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COMPUTATION OF SOME NEW STATUS NEIGHBORHOOD INDICES OF GRAPHS

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ABSTRACT

In this paper, we propose the total status neighborhood index, modified vertex status neighborhood index, status neighborhood inverse degree, status neighborhood zeroth order index, F-status neighborhood index, F_1-status neighborhood index, general vertex status neighborhood index of a graph. Also we introduce the total status neighborhood polynomial, third status neighborhood polynomial, F-status neighborhood polynomial, F_1-status neighborhood polynomial of a graph. We compute exact formulas for complete graphs, complete bipartite graphs, wheel graphs and friendship graphs.

Keywords: *status, distance, status neighborhood index, F-status neighborhood index, graph.*

Mathematics Subject Classification: *05C05, 05C07, 05C12, 05C35.*

1. INTRODUCTION

Throughout the paper, we consider only finite, undirected simple, connected graphs. Let $V(G)$ be the vertex set and $E(G)$ be the edge set of a graph G. The edge between the vertices u and v is denoted by uv. The degree of a vertex u is the number of vertices adjacent to u and is denoted by $d_G(u)$. The distance $d(u, v)$ between any two vertices u and v is the length of shortest path connecting u and v. The status $\sigma(u)$ of a vertex u in G is the sum of its distance from every other vertex of G. Let $N(v) = N_G(v) = \{u{:}uv\in(G)\}$. Let $\sigma_n(v) = \sum_{u\in N(v)} \sigma(u)$ be the status sum of neighbor vertices. For graph theoretic terminology, we refer the book [1].

Many distance based indices of a graph such as Wiener index [4] have been appeared in the literature. In this paper, we introduce some new status neighborhood indices of graphs.

The third or vertex status neighborhood index was introduced by Kulli in [5] and it is defined as

$$SN_3(G) = \sum_{u\in V(G)} \sigma_n(u)^2$$

Recently some variants of status neighborhood indices were studied in [6].

We introduce the following status neighborhood indices:

The modified the third or vertex status neighborhood index of a graph G is defined as

$$^{m}SN_3(G) = \sum_{u\in V(G)} \frac{1}{\sigma_n(u)^2}.$$

The F-status neighborhood index of a graph G is defined as

$$FSN(G) = \sum_{u\in V(G)} \sigma_n(u)^3.$$

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The total status neighborhood index of a graph G is defined as

$$T_{sn}(G) = \sum_{u \in V(G)} \sigma_n(u).$$

The status neighborhood inverse degree of a graph G is defined as

$$SNI(G) = \sum_{u \in V(G)} \frac{1}{\sigma_n(u)}.$$

The status neighborhood zeroth order index of a graph G is defined as

$$SNZ(G) = \sum_{u \in V(G)} \frac{1}{\sqrt{\sigma_n(u)}}.$$

We continue this generalization and introduce the general third or vertex status neighborhood index of a graph G, and it is defined as

$$SN_3^a(G) = \sum_{u \in V(G)} \sigma_n(u)^a,$$

where a is a real number.

Also we introduce the F_1-status neighborhood index of a graph G and it is defined as

$$F_1SN(G) = \sum_{uv \in E(G)} \left[\sigma_n(u)^2 + \sigma_n(v)^2\right].$$

Recently, some variants of status indices were studied, for example, in [7, 8, 9, 10, 11, 12, 13, 14, 15].

The third or vertex status neighborhood polynomial was defined by Kulli in [5], defined as

$$SN_3(G, x) = \sum_{u \in V(G)} x^{\sigma_n(u)^2}.$$

We now introduce the total status neighborhood polynomial, F-status neighborhood polynomial, F_1-status neighborhood polynomial of a graph G, and they are defined as

$$T_{sn}(G, x) = \sum_{u \in V(G)} x^{\sigma_n(u)}.$$

$$FSN(G, x) = \sum_{u \in V(G)} x^{\sigma_n(u)^3}.$$

$$F_1SN(G, x) = \sum_{uv \in E(G)} x^{\sigma_n(u)^2 + \sigma_n(v)^2}.$$

Recently some different polynomials were studied in [16, 17, 18, 19, 20, 21].

In this paper, the modified vertex status neighborhood index, status neighborhood zeroth order index, F-status neighborhood index, F_1-status neighborhood index, general vertex status neighborhood index of some standard graphs and friendship graphs are determined. Also the total status neighborhood polynomial, vertex status neighborhood polynomial, F_1-status neighborhood polynomial of some standard graphs and friendship graphs are computed.

2. RESULTS FOR COMPLETE GRAPHS

Let K_n be a complete graph with n vertices and $\frac{n(n-1)}{2}$ edges.

Theorem 1: The general third or vertex status neighborhood index of a complete graph K_n is

$$SN_3^a(K_n) = n(n-1)^{2a}. \tag{1}$$

Proof: Let K_n be a complete graph with n vertices. For any vertex u of K_n, $\sigma(u) = n - 1$. Thus $\sigma_n(u) = (n - 1)^2$ for any vertex of K_n. Thus

$$SN_3^a(K_n) = \sum_{u \in V(K_n)} \sigma_n(u)^a = n(n-1)^{2a}.$$

We obtain the following results by using Theorem 1.

Corollary 1.1: Let K_n be a complete graph with K_n with n vertices. Then

(i) $SN_3(K_n) = n(n-1)^4$ (ii) ${}^mSN_3(K_n) = \frac{n}{(n-1)^4}$.

(iii) $FSN(K_n) = n(n-1)^6$ (iv) $T_{sn}(K_n) = n(n-1)^2$.

(v) $SNI(K_n) = \frac{n}{(n-1)^2}$ (vi) $SNZ(K_n) = \frac{n}{n-1}$.

Proof: Put a = 2, –2, 3, 1, –1, –½ in equation (1), we obtain the desired results.

Theorem 2: The general second status neighborhood index of a complete graph K_n is

(i) $F_1SN(K_n) = n(n-1)^5$. (ii) $F_1SN(K_n, x) = \frac{n(n-1)}{2} x^{2(n-1)^4}$.

Proof: Let K_n be a complete graph with n vertices and $\frac{n(n-1)}{2}$ edges. For any vertex u of K_n, $\sigma_n(u) = (n-1)^2$. Therefore

(i) $$F_1SN(K_n) = \sum_{uv \in E(K_n)} \left[\sigma_n(u)^2 + \sigma_n(u)^2\right] = \left[(n-1)^4 + (n-1)^4\right]\frac{n(n-1)}{2}$$

$$= n(n-1)^5.$$

(ii) $$F_1SN(K_n) = \sum_{uv \in E(K_n)} x^{\sigma_n(u)^2 + \sigma_n(u)^2} = x^{(n-1)^4 (n-1)^4} \times \frac{n(n-1)}{2}$$

$$= \frac{n(n-1)}{2} x^{2(n-1)^4}.$$

Theorem 3: The total status neighborhood polynomial and F-status neighborhood polynomial of a complete graph K_p are given by

(i) $T_{sn}(K_n, x) = nx^{(n-1)^2}$. (ii) $FSN(K_n, x) = nx^{(n-1)^6}$.

Proof: Let K_n be a complete graph with n vertices. Then $\sigma_n(u) = (n-1)^2$ for any vertex u of K_n. Thus

(i) $$T_{sn}(K_n, x) = \sum_{u \in V(G)} x^{\sigma_n(u)} = nx^{(n-1)^2}.$$

(ii) $$FSN(K_n, x) = \sum_{u \in V(G)} x^{\sigma_n(u)^3} = nx^{(n-1)^6}.$$

3. RESULTS FOR COMPLETE BIPARTITE GRAPHS

Let $K_{p,q}$ be a complete bipartite graph with $p+q$ vertices and pq edges. For vertex set of $K_{p,q}$ can be partitioned into two independent sets V_1 and V_2 such that $u \in V_1$ and $v \in V_2$ for every edge uv in $K_{p,q}$. Therefore $d_K(u)=q$, $d_K(v)=p$, where $K=K_{p,q}$. Then $\sigma(u)= q + 2p - 2$ and $\sigma(v)= p + 2q - 2$. By calculation, we obtain $\sigma_n(u)= p(q + 2p - 2)$ and $\sigma_n(v)= q(p + 2q - 2)$. Therefore

$\sigma_n(u) \setminus u \in V(G)$	$q(p + 2q - 2)$	$p(q + 2p - 2)$
Number of edges	p	q

Table-1: Status neighborhood vertex partition of $K_{p,q}$

Theorem 4: The general vertex status neighborhood index of a complete bipartite graph $K_{p,q}$ is

$$SN_v^a(K_{p,q}) = p\left[q(p+2q-2)\right]^a + q\left[p(q+2p-2)\right]^a. \qquad (2)$$

Proof: By definition and by using Table 1, we deduce

$$SN^a(K_{p,q}) = \sum_{u \in V(G)} \sigma_n(u)^a = p\left[q(p+2q-2)\right]^a + q\left[p(q+2p-2)\right]^a.$$

From Theorem 4, we establish the following results.

Corollary 4.1: Let $K_{p,q}$ be a complete bipartite graph. Then

(i) $SN\left(K_{p,q}\right) = pq^2\left(p+2q-2\right)^2 + p^2q\left(q+2p-2\right)^2$.

(ii) ${}^{m}SN\left(K_{p,q}\right) = \dfrac{p}{q^2\left(p+2q-2\right)^2} + \dfrac{q}{p^2\left(q+2p-2\right)^2}$.

(iii) $FSN\left(K_{p,q}\right) = pq^3\left(p+2q-2\right)^3 + p^3q\left(q+2p-2\right)^3$.

(iv) $T_{sn}\left(K_{p,q}\right) = pq\left(3pq-4\right)$.

(v) $SNI\left(K_{p,q}\right) = \dfrac{p}{q\left(p+2q-2\right)} + \dfrac{q}{p\left(q+2p-2\right)}$.

(vi) $SNZ\left(K_{p,q}\right) = \dfrac{p}{\sqrt{q\left(p+2q-2\right)}} + \dfrac{q}{\sqrt{p\left(q+2p-2\right)}}$.

Proof: Put a = 2, –2, 3, 1, –1, –½ in equation (2), we obtain the desired results.

Theorem 5: Let $K_{p,q}$ be a complete bipartite graph with $p+q$ vertices and pq edges. Then

(i) $F_1SN\left(K_{p,q}\right) = pq\left[q^2\left(p+2q-2\right)^2 + p^2\left(q+2p-2\right)^2\right]$.

(ii) $F_1SN\left(K_{p,q},x\right) = pqx^{q^2\left(p+2q-2\right)^2 + p^2\left(q+2p-2\right)^2}$.

Proof: We have

(i) $F_1SN\left(K_{p,q}\right) = \sum_{uv\in E(G)}\left[\sigma_n(u)^2 + \sigma_n(v)^2\right] = pq\left[q^2\left(p+2q-2\right)^2 + p^2\left(q+2p-2\right)^2\right]$.

(ii) $F_1SN\left(K_{p,q},x\right) = \sum_{uv\in E(G)} x^{\sigma_n(u)^2+\sigma_n(v)^2} = pqx^{q^2\left(p+2q-2\right)^2 + p^2\left(q+2p-2\right)^2}$.

Theorem 6: The total status neighborhood polynomial and F-status neighborhood polynomial of a complete bipartite graph $K_{p,q}$ is

(i) $T_{sn}\left(K_{p,q},x\right) = px^{q\left(p+2q-2\right)} + qx^{p\left(q+2p-2\right)}$

(ii) $FSN\left(K_{p,q},x\right) = px^{q^3\left(p+2q-2\right)^3} + qx^{p^3\left(q+2p-2\right)^3}$.

Proof: We have

(i) $T_{sn}\left(K_{p,q},x\right) = \sum_{u\in V(G)} x^{\sigma_n(u)} = px^{q\left(p+2q-2\right)} + qx^{p\left(q+2p-2\right)}$.

(ii) $FSN\left(K_{p,q},x\right) = \sum_{u\in V(G)} x^{\sigma_n(u)^3} = px^{q^3\left(p+2q-2\right)^3} + qx^{p^3\left(q+2p-2\right)^3}$.

4. RESULTS FOR WHEEL GRAPHS

A wheel graph W_n is the join of K_1 and C_n. A graph W_4 is shown in Figure 1.

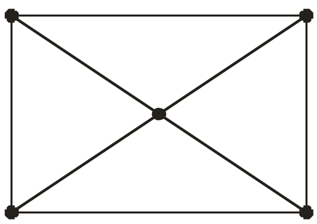

Figure-1: Wheel graph W_4

A graph W_n has n + 1 vertices and 2n edges. In this graph, there are two types of status vertices as follows:

$$V_1 = \{u \in V(W_n) \mid \sigma(u) = n\}, \qquad |V_1| = 1.$$

$$V_2 = \{u \in V(W_n) \mid \sigma(u) = 2n-3\}, \qquad |V_2| = n.$$

By calculation, we find that there are two types of status neighborhood vertices as given in Table 2.

$\sigma_n(u) \setminus u \in V(W_n)$	$n(2n-3)$	$5n-6$
Number of vertices	1	n

Table-2: Status neighborhood vertex partition of W_n

In W_n ,we obtain that there are types of status edges as follows:

$$E_1 = \{uv \in E(W_n) \mid \sigma(u) = \sigma(v) = 2n-3\}, \qquad |E_1| = n.$$

$$E_2 = \{uv \in E(W_n) \mid \sigma(u) = n, \ \ \sigma(v) = 2n-3\}, \qquad |E_2| = n.$$

By calculation, in W_n, there are two types of status neighborhood edges as given in Table 3.

$\sigma_n(u), \sigma_n(v) \setminus uv \in E(W_n)$	$(5n-6, 5n-6)$	$(5n-6, n(2n-3))$
Number of edges	n	n

Table-3: Status neighborhood edge partition of W_n

Theorem 7: The general vertex status neighborhood index of a wheel graph W_n is given by

$$SN^a(W_n) = [n(2n-3)]^a + n(5n-6)^a. \tag{3}$$

Proof: From definition and by using Table 2, we deduce

$$SN^a(W_n) = \sum_{u \in V(W_n)} \sigma_n(u)^a = [n(2n-3)]^a + n(5n-6)^a.$$

We obtain the following results from Theorem 7.

Corollary 7.1: Let W_n be a wheel graph with n + 1 vertices and 2n edges. Then

(i) $SN(W_n) = 4n^4 + 13n^3 - 51n^2 + 36n.$

(ii) $^m SN(W_n) = \dfrac{1}{n^2(2n-3)^2} + \dfrac{n}{(5n-6)^2}.$

(iii) $FSN(W_n) = n^3(2n-3)^3 + n(5n-6)^3.$

(iv) $T_{sn}(W_n) = 7n^2 - 9n.$

(v) $SNI(W_n) = \dfrac{1}{n(2n-3)} + \dfrac{n}{5n-6}.$

(vi) $SNZ(W_n) = \dfrac{1}{\sqrt{n(2n-3)}} + \dfrac{n}{\sqrt{5n-6}}.$

Proof: Put a = 2, –2, 3, 1, – 1, –½ in equation (3), we obtain the desired results.

Theorem 8: The F_1-status neighborhood index and F_1-status neighborhood polynomial of a wheel graph W_n are given by

(i) $F_1SN(W_n) = 4n^5 - 12n^4 + 84n^3 - 180n^2 + 108n.$

(ii) $F_1SN(W_n, x) = nx^{50n^2-120n+72} + nx^{4n^4-12n^3+34n^2-60n+36}.$

Proof:

(i) By definition and by using Table 3, we derive

$$F_1SN(W_n) = \sum_{uv \in E(W_n)} \left[\sigma_n(u)^2 + \sigma_n(v)^2\right]$$

$$= n\left[(5n-6)^2 + (5n-6)^2\right] + n\left[(5n-6)^2 + (2n^2-3n)^2\right]$$

$$= 4n^5 - 12n^4 + 84n^3 - 180n^2 + 108n.$$

(ii) From definition and by using Table 3, we have

$$F_1SN(W_n,x)=\sum_{uv\in E(W_n)} x^{\sigma_n(u)^2+\sigma_n(v)^2}$$

$$= nx^{(5n-6)^2+(5n-6)^2} + nx^{(5n-6)^2+(2n^2-3n)^2}$$

$$= nx^{50n^2-120n+72} + nx^{4n^4-12n^3+34n^2-60n+36}.$$

Theorem 9: The total status neighborhood polynomial and *F*-status neighborhood polynomial of a wheel graph W_n are given by

(i) $T_{sn}(W_n,x)=x^{n(2n-3)}+nx^{5n-6}$.

(ii) $FSN(W_n,x)=x^{n^3(2n-3)^3}+nx^{(5n-6)^3}$.

Proof:

(i) By definition and by using Table 2, we obtain

$$T_{sn}(W_n,x)=\sum_{u\in V(W_n)} x^{\sigma_n(u)} = x^{n(2n-3)}+nx^{5n-6}$$

(ii) From definition and by using Table 2, we have

$$FSN(W_n,x)=\sum_{u\in V(W_n)} x^{\sigma_n(u)^3} = x^{n^3(2n-3)^3}+nx^{(5n-6)^3}$$

5. RESULTS FOR FRIENDSHIP GRAPHS

A friendship graph F_n is the graph obtained by taking $n \geq 2$ copies of C_3 with vertex in common. A graph F_4 is shown in Figure 2.

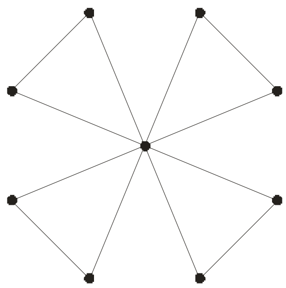

Figure-2: Friendship graph F_4.

A friendship graph F_n has $2n+1$ vertices and $3n$ edges. In F_n, we obtain two types of status vertices as follows:

$V_1 = \{u \in V(F_n) \mid \sigma(u) = 2n\}$, $|V_1| = 1$.

$V_2 = \{u \in V(F_n) \mid \sigma(u) = 4n - 2\}$, $|V_2| = 2n$.

By calculation, there are two types of status neighborhood vertices in F_n as given in Table 4.

$\sigma_n(u) \setminus u \in V(F_n)$	$2n(4n-2)$	$6n-2$
Number of vertices	1	$2n$

Table-4: Status neighborhood vertex partition of F_n

In a graph F_n there are two types of status edges as follows:

$E_1 = \{uv \in E(F_n) \mid \sigma(u) = \sigma(v) = 4n-2\}$, $|E_1| = n$.

$E_2 = \{uv \in E(F_n) \mid \sigma(u) = 2n,\ \sigma(v) = 4n-2\}$, $|E_2| = 2n$.

By calculation, we have two types of status neighborhood edges in F_n as given in Table 5.

$\sigma_n(u), \sigma_n(v) \setminus uv \in E(F_n)$	$(6n-2, 6n-2)$	$(6n-2, 2n(4n-2))$
Number of edges	n	$2n$

Table-5: Status neighborhood edge partition of F_n

Theorem 10: The general vertex status neighborhood index of a friendship graph F_n is given by

$$SN^a(F_n) = [2n(4n-2)]^a + 2n(6n-2)^a. \tag{4}$$

Proof: From definition and by using Table 4, we deduce

$$SN^a(F_n) = \sum_{u \in V(F_n)} \sigma_n(u)^a = [2n(4n-2)]^a + 2n(4n-2)^a.$$

We establish the following results by using Theorem 10.

Corollary 10.1: Let F_n be a friendship graph with $2n+1$ vertices and $3n$ edges. Then

(i) $SN(F_n) = 64n^4 + 8n^3 - 32n^2 + 8n.$

(ii) ${}^{m}SN(F_n) = \dfrac{1}{4n^2(4n-2)^2} + \dfrac{n}{2(3n-1)^2}.$

(iii) $FNS(F_n) = 8n^3(4n-2)^3 + 2n(6n-2)^3.$

(iv) $T_{sn}(F_n) = 20n^2 - 8n.$

(v) $SNI(F_n) = \dfrac{1}{2n(4n-2)} + \dfrac{n}{3n-1}.$

(vi) $SNZ(F_n) = \dfrac{1}{2\sqrt{n(n-1)}} + \dfrac{2n}{\sqrt{6n-2}}.$

Proof: Put a = 2, –2, 3, 1, – 1, –½ in equation (4), we obtain the desired results.

Theorem 11: The F_1-status neighborhood index and F_1-status neighborhood polynomial of a friendship graph F_n are given by

(i) $F_1SN(F_n) = 128n^5 - 128n^4 + 176n^3 - 96n^2 + 16n.$

(ii) $F_1SN(F_n, x) = nx^{2(6n-2)^2} + 2nx^{(6n-2)^2 + (8n^2-4n)^2}.$

Proof:

(i) By definition and by using Table 5, we deduce

$$F_1SN(F_n) = \sum_{uv \in E(F_n)} \left[\sigma_n(u)^2 + \sigma_n(v)^2\right]$$

$$= n\left[(6n-2)^2 + (6n-2)^2\right] + 2n\left[(6n-2)^2 + (8n^2-4n)^2\right]$$

$$= 128n^5 - 128n^4 + 176n^3 - 96n^2 + 16n.$$

(ii) By using definition and Table 5, we derive

$$F_1SN(F_n, x) = \sum_{uv \in E(F_n)} x^{\sigma_n(u)^2 + \sigma_n(v)^2}$$

$$= nx^{(6n-2)^2 + (6n-2)^2} + 2nx^{(6n-2)^2 + (8n^2-4n)^2}$$

$$= nx^{2(6n-2)^2} + 2nx^{(6n-2)^2 + (8n^2-4n)^2}$$

Theorem 12: The total status neighborhood polynomial and F-status neighborhood polynomial of a friendship graph F_n are given by

(i) $T_{sn}(F_n, x) = x^{2n(4n-2)} + 2nx^{6n-2}.$

(ii) $FSN(F_n, x) = x^{8n^3(4n-2)^3} + 2nx^{(6n-2)^3}.$

Proof:

(i) By using definition and Table 4, we obtain

$$T_{sn}(F_n, x) = \sum_{u \in V(F_n)} x^{\sigma_n(u)} = x^{2n(4n-2)} + 2nx^{6n-2}.$$

(ii) From definition and by using Table 4, we deduce

$$FSN(F_n, x) = \sum_{u \in V(F_n)} x^{\sigma_n(u)^3} = x^{8n^3(4n-2)^3} + 2nx^{(6n-2)^3}.$$

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