Connectedness in Soft Minimal Structure

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***Abstract*—In the present paper we introduces the concept of soft connectedness in soft m-structure and studied some of their properties and characterizations.**

***Index Terms*—Soft m-structure , Soft m-connectedness and Soft m-connectedness between soft sets.**

I. Introduction

The concept of soft set is fundamentally important in almost every scientific field. Soft set theory is a new mathematical tool for dealing with uncertainties and is a set associated with parameters and has been applied in several directions.Since in 1999 Molodtsov [19] originated the idea of soft sets.In 2002, Maji et. al [15], gave first practical application of soft sets in decision making problems. Many researchers have contributed toward the algebraic structures of soft set theory ([1], [23]). In 2011 Shabir and Naz [21] initiated the study of soft topological spaces. In the recent past many soft topological concepts such as soft mappings ([12], [25], [9], [10], [13]). Soft regular-open sets[6], soft semi-open sets[17],soft preopen sets [2], soft α-open sets [3],soft β-open sets [4],soft b-open sets [5],soft connectedness [11], [20],soft semi-connectedness [8], [17],soft preconnectedness [24] etc. play an important part in soft topological spaces.In the present paper we introduces the concept of soft connectedness in soft m-structure and studied some of their properties and characterizations.

II. Preliminaries

Since we shall require the following known definitions, notations and some properties, we recall them in this section. Let U is an initial universe set , E be a set of parameters , P(U) denote the power set of U and A $\subseteq$ E.

Definition 2.1: [19] A pair (F, A) is called a soft set over U, where F is a mapping given by F: A $\to$ P(U). In other words,a soft set over U is a parameterized family of subsets of the universe U. For all e $\in$ A , F (e) may be considered as the set of e-approximate elements of the soft set (F, A).

Definition 2.2: [16] For two soft sets (F, A) and (G, B) over a common universe U ,we say that (F, A) is a soft subset of (G, B), denoted by (F, A) $\subseteq$ (G, B), if

(a) A $\subseteq$ B and

(b) F (e) $\subseteq$ G (e) for all e $\in$ E.

Definition 2.3: [16] Two soft sets (F, A) and (G, B) over a common universe U are said to be soft equal denoted by (F, A) = (G, B) If (F, A) $\subseteq$ (G, B) and (G, B) $\subseteq$ (F, A).

Definition 2.4: [7] The complement of a soft set (F, A), denoted by $(F, A)^c$, is defined by $(F, A)^c$ = (F^c, A), where F^c : A $\to$ P(U) is a mapping given by F^c(e) = U $-$ F(e), for all e $\in$ E.

Definition 2.5: [16] Let a soft set (F, A) over U.

(a) Null soft set denoted by ϕ if for all e $\in$ A , F (e) = ϕ.

(b) Absolute soft set denoted by $\widetilde{U}$, if for each e $\in$ A , F (e) = U.

Clearly, $\widetilde{U}^c$ = ϕ and ϕ^c = $\widetilde{U}$.

Definition 2.6: [7] Union of two sets (F , A) and (G , B) over the common universe U is the soft (H , C), where C = A $\cup$ B, and for all e $\in$ C ,

$$H(e) = \begin{cases} F(e), & ife \in A - B \\ G(e), & ife \in B - A \\ H(e), & \text{if } e \in A \cap B \end{cases}$$

Definition 2.7: [7] Intersection of two soft sets (F, A) and (G, B) over a common universe U , is the soft set (H, C) where C = A $\cap$ B and H (e) = F (e) $\cap$ G (e) for each e $\in$ E.

Let X and Y be an initial universe sets and E and K be the non empty sets of parameters, S(X, E) denotes the family of all soft sets over X and S(Y, K) denotes the family of all soft sets over Y.

Definition 2.8: [12] Let S(X,E) and S(Y,K) be families of soft sets. Let u: X $\to$ Y and p: E $\to$ K be mappings. Then a mapping f_{pu}: S(X, E) $\to$ S(Y, K) is defined as:

(i)Let (F, A) be a soft set in S(X, E). The image of (F, A) under f_{pu}, written as f_{pu} (F, A) = (f_{pu}(F), p(A)), is a soft set in S(Y,K) such that

$$f_{pu}(F)(k) = \begin{cases} \bigcup_{e \in p^{-1}(k) \bigcap A} u(F(e)), & p^-1(k) \bigcap A \neq \phi \\ \phi, & p^{-1}(k) \bigcap A = \phi \end{cases}$$

For all k $\in$ K.

(ii) Let (G , B) be a soft set in S(Y , K). The inverse image of (G , B) under f_{pu}, written as

$$f_{pu}^{-1}(G)(e) = \begin{cases} u^{-1}G(p(e)), & p(e) \in B \\ \phi, & otherwise \end{cases}$$

For all e $\in$ E.

Definition 2.9: [18]Let f_{pu} : S(X, E) $\to$ S(Y, K) be a mapping and u : X $\to$ Y and p : E $\to$ K be mappings. Then f_{pu} is soft onto, if u : X $\to$ Y and p : E $\to$ K are onto and f_{pu} is soft one-one, if u : X $\to$ Y and p : E $\to$ K are one-one.

Definition 2.10: [21] A subfamily τ of S(X , E) is called a soft topology on X if:

1) $\widetilde{\phi}$, $\widetilde{X}$ belong to τ .
2) The union of any number of soft sets in τ belongs to τ.
3) The intersection of any two soft sets in τ belongs to τ.

The triplet (X ,τ, E) is called a soft topological space over X. The members of τ are called soft open sets in X and their complements called soft closed sets in X.

Definition 2.11: If (X ,τ, E) is soft topological space and a soft set (F , E) over X.

(a) The soft closure of (F , E) is denoted by Cl(F,E) , is defined as the intersection of all soft closed super sets of (F,E) [21].

(b) The soft interior of (F , E) is denoted by Int(F,E), is defined as the soft union of all soft open subsets of (F, E) [25].

Definition 2.12: [25] The soft set (F,E)$\in$ S(X,E) is called a soft point if there exist x $\in$ X and e $\in$ E such that F(e) = {x} and F(e') = ϕ for each e' $\in$ E – {e}, and the soft point (F,E) is denoted by x_e.

Definition 2.13: [14] Let (X,τ,E) be a soft topological space, and (A,E),(B,E) be two soft sets over X. The soft sets (A,E) and (B,E) are said to soft separated , if (A,E) $\cap$ Cl(B,E) = ϕ and Cl(A,E) $\cap$ (B,E) = ϕ.

Definition 2.14: [14] Let (X,τ,E) be a soft topological space, and If there exist two non-empty soft separated sets (A,E),(B,E) such that (A,E) $\cup$ (B,E) = $\tilde{X}$,then (A,E) and (B,E) are said to be soft disconnection for soft topological space (X,τ,E).(X,τ,E) is said to be soft disconnected if (X,τ,E) has a soft disconnection.Otherwise, (X,τ,E) is said to be soft connected.

Definition 2.15: [17] Let (X,τ ,E) be soft topological space .Two nonempty soft sub sets (F,A) and (F,B) of S(X,E) are called soft semiseparated iff scl(F,A) $\cap$ (F,B) = (F,A) $\cap$ scl(F,B) = ϕ.

Definition 2.16: [17] Let (X,τ ,E)be a soft topological space. If there does not exist a soft semiseparation of X , then it is said to be soft s-connected .

Definition 2.17: [24] Let (X,τ ,E) be soft topological space .Two nonempty soft sub sets (F,A) and (F,B) of S(X,E) are called soft preseparated iff Pcl(F,A) $\cap$ (F,B) = (F,A) $\cap$ Pcl(F,B) = ϕ .

Definition 2.18: [24] Let (X,τ ,E)be a soft topological space. If there does not exist a soft preseparation of X , then it is said to be soft P-connected .

Definition 2.19: A soft set (A, E) of a soft topological space(X,τ,E) is called :

(a) Soft regular open (A, E) = Int(Cl(A, E)) [6];
(b) Soft α-open if (A, E) $\subset$ Int(Cl(Int(A, E))) [3] ;
(c) Soft semiopen if (A, E) $\subset$ Cl(Int(A, E)) [17] ;
(d) Soft preopen if (A, E) $\subset$ Int(Cl(A, E)) [2] ;
(e) Soft b-open if (A, E) $\subset$ Int(Cl(A, E)) $\cup$ Cl(Int (A, E)) [5].
(f) Soft β-open if (A, E) $\subset$ Cl(Int(Cl(A, E))) [4]

The family of all soft regular open (resp. soft α-open, soft semi open , soft pre open , soft β-open , soft b-open) sets of X will be denoted by SRO(X,E) (resp. SαO(X,E), SSO(X,E) , SPO(X,E) , SβO(X, E) , SbO(X, E)).

Definition 2.20: Let (A,E) be a soft subset of a soft topological space (X,τ,E). Then:

(a) The intersection of all soft semi open sets containing (A, E) is called semi closure of (A,E). It is denoted by scl(A,E) [17].
(b) The intersection of all soft pre open sets containing (A, E) is called preclosure of (A,E). It is denoted by pcl(A,E)[2].
(c) The intersection of all soft α open sets containing (A,E) is called α-closure of (A,E). It is denoted by αcl((A,E))[3] .
(d) The intersection of all soft b-open sets containing (A,E) is called b-closure of (A,E). It is denoted by bcl(A,E)[5].
(e) The intersection of all soft β-open sets containing (A,E) is called β-closure of (A,E). It is denoted by βcl(A,E)[4].

Definition 2.21: A soft mapping f_{pu} : (X,τ,E)$\rightarrow$ (X,σ,K) is said be :

(a) Soft continuous if f_{pu}^{-1} (U, K) $\in$ τ for every soft set (U, K) $\in\sigma$ [25] .
(b) Soft α-continuous if f_{pu}^{-1} (U, K) $\in$ SαO (X, E) for every soft set (U, K) $\in$ σ [3].
(c) Soft semi continuous if f_{pu}^{-1} (U, K) $\in$ SSO (X, E) for every soft set (U, K) $\in$ σ [17] .
(d) Soft pre continuous if f_{pu}^{-1} (U, K) $\in$ SPO (X, E) for every soft set (U, K) $\in$ σ [2].
(e) Soft b-continuous if f_{pu}^{-1} (U, K) $\in$ SbO (X, E) for every soft set (U, K) $\in$ σ [5].
(f) Soft β-continuous if f_{pu}^{-1} (U, K) $\in$ SβO(X, E) for every soft set (U, K) $\in$ σ [4].

Definition 2.22: A soft mapping f_{pu} : (X,τ,E)$\rightarrow$ (X,σ,K) is said be :

(a) Soft open if f_{pu}(U, E) $\in$ σ for every soft set (U, E) $\in$ τ [26] .
(b) Soft α-open if f_{pu} (U, E) $\in$ SαO(Y, K) for every soft set (U, E) $\in$ τ [3].
(c) Soft semi open if f_{pu}(U, E) $\in$ SSO(Y, K) for every soft set (U, E) $\in$ τ [17].
(d) Soft pre open if f_{pu}(U, E) $\in$ SPO(Y, K) for every soft set (U, E) $\in$ τ [2].
(e) Soft b-open if f_{pu}(U, E) $\in$ SbO(Y, K) for every soft set (U, E) $\in$ τ [5].
(f) Soft β-open if f_{pu}(U, E) $\in$ Sβ O(Y, K) for every soft set (U, E) $\in$ τ [4].

Definition 2.23: [22] A soft subfamily $m_{(X,E)}$ of S(X,E) over X is called a soft minimal structure (briefly soft m-structure) on X if $\phi \in m_{(X,E)}$ and $\tilde{X} \in m_{(X,E)}$.

Each member of $m_{(X,E)}$ is called a soft m-open set and complement of a soft m-open set is called a soft m-closed set.

Remark 2.24: [22] Let (X,τ,E) be a soft topological space. Then the families τ , SO(X,E), SPO(X,E),SαO(X,E), SβO(X,E), SbO(X,E), SRO(X,E), are all soft m-structures on X.

Definition 2.25: [22] Let X be a nonempty set, E be set of parameters and $m_{(X,E)}$ be a soft m-structure over X .The soft $m_{(X,E)}$-closure and the soft $m_{(X,E)}$-interior of a soft set (A,E) over X are defined as follows :

(1) $m_{(X,E)}$-Cl(A,E) = $\cap$ {(F,E) : (A,E) $\subset$ (F,E) ,$(F,E)^c \in m_{(X,E)}$ }

(2)$m_{(X,E)}$-Int(A,E) = $\cup$ {(F,E) : (F,E) $\subset$ (A,E) ,(F,E) $\in m_{(X,E)}$ }.

Remark 2.26: [22] Let (X,τ,E) be a soft topological space and (A,E) be a soft set over X. If $m_{(X,E)} = \tau$ (respectively SO(X,E), SPO(X,E), SαO(X,E), SβO(X,E), SbO(X,E), SRO(X,E)), then we have:

(1) $m_{(X,E)}$-Cl(A,E) = Cl(A,E) (resp. SCl(A,E) ,PCl(A,E),αCl(A,E),β Cl(A,E), bCl(A,E),S_θCl(A,E)),

(2) $m_{(X,E)}$-Int(A,E)= Int(A,E) (resp. SInt(A,E) ,PInt(A,E),αInt(A,E),βInt(A,E), bInt(A,E),S_θInt(A,E)).

Theorem 2.27: [22] Let S(X,E) be a family of soft sets and $m_{(X,E)}$ a soft minimal structure on X.
For soft sets (A,E) and (B,E) of X, the following holds:

(a) (i): $m_{(X,E)}$-Int$(A,E)^c$ = $(m_{(X,E)} - Cl(A,E))^c$ and (ii) : $m_{(X,E)}$-Cl$(A,E)^c$ = $(m_{(X,E)} - Int(A,E))^c$

(b) If $(A,E)^c \in m_{(X,E)}$, then $m_{(X,E)}$-Cl(A,E) = (A,E) and if (A,E) $\in m_{(X,E)}$,then $m_{(X,E)}$-Int(A,E) = (A,E).

(c) $m_{(X,E)}$-Cl(ϕ) = ϕ ,$m_{(X,E)}$-Cl($\tilde{X}$) = $\tilde{X}$, $m_{(X,E)}$-Int(ϕ) = ϕ ,$m_{(X,E)}$-Int($\tilde{X}$) = $\tilde{X}$.

(d) If (A,E) $\subset$ (B,E), then $m_{(X,E)}$-Cl(A,E) $\subset$ $m_{(X,E)}$-Cl(B,E) ,$m_{(X,E)}$-Int(A,E) $\subset$ $m_{(X,E)}$-Int(B,E).

(e) (A,E) $\subset$ $m_{(X,E)}$-Cl(A,E) and $m_{(X,E)}$-Int(A,E) $\subset$ (A,E)

(f) $m_{(X,E)}$-Cl($m_{(X,E)}$-Cl(A,E)) = $m_{(X,E)}$-Cl(A,E) and $m_{(X,E)}$-Int($m_{(X,E)}$-Int(A,E)) = $m_{(X,E)}$-Int(A,E)

III. CONNECTEDNESS IN SOFT MINIMAL STRUCTURE

Definition 3.1: Let X be a nonempty set, E be set of parameters and $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$ .In (X,$m_{(X,E)}$) two nonempty soft sets (A,E) and (B,E) over X are called soft m-separated iff $m_{(X,E)}$-Cl(A,E) $\cap$ (B,E) = (A,E) $\cap$ $m_{(X,E)}$-Cl(B,E) = ϕ .

Remark 3.2: Let (X,τ,E) be a soft topological space over X. If, $m_{(X,E)} = \tau$ (respt. SSO(X,E),SPO(X,E),SbO(X,E)) and $m_{(X,E)}$-Cl(A,E) = Cl(A,E) (resp. SCl(A,E) ,PCl(A,E) , bCl(A,E)) we get the definition of soft separated(resp. soft semiseparated , soft preseparated , soft b-separated)sets.

Definition 3.3: Let $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$.Then (X,$m_{(X,E)}$) is said to be soft m-connected, if there does not exist two nonempty soft m-separated sets (A,E) and (B,E) over X,such that (A,E) $\cup$ (B,E) = $\tilde{X}$ .Otherwise it is soft m-disconnected .In this case, the pair (A,E) and (B,E) is called the soft m-disconnection over X.

Remark 3.4: Let (X,τ,E) be a soft topological space over X. If we replace soft m-separation by soft separated (resp. soft semiseparated , soft preseparated , soft b-separated)sets we get the definition soft connectedness (resp. soft semi connectedness,soft pre connectedness ,soft b-connectedness).

Theorem 3.5: Let (X,$m_{(X,E)}$) be a soft m-structure over X with property $\mathbf{B}$. Then the following conditions are equivalent :

(1) (X,$m_{(X,E)}$) has a soft m-disconnection.

(2) There exist two disjoint soft m-closed sets (A,E) ,(B,E) $\in m_{(X,E)}$ such that (A,E) $\cup$ (B,E) = $\tilde{X}$.

(3) There exist two disjoint soft m-open sets (A,E) ,(B,E) $\in m_{(X,E)}$ such that (A,E) $\cup$ (B,E) = $\tilde{X}$.

(4) (X,$m_{(X,E)}$) has a proper soft m-open and soft m-closed set over X.

Proof: (1) $\rightarrow$ (2) : Let (X,$m_{(X,E)}$) have a soft m-disconnection (A,E) and (B,E) ,Then (A,E) $\cap$ (B,E) = ϕ and

$m_{(X,E)}$-Cl(A,E) = $m_{(X,E)}$-Cl(A,E) $\cap$ ((A,E) $\cup$ (B,E)) = ($m_{(X,E)}$-Cl(A,E) $\cap$ (A,E)) $\cup$ ($m_{(X,E)}$-Cl(A,E) $\cap$ (B,E)) = (A,E).

Therefore,(A,E) is soft m-closed set over X .Similar ,we can see that (B,E) is also a soft m-closed set over X.

(2) $\rightarrow$ (3) : Let (X,$m_{(X,E)}$) has a soft m-disconnection (A,E) and (B,E) such that (A,E) and (B,E) are soft m-closed.Then $(A,E)^c$ and $(B,E)^c$ are soft m-open sets in $m_{(X,E)}$. Then it is easy to see $(A,E)^c \cap (B,E)^c = \phi$ and $(A,E)^c \cup (B,E)^c = \tilde{X}$.

(3) $\rightarrow$ (4) : Let (X,$m_{(X,E)}$) have a soft m-disconnection (A,E) and (B,E) such that (A,E) and (B,E) are soft m-open over X.Then (A,E) and(B,E) are also soft closed in (X,$m_{(X,E)}$).

(4) $\rightarrow$ (1) : Let (X,$m_{(X,E)}$) has a proper soft m-open and soft m-closed set (F,E) over X. Put (H,E) = $(F,E)^c$.Then (H,E) and (F,E) are non-empty soft m-closed set in (X,$m_{(X,E)}$). (H,E) $\cap$ (F,E) = ϕ and (H,E) $\cup$ (F,E) = $\tilde{X}$.Therefore, (H,E) and (F,E) is a soft m-disconnection of (X,$m_{(X,E)}$).

Remark 3.6: Let (X,τ,E) be a soft topological space over X ,if $m_{(X,E)} = \tau$ (respt. SSO(X,E),SPO(X,E),SbO(X,E))Then the following conditions are equivalent :

(1) (X,τ,E) has a soft disconnection(respt. soft semi disconnection , soft pre disconnection ,soft b-disconnection).

(2) There exist two disjoint soft closed(respt. soft semi-closed,soft pre-closed,soft b-closed) sets (A,E) ,(B,E) such that (A,E) $\cup$ (B,E) = $\tilde{X}$.

(3) There exist two disjoint soft open(respt. soft semi-open,soft pre-open,soft b-open) sets (A,E) ,(B,E) such that (A,E) $\cup$ (B,E) = $\tilde{X}$.

(4) (X,τ,E) has a proper soft open(respt. soft semi-open,soft pre-open,soft b-open) and soft closed (respt. soft semi-closed,soft pre-closed,soft b-closed)set over X.

Theorem 3.7: Let (X,$m_{(X,E)}$) be a soft m-structure over X with property $\mathbf{B}$. Then the following conditions are equivalent : (1) (X,$m_{(X,E)}$) is a soft m-connected.

(2) There exist two disjoint soft m-closed sets (A,E) ,(B,E) $\in m_{(X,E)}$ such that (A,E) $\cup$ (B,E) = $\tilde{X}$.

(3) There exist two disjoint soft m-open sets (A,E) ,(B,E) $\in m_{(X,E)}$ such that (A,E) $\cup$ (B,E) = $\tilde{X}$.

(4) (X,$m_{(X,E)}$) at most has two soft m-closed and soft m-open sets over X, that is ϕ and $\tilde{X}$.

Remark 3.8: Let (X,τ,E) be a soft topological space over X ,if $m_{(X,E)}$ = τ (respt. SSO(X,E),SPO(X,E),SbO(X,E)),Then the following conditions are equivalent :

(1) (X,τ,E) is a soft connected(respt. soft semi connected, soft pre connected ,soft b-connected).

(2) There exist two disjoint soft closed(respt. soft semi-closed,soft pre-closed,soft b-closed) sets (A,E) ,(B,E) such that (A,E) $\cup$ (B,E) = $\tilde{X}$.

(3) There exist two disjoint soft open(respt. soft semi-open,soft pre-open,soft b-open) sets (A,E) ,(B,E) such that (A,E) $\cup$ (B,E) = $\tilde{X}$.

(4) (X,τ,E) has a proper soft open(respt. soft semi-open,soft pre-open,soft b-open) and soft closed (respt. soft semi-closed,soft pre-closed,soft b-closed)set over X.

Definition 3.9: Let (X,$m_{(X,E)}$) be a soft m-structure over X with property **B**, Y $\subset$ X in (X,$m_{(X,E)}$) .The soft space (Y,$m_{(Y,E)}$) is called a soft m-subspace of (X,$m_{(X,E)}$) if, $m_{(Y,E)}$ = {(A,E) $\cap$ $\tilde{Y}$: (A,E) $\in$ $m_{(X,E)}$}.

Lemma 3.10: Let (X,$m_{(X,E)}$) be a soft m-structure over X with property **B**, (Y,$m_{(Y,E)}$) be soft m-subspace of (X,$m_{(X,E)}$).If (A,E) and (B,E) are soft sets in (Y,$m_{(Y,E)}$),then (A,E) and (B,E) are a soft m-separation of (Y,$m_{(Y,E)}$) if and only if (A,E) and (B,E) are a soft m-separation of (X,$m_{(X,E)}$.

Proof: We have , $m_{(Y,E)}$-Cl(A,E) $\cap$ (B,E) = ($m_{(X,E)}$-Cl(A,E) $\cap$ $\tilde{Y}$) $\cap$ (B,E) = $m_{(X,E)}$-Cl(A,E) $\cap$ (B,E).

Similar, we have

$m_{(Y,E)}$-Cl(B,E) $\cap$ (A,E) = $m_{(X,E)}$-Cl(B,E) $\cap$ (A,E).

Therefore, the lemma holds.

Lemma 3.11: Let (X,$m_{(X,E)}$) be a soft m-structure over X with property **B**, $\tilde{Y}$ $\subset$ $\tilde{X}$.(Y,$m_{(Y,E)}$) be soft m-subspace of (X,$m_{(X,E)}$).(Y,$m_{(Y,E)}$) is soft m-connected. If (A,E) and (B,E) are a soft m-separation of (X,$m_{(X,E)}$),such that $\tilde{Y}$ $\subset$ (A,E) $\cup$ (B,E) ,then $\tilde{Y}$ $\subset$ (A,E) or $\tilde{Y}$ $\subset$ (B,E).

Proof: We have , $\tilde{Y}$ $\subset$ (A,E) $\cup$ (B,E),we have $\tilde{Y}$ =($\tilde{Y}$ $\cap$ (A,E))$\cup$ ($\tilde{Y}$ $\cap$ (B,E)). By lemma 3.10 ,$\tilde{Y}$ $\cap$ (A,E) and $\tilde{Y}$ $\cap$ (B,E) are a soft m-separation of (Y,$m_{(Y,E)}$).Since,(Y,$m_{(Y,E)}$) is soft m-connected , we have $\tilde{Y}$ $\cap$ (A,E) = ϕ or $\tilde{Y}$ $\cap$ (B,E) = ϕ .Therefore, $\tilde{Y}$ $\subset$ (A,E) or $\tilde{Y}$ $\subset$ (B,E).

Lemma 3.12: Let $\{(X_\alpha, m_{(X_\alpha,E)})$: α $\in$ J } be a soft family non-empty soft m-connected subspaces of soft topological space (X,$m_{(X,E)}$).If $\bigcap_{\alpha\in J}$ $\neq \phi$,then $(\cup_{\alpha\in J} X_\alpha, m_{(\cup_{\alpha\in J} X_\alpha,E)})$ is a soft m-connected subspace of (X,$m_{(X,E)}$).

Proof : Let Y = $(\bigcup_{\alpha\in J} X_\alpha)$. Choose a soft point x_e $\in$ $\tilde{Y}$.Let (C,E) and (D,E) be a soft m-disconnection of $(\cup_{\alpha\in J} X_\alpha, m_{(\cup_{\alpha\in J} X_\alpha,E)})$ .Then, x_e $\in$ (C,E) and x_e $\in$ (D,E) ,we assume that x_e $\in$ (C,E).For each α $\in$ J,Since,$\{(X_\alpha, m_{(X_\alpha,E)})$ is soft m-connected,it follows from lemma 3.11 that $\tilde{(X_\alpha)}$ $\subset$ (C,E) or $\tilde{(X_\alpha)}$ $\subset$ (D,E).Therefore,we have $\tilde{Y}$ $\subset$ (C,E) since x_e $\in$ (C,E) and then (D,E) = ϕ,which is a contradiction. Thus $(\cup_{\alpha\in J} X_\alpha, m_{(\cup_{\alpha\in J} X_\alpha,E)})$ is a soft m-connected subspace of (X,$m_{(X,E)}$).

Theorem 3.13: Let $\{(X_\alpha, m_{(X_\alpha,E)})$: α $\in$ J } be a soft family non-empty soft m-connected subspaces of soft topological space (X,$m_{(X,E)}$).If $X_\alpha \cap X_\beta \neq \phi$ for $\alpha, \beta \in J$,then $(\cup_{\alpha\in J} X_\alpha, m_{(\cup_{\alpha\in J} X_\alpha,E)})$ is a soft m-connected subspace of (X,$m_{(X,E)}$).

Proof : Let α_o $\in$ J. For β $\in$ J,Put $A_\beta = X_{\alpha_o} \cup X_\beta$ By lemma 3.12 , $\{(A_\beta, m_{(X_\beta,E)}$ is soft m-connected.Then, $\{\{(A_\beta, m_{(X_\beta,E)} : \beta \in J\}$ is a family soft m-connected subspace of (X,$m_{(X,E)}$),and $\bigcap_{\beta\in J} A_\beta = X_{\alpha_o} \neq \phi$ .Obvious,$(\bigcup_{\alpha\in J} X_\alpha$ = $(\bigcup_{\beta\in J} A_\beta$.It follows from lemma 3.12 that $(\cup_{\alpha\in J} X_\alpha, m_{(\cup_{\alpha\in J} X_\alpha,E)})$ is a soft m-connected subspace of (X,$m_{(X,E)}$).

Theorem 3.14: Let (X,$m_{(X,E)}$) be a soft m-structure over X with property **B**, $\tilde{Y}$ $\subset$ $\tilde{X}$.(Y,$m_{(Y,E)}$) be soft m-subspace of (X,$m_{(X,E)}$). If $\tilde{Y}$ $\subset$ $\tilde{A}$ $\subset$ $m_{(X,E)}$-Cl(F,E), then (A,$m_{(A,E)}$) is a soft connected m-subspace of (X,$m_{(X,E)}$) .In particular, $m_{(X,E)}$-Cl(F,E) is a soft connected m-subspace of (X,$m_{(X,E)}$).

Proof: Let (C,E) and (D,E) be a soft m-disconnection of (A,$m_{(A,E)}$) . By lemma 3.11 , we have $\tilde{A}$ $\subset$ (C,E) or $\tilde{A}$ $\subset$ (D,E). We assume that , $\tilde{A}$ $\subset$ (C,E) By lemma 3.10, we have, $m_{(X,E)}$-Cl(C,E) $\cap$ (D,E) = ϕ ,and hence, $\tilde{A}$ $\cap$ (D,E) = ϕ ,which is a contradiction.

Theorem 3.15: Let f_{pu} : (X,$m_{(X,E)}$) $\rightarrow$ (Y,$m_{(Y,K)}$) be soft continuous mapping ,where $m_{(X,E)}$ and $m_{(Y,K)}$ are soft minimal structure over X and Y respectively, If (X,$m_{(X,E)}$) is soft m-connected ,then the soft image of (X,$m_{(X,E)}$) is also soft m-connected.

Proof: Let f_{pu} : (X,$m_{(X,E)}$) $\rightarrow$ (Y,$m_{(Y,K)}$) be soft continuous mapping. Contrarily, Suppose that (Y,$m_{(Y,K)}$) is soft m-disconnected and pair (A,K) and (B,K) is a soft m-disconnection of (Y,$m_{(Y,K)}$). Since f_{pu} : (X,$m_{(X,E)}$) $\rightarrow$ (Y,$m_{(Y,K)}$) is soft continuous, therefore f_{pu}^{-1}(A,K) $\in$ $m_{(X,E)}$, f_{pu}^{-1}(B,K) $\in$ $m_{(X,E)}$. Clearly the pair f_{pu}^{-1}(A,K) and f_{pu}^{-1}(B,K) is a soft m-disconnection of (X,$m_{(X,E)}$), a contradiction. Hence, (Y,$m_{(Y,K)}$) is soft m-connected. This is completes the proof.

Remark 3.16: Let (X,τ,E) and (Y,ϑ,K) be two soft topological space over X and Y respectively, if $m_{(X,E)}$ = τ ,$m_{(Y,K)}$ = ϑ. f_{pu} : (X ,τ,E) $\rightarrow$ (Y,ϑ,K) is soft continuous mapping. If (X ,τ,E) is soft connected(respt. soft semi connected, soft pre connected ,soft b-connected) ,then the soft image of (X ,τ,E) is also soft connected (respt. soft semi connected , soft pre connected , soft b-connected).

Definition 3.17: Let $m_{(X,E)}$ be a soft m-structure over X, A soft set (F,E) in (X,$m_{(X,E)}$) is soft m-connected, if it is soft m-connected as a soft m-subspace.

Remark 3.18: Let (X,τ,E) be a soft topological space over X . A soft set (F,E) in (X,τ,E) is soft connected (respt. soft semi-connected,soft pre-connected and soft b-connected), if it is soft connected(respt. soft semi-connected,soft pre-connected and soft b-connected) as a soft subspace.

Theorem 3.19: Let $m_{(X,E)}$ be a soft m-structure over X , the pair (F_1,E) and (F_2,E) of soft sets be a soft m-disconnection in (X,$m_{(X,E)}$) and (F_3,E) be a soft m-connected of (X, $m_{(X,E)}$) .Then (F_3,E) is contained in (F_1,E) or (F_2,E).

Proof: Contrarily suppose that (F_3,E) is neither contained in (F_1,E) nor in (F_2,E).Then (F_3,E) $\cap$ (F_1,E) ,(F_3,E) $\cap$ (F_2,E) are both nonempty soft subsets of (F_3,E) ,such that ((F_3,E) $\cap$ (F_1,E)) $\cap$ ((F_3,E) $\cap$ (F_2,E)) = ϕ and ((F_3,E) $\cap$ (F_1,E)) $\cup$

((F_3,E) ∩ (F_2,E)) = (F_3,E).This gives that pair of ((F_3,E) ∩ (F_1,E)) and ((F_3,E) ∩ (F_2,E)) is a soft m-disconnection of (F_3,E) .This contradiction proves the theorem.

Theorem 3.20: Let $m_{(X,E)}$ be a soft m-structure over X ,(G,E) be a soft m-connected set in (X,$m_{(X,E)}$) and (F,E) be soft set over X such that (G,E) ⊂ (F,E) ⊂ $m_{(X,E)}$-Cl(G,E).Then (F,E) is soft m-connected.

Proof: It is sufficient to that $m_{(X,E)}$-Cl(G,E) is soft m-connected .On contrary ,suppose that $m_{(X,E)}$-Cl(G,E) is soft m-disconnected .Then there exists a soft m-disconnection ((H,E),(K,E)) of $m_{(X,E)}$-Cl(G,E) .That is ,there are ((H,E)∩ (G,E)),((K,E)∩ (G,E)) soft sets in (G,E) such that ((H,E)∩ (G,E))∩ ((K,E)∩ (G,E)) = ((H,E)∩ (K,E))∩ (G,E) = ϕ ,and ((H,E)∩ (G,E))∪ ((K,E)∩(G,E)) = ((H,E)∪ (K,E))∩ (G,E) = (G,E). This gives that pair ((H,E)∩ (G,E)) and ((K,E)∩ (G,E)) is a soft m-disconnection of (G,E) ,a contradiction .This proves that $m_{(X,E)}$-Cl(G,E) is soft m-connected. Hence the proof.

Lemma 3.21: Let $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$ and(A,E) and (B,E) be two soft sets over X .In (X,$m_{(X,E)}$) the following statements are equivalent:

(1) ϕ, $\tilde{X} \in m_{(X,E)}$.

(2) (X,$m_{(X,E)}$) is not the soft union of two disjoint soft sets (A,E) and (B,E) $\in m_{(X,E)}$.

(3)(X,$m_{(X,E)}$) is not the soft union of two disjoint soft sets $(A,E)^c$ and $(B,E)^c \in m_{(X,E)}$.

(4)(X,$m_{(X,E)}$) is not the soft union of two nonempty soft m-separated sets.

Remark 3.22: Let (X, τ ,E) be soft topological space over X, we put $m_{(X,E)}$ = τ (respt. SSO(X,E),SPO(X,E),SbO(X,E)) and(A,E) and (B,E) be two soft sets over X .In (X, τ ,E) the following statements are equivalent:

(1) ϕ and $\tilde{X}$ are the only soft clopen(respt. soft semi clopen,soft pre clopen,soft b-clopen) sets in (X, τ ,E).

(2) (X, τ ,E) is not the soft union of two soft disjoint soft open(respt. soft semi open ,soft pre open ,soft b-open) sets .

(3) (X, τ ,E) is not the soft union of two soft disjoint soft closed (respt. soft semi closed ,soft pre closed,soft b-closed)sets.

(4) (X, τ ,E) is not the soft union of two nonempty soft separated(soft semi separated,soft pre separated,soft b-separated) sets.

Theorem 3.23: Let $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$ .In (X,$m_{(X,E)}$) the following statements are equivalent:

(1) (X, $m_{(X,E)}$) is soft m-connected space.

(2)(X, $m_{(X,E)}$) is not the soft union of any two soft m-separated sets.

Proof : (1) → (2) : Assume (1), Suppose (2) is false,then let (A,E) and (B,E) are two soft m-separated sets such that $\tilde{X}$ = (A,E) ∪ (B,E). Since (X, $m_{(X,E)}$) is soft m-connected $m_{(X,E)}$-Cl(A,E) ∩ (B,E)=(A,E) ∩ $m_{(X,E)}$-Cl(B,E) = ϕ .Since (A,E) ⊂ $m_{(X,E)}$-Cl(A,E) and (B,E) ⊂ $m_{(X,E)}$-Cl(B,E),then (A,E) ∪ (B,E) = ϕ. Now $m_{(X,E)}$-Cl(A,E) ⊂ $(B,E)^c$ =(A,E). Hence, $m_{(X,E)}$-Cl(A,E) = (A,E). Therefore, $(A,E)^c \in m_{(X,E)}$.By the same way we show that $(B,E)^c \in m_{(X,E)}$ which is a contradiction with remark

Lemma 3.24: 4.3.This shows that (2) is true .Therefore (1) → (2).

(2) → (1) : Assume that (2) is not true .Let $(A,E)^c$ and $(B,E)^c$ are two soft m-disjoint nonempty and $(A,E)^c$ and $(B,E)^c \in m_{(X,E)}$ such that $\tilde{X}$ = $(A,E)^c \cup (B,E)^c$.Then, $m_{(X,E)}$-Cl$(A,E)^c$ ∩ (B,E)=(A,E) ∩ $m_{(X,E)}$-Cl$(B,E)^c$ = $(A,E)^c \cap (B,E)^c = \phi$ .This contradicts the hypothesis of (2) .This show that (1) is true.Therefore, (2) → (1).

Remark 3.25: Let (X, τ ,E) be soft topological space over X,we put $m_{(X,E)}$ = τ .Then, the following statements are equivalent :

(1) (X, τ ,E) is soft connected(soft semi connected,soft pre connected, soft b-connected) space.

(2) (X, τ ,E) is not the soft union of any two soft separated(soft semi separated,soft pre separated, soft b-separated) sets.

Remark 3.26: (1)Let $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$ and (A,E) be soft set over X ,If $\phi \neq$ (A,E) ⊂ (X,$m_{(X,E)}$) then (A,E) is a soft m-connected set in $m_{(X,E)}$ whenever (X,$m_{(X,E)}$) is a soft m-connected space.

(2) Let (X, τ ,E) be soft topological space over X ,we put $m_{(X,E)}$ = τ ,If $\phi \neq$ (A,E) ⊂ (X, τ ,E) then (A,E) is a soft connected (soft semi connected,soft pre connected, soft b-connected) set over X whenever (X, τ ,E) is a soft connected(soft semi connected,soft pre connected, soft b-connected) space.

Theorem 3.27: Let $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$. In (X,$m_{(X,E)}$), let soft set (A,E) be a soft m-connected set.Let (B,E) and (C,E) are soft m-separated sets.If (A,E) ⊂ (B,E) ∪ (C,E) .Then either (A,E) ⊂ (B,E) or (A,E) ⊂ (C,E).

Proof: Suppose (A,E) is soft m-connected set and (B,E) ,(C,E) are soft m-separated sets such that (A,E) ⊂ (B,E) ∪ (C,E).Let (A,E) notsubset (B,E) and (A,E) notsubset (C,E). Suppose (A_1,E) = (B,E) ∩ (A,E) $\neq \phi$ and (A_2,E) = (C,E) ∩ (A,E) $\neq \phi$ .Then, (A,E) = (A_1,E) ∪ (A_2,E) . Since, (A_1,E) ⊂ (B,E).Hence, $m_{(X,E)}$-Cl(A_1,E) ⊂ $m_{(X,E)}$-Cl(B,E).Since,$m_{(X,E)}$-Cl(B,E)∩ (C,E) = ϕ then $m_{(X,E)}$-Cl (A_1,E) ∩ (A_2,E) = ϕ. Since (A_2,E) ⊂ (C,E).Hence, $m_{(X,E)}$-Cl(A_2,E) ⊂ $m_{(X,E)}$-Cl(C,E).Since,$m_{(X,E)}$-Cl(C,E)∩ (B,E) = ϕ .Then $m_{(X,E)}$-Cl (A_2,E) ∩ (A_1,E) = ϕ.But (A,E) = (A_1,E)∪ (A_2,E),therefore, (A,E) is not soft m-connected space.This is a contradiction .Then either (A,E) ⊂ (B,E) or (A,E) ⊂ (C,E).

Remark 3.28: Let (X, τ ,E) be soft topological space over X,we put $m_{(X,E)}$ = τ and let (A,E) be a soft connected (respt. soft semi connected,soft pre connected, soft b-connected)set.Let (B,E) and (C,E) are soft separated(respt. soft semi separated,soft pre separated, soft b-separated) sets.If (A,E) ⊂ (B,E) ∪ (C,E) .Then either (A,E) ⊂ (B,E) or (A,E) ⊂ (C,E).

Theorem 3.29: Let $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$. In (X,$m_{(X,E)}$), let soft set (A,E) be a soft m-connected set then $m_{(X,E)}$-Cl(A,E) is soft m-connected.

Proof: Suppose soft set (A,E) be a soft m-connected set and $m_{(X,E)}$-Cl(A,E) is not .Then there exist two soft m-separated sets (B,E) and (C,E) such that $m_{(X,E)}$-Cl(A,E) = (B,E) ∪ (C,E)

.But (A,E) $\subset m_{(X,E)}$-Cl(A,E),then (A,E) = (B,E) $\cup$ (C,E) and since (A,E) is soft m-connected set then by theorem 3.27 either (A,E) $\subset$ (B,E) or (A,E) $\subset$ (C,E).

(i) If (A,E) $\subset$ (B,E) then $m_{(X,E)}$-Cl(A,E) $\subset$ $m_{(X,E)}$-Cl(B,E). But $m_{(X,E)}$-Cl(B,E) $\cap$ (C,E) = ϕ.Hence, $m_{(X,E)}$-Cl(A,E)$\cap$ (C,E) = ϕ.Since, (C,E) $\subset$ $m_{(X,E)}$-Cl(A,E), then (C,E) = ϕ this is a contradiction.

(ii) If (A,E) $\subset$ (C,E) then the same way we can prove that (B,E) = ϕ which is a contradiction .Therefore, $m_{(X,E)}$-Cl(A,E) is soft m-connected.

Remark 3.30: Let (X, τ ,E) be soft topological space over X,we put $m_{(X,E)} = \tau$ let soft set (A,E) be a soft connected (respt. soft semi connected,soft pre connected, soft b-connected)set then $m_{(X,E)}$-Cl(A,E) is soft connected(respt. soft semi connected,soft pre connected, soft b-connected).

Theorem 3.31: Let $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$. In (X,$m_{(X,E)}$), let soft set (A,E) be a soft m-connected set and (A,E) $\subset$ (B,E) $\subset$ $m_{(X,E)}$-Cl(A,E) then (B,E) is soft m-connected.

Proof: If (B,E) is not soft m-connected,then there exist two soft set (C,E) and (D,E) such that $m_{(X,E)}$-Cl(C,E) $\cap$ (D,E) = (C,E) $\cap$ $m_{(X,E)}$-Cl(D,E)= ϕ and (B,E) = (C,E) $\cup$ (D,E) .Since, (A,E) $\subset$ (B,E) ,thus either (A,E) $\subset$ (C,E) or (A,E) $\subset$ (D,E).Suppose (A,E) $\subset$ (C,E) then $m_{(X,E)}$-Cl(A,E) $\subset$ $m_{(X,E)}$-Cl(C,E),thus $m_{(X,E)}$-Cl(A,E) $\subset$ (D,E) = $m_{(X,E)}$-Cl(C,E) $\subset$ (D,E) = ϕ.But (D,E) $\subset$ (B,E) $\subset$ $m_{(X,E)}$-Cl(A,E),thus $m_{(X,E)}$-Cl(A,E) $\cap$ (D,E) =(D,E) .Therefore, (D,E) =ϕ which is a contradiction.Thus, (B,E) is soft m-connected set.

If (A,E) $\subset$ (B,E) ,then by the same way we can prove that (C,E) = ϕ .This is a contradiction .Thus (B,E) is soft m-connected.

Remark 3.32: Let (X, τ ,E) be soft topological space over X,we put $m_{(X,E)} = \tau$ let soft set (A,E) be a soft connected (respt. soft semi connected,soft pre connected, soft b-connected)set and (A,E) $\subset$ (B,E) $\subset$ $m_{(X,E)}$-Cl(A,E) then (B,E) is soft connected(respt. soft semi connected,soft pre connected, soft b-connected).

Theorem 3.33: Let $m_{(X,E)}$ be a soft m-structure over X with property $\mathbf{B}$, (X,$m_{(X,E)}$) is soft m-connected if and only if the only soft sets in (X,$m_{(X,E)}$) that are both soft open and soft closed over X are ϕ and $\tilde{X}$.

Proof : Let (X,$m_{(X,E)}$) is soft m-connected. Suppose to the contrary that (F,E) $\in m_{(X,E)}$ and $(F,E)^c \in m_{(X,E)}$ over X different from ϕ and $\tilde{X}$.Clearly, $(F,E)^c \in m_{(X,E)}$ different from ϕ and $\tilde{X}$. Now we have (F,E) , $(F,E)^c$ is a soft m-separation over X.This is contradiction.Thus the only soft closed and open sets over X are ϕ and $\tilde{X}$. Conversely, let (F,E) ,(G,E) be a soft separation over X.

Remark 3.34: Let (X,τ,E) be a soft topological space over X and (F,E) be soft set over X .(X,τ,E) is soft connected(soft semi connected, pre connected , b-connected) if and only if there does not exist nonempty soft set (E,E) over X which is both soft open (respt. soft semi open,soft pre open , soft b-open) and soft closed(respt. soft semi closed, soft pre closed, soft b-closed) set over X.

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