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Theory and Applications of Butterfly Network in Graph Theory

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ABSTRACT: A path partition of a graph is a collection of vertex-disjoint paths that cover all vertices of the graph. The path-partition problem is to find the path-partition number $p(G)$ of a graph G , which is the minimum cardinality of a path partition of G . Obviously G has a Hamiltonian path if and only if $[2]$
 $p(G) = 1$. Since the Hamiltonian path problem is NP complete for planar graphs, bipartite graphs, chordal graphs, chordal bipartite graphs and strongly chordal graphs, so is the path-partition problem. On the other hand, the path-partition problem is polynomially solvable for trees, interval graphs, circular-arc graphs, co graphs, co comparability graphs, block graphs and bipartite distance hereditary graphs.

KEYWORDS: Graph, Planar graphs, Edge partition graphs, Chordal graphs, Chordal bipartite graphs and Strongly Butterfly Network, Benes Network[1]

I. PRELIMINARIES

Definition 1.2: A graph is an ordered pair $G = (V, E)$ comprising set V of vertices or nodes together with a set E of edges or lines, which are 2-element subsets of $V[3]$.

Definition 1.3

An edge partition of a graph G is a partition of its edges E into subsets $\{E_i\}$. We can define $\{V_i\}$ to be the set of endpoints of edges in $\{E_i\}$. We then have that $[V_i, E_i]$ is a graph[4].

Definition 1.4

A graph G to be planar, if it can be so drawn without any of the curves or lines representing its edges crossing one another or meeting any other vertex on its way from one vertex to the other[5].

II. BUTTERFLY NETWORK

The n -dimensional butterfly network, denoted by $BF(n)$, has vertex

Set $V = \{(x; i) : x \in V(Q_n), 0 \leq i \leq n\}$. The vertices

$(x; i)$ and $(y; j)$ are linked by an edge in $BF(n)$ if and only if $j = i + 1$ and either

(i) $x = y$, or

(ii) x differs from y in precisely the j^{th} bit.

For $x = y$, the edge is said to be a straight edge[6]. Otherwise, the edge is a cross edge. For fixed i , the vertex $(x; i)$ is a vertex on level i . The Butterfly network $BF(n)$ has $(n+1)2^n$ vertices because $BF(n)$ has $n + 1$ levels and there are 2^n vertices in every level. Each vertex on level 0 and n is of degree 2, otherwise, every vertex is of degree 4. It is clear that $BF(n)$ is Eulerian since it is connected and has no odd degree vertices[6].

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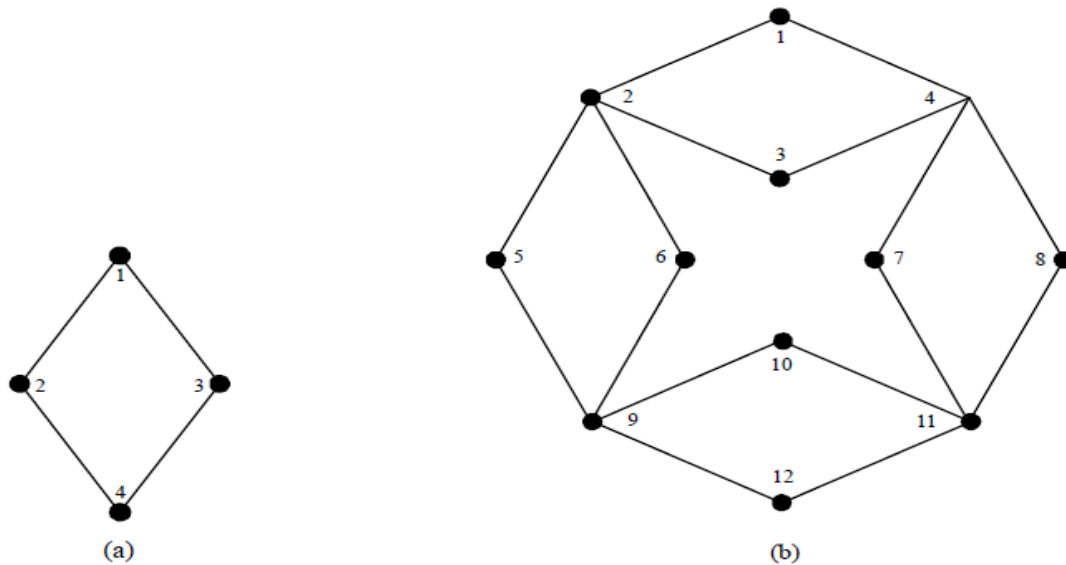


Figure 2.1: (a) $BF(1)$, (b) $BF(2)$

Theorem 2.1:

For a butterfly network of dimension n , $p(BF(n)) = 2^{n-1}$, $n \geq 3$ [7]

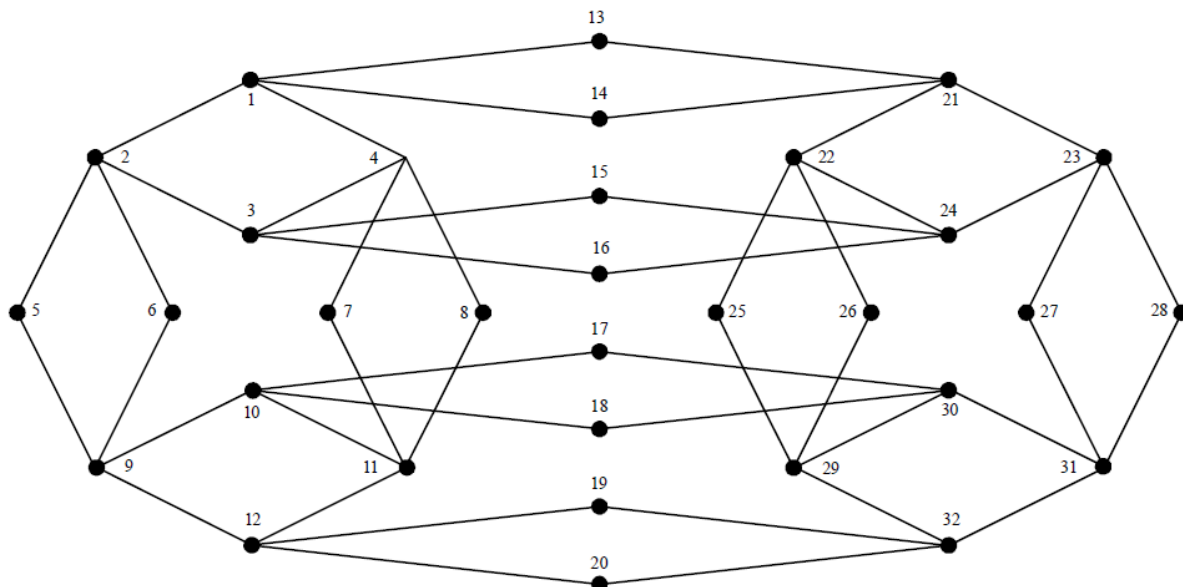


Figure 4.3: $BF(3)$

The number of paths for $BF(3)$ shown in Figure 4.3 is $p(BF(3)) = 4$ and the paths are $\{6, 9, 5, 2, 1, 13, 21, 14\}$, $\{8, 11, 7, 4, 3, 15, 24, 16\}$,

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{26,22,25,29,30,17,10,18},{27,23, 28, 31, 32,19, 12, 20}

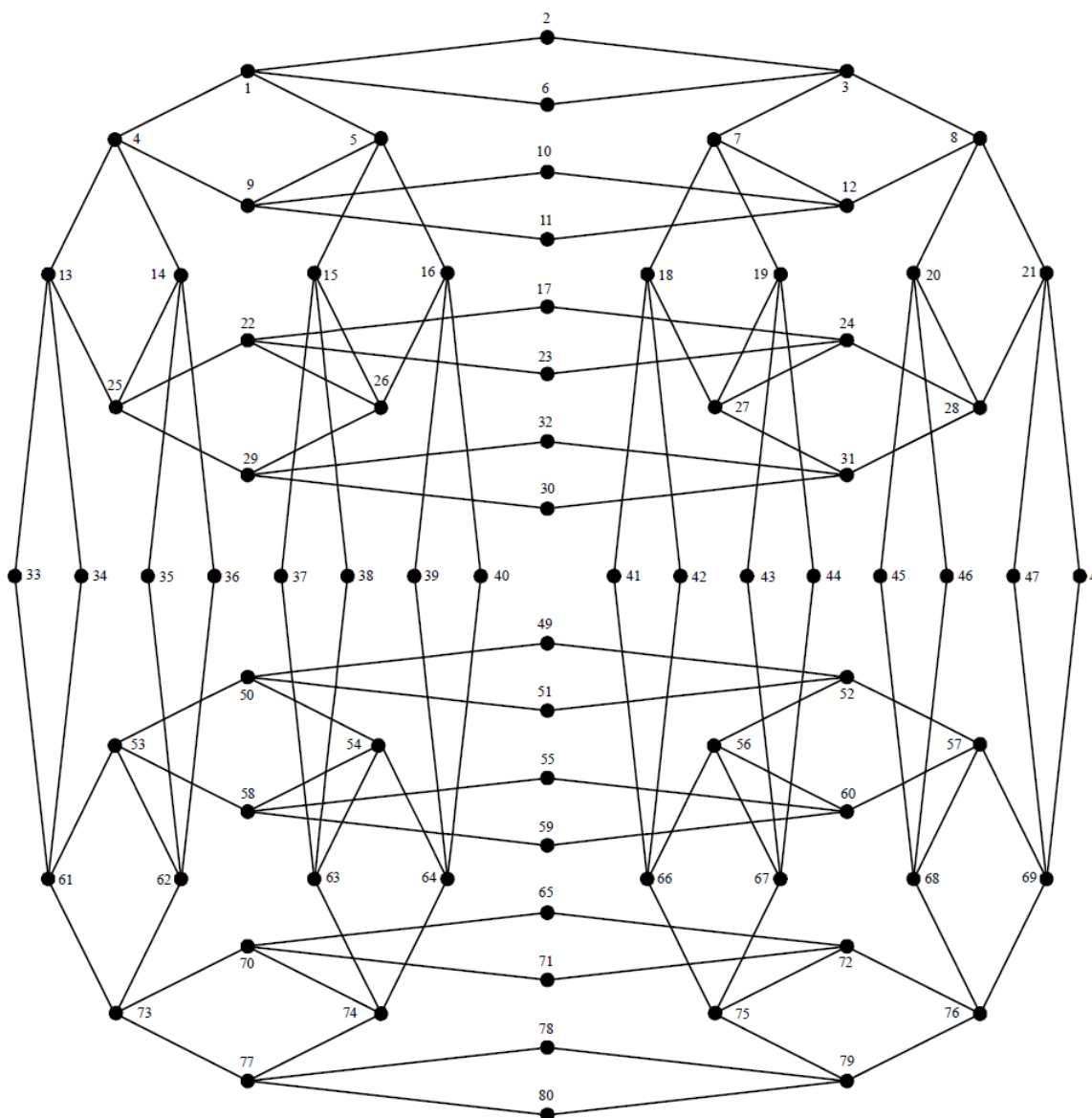


Figure 2. 2: BF(4)

The number of paths for BF(4) shown in Figure 4.4 is $p(\text{BF}(4)) = 8$ and the paths are [8] {2, 1, 6, 3,8, 12, 10, 9, 11}, {17, 24, 23, 22, 25, 29, 32, 31, 30}, {49,52,51,50,54,58,55, 60, 59}, {65,70, 71, 72, 76, 79, 78, 77, 80}, {33,13,34,61,53,62,36,14,35},{37,63,38,15,26, 16, 36,64, 40}, {41,66,42,18, 27, 19, 43, 67, 44}, {45,68,46,20,28,21,48,69,47}

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III. CONCLUSION

In this paper we studied the theory and applications of Butterfly Graph. This butterfly useful in Networking system.

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