



A New Score Function of Pentagonal Neutrosophic Number and its Application in Networking Problem

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Abstract: Pentagonal neutrosophic number is an extended version of single typed neutrosophic number. Real-humankind problems have different sort of ambiguity in nature and amongst them; one of the important problems is solving the networking problem. In this contribution, the conception of pentagonal neutrosophic number has been focused in a distinct framework of reference. Here, we develop of a new score function and its estimation have been formulated in different perspectives. Further, a time computing based networking problem is considered here in pentagonal neutrosophic arena and solved it using an influx of dissimilar logical & innovative thinking. Lastly, computation of total completion time of the problem reflects the impotency of this noble work.

Keywords: Pentagonal neutrosophic number, Networking problem, Score function.

Introduction:

Researchers though have various fields to work on but hesitant theory is one of the vital topics in today's world to deal with. Professor Zadeh [1] was first to familiarize with the fuzzy set theory (in 1965) to handle hesitant idea. The theory of fuzziness has a leading feature to solve clear soundly engineering and statistical problem. Applying the uncertainty theory, plentiful varieties of realistic problem can be solved, networking problem, decision making problem, influence on social science, etc. Pertaining the concept of Zadeh's research paper, Atanassov [2] created phenomenally the intuitionistic fuzzy set where he meticulously elucidates the concept of membership and non-membership function. With the going researches triangular [3], trapezoidal [4], pentagonal [5], hexagonal [6] fuzzy numbers are constructed in indefinite environment. The notion of triangular intuitionistic fuzzy set was put forth by Liu & Yuan [7]. The elementary idea of trapezoidal intuitionistic fuzzy set in research arena was constructed by Ye [8]. Unsurprisingly a basic question ascends onto our mind that how can mathematical model deal with the idea of vagueness? Different sorts of methodologies have been devised by the researchers to describe intricately the conceptions of some new uncertain parameters and to handle these complicated problems, the decision makers put forth their various ideas in disjunctive areas. F. Smarandache [9] in 1998 germinated the notion of having neutrosophic set holding three different fundamental element (i) truth, (ii) indeterminate, and (iii) falsity. Each and every attributes of the neutrosophic sets are very relevant factors to our real life models. Afterwards, Wang et al. [10] progressed with single typed neutrosophic set which serves the solution to any sort of complicated problem in a very efficient way. Later on, Chakraborty et al. [11, 12] abstracted the concept of triangular and trapezoidal neutrosophic numbers and functionalized it in diversified real life problem fruitfully. Also, Maity et al. [13] constructed ranking and defuzzification using totally dissimilar sort of attributes. Bosc and Pivert [14] fostered the concept of bipolarity to deal with human decision making problem on the base of positive and negative sides. Lee [15] continued the expound the theory of bipolar fuzzy set into their research article. Broadening the hypothesis into

groups and semi-groups structure field was done by Kang and Kang [16]. With ongoing researches Deli et al. [17] build up with the concept of bipolar neutrosophic number and applied it in the field of decision-making associated problem. Broumi et al. [18] put forward the concept of bipolar neutrosophic graph theory and successively Ali and Smarandache [19] proposed the perception of the indeterminate complex neutrosophic set. Chakraborty [20] acquainted us with bipolar number in distinctive aspects. Sequentially, the notion of use of operators in bipolar neutrosophic set was put forward by Wang et al. [21]. He applied in decision related problem. Researchers dealing with the evaluation of any scientific decision, multi-criteria decision making (MCDM) problem is at the utmost concerned. Nowadays utilization of group of criteria is more likely agreeable. Application of MCDM has a wider aspect in disjunctive fields under numerous skepticism frameworks. Researchers show their enthusiasm against problems relating to multi-criteria group decision making (MCGDM) problem. Several applications and progressions on neutrosophic theory could be found under multi-criteria decision making problem, moving with literature surveys showed in [22-25], graph theory [26-30], optimization systems [31-33] etc. On the recent times, Abdel [34] structured the view point of plithogenic set which had a vast significant in uncertain field in research area. Correspondingly, Chakraborty [35, 36] established the outset of cylindrical neutrosophic number and applied it in networking planning problem, MCDM problem and in minimal spanning tree problem. Recently, the concept of pentagonal fuzzy number was first incubated by R. Helen [37]. Later on, utilizing this concept, Christi [38] established pentagonal intuitionistic number and solved transportation problem very proficiently. Chakraborty [39, 40] set forth the idea of pentagonal neutrosophic number and its application in transportation problem and graphical research area. Also, Ye [41] manifested the idea of Single valued neutrosophic minimal spanning tree and clustering method & Mandal & Basu [42] focused on similarity measure based spanning tree problems in neutrosophic arena. Mullai et.al [43] ignited the minimum spanning tree problem & Broumi et.al [44] introduced shortest path problem in neutrosophic graphs. Also, Broumi et.al [45] manifested neutrosophic shortest path to solve Dijkstra algorithm & some published articles [46-47] are addressed here related with neutrosophic domain which plays an essential role in research arena.

This paper deals with the conception of pentagonal neutrosophic number in different aspect. Nowadays researchers are very much interested in doing networking problem in neutrosophic domain. In this article, we consider a networking based PERT problem in pentagonal neutrosophic where we utilize the idea of our developed score function for solving the problem.

1.1 Motivation

The idea of vagueness plays an essential role in construction of mathematical modeling, economic problem and social real life problem etc. Now there will be a vital point that if someone considers pentagonal neutrosophic number in networking domain then what will be the final solution and the critical path? How should we convert a pentagonal neutrosophic number into crisp number? From this aspect we actually try to develop this research article.

1.2 Novelties

Till date lots of research works are already published under neutrosophic environment. Under numerous fields researches have established formulas to work on. Although many fields are unknown and works are still going on. Our job is to give a try on developing new ideas on unfamiliar points.

- (i) To develop score and accuracy function.
- (ii) Usage of our function in networking problem.

2. Preliminaries

Definition 2.1: Fuzzy Set: [1] Set \tilde{M} called as a fuzzy set when represented by the pair $(x, \mu_{\tilde{M}}(x))$ and thus stated as $\tilde{M} = \{(x, \mu_{\tilde{M}}(x)): x \in X, \mu_{\tilde{M}}(X) \in [0,1]\}$ where $x \in$ the crisp set X and $\mu_{\tilde{M}}(X) \in$ the interval $[0,1]$.

Definition 2.2: Intuitionistic Fuzzy Set (IFS): [2] An fuzzy set [2] \tilde{S}_F in the universal discourse X , symbolized widely by x is referred as Intuitionistic set if $\tilde{S}_F = \{ \langle x; [\gamma(x), \delta(x)] \rangle : x \in X \}$, where $\gamma(x): X \rightarrow [0,1]$ is termed as the certainty membership function which specify the degree of confidence, $\delta(x): X \rightarrow [0,1]$ is termed as the uncertainty membership function which specify the degree of indistinctness.

$\gamma(x), \delta(x)$ exhibits the following the relation

$$0 \leq \gamma(x) + \delta(x) \leq 1.$$

2.3 Definition: Neutrosophic Set: [9] A set $\tilde{N}e_M$ in the universal discourse X , figuratively represented by x named as a neutrosophic set if $\tilde{N}e_M = \{ \langle x; [\lambda_{\tilde{N}e_M}(x), \pi_{\tilde{N}e_M}(x), \sigma_{\tilde{N}e_M}(x)] \rangle : x \in X \}$, where $\lambda_{\tilde{N}e_M}(x): X \rightarrow [0,1]$ is stated as the certainty membership function, which designates the degree of confidence, $\pi_{\tilde{N}e_M}(x): X \rightarrow [0,1]$ is stated as the uncertainty membership, which designates the degree of indistinctness, and $\sigma_{\tilde{N}e_M}(x): X \rightarrow [0,1]$ is stated as the untruthful membership, which designates the degree of deceptiveness on the decision taken by the decision maker.

$\lambda_{\tilde{N}e_M}(x), \pi_{\tilde{N}e_M}(x) \& \sigma_{\tilde{N}e_M}(x)$ displays the following relation:

$$-0 \leq \lambda_{\tilde{N}e_M}(x) + \pi_{\tilde{N}e_M}(x) + \sigma_{\tilde{N}e_M}(x) \leq 3 +.$$

2.4 Definition: Single-Valued Neutrosophic Set: [10] A Neutrosophic set $\tilde{N}e_M$ in the definition 2.3 is assumed as a Single-Valued Neutrosophic Set ($\tilde{S}N\tilde{e}_M$) if x is a single-valued independent variable. $\tilde{S}N\tilde{e}_M = \{ \langle x; [\lambda_{\tilde{S}N\tilde{e}_M}(x), \pi_{\tilde{S}N\tilde{e}_M}(x), \sigma_{\tilde{S}N\tilde{e}_M}(x)] \rangle : x \in X \}$, where $\lambda_{\tilde{S}N\tilde{e}_M}(x), \pi_{\tilde{S}N\tilde{e}_M}(x) \& \sigma_{\tilde{S}N\tilde{e}_M}(x)$ signified the notion of correct, indefinite and incorrect memberships function respectively.

If three points d_0, e_0 & f_0 exists for which $\lambda_{\tilde{S}N\tilde{e}_M}(d_0) = 1, \pi_{\tilde{S}N\tilde{e}_M}(e_0) = 1$ & $\sigma_{\tilde{S}N\tilde{e}_M}(f_0) = 1$, then the $\tilde{S}N\tilde{e}_M$ is termed neut-normal.

$\tilde{S}C\tilde{S}_M$ is called neut-convex indicating that $\tilde{S}C\tilde{S}_M$ is a subset of a real line by meeting the resulting conditions:

- i. $\lambda_{\tilde{S}N\tilde{e}_M}(\delta d_1 + (1 - \delta)d_2) \geq \min\{\lambda_{\tilde{S}N\tilde{e}_M}(d_1), \lambda_{\tilde{S}N\tilde{e}_M}(d_2)\}$
- ii. $\pi_{\tilde{S}N\tilde{e}_M}(\delta d_1 + (1 - \delta)d_2) \leq \max\{\pi_{\tilde{S}N\tilde{e}_M}(d_1), \pi_{\tilde{S}N\tilde{e}_M}(d_2)\}$
- iii. $\sigma_{\tilde{S}N\tilde{e}_M}(\delta d_1 + (1 - \delta)d_2) \leq \max\{\sigma_{\tilde{S}N\tilde{e}_M}(d_1), \sigma_{\tilde{S}N\tilde{e}_M}(d_2)\}$

where d_1 & $d_2 \in \mathbb{R}$ and $\delta \in [0,1]$

2.5 Definition: Single-Valued Pentagonal Neutrosophic Number: A Single-Valued Pentagonal Neutrosophic Number (\tilde{M}) is demarcated as $\tilde{S}s = \langle [(s^1, t^1, u^1, v^1, w^1); \mu], [(s^2, t^2, u^2, v^2, w^2); \theta], [(s^3, t^3, u^3, v^3, w^3); \eta] \rangle$, where $\mu, \theta, \eta \in [0,1]$. The correct membership function ($\mu_{\tilde{S}s}: \mathbb{R} \rightarrow [0, \mu]$), the indefinite membership function ($\theta_{\tilde{S}s}: \mathbb{R} \rightarrow [\theta, 1]$) and the incorrect membership function ($\eta_{\tilde{S}s}: \mathbb{R} \rightarrow [\eta, 1]$) are given as:

$$\mu_{\tilde{S}s}(x) = \begin{cases} \mu_{\tilde{S}s1}(x) & s^1 \leq x < t^1 \\ \mu_{\tilde{S}s2}(x) & t^1 \leq x < u^1 \\ \mu & x = u^1 \\ \mu_{\tilde{S}s2}(x) & u^1 \leq x < v^1 \\ \mu_{\tilde{S}s1}(x) & v^1 \leq x < w^1 \\ 0 & \text{otherwise} \end{cases}, \quad \theta_{\tilde{S}s}(x) = \begin{cases} \theta_{\tilde{S}s1}(x) & s^2 \leq x < t^2 \\ \theta_{\tilde{S}s2}(x) & t^2 \leq x < u^2 \\ \theta & x = u^2 \\ \theta_{\tilde{S}s2}(x) & u^2 \leq x < v^2 \\ \theta_{\tilde{S}s1}(x) & v^2 \leq x < w^2 \\ 1 & \text{otherwise} \end{cases}$$

$$\eta_{\tilde{S}}(x) = \begin{cases} \eta_{\tilde{S}t1}(x) & s^3 \leq x < t^3 \\ \eta_{\tilde{S}t2}(x) & t^3 \leq x < u^3 \\ \vartheta & x = u^3 \\ \eta_{\tilde{S}v2}(x) & u^3 \leq x < v^3 \\ \eta_{\tilde{S}v1}(x) & v^3 \leq x < w^3 \\ 1 & \text{otherwise} \end{cases}$$

3. Proposed Score Function:

Score function utterly relies upon the value of exact membership indicator degree, inexact membership indicator degree and hesitancy membership indicator degree for a pentagonal neutrosophic number. The fundamental use of score function is to drag the judgment of conversion of pentagonal neutrosophic number to real number. A score function is developed for any Pentagonal Single typed Neutrosophic Number (PSNN).

$$\tilde{P}_{Pen} = (P_1, P_2, P_3, P_4, P_5; \alpha, \beta, \gamma)$$

Score function is described as $\tilde{S}_{Pen} = \frac{1}{15} \{(P_1 + P_2 + P_3 + P_4 + P_5) \times (2 + \alpha - \beta - \gamma)\}$

Here, $\tilde{S}_{Pen} \in [0,1]$

3.1 Relationship between any two pentagonal neutrosophic fuzzy numbers:

Let us consider any two pentagonal neutrosophic fuzzy number defined as follows

$$P_{Pen1} = (\alpha_{Pen1}, \beta_{Pen1}, \gamma_{Pen1}), P_{Pen2} = (\alpha_{Pen2}, \beta_{Pen2}, \gamma_{Pen2})$$

- 1) $S_{Pen1} > S_{Pen2}, P_{Pen1} > P_{Pen2}$
- 2) $S_{Pen1} < S_{Pen2}, P_{Pen1} < P_{Pen2}$
- 3) $S_{Pen1} = S_{Pen2}, P_{Pen1} = P_{Pen2}$

Table 3.1: Numerical Examples

Pentagonal Neutrosophic Number (P_{Pen})	Score Value (S_{Pen})	Ordering
$P_{Pen1} = < (0.3, 0.4, 0.5, 0.6, 0.7; 0.4, 0.7, 0.6) >$	0.1833	$P_{Pen2} > P_{Pen3} > P_{Pen4} > P_{Pen1}$
$P_{Pen2} = < (0.3, 0.35, 0.45, 0.55, 0.7; 0.6, 0.5, 0.4) >$	0.2663	
$P_{Pen3} = < (0.25, 0.3, 0.4, 0.5, 0.7; 0.6, 0.5, 0.5) >$	0.2293	
$P_{Pen4} = < (0.4, 0.45, 0.5, 0.6, 0.7; 0.3, 0.5, 0.6) >$	0.2120	

4. PERT in Pentagonal Neutrosophic Environment and the Proposed Model

PERT system or Project Evaluation and Review Technique are a project managing scheme which is used to plan, arrange, systemize and equalize tasks amongst a project. These techniques basically examine the minimum time required in finishing the total task and also calculate the time required in completion of each task for the given project.

PERT arrangement entails the specified steps:

1. Identification of specified activities and milestones.
2. In determination of accurate sequence of the activities.
3. In construction of a network map.
4. Evaluation of time needed for ac task.
5. Determination of the critical path.
6. Updating the PERT chart on progression with the project.

The chief purpose of PERT chart is to simplify and to decrease both time and cost of completion of any decision forming project. This method is proposed for wide-ranging, one-time, non-routine difficult projects having high degree of dependence. In projects, where series of tasks are present, some are always executed successively while rest are accomplished matching with other activities. In case of new projects having huge uncertainty in technology and networking system PERT is essentially used. For handling the uncertainties, triangular neutrosophic setting For PERT activity duration has been introduced.

The three time estimations for activity duration are:

Optimistic Time(δ_t): In general, the optimistic time requires minimum time for completing the activities and it is considered with three standards deviations from mean and approximately there is 1% chance for the activity to complete within time.

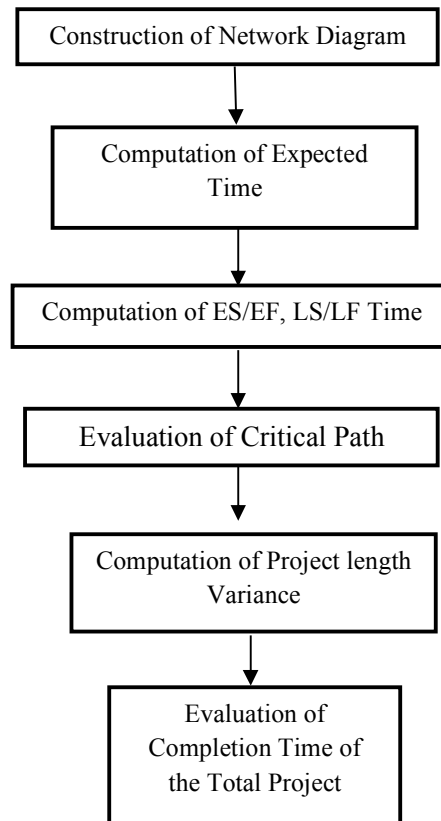
Pessimistic time(β_t): . It is known for tasks taking the longest time. Here also the three standards deviations are used.

Most Likely time(\bar{m}_t): – The completion time in general status for most likely have the highest probability and is absolutely different from the projected time

We choose all the different three activities duration for the model put forward as in triangular neutrosophic number. Score value $R(\tilde{S}_{Pen}, 0) = \frac{1}{15}(P_1 + P_2 + P_3 + P_4 + P_5) \times (2 + \alpha - \beta - \gamma)$ is presented to attain the pentagonal neutrosophic number($P_1, P_2, P_3, P_4, P_5; \alpha, \beta, \gamma$). By the use of formulas the expected time $E_t = \frac{(o_t + 4m_t + p_t)}{6}$ and the standard deviation $\sigma_t = \frac{(p_t - o_t)}{6}$ is calculated where o_t, p_t, m_t denotes the optimistic time, pessimistic time and most likely time respectively for all crisp value. For the add-on calculations of latest time, critical path and float CPM method is used. Considering the forward pass with zero starting time, the first event progresses from left to right and reaches to the final event. Let us assume j, k for any activity, the earliest time event of j is ES_j therefore $S_k = ES_j + t_{jk}$. There might be a case where in an event more than one activity enters then the earliest time is calculated as $ES_k = \max\{ES_j + t_{kj}\}$ for all activities radiating from node j to k. Backward pass starts with the final node and calculation progresses from right to left till the initial event. Let us assume j, k for any activity, the latest finished time event of j is LF_j therefore, $F_j = LF_k - t_{jk}$. There might be a case where in an event more than one activity enters then the latest finish time is calculated as $LF_j = \min\{LF_k - t_{kj}\}$ for all activities radiating from node k to i. Once the critical path is calculated, computation of project length variance is done which is sum of the variances of all critical activities. After that standard normal variable $Z = \frac{T_{sd} - T_{ex}}{\sigma}$ is computed where

T_{sd} is the schedules time given for a project to complete and , T_{ex} is the expected project length duration. By the use of normal curve, the probability of project completion within the definite time can be approximated.

Flowchart-



4.1 Illustrative Example:

Activity	Description	Predecessors	Optimistic Time	Pessimistic Time	Most Likely Time
A	Selection of Manager and Other Marketing members	_____	< 0.5,1.8,2.5,3,4.4; 0.5,0.5,0.8 >	< 1.4,2,2.6,3,4.5; 0.4,0.5,0.7 >	< 2.2,2.8,3.8,4.6,5.5; 0.7,0.5,0.6 >
B	Choice of Market Areas	_____	< 0.7,1.6,2.8,3.5,4.8; 0.6,0.6,0.3 >	< 2,3,4,5,6; 0.6,0.7,0.6 >	< 1.5,2,2.5,3,4; 0.6,0.5,0.7 >
C	Selection of Marketing Products	A	< 1,2,3,4,5; 0.7,0.6,0.4 >	< 2,2.5,3,3.5,4.5; 0.8,0.6,0.8 >	< 1.8,2.6,3.6,4.2,5.5; 0.6,0.5,0.4 >
D	Ultimate Planning and Master-plan	B	< 2.5,3,4,4.5,6; 0.6,0.5,0.7 >	< 0.8,1.8,2.5,3.6,5; 0.4,0.6,0.7 >	< 1.1,8,2.6,3.6,5; 0.6,0.7,0.5 >
E	Training Schedule	B	< 1.5,2.5,3,4,5.5; 0.7,0.6,0.4 >	< 2,3,4,5,6; 0.8,0.6,0.7 >	< 1.4,2.2,2.8,3.5,4.5; 0.6,0.7,0.5 >
F	Delay Times	C,D	< 2,2.5,3.5,4,5.5; 0.7,0.6,0.4 >	< 1.6,2.4,3.2,4.5,5.6; 0.8,0.7,0.5 >	< 2.2,2.8,3.6,4.5,5.5; 0.7,0.4,0.6 >

G	Estimation of the total time	E	< 1.6,2,2.5,3,4.5; 0.6,0.7,0.5 >	< 2,2.5,3.5,4,5.5; 0.8,0.4,0.6 >	< 2.6,3.5,4,5,6; 0.7,0.5,0.5 >
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Draw the project network and find the probability that the project is completed in 5.6 days?

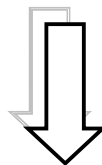
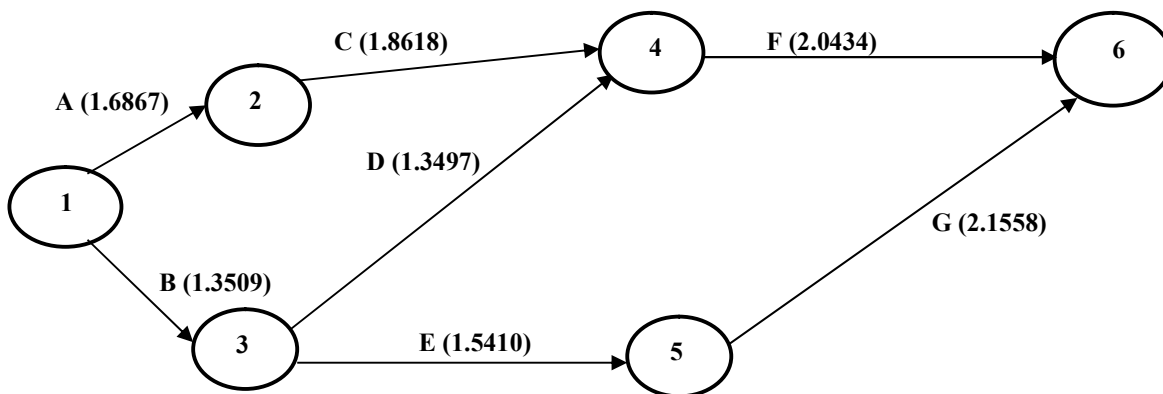
Step-1

Optimistic Time(o_t)	Pessimistic Time(p_t)	Most Likely Time(m_t)	$E_{jk} = \frac{o_t + 4m_t + p_t}{6}$	$\sigma_{jk}^2 = \left(\frac{p_t - o_t}{6}\right)^2$
0.9760	1.0800	2.0160	1.6867	0.0003
1.5187	1.7333	1.2133	1.3509	0.0013
1.7000	1.4467	2.0060	1.8618	0.0018
1.8667	1.0047	1.3067	1.3497	0.0206
1.8700	2.0000	1.3440	1.5410	0.0005
1.9833	1.8453	2.1080	2.0434	0.0005
1.2693	2.1000	2.3913	2.1558	0.0192



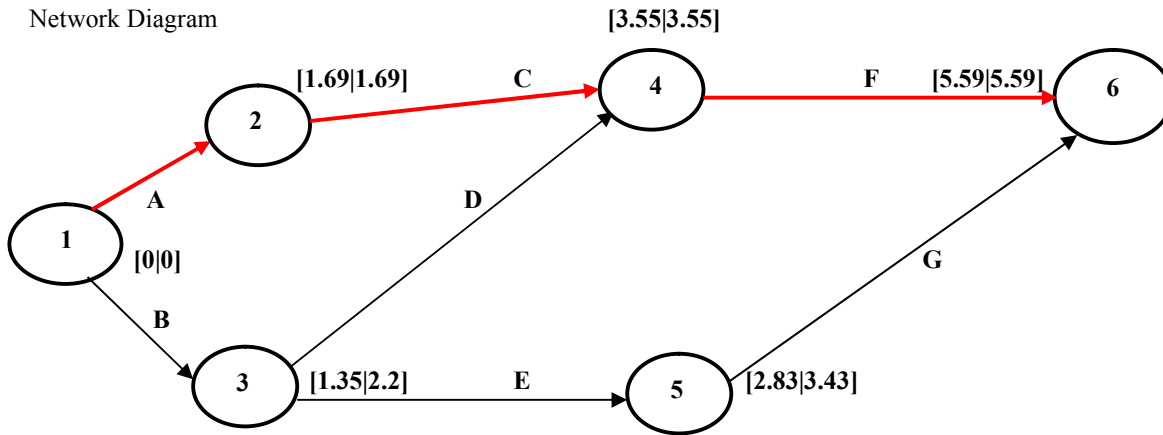
Step-2

Network Diagram



Step-3

Network Diagram



→ Line denote the Critical Path

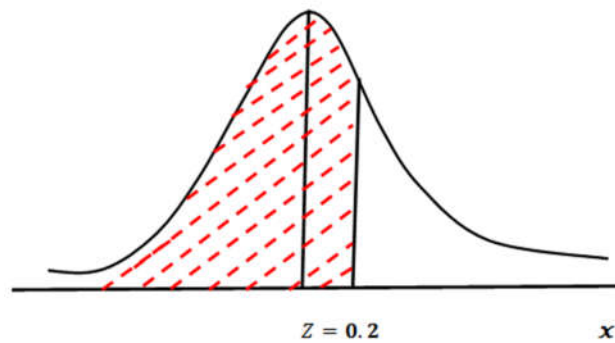
So, expected project duration-5.59 days

Critical path- 1→2→4→6

Project length variance $\sigma^2 = 0.0026$, Standard deviation-0.051

Probability that the project will be finished within 5.6 days is $P\left(z \leq \frac{5.6-5.59}{0.051}\right) = P(z \leq 0.2)$

Area under the normal curve $P(z \leq 0.2) = 0.5 + \phi(0.2) = 0.5793$



Normal Distribution Curve

5. Conclusion and future research scope

The idea of pentagonal neutrosophic number is intriguing, competent and has an ample scope of utilization in various research domains. In this research article, we vigorously erect the perception of pentagonal neutrosophic number from different aspects. We introduced a score function here in pentagonal neutrosophic domain. Additionally, we consider a networking problem in neutrosophic environment and solve the problem utilizing the

idea of score function. Since, there is no such articles is till now established in pentagonal networking neutrosophic arena, thus we cannot compare our work with other methods.

Further, researchers can immensely apply this idea of neutrosophic number in numerous flourishing research fields like engineering problem, mobile computing problems, diagnoses problem, realistic mathematical modeling, social media problem etc.

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