not admit a SDC labeling.
- P (r.Fl_n), n ≥ 2& r=2 is a SDC graph if r>2 does not admit a SDC labeling.
- P (r. J (m, m)), where m is odd and m≥ 1 & r=2 is a SDC graph. if r>2 does not admit a SDC labeling
- P (r. ($C_n \odot K_1$), n≥3& r=2 is a SDC graph if r>2 does not admit a SDC labeling.
- P (r. S ($K_{1, n}$)), n ≥2 & r=2 is a SDC graph if r>2 does not admit a SDC labeling.

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