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Ch Shashi Kumar
Vignan Institute of Technology & Science

T. Siva Nageswara Rao
Vignan University

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T. Siva Nageswara Rao[1] , Ch. Shashi Kumar[2], Y. Srinivasa Rao[3], V. Venkateswara Rao[4]

[1&4] Division of Mathematics, Vignan's Foundation for Science Technology & Research (Deemed to be University), Vadlamudi, Guntur (Dt.), A.P, India.

E-mail: shivathottempudi@gmail.com, vunnamvenky@gmail.com.

[2]Department of Basic Science & Humanities , Vignan's Institute of Technology and Science, Deshmukhi, T.S, India.

E-mail: skch17@gmail.com.

[3]Research Scholar, Department of Mathematics, Acharya Nagarjuna University, Guntur (Dt.), A.P, India,

E-mail: sandhyasrinivas2009@gmail.com

Abstract:

In the present article, we deduce a characterization of BSVN detour interior and boundary vertices. We established the relations between BSVN cut node and BSVN detour boundary nodes. Further, we studied properties of BSVN boundary nodes and BSVN interior nodes. Application of detour boundary node, detour interior is given on modeling wireless sensor network in terms of BSVN graphs.

Keywords: Detour distance**,** BSVN detour boundary nodes, BSVN detour interior nodes.

1. Introduction:

The Neutrosophic sets launch by Smarandache [15, 16] are a great exact implement for the situation uncertainty in the real world. These uncertainty idea comes from the theories of fuzzy sets [9], intuitionistic fuzzy sets [6, 8] and interval valued intuitionistic fuzzy sets [7]. The representation of the neutrosophic sets are truth, indeterminacy and falsity value. These T, I, F values belongs to standard or nonstandard unit interval denoted by $]^{-}0, 1^{+}[$ [10,14].

The idea of subclass of the NS and SVNS introduced by Wang et al. [17]. The idea of SVNS initiation by intuitionistic fuzzy sets [5,11], in this the functions Truth, Indeterminacy, Falsity are not dependent and these values are present within [0, 1] [12].

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Neutrosophic theory is widely expands in all fields especially authors discoursed about topology with respect to neutrosophic [18].

Graph theory has at this time turn into a most important branch of mathematics. It is the division of combinatory. The Graph is a extensively important to analyze combinatorial complication in dissimilar areas in mathematics, optimization and computer science. Mainly significant object is well-known. The uncertainty on the subject of vertice and edges or both representation to be a fuzzy graph.

In a graph theory the new graph model was invites by using BSVN set is known as BSVN Graph(BSVNG). In [3, 4, 13] Broumi et al. explained BSVN graphs from the recall of fuzzy, bipolar fuzzy and single valued neutrosophic graphs.

In this manuscript, discus about BSVN graphs and neutrosophic detour distance between two vertices of the graph based on this define BSVN eccentricity, radius, diameter, center and periphery with respect to detour distance. Also find some important results on these topics.

2. Preliminaries:

Explanation 2.1 BSVN sets:-

A BSVN set is explained as the membership functions represented as an object in W is denoted by $\left\{< w, T^P, I^P, F^P, T^N, I^N, F^N >: w \in W\right\}$, the functions T^P, I^P, F^P are mapping from W to $[0,1]$ and T^N, I^N, F^N are mapping from W to $[-1,0]$.

Explanation 2.2 BSVN relation on W

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Let W be a non-empty set. Then we call mapping $Z=\left(W,T^{P},I^{P},F^{P},T^{N},I^{N},F^{N}\right)$, $F^{N}\left(w_1,w_2\right):W\times W\to[-1,0]\times[0,1]$ is a BSVN relation on W such that $T_Z^P\left(w_1,w_2\right)\in[0,1],I_Z^P\left(w_1,w_2\right)\in[0,1],F_Z^P\left(w_1,w_2\right)\in[0,1]$

$T_Z^N\left(w_1,w_2\right)\in[-1,0],I_Z^N\left(w_1,w_2\right)\in[-1,0],F_Z^N\left(w_1,w_2\right)\in[-1,0]$.

Explanation 2.3 Let $Z_1=\left(T_{Z_1}^P,I_{Z_1}^P,F_{Z_1}^P,T_{Z_1}^N,I_{Z_1}^N,F_{Z_1}^N\right)$ and $Z_2=\left(T_{Z_2}^P,I_{Z_2}^P,F_{Z_2}^P,T_{Z_2}^N,I_{Z_2}^N,F_{Z_2}^N\right)$ be a BSVN graphs on a set W. If Z_2 is a BSVN relation on Z_1, then

$T_{Z_2}^P\left(w_1,w_2\right)\le\min\left(T_{Z_2}^P\left(w_1\right),T_{Z_2}^P\left(w_2\right)\right)\ge\max\left(T_{Z_2}^N\left(w_1\right),T_{Z_2}^N\left(w_2\right)\right)$

$I_{Z_2}^P\left(w_1,w_2\right)\ge\max\left(I_{Z_1}^P\left(w_1\right),I_{Z_1}^P\left(w_2\right)\right)\le\min\left(I_{Z_1}^N\left(w_1\right),I_{Z_1}^N\left(w_2\right)\right)$

$F_{Z_2}^P\left(w_1,w_2\right)\ge\max\left(F_{Z_1}^P\left(w_1\right),F_{Z_1}^P\left(w_2\right)\right)\le\min\left(F_{Z_1}^N\left(w_1\right),F_{Z_1}^N\left(w_2\right)\right)$ for all $w_1,w_2\in W$

Explanation 2.4. The symmetric property defined on **BSVN** relation Z on W is explained by

$T_Z^P\left(w_1,w_2\right)=T_Z^P\left(w_2,w_1\right)$, $I_Z^P\left(w_1,w_2\right)=I_Z^P\left(w_2,w_1\right)$, $F_Z^P\left(w_1,w_2\right)=F_Z^P\left(w_2,w_1\right)$

$T_Z^N\left(w_1,w_2\right)=T_Z^N\left(w_2,w_1\right)$, $I_Z^N\left(w_1,w_2\right)=I_Z^N\left(w_2,w_1\right)$, $F_Z^N\left(w_1,w_2\right)=F_Z^N\left(w_2,w_1\right)$

for all $w_1,w_2\in W$

Explanation 2.5 BSVN graph

The new graph in SVN is denoted by $G^*=\left(V,E\right)$ is a pair $G=\left(Z_1,Z_2\right)$, where $Z_1=\left(T_{Z_1}^P,I_{Z_1}^P,F_{Z_1}^P,T_{Z_1}^N,I_{Z_1}^N,F_{Z_1}^N\right)$ is a BSVNS in V and $Z_2=\left(T_{Z_2}^P,I_{Z_2}^P,F_{Z_2}^P,T_{Z_2}^N,I_{Z_2}^N,F_{Z_2}^N\right)$ is BSVNS in V^2 defined as

$T_{Z_2}^P\left(w_1,w_2\right)\le\min\left(T_{Z_1}^P\left(w_1\right),T_{Z_1}^P\left(w_2\right)\right)$

$I_{Z_2}^P\left(w_1,w_2\right)\ge\max\left(I_{Z_1}^P\left(w_1\right),I_{Z_1}^P\left(w_2\right)\right)$

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$F_{Z_2}^P(w_1,w_2)\ge \max\left(F_{Z_1}^P(w_1),F_{Z_1}^P(w_2)\right)$

$T_{Z_2}^N(w_1,w_2)\ge \max\left(T_{Z_1}^N(w_1),T_{Z_1}^N(w_2)\right)$

$I_{Z_2}^N(w_1,w_2)\le \min\left(I_{Z_1}^N(w_1),I_{Z_1}^N(w_2)\right)$

$F_{Z_2}^N(w_1,w_2)\le \min\left(F_{Z_1}^N(w_1),F_{Z_1}^N(w_2)\right)$ for all $w_1,w_2\in V$

The BSVNSG of an edge denoted by $w_1w_2\in V^2$

Explanation 2.6 Let $G=(Z_1,Z_2)$ be a BSVNSG and $a_1,c_1\in V$

A path $P:a_1=w_0,w_1,w_2,........w_{k-1},w_k=c_1$ in G is sequence of distinct vertices such that $\begin{pmatrix} T_{Z_2}^P(w_{m-1},w_m)>0,\ I_{Z_2}^P(w_{m-1},w_m)>0,\ F_{Z_2}^P(w_{m-1},w_m)>0, \\ T_{Z_2}^N(w_{m-1},w_m)>0,\ I_{Z_2}^N(w_{m-1},w_m)>0,\ F_{Z_2}^N(w_{m-1},w_m)>0 \end{pmatrix}$, $m=1,2,..........,k$ and length of the path is k , where is a_1 called initial vertex and c_1 is called terminal vertex in the path.

Explanation 2.7 A BSVN graph $G=(Z_1,Z_2)$ of $G^*=(V,E)$ is called strong BSVN graph if

$T_{Z_2}^P(w_1,w_2)= \min\left(T_{Z_1}^P(w_1),T_{Z_1}^P(w_2)\right)$

$I_{Z_2}^P(w_1,w_2)= \max\left(I_{Z_1}^P(w_1),I_{Z_1}^P(w_2)\right)$

$F_{Z_2}^P(w_1,w_2)= \max\left(F_{Z_1}^P(w_1),F_{Z_1}^P(w_2)\right)$

$T_{Z_2}^N(w_1,w_2)= \max\left(T_{Z_1}^N(w_1),T_{Z_1}^N(w_2)\right)$

$I_{Z_2}^N(w_1,w_2)= \min\left(I_{Z_1}^N(w_1),I_{Z_1}^N(w_2)\right)$

$F_{Z_2}^N(w_1,w_2)= \min\left(F_{Z_1}^N(w_1),F_{Z_1}^N(w_2)\right)$ for all $(w_1,w_2)\in E$

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If $P: a_1 = w_0, w_1, w_2, ... w_{k-1}, w_k = c_1$ be a path of length k between a_1 and c_1 then

$\left(T^P_{Z_2}(a_1,c_1), I^P_{Z_2}(a_1,c_1), F^P_{Z_2}(a_1,c_1)\right)^k$ and $\left(T^N_{Z_2}(a_1,c_1), I^N_{Z_2}(a_1,c_1), F^N_{Z_2}(a_1,c_1)\right)^k$ is defined as

$$\left(T^P_{Z_2}(a_1,c_1), I^P_{Z_2}(a_1,c_1), F^P_{Z_2}(a_1,c_1)\right)^k = \begin{cases} \sup\left\{T^P_{Z_2}(a_1,w_1) \wedge T^P_{Z_2}(w_1,w_2) \wedge ..... \wedge T^P_{Z_2}(w_{k-1},c_1)\right\}, \\ \inf\left\{I^P_{Z_2}(a_1,w_1) \vee I^P_{Z_2}(w_1,w_2) \vee ..... \vee I^P_{Z_2}(w_{k-1},c_1)\right\}, \\ \inf\left\{F^P_{Z_2}(a_1,w_1) \vee F^P_{Z_2}(w_1,w_2) \vee ..... \vee F^P_{Z_2}(w_{k-1},c_1)\right\} \end{cases}$$

$$\left(T^N_{Z_2}(a_1,c_1), I^N_{Z_2}(a_1,c_1), F^N_{Z_2}(a_1,c_1)\right)^k = \begin{cases} \sup\left\{T^N_{Z_2}(a_1,w_1) \vee T^N_{Z_2}(w_1,w_2) \vee ..... \vee T^N_{Z_2}(w_{k-1},c_1)\right\}, \\ \inf\left\{I^N_{Z_2}(a_1,w_1) \wedge I^N_{Z_2}(w_1,w_2) \wedge ..... \wedge I^N_{Z_2}(w_{k-1},c_1)\right\}, \\ \inf\left\{F^N_{Z_2}(a_1,w_1) \wedge F^N_{Z_2}(w_1,w_2) \wedge ..... \wedge F^N_{Z_2}(w_{k-1},c_1)\right\} \end{cases}$$

$\left(T^P_{Z_2}(a_1,c_1), I^P_{Z_2}(a_1,c_1), F^P_{Z_2}(a_1,c_1)\right)^\infty$ and $\left(T^N_{Z_2}(a_1,c_1), I^N_{Z_2}(a_1,c_1), F^N_{Z_2}(a_1,c_1)\right)^\infty$ is said to be the strength of connectedness between two vertices a_1 and c_1 in G, where

$$\left(T^P_{Z_2}(a_1,c_1), I^P_{Z_2}(a_1,c_1), F^P_{Z_2}(a_1,c_1)\right)^\infty = \left(\sup_{k\in N}\left\{T^P_{Z_2}(a_1,c_1)\right\}, \inf_{k\in N}\left\{I^P_{Z_2}(a_1,c_1)\right\}, \inf_{k\in N}\left\{F^P_{Z_2}(a_1,c_1)\right\}\right)$$

$$\left(T^N_{Z_2}(a_1,c_1), I^N_{Z_2}(a_1,c_1), F^N_{Z_2}(a_1,c_1)\right)^\infty = \left(\inf_{k\in N}\left\{T^N_{Z_2}(a_1,c_1)\right\}, \sup_{k\in N}\left\{I^N_{Z_2}(a_1,c_1)\right\}, \sup_{k\in N}\left\{F^N_{Z_2}(a_1,c_1)\right\}\right)$$

If $\left(T^P_{Z_2}(a_1,c_1) \ge \left(T^P_{Z_2}(a_1,c_1)\right)^\infty, I^P_{Z_2}(a_1,c_1) \le \left(I^P_{Z_2}(a_1,c_1)\right)^\infty, F^P_{Z_2}(a_1,c_1) \le \left(F^P_{Z_2}(a_1,c_1)\right)^\infty\right)$ and $\left(T^N_{Z_2}(a_1,c_1) \le \left(T^N_{Z_2}(a_1,c_1)\right)^\infty, I^N_{Z_2}(a_1,c_1) \ge \left(I^N_{Z_2}(a_1,c_1)\right)^\infty, F^N_{Z_2}(a_1,c_1) \ge \left(F^N_{Z_2}(a_1,c_1)\right)^\infty\right)$ then the arc a_1c_1 in G is called a strong arc. A path $a_1 - c_1$ is strong path if all arcs on the path are strong.

3. BSVN detour distance

Explanation 3.1

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BSVN detour distance is defined as the length of , a-c strong path between a and c if there is no other strong path longer than P between a and c and we denote this by B.$S.N.D(a, c)$. Any a-c strong path whose length is $B.S.N.D(a, c)$ is called a a-c BSVN detour path.

4. BN detour boundary node of a BN graph

Explanation 4.1 In a connected BN graph G, a node n_2 is said to be a BN detour *boundary* node of a node n_1 if $B.N.D(n_1, n_2) \geq B.N.D(n_1, n_3)$ for each n_3 in G, where n_3 is a neighbor of n_2. The set of all BN detour boundary nodes of n_1 denoted by $n'_{1\ B.N.D}$.

Explanation 4.2 If the BN sub graph formed by strong neighbor of a node n_2 in a BN graph G, form a complete BN graph then the node n_2 is said to be a complete node of G.

Theorem 4.3 *A node in a complete BN graph is BN detour boundary node of every other nodes iff the node is complete.*

Proof. Let a node n_2 be a complete node in a connected BN graph G. Let n_1 be an another node of G. Each arc in G is strong, because of completeness of G [1]. So $B.N.D(n_1, n_2) = |V| - 1 = B.N.D(n_1, n_3)$, $\forall n_3 \in N(n_2)$, where $|V|$ = numbers of nodes in G.Therefore n_2 is a BN detour boundary node of n_1.

Conversely, let n_2 be a BN detour boundary node of every other node. Then each arc in G is strong, because of completeness of G [1]. Then $B.N.D(n_1, n_2) = |V| - 1$, $\forall n_1 \in G$. So all neighbor of n_2 are strong neighbor. Hence by Explanation 4.2, the node n_2 is complete.

Theorem 4.4 *If a node in a connected BN graph G is a complete node of G, then the node is a BN detour boundary node of all other node.*

Proof. Let a node n_2 be a complete node in a connected BN graph G and let n_1 be another node of G. Assume that $n_1 = w_0, w_1, \ldots, w_{k-1}, w_k = n_2$ be a $n_1 - n_2$ BN detour and n_3 be a strong neighbor of n_2. There arise two cases

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Case 1: If $n_3 = w_{k-1}$, then $B.N.D(n_1, n_3) \leq B.N.D(n_1, n_2)$. Hence n_2 be a BN detour boundary node of n_1.

Case 2: If $n_3 \neq w_{k-1}$, since n_3 is a strong neighbor of n_2, so the arc (n_3, w_{k-1}) is a strong arc and also $n_3 \neq w_{k-1}$. So the length of the path $n_1 = w_0, w_1, \ldots, w_{k-1}, n_3, w_k = n_2$ is greater than than the length of the path $n_1 = w_0, w_1, \ldots, w_{k-1}, w_k = n_2$. Hence $B.N.D(n_1, n_3) \leq B.N.D(n_1, n_2)$.Therefore n_2 is a BN detour boundary node of n_1.

Theorem 4.5 *A connected BN graph G is a BN tree iff G is BN detour graph.*

Proof. Let G be a BN tree. Then between any two nodes in G, there is exactly one BN strong path. So $B.N.D(n_1, n_2) = B.N.D(n_1, n_2)$ for any two nodes n_1, n_2 in G. Hence G is BN detour graph.

Conversely, let G be a BN detour graph, which has $|V|$ nodes. Then $B.N.D(n_1, n_2)= B.N.D(n_1, n_2)$for any two nodes n_1, n_2 in G. If $|V| = 2$ then G is a BN tree.

Let $|V| \geq 3$. If possible, let G be not a BN tree. So $\exists$ two nodes p, q in G for which there is at least two strong path between p and q. Let Q_1 and Q_2 be two $p-q$ bipolar neutrosophic strong paths. So $Q_1 \cup Q_2$ has a cycle $C(say)$ in G. If node n_1 and n_2 are adjacent nodes in G, then we have $B.N.D(n_1, n_2) = 1$ and $B.N.D(n_1, n_2) > 1$. This contradicts the fact that $B.N.D(n_1, n_2) = B.N.D(n_1, n_2)$. Hence G is a BN tree.

Theorem 4.6 *In a BN tree G, a node n_2 is a BN detour boundary node of G iff n_2 cannot be a BN cut node of G.*

Proof. Let G be a BN tree and a node n_2 in G be a BN detour boundary node of a node n_3 in G. If possible, let n_2 be a BN cut node of G.

Let E be a BN maximum spanning tree in G, which is unique in G. Since n_2 is a BN cut node, so n_2 cannot be an internal node of E. Let $x \in N_{B.N.S}(n_2)$ such that x does not lie on the BN

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detour in E. Therefore $B.N.D(p, q)$ is same when p, q be any two nodes of E and G both. But $B.N.D(n_3, x) = B.N.D(n_3, n_2)+B.N.D(n_2, x) > B.N.D(n_3, n_2)$. This contradicts the fact that n_2 is a BN detour *boundary* node of a node n_3 in G. Therefore the node n_2 cannot be a BN cut node of G.

Conversely, let n_2 be not a BN cut node of the BN graph G. So n_2 is end node of maximum bipolar spanning tree, which is unique. Then n_2 has a strong neighbor which is also unique [2]. So there does not exist any extension of any BN detour for a node x to n_2. Hence n_2 is a BN detour boundary node of G.

Explanation 4.7 A node n_1 in a BN graph G is said to be a BN end node of G if n_2 is only strong neighbor of n_1, where $n_2 \in G$.

Theorem 4.8 *A node n_2 in a BN tree G is a BN detour boundary node iff n_2 is a BN end node.*

Proof. Let a node n_2 be a BN detour boundary node for a node n_1 in a BN tree G. Let E be a maximum bipolar spanning tree in G, which is unique in G [2]. By Explanation 4.7, each node of G is a BN cut node of G or a BN end node of G [2]. So by Explanation 4.7, n_2 must be a BN end node of G.

Conversely, let n_2 be a BN end node of a BN tree G. Let E be the maximum bipolar spanning tree of G. Then n_2 is a BN end node of E. Hence n_2 is not a BN cut node of G. Therefore by Explanation 4.7, n_2 is a BN detour *boundary* node of G.

5. BN detour interior node of a BN graph

In a connected BN graph G, a node n_2 lie between the nodes n_1 and n_3 in the sense of BN detour distance if $B.N.D(n_1, n_3) = B.N.D(n_1, n_2) + B.N.D(n_2, n_3)$.

Explanation 5.1 In a connected BN graph G, a node n_2 is said to be a BN detour interior node if for each node n_1 in G different from n_2, there is a node n_3 in G for which $B.N.D(n_1, n_3) = B.N.D(n_1, n_2) + B.N.D(n_2, n_3)$.

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Explanation 5.2 The set of all BN detour *interior* node of G, denoted by $Int_{B.N.D}(G)$, form a BN sub graph of G.

Theorem 5.3 *A node in a connected BN graph G is a BN detour boundary node of G iff the node cannot be a BN detour interior node of G.*

Proof. Let n_2 be a BN detour boundary node of a node n_1 in a connected BN graph G. If possible, let n_2 be a BN detour interior node of G. So there exist a node n_3 different from n_1 and n_2 such that n_2 lies between n_1 and n_3.

Let U: $n_1 = w_1, w_2, \ldots, n_2 = w_k, w_{k+1}, \ldots, w_l = n_3$ be a $n_1 - n_3$ BN detour and $1 < k < l$. Then $w_{k+1} \in N_{B.N.S}(n_2)$, and this implies $B.N.D(n_1, w_{k+1}) > B.N.D(n_1, n_2)$, this is a contradiction. Hence n_2 cannot be a BN detour interior node of G.

Conversely, let a node n_2 in G, which is not a BN detour interior node of G. Then there exist a node n_1 in G for which any node n_3 different from n_1 and n_2, $B.N.D(n_1, n_3) \neq B.N.D(n_1, n_2)+B.N.D(n_2, n_3)$. Therefore $B.N.D(n_1, q) \leq B.N.D(n_1, n_2)$ where $q \in N_{B.N.S}(n_2)$. This implies that n_2 is a BN detour boundary node of n_1.

Theorem 5.4 *A BN end node of a connected BN graph G cannot be a BN detour interior node.*

Proof. Let q be a BN end node of a BN graph G. Then there is only one BN strong neighbor of q. So there is no strong BN detour for which n_2 lies between n_1 and n_3, where n_1 and n_3 be two node of G and also different from n_2. Hence n_2 is not a BN detour interior node of G.

6. Application:

Modeling of wireless sensor network in terms of BSVN graph and determination of its boundary and interior stations

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In a wireless sensor network, if the sensor failure or sensor give expansive errors or disconnection of network, then the capability of each station to capture the sense of occurrence and communication between them are uncertain. Here we present a BN graph G (see Figure 1) which is applied on a wireless sensor network (W.S.N) to determine its boundary and interior station which is shown in Figure 1. The nodes are a, b, c, d, e, f of G represents the stations and each edge represents the communication between corresponding stations.

The positive membership value of each nodes of G represents the capability of the station to capture the sense of occurrence. Its value is 0 if the capability is $\leq 5\%$ and its value is 1 if the capability is $\geq 80\%$. So the positive membership value of each node lies in (0, 1) if the capability lies between > 5% and < 80%. The negative membership value of each node of G represents the disability of the station to capture the sense of occurrence (disability means it gives expansive error, change in sensor position or disconnection of network). Its value is 0 if the disability is $\leq$ 10% and its value is -1 if the disability is $\geq 75\%$. So the negative membership value of each node lies in $(-1, 0)$ if the disability lies between > 10% and < 75%. The positive membership value of each edge represents the ability to communicate of two corresponding stations. Its value is 0 if the ability is $\leq 25\%$ and its value is 1 if the ability is $\geq 70\%$. So the positive membership value of each edge lies in (0, 1) if the ability lies between > 25% and < 70%. The negative membership value of each edge represents the disability to communicate of two corresponding stations. Its value is 0 if the disability is $\leq$ 30% and its value is -1 if the disability is $\geq 80\%$. So the negative membership value of each edge lies in $(-1, 0)$ if the disability lies between > 30% and < 80%. Here the middle value is called indeterminacy value of neutrosophic theory. This value is based upon the confusion between Truth value and falsity.

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In W.S.N connecting and covering the whole area are very essential. If the sensor failure or sensor give expansive errors or disconnection of network to coverage the whole area, then we have to find out the boundary stations and interior stations of the W.S.N, which is equivalent to determine the BN detour boundary and interior nodes of *G*.

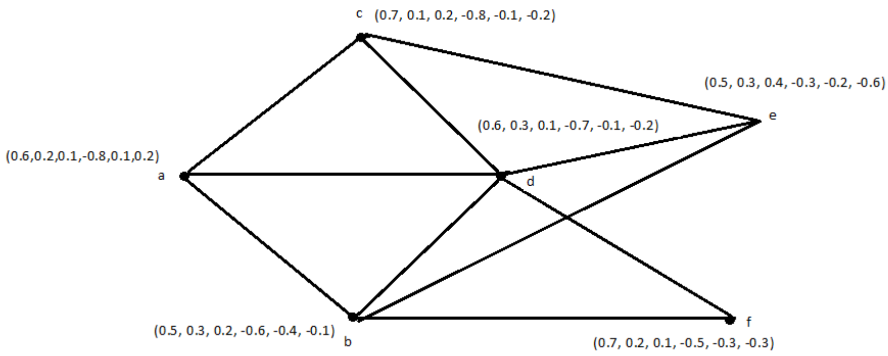

Figure 1: Modeling of wireless sensor network in terms of BSVN graph

For the BN graph in Figure 1,

$B.N.D(\mathrm{a}, c) = 1$, $B.N.D(a, b) = 3$, $B.N.D(a, e) = 4$, $B.N.D(a, d) = 1$, $B.N.D(a, f) = 3$,

$B.N.D(\mathrm{b}, e) = 1$, $B.N.D(\mathrm{b}, d) = 2$, $B.N.D(\mathrm{b}, f) = 2$,

$B.N.D(\mathrm{c}, b) = 4$, $B.N.D(\mathrm{c}, e) = 5$, $B.N.D(\mathrm{c}, d) = 2$, $B.N.D(\mathrm{c}, f) = 4$,

$B.N.D(\mathrm{e}, d) = 3$, $B.N.D(\mathrm{e}, f) = 3$,

$B.N.D(\mathrm{d}, f) = 2$.

So $a'\, B.F.D = \{\mathrm{e}\}$, $c'\, B.F.D = \{\mathrm{e}\}$, $b'\, B.F.D = \{\mathrm{c}\}$, $e'\, B.F.D = \{\mathrm{c}\}$, $d'\, B.F.D = \{\mathrm{e}\}$,

$f'\, B.F.D = \{\mathrm{c}\}$.

Therefore c, *e* are BN detour *boundary* nodes and a, *b, e, d* are BN detour interior nodes of *G*. Hence the stations at c, *e* are boundary stations and the stations a, *b, d, f* are the interior stations of the W.S.N.

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