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On Sequential Graphs

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Abstract

A labeling or valuation of a graph G is an assignment f of labels to the vertices of G that indices for each edge xy a label depending on the vertex labels f(x) and f(y). In this paper we study some classes of graphs which admit sequential labeling.

Keywords: Labeling, Sequential graph, Braid graph, Total graph, Cyclic graph.

1. INTRODUCTION

Unless mentioned a graph in this paper shall mean a simple finite graph without isolated vertices. For all terminology and notations in Graph Theory, we follow Harary [3] and for all terminology regarding Sequential labeling we follow Grace [2].

Let G be a (p, q) graph. Let V(G), E(G) denote respectively the vertex set and edge set of G. Consider an injective function g : V(G) → X where X = {0, 1, 2,…, q} if G is a tree and X = {0,1, 2,..., q □1} otherwise. Define the function g^*: E (G) → N, by $g^*(uv) = g(u) + g(v)$ for all edges uv, where N is the set of all natural numbers. If $g^*(E(G))$ is a sequence of distinct two integers say {k, k + d, k + 2d,…, k + (q - 1)d} for some k and d, then the function g is said to be (k, d) - Sequential labeling and the graph which admits such a labeling is called as a Sequential graph.

If d = 1, G is a called k- sequential graph

Definition1.1: A chord of a cycle C_n is called a P_k - chord if it divides the cycle into two cycles C_k and C_{n-k+2}.

Theorem1.2: Let G be a graph obtained from C_{2t+1} with a P_4 - chord. Then G is a (t+2, 1), $t \geq 1$ Sequential graph.

Proof: Let $C_{2t+1} = (u_1 u_2, \ldots, u_{2t+1} u_1)$ and let $u_2 u_{2t}$ be a P_4-chord of C_{2t+1}.
The graph G consists of 2t + 1 vertices and 2t + 2 edges.

Define $f : V(G) \rightarrow \{0, 1, 2, \ldots, 2t + 1\}$ as follows:

$$f(u_{2i-1}) = i, \quad 1 \leq i \leq t + 1$$
$$f(u_{2i}) = (t + 1) + i, \quad 1 \leq i \leq t$$

Also $f(u_i) < f(u_j)$ for all $i \neq j$
Clearly vertex labels are distinct.

Then the induced edge labels are given by $f^*(u_i v_i) = f(u_i) + f(v_i)$ and are as follows:

$$f^*(u_i u_{i+1}) = t + i + 2, \quad 1 \leq i \leq 2t$$
$$f^*(u_1 u_{2t+1}) = t + 2$$
$$f^*(u_2 u_{2t}) = 3t + 3$$

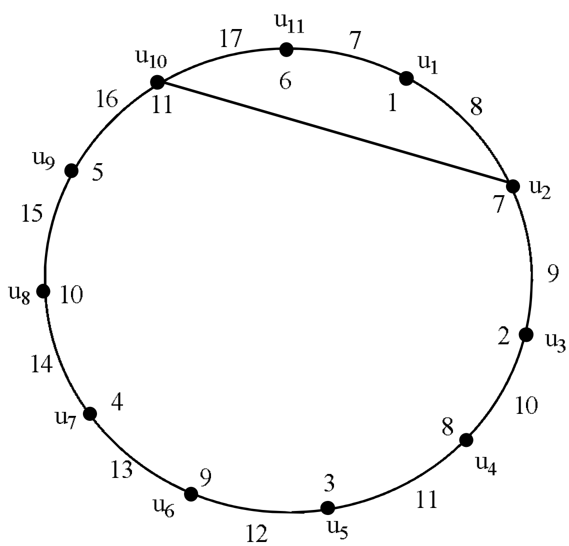
Thus the set of labels of the edges of the cycle = {t + 2, t + 3,…, 3t + 1, 3t + 2} and the label of the chord is 3t + 3.

Clearly edge values are distinct and is of the form {t + 2, t + 3,…, 3t + 2, 3t + 3}.

Thus the induced edge labels are given by $f^*(E(G)) = \{k, k + d, k + 2d, \ldots, k + (q - 1)d\}$
where k = t + 2 and d = 1.

Therefore G is a k-Sequential graph.

Illustration 1.3: (7, 1) - Sequential labeling of C_{11} with P_4-chord is given below.



Theorem 1.4: The graph $K_{1,n} + K_{1,m}$ is a (2t + 1,1) - Sequential graph for all m, n and for any non-negative integer t.

Proof: Let $V(K_{1,n}) = \{u_0, u_1, \ldots, u_n\}$ where $\deg u_0 = n$ and $V(K_{1,m}) = \{v_0, v_1, \ldots, v_m\}$ where $\deg v_0 = m$. Join each vertices of $K_{1,n}$ to every vertices of $K_{1,m}$, then we get the graph $K_{1,n} + K_{1,m}$.
Let $G = K_{1,n} + K_{1,m}$

The edge set of G is $E(G) = \{u_0u_i ; 1 \le i \le n\} \cup \{v_0v_i ; 1 \le i \le m\} \cup \{u_iv_j ; 1 \le i \le n, 1 \le j \le m\}$

Note that G has $n + m + 2$ vertices and $n + m + (n + 1)(m + 1)$ edges.

Let t be a non-negative integer. Define $f : V(G) \to \{0, 1, 2, \ldots, (n + m + (n + 1)(m + 1)) - 1\}$ as follows:

$f(u_i) = i + t, \quad 0 \le i \le n$

$f(v_0) = n + t + 1$

$f(v_i) = i(n + 2) + n + t, \quad 1 \le i \le m$

Then the induced edge labels are given by $f^*(u_iv_i) = f(u_i) + f(v_i)$ and are as follows:

$f^*(u_0u_i) = 2t + i, 1 \le i \le n$

$f^*(v_0v_i) = 2t + i(n + 2) + 2n + 1, 1 \le i \le n$

$f^*(v_0u_i) = 2t + (n + 1) + i, 1 \le i \le n$

$f^*(v_ju_i) = 2t + (j + 1)(n + 1) + i + (j - 1), \quad 0 \le i \le n, 1 \le j \le m$

Thus the set of labels of the edges of $K_{1,n} = \{2t + 1, 2t + 2, 2t + 3, \ldots, 2t + n\}$

The set of labels of the edges $v_0u_i, 0 \le i \le n = \{2t + n + 1, 2t + n + 2, \ldots, 2t + 2n + 1\}$

The set of labels of the edges v_0v_i and v_1u_i, $0 \le i \le n$

$= \{2t + 2(n + 1)\} \cup \{2t + 2(n + 1) + 1, 2t + 2(n + 1) + 2, \ldots, 2t + 2(n + 1) + n\}$

The set of labels of the edges v_0v_2 and v_2u_i, $0 \le i \le n$

$= \{2(n + 1) + n + 1\} \cup \{2t + 3(n + 1) + 2, 2t + 3(n + 1) + 3, \ldots, 2t + 3(n + 1) + n\}$

The set of labels of the edges v_0v_m and v_mu_i, $0 \le i \le n$

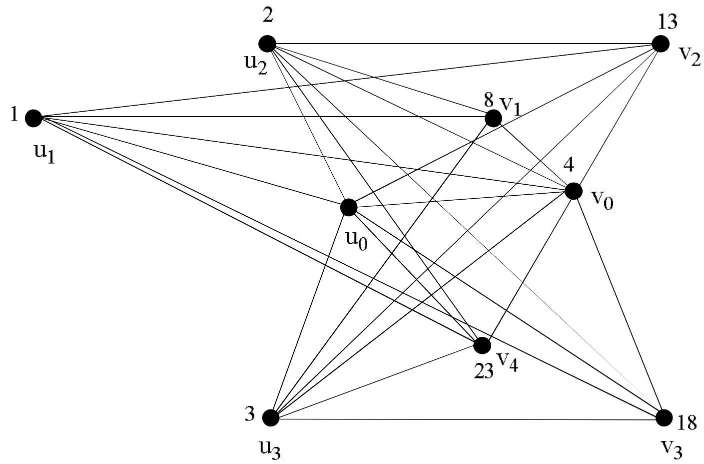
$= \{2t + (m + 2)(n + 1) + m - 2\} \cup \{2t + (m + 2)(n + 1) + m - 1,$
$2t + (m + 2)(n + 1) + m, \ldots, 2t + (m + 1)(n + 1) + m + n\}$

Thus the edges values of the graph G is distinct and is of the form
$2t + 1, 2t + 2, 2t + 3, \ldots, 2t + n, 2t + n + 1, 2t + n + 2, \ldots, 2t + 2n + 1, \ldots, 2t + 2(n + 1) + n, \ldots, 2t + 3(n + 1) + n, \ldots, 2t + (m + 2)(n + 1) + m − 2, \ldots, 2t + (m + 1)(n + 1) + m + n.$

Thus the induced edge labels are given by $f^*(E(G)) = \{k, k + 1, \ldots, k + (q - 1)\}$ where $k = 2t + 1$ and $d = 1$

Therefore f is a Sequential labeling. Thus G is a k-Sequential graph.

Illustration: 1.5: $K_{1,3} + K_{1,4}$ is a sequential graph.



Theorem1.6: The graph $P_2 + mK_1$ is a $(2t + 1, 1)$ - Sequential graph for all m and for any non-negative integer t.

Proof: Consider a path P_2 with two vertices v_1, v_2. Let $y_1, y_2, \ldots, y_m$ be the m isolated vertices. Join v_1, v_2 with y_i, $1 \leq i \leq m$. The graph obtained is $P_2 + mK_1$

Let $G = P_2 + mK_1$. The vertex set of G is $V(G) = \{v_1, v_2, y_1, y_2, \ldots, y_n\}$
$E(G) = \{(v_1, v_2)\} \cup \{(v_1, y_i),\ 1 \leq i \leq m\} \cup \{(v_2, y_i),\ 1 \leq i \leq m\}$

Then $|V(G)| = 2 + m$ and $|E(G)| = 2m + 1$

Let t be an integer such that $t \geq 0$.

Define labeling $f : V(G) \to \{0, 1, 2, \ldots, 2m\}$ as follows:

$f(v_1) = t$
$f(v_2) = t + 1$
$f(y_i) = t + 2i, \quad 1 \leq i \leq m$

Then the induced edge labels are given by $f^*(u_iv_i) = f(u_i) + f(v_i)$ and are as follows:

$f^*(v_1v_2) = 2t + 1$
$f^*(v_1y_i) = 2t + 2i, \quad 1 \leq i \leq m$
$f^*(v_2y_i) = 2t + 2i + 1, \quad 1 \leq i \leq m$

Thus the label of the edge v_1v_2 is $2t + 1$.

The set of labels of the edges v_1y_i, $1 \leq i \leq m$ are $\{2t + 2, 2t + 4, 2t + 6, \ldots, 2t + 2m\}$

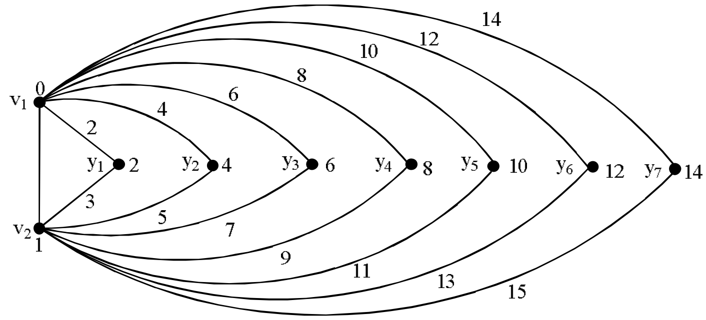
The set of labels of edges v_2y_i, $1 \leq i \leq m$ are $\{2t + 3, 2t + 5, \ldots, 2t + 2m - 1, 2t + 2m + 1\}$

Therefore the values of the edges form the set $\{2t + 1, 2t + 2, 2t + 3, \ldots, 2t + 2m, 2t + 2m + 1\}$

Thus the induced edge labels are given by $f^*(E(G)) = \{k, k + d, k + 2d, \ldots, k + (q - 1)\}$
where $k = 2t + 1$ and $d = 1$.

Thus f is a Sequential labeling of G. Hence $P_2 + m K_1$ is a k-Sequential graph.

Illustration 1.7: (1, 1) - Sequential labeling of $P_2 + 7K_1$ is given below.



Theorem 1.8: The total graph of the path G = $T(P_n)$ is a (2t + 1, 1) - Sequential graph for all n and for any non-negative integer t.

Proof: The vertex set of G is $V(G) = \{u_i, 1 \le i \le n, v_i, 1 \le i \le n-1\}$
The edge set of G is $E(G) = \{u_iu_{i+1}, 1 \le i \le n-1\} \cup \{v_iv_{i+1}, 1 \le i \le n-2\}$
$\cup \{v_iu_{i+1}, 1 \le i \le n-1\} \cup \{u_iv_i ; 1 \le i \le n-1\}$

Then $|V(G)| = 2n - 1$ and $E(G) = 4n - 5$

Let t be a n integer such that $t \ge 0$. Define $f : V(G) \to \{0, 1, 2, \ldots, 4n-6\}$ as follows:

$f(u_i) = 2i + t - 2, \quad 1 \le i \le n$

$f(v_i) = 2i + t - 1, \quad 1 \le i \le n-1$

Then the induced edge labels are given by $f^*(u_iv_i) = f(u_i) + f(v_i)$ and are as follows :

$f^*(v_iv_{i+1}) = 2t + 4i, \quad 1 \le i \le n-2$

$f^*(u_iu_{i+1}) = 2t + 4i - 2, \quad 1 \le i \le n-1$

$f^*(u_iv_i) = 2t + 4i - 3, \quad 1 \le i \le n-1$

$f^*(v_iu_{i+1}) = 2t + 4i - 1, \quad 1 \le i \le n-1$

The set of labels of the edges v_iv_{i+1}, $1 \le i \le n-2$
$= \{2t + 4, 2t + 8, 2t + 12, \ldots, 2t + 4n - 12, 2t + 4n - 8\}$

The set of labels of the edge u_iu_{i+1}, $1 \le i \le n-2$
$= \{2t + 2, 2t + 6, 2t + 10, \ldots, 2t + 4n - 10, 2t + 4n - 6\}$

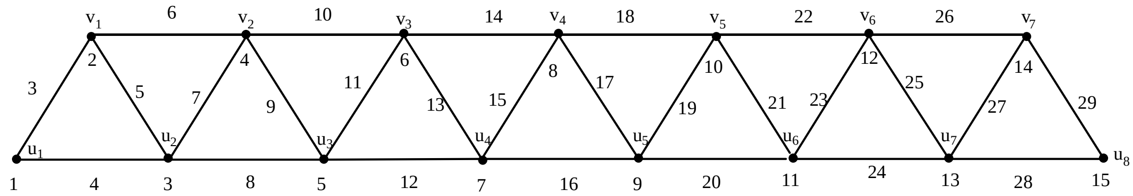
The set of labels of the edges u_iv_i, $1 \le i \le n-1$, v_iu_{i+1}, $1 \le i \le n-1$
$= \{2t + 1, 2t + 3, 2t + 5, \ldots, 2t + 4n - 7, 2t + 4n - 5\}$

Thus the values of the edges form the set
$= \{2t + 1, 2t + 3, 2t + 5, \ldots, 2t + 4n - 7, 2t + 4n - 6, 2t + 4n - 5\}$
Thus the induced edge labels are given by $f^*(E(G)) = \{k, k + d, k + 2d, \ldots, k + (q-1)d\}$ where $k = 2t + 1$ & $d = 1$

Hence the above defined labeling pattern f admits Sequential labeling.

Therefore, $T(P_n)$ is a k-Sequential graph.

Illustration: 1.9: (3,1) is a Sequential labeling of $T(P_8)$



Theorem 1.10: The graph $G = T(P_n) \odot K_m^c$ is a (2t + 1,1) - Sequential graph for all m, n and for any non-negative integer t.

Proof: The vertex set of G is

$V(G) = \{u_i ; 1 \le i \le n\} \cup \{v_i ; 1 \le i \le n-1\} \cup \{u_{ij} ; 1 \le i \le n, 1 \le j \le m\}$
$\cup \{v_{ij} ; 1 \le i \le n-1, 1 \le j \le m\}$

The edge set of G is

$E(G) = \{(u_iu_{i+1}) ; 1 \le i \le n-1\} \cup \{(v_iv_{i+1}) ; 1 \le i \le n-2\} \cup \{(u_iv_i) ; 1 \le i \le n-1\} \cup \{(v_iu_{i+1}) ;$
$1 \le i \le n-1\} \cup \{(u_iu_{ij}) ; 1 \le i \le n, 1 \le j \le m\} \cup \{(v_iv_{ij}) ; 1 \le i \le n-1, 1 \le j \le m\}$

Then $|V(G)| = 2n(m+1) - m - 1$

$|E(G)| = 2n(m+2) - m - 5 = q$ (say)

Let t be an integer such that $t \ge 0$.

Define a labeling $f : V(G) \to \{0, 1, 2, \ldots, 2n(m+2) - m - 6\}$ as follows:

$f(v_i) = 2i + t - 1, \ 1 \le i \le n-1$
$f(u_i) = 2i + t - 2, \ 1 \le i \le n$
$f(v_{ij}) = (n-1)(4 + j - 1) - i + t, \ 1 \le i \le n-1, 1 \le j \le m$
$f(u_{ij}) = (n-1)(4 + m) + n(j-1) + t - i + 1, \quad 1 \le i \le n, 1 \le j \le m$

The vertex labels are distinct.

Then the induced edge labels are given by $f^*(u_iv_i) = f(u_i) + f(v_i)$ and are as follows:

$f^*(v_iv_{i+1}) = 2t + 4i, \ 1 \le i \le n-2$
$f^*(u_iu_{i+1}) = 2t + 4i - 2, \quad 1 \le i \le n-1$
$f^*(u_iv_i) = 2t + 4i - 3, \quad 1 \le i \le n-1$
$f^*(v_iu_{i+1}) = 2t + 4i - 1, \quad 1 \le i \le n-1$
$f^*(v_iv_{ij}) = 2t + i + (n-1)(4 + j - 1) - 1, \ 1 \le i \le n-1, 1 \le j \le m$
$f^*(u_iu_{ij}) = 2t + i + (n-1)(4 + m) + n(j-1) - 1, \ 1 \le i \le n, 1 \le j \le m$

Thus the set of labels of the edges v_iv_{i+1}, $1 \le i \le n-2$

$= \{2t + 4, 2t + 8, 2t + 12, \ldots, 2t + 4n - 12, \ 2t + 4n - 8\}$

The set of labels of the edges u_iu_{i+1}, $1 \le i \le n-1$

$= \{2t + 2, 2t + 6, 2t + 12, \ldots, 2t + 4n - 10, 2t + 4n - 6\}$

The set of labels of the edges u_iv_i, v_iu_{i+1}, $1 \le i \le n-1$

$= \{2t + 1, 2t + 3, 2t + 5, \ldots, 2t + 4n - 7, 2t + 4n - 5\}$

The set of labels of the edges $v_1v_{1j}, v_2v_{2j}, \ldots, v_{n-1}v_{n-1j}, u_1u_{1j}, u_2u_{2j}, \ldots, u_nu_{nj}$, $1 \le j \le m$

$= \{2t + 4n - 4, 2t + 4n - 3, 2t + 4n - 2, \ldots, 2t + 2n(m+2) - m - 6, 2t + 2n(m+2) - m - 5\}$

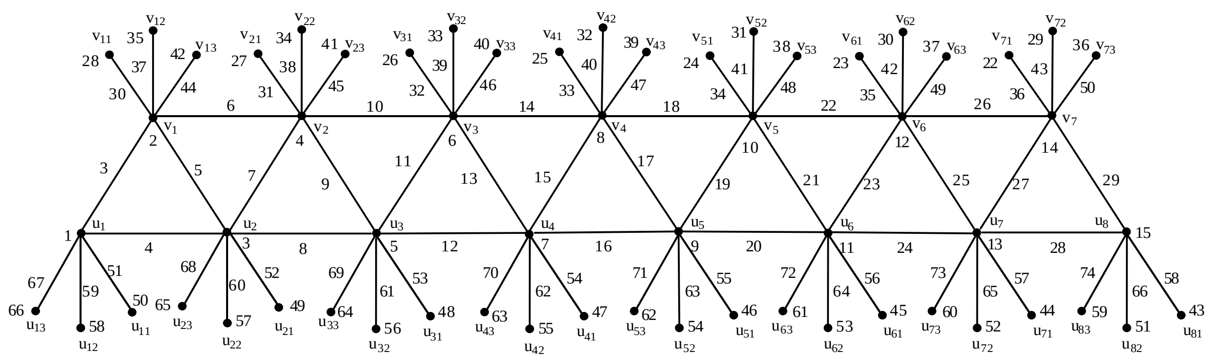
Therefore the set of labels of the edges of G is $\{2t + 1, 2t + 2, 2t + 3, \ldots, 2t + 4n - 6,$
$2t + 4n - 5, \ldots, 2t + 2n(m+2) - m - 6, 2t + 2n(m+2) - m - 5\}$

Thus the induced edge labels are given by $f^*(E(G)) = \{k, k + d, k + 2d,\dots, k + (q - 1)d\}$ where $k = 2t + 1$ and $d = 1$

Thus the above defined labeling pattern f admits Sequential labeling for G.

Therefore $T(P_n) \odot K_m^c$ is a k-Sequential graph.

Illustration 1.11: (3,1) - Sequential labeling of $T(P_8) \odot K_3^c$



Theorem 1.12: The braid graph B(n) is a (2t + 1, 1) - Sequential graph for all $n \geq 3$ and for any non-negative integer t.

Proof: The vertex set of B(n) is $V(B(n)) = \{x_1, x_2,\dots, x_n, y_1, y_2,\dots, y_n\}$
The edge set of B(n) is

$E(B(n)) = \{x_ix_{i+1}\ ;\ i = 1,2,3,\dots, n - 1\} \cup \{y_iy_{i+1}\ ;\ i = 1, 2,\dots, n - 1\} \cup \{x_iy_{i+1}\ ;$
$i = 1, 2,\dots, n - 1\} \cup \{y_ix_{i+2}\ ;\ i = 1, 2,\dots, n - 2\}$

Then $|V(B(n))| = 2n$ and $|E(B(n))| = 4n - 5$

Let t be an integer such that $t \geq 0$. Define labeling $f : V(B(n)) \to \{0, 1, 2,\dots, 4n - 4\}$ as follows:

$f(x_i) = 2i + t - 2, \quad i = 1, 2,\dots, n$
$f(y_i) = 2i + t - 1, \quad i = 1, 2,\dots, n$

Then the induced edge labels are given by $f^*(u_iv_i) = f(u_i) + f(v_i)$ and are as follows:

$f^*(x_ix_{i+1}) = 2t + 4i - 2, \ 1 \leq i \leq n - 1$
$f^*(y_iy_{i+1}) = 2t + 4i, \ 1 \leq i \leq n - 1$
$f^*(x_iy_{i+1}) = 2t+4i - 1, \ 1 \leq i \leq n - 1$
$f^*(y_ix_{i+2}) = 2t + 4i + 1, \ 1 \leq i \leq n - 2$

The set of labels of edges x_ix_{i+1}, $1 \leq i \leq n - 1$
$= \{2t + 2, 2t + 6,\dots, 2t + 4n - 10, 2t + 4n - 6\}$

The set of labels of the edges y_iy_{i+1}, $1 \leq i \leq n - 1$
$= \{2t + 4, 2t + 8,\dots, 2t + 4n - 8, 2t + 4n - 4\}$

The set of labels of the edges x_iy_{i+1}, $i = 1,2,\dots, n - 1$ and y_ix_{i+2}, $i = 1, 2,\dots, n - 2$
$= \{2t + 3, 2t + 5,\dots, 2t + 4n - 7, 2t + 4n - 5\}$

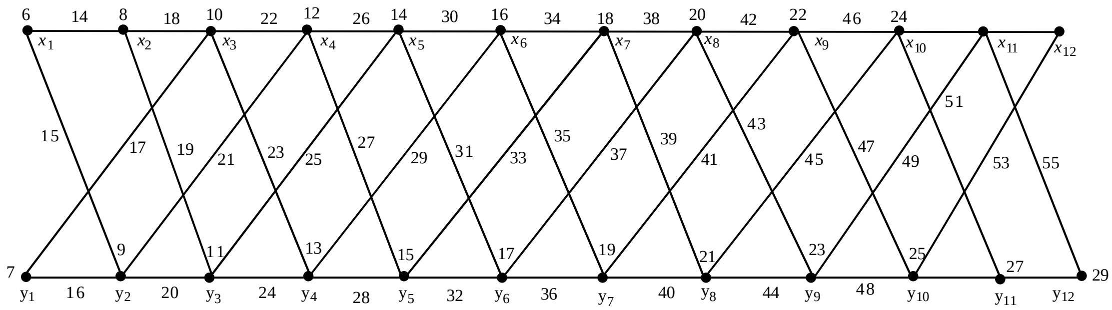
Hence the values of the edges form the set $\{2t + 2, 2t + 3,\dots, 2t + 4n - 5, 2t + 4n - 4\}$

Thus the induced edge labels are given by $f^*(E(G(B(n)))) = \{k, k + d, k + 2d, \ldots, k + (q - 1)d\}$ where $k = 2t + 2$ and $d = 1$

So that f is a Sequential labeling of B(n).

Hence B(n) is a k-Sequential graph.

Illustration 1.13: (14, 1) - Sequential labeling of B(12)



Theorem1.14: The graph $G^* = B(n) \odot K_m^c$ is a (2t + 1, 1) - Sequential labeling for all m, $n \geq 3$ and for any non-negative integer t.

Proof: Let x_i, y_i, $1 \leq i \leq n$ be the vertices of B(n).
Join x_i and y_i, $1 \leq i \leq n$ to new vertices x_{ij} and y_{ij}, $1 \leq j \leq m$ respectively.

The resultant graph is $G^* = B(n) \odot K_m^c$

$E(G^*) = \{x_i x_{i+1} ; 1 \leq i \leq n - 1\} \cup \{y_i y_{i+1} ; 1 \leq i \leq n - 1\} \cup \{x_i y_{i+1} ; 1 \leq i \leq n - 1\} \cup \{y_i x_{i+2} ; 1 \leq i \leq n - 2\} \cup \{x_i x_{ij} ; 1 \leq i \leq n, 1 \leq j \leq m\} \cup \{y_i y_{ij} ; 1 \leq i \leq n, 1 \leq j \leq m\}$

G^* has 2n(m + 1) vertices and 4n + 2nm – 5 edges.

Let t be a non-negative integer. Define a labeling $f : V(G^*) \rightarrow \{0, 1, 2, \ldots, 4n + 2nm - 6\}$ as follows:

$f(x_i) = 2i + t - 2, \quad 1 \leq i \leq n$

$f(y_i) = 2i + t - 1, \quad 1 \leq i \leq n$

$f(x_{ij}) = 4(n - 1) + mn - (i - 1) + (j - 1)n + t + 1, \quad 1 \leq i \leq n, 1 \leq j \leq m.$

$f(y_{ij}) = 4(n - 1) - (i - 1) + (j - 1)n + t, \quad 1 \leq i \leq n, 1 \leq j \leq m.$

Then the induced edge labels are given by $f^*(u_i v_i) = f(u_i) + f(v_i)$ and are as follows:

$f^*(y_i y_{i+1}) = 2t + 4i, \quad 1 \leq i \leq n - 1$

$f^*(x_i x_{i+1}) = 2t + 4i - 2, \quad 1 \leq i \leq n - 1$

$f^*(x_i y_{i+1}) = 2t + 4i - 1, \quad 1 \leq i \leq n - 1$

$f^*(y_i x_{i+2}) = 2t + 4i + 1, \quad 1 \leq i \leq n - 2$

$f^*(x_i x_{ij}) = 2t + i + n(m + j + 3) - 4, \quad 1 \leq i \leq n - 1, 1 \leq j \leq m$

$f^*(y_i y_{ij}) = 2t + i + n(j + 3) - 4, \quad 1 \leq i \leq n, 1 \leq j \leq m$

Thus the set of labels of edges $x_i x_{i+1}$, $1 \leq i \leq n - 1$

$= \{2t + 2, 2t + 6, 2t + 10, \ldots, 2t + 4n - 10, 2t + 4n - 6\}$

The set of labels of edges $y_i y_{i+1}$, $1 \leq i \leq n - 1$

$= \{2t + 4, 2t + 8, 2t + 12, \ldots, 2t + 4n - 8, 2t + 4n - 4\}$

The set of labels of edges $x_i y_{i+1}$, and $y_i x_{i+2}$, $1 \leq i \leq n - 1$

= {2t + 3, 2t + 5, 2t + 7,…, 2t + 4n – 7, 2t + 4n – 5}

The set of labels of edges $x_i x_{ij}$, $y_i y_{ij}$, $1 \le i \le n, 1 \le j \le m$

= {2t + 4n – 3, 2t + 4n – 2, 2t + 4n – 1,…, 2t + 4n + 2n m – 5, 2t + 4n + 2 nm – 4}

Therefore the set of labels of the edges of G^*

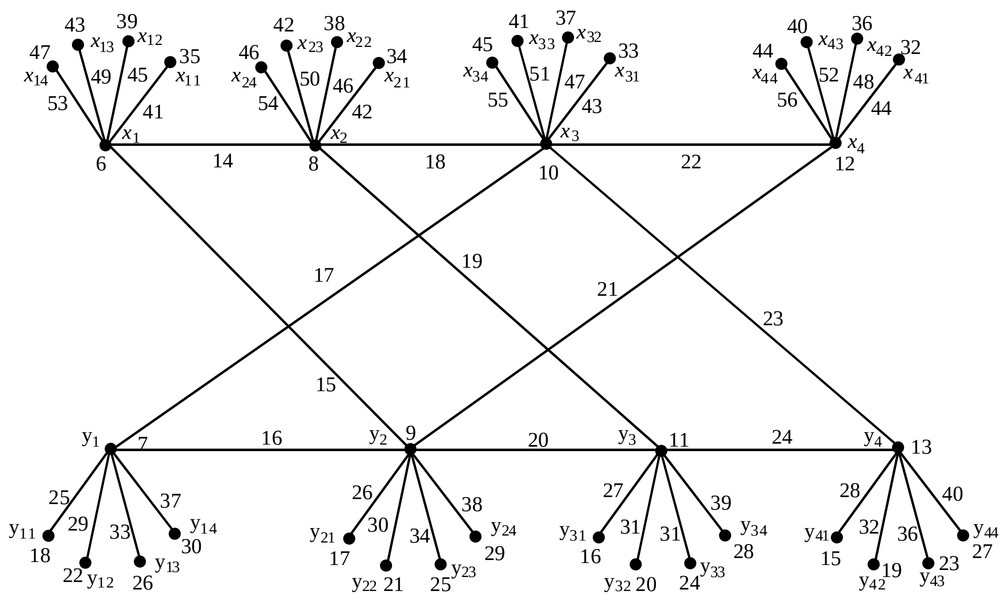
= {2t + 2, 2t + 3, 2t + 4,…, 2t + 4n – 5, 2t + 4n – 4, 2t + 4n – 3, 2t + 4n – 2, 2t + 4n – 1,… , 2t + 4n + 2n m – 5, 2t + 4n + 2n m – 4}

Thus the induced edge labels are given by $f^*(E(G^*)$ = { k, k + d, k + 2d,…, k + (q – 1)d}
where k = 2t + 2 and d = 1

Therefore the vertex function f defined above is a Sequential labeling for G^*.

Thus $G^*$is a k-Sequential graph.

Illustration 1.15: (14, 1) - Sequential labeling of B(4) $\odot$ K_4^c



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