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Coc-b-connected spaces

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Abstract :

We introduce and study the recall the notion of coc-b-connected space. And we prove many of the proposition and remarks which are related to it. And we discuss the definition of coc-b-locally connected, remarks and proposition about this concept . This study presents the definition of hyper connected by coc-b-open set. Also we give some proposition and remarks about this subject and give some important generalizations on this concept and we prove some results on the concept.

Mathematics subject classification : 54XX

Introduction

In [5] M.C .Gemignani studied the concept of connected spaces and in [2] R. Engleking studied the characterizations of continuity provided that the continuous image of connected space is connected . Several properties of connected space in [11,10]. We recall that any two subsets A and B of a space X are called τ –separated iff $\overline{A} \cap B = A \cap \overline{B} = \emptyset$ see [8].

Definition(1):

Let X be topological space .Then A is called cocompact b-open set (notation : coc-b-open set) if for every $x \in A$, there exists an b-open set $U \subseteq X$ and a compact set K such that $x \in U - K \subseteq A$. The complement of coc-b-open set is called coc-b-closed set .

Remark(2):

Everyopen set is coc-b-open set.

But the converse is not true the following example shows: Let $X = \{a, b, c\}$

$\tau = \{X, \emptyset, \{a\}, \{b\}, \{a, b\}\}$. The coc-b-open sets are $\{X, \emptyset, \{a\}, \{b\}, \{c\}, \{a, b\}, \{a, c\}, \{b, c\}\}$.

Then $\{a, c\}$ is an coc-b-open but it is not open.

Definition(3):

Let $f: X \to Y$ be a function of a space X into a space Y then f is called an coc-b-continuous function if $f^{-1}(A)$ is an coc-b-open set in X for every open set A in Y .

Definition(4):

Let $f: X \to Y$ be a function of a space X into a space Y, then f is called an coc-b-irresolute (coc'-b-continuous for brief) function if $f^{-1}(A)$ is an coc-b-open set in X for every coc-b-open set A in Y.

Definition(5):

Let (X, τ) be topology space .Two subsets A and B of a space X are called coc-b-separated if $\overline{A}^{b-coc} \cap B = A \cap \overline{B}^{b-coc} = \emptyset$.

Definition(6): [9]

A subset A is said to be ω-open set if for each $x \in A$,there exists an open set U_x such that $x \in U_x$ and $U_x - A$ is countable.

Definition(7):

Let X be a space and $A \subseteq X$. The union of all coc-b-open sets of X contained in A is called coc-b-Interior of A and denoted by $A^{\circ b-coc}$or coc-b-$In_\tau(A)$.
Coc-b-$In_\tau(A)$
$= \cup\{B: B \text{ is } coc-b-open \text{ in } X \text{ and } B \subseteq A\}$.

Definition(8):

Let (X,τ) be topology space and $\emptyset \neq A \subseteq X$. Then A is called coc-b-connected set if is not union of any two coc-b-separated sets .

Definition(9):

A set is called coc-b-clopen if it is coc-b-open and coc-b-closed.

Proposition(10):

Let (X,τ) be topological space ,then the following statements are equivalent :

1-X is coc-b-connected space .

2-The only coc-b-clopen sets in the space are X and $\emptyset$.

3-There exist no two disjoint coc-b-open sets A and B such that $X = A \cup B$.

Proof:

(1)→(2) Let X be coc-b-connected space ,suppose that D is coc-b-clopen set such that $D \neq \emptyset$ and $D \neq X$ .Let $E = X - D$ .Since $D \neq X$ then $E \neq \emptyset$. Since D is coc-b-open , then E is coc-b-closed .But $\overline{D}^{b-coc} \cap E = D \cap E = \emptyset$. (since D is coc-b-clopen set and E is coc-b-closed set) hence $D \cap E = D \cap \overline{E}^{b-coc} = \emptyset$. Then D and E are two coc-b-separated sets and $X = D \cup E$. Hence X is not coc-b-connected space which is a contradiction . Therefore the only coc-b-clopen set in the space are X and $\emptyset$.

(2)→(3) Suppose the only coc-b-clopen set in the space are X and $\emptyset$. Assume that there exists two disjoint coc-b-open W and B such that $X = W \cup B$ .Since $W = B^c$ then W is coc-b-clopen set .But $W \neq \emptyset$ and $W \neq X$ which is a contradiction .Hence there exists no two disjoint coc-b-open set W and B such that $X = W \cup B$.

(3)→(1) Suppose that X is not coc-b-connected space . Then there exist two coc-b-separated sets A and B such that $X = A \cup B$. Since $\overline{A}^{b-coc} \cap B = \emptyset$ and $A \cap B \subseteq \overline{A}^{b-coc} \cap B$ thus $A \cap B = \emptyset$. Since $\overline{A}^{b-coc} \subseteq B^c = A$ then A is coc-b-closed set and since $\overline{B}^{b-coc} \cap A = \emptyset$ and $A \cap B \subseteq \overline{B}^{b-coc} \cap A$ thus $A \cap B = \emptyset$, since $\overline{B}^{b-coc} \subseteq A^c = B$ then B is coc-b-closed set, since $A = B^c$ then A and B are two disjoint coc-b-open sets such that $X = A \cup B$ which is a contradiction .Hence X is coc-b-connected space .

Remark(11):

Every coc-b-connected space is connected space .But the converse is not true in general.

Example(12):

Let $X = \{1,2,3\}$ and $\tau = \{\emptyset, X, \{1\}, \{2\}, \{1,2\}\}$ then X is connected space but X is not coc-b-connected space since $\{2\}, \{1,3\}$ are coc-b-open set and $X = \{2\} \cup \{1,3\}$.

Proposition(13):

Let A be coc-b-connected set and D, E coc-b-separated sets .If $A \subseteq D \cup E$ then either $A \subseteq D$ or $A \subseteq E$.

Proof:

Suppose A be a coc-b-connected set and D ,E coc-b-separated sets and $A \subseteq D \cup E$ .Let $A \nsubseteq D$ and $A \nsubseteq E$.

Suppose $A_1 = D \cap A \neq \emptyset$ and $A_2 = E \cap A \neq \emptyset$ then $A = A_1 \cup A_2$ .Since $A_1 \subseteq D$ hence $\overline{A_1}^{b-coc} \subseteq \overline{D}^{b-coc}$,since $\overline{D}^{b-coc} \cap E = \emptyset$ then $\overline{A_1}^{b-coc} \cap A_2 = \emptyset$,since $A_2 \subseteq E$ hence $\overline{A_2}^{b-coc} \subseteq \overline{E}^{b-coc}$, since $\overline{E}^{b-coc} \cap D = \emptyset$ then $\overline{A_2}^{b-coc} \cap A_1 = \emptyset$ .But $A = A_1 \cup A_2$ therefore A is not coc-b-connected space which is a contradiction .Then either $A \subseteq D$ or $A \subseteq E$.

Proposition(14):

Let (X,τ) be a topological space such that any two element x and y of X are contained in some coc-b-connected subspace of X. Then X is coc-b-connected .

Proof:

Suppose X is not coc-b-connected. Then X is the union of two coc-b-separated sets A ,B. Since A, B are nonempty sets. Thus there exists a, b such that $a \in A$, $b \in B$. Let D be coc-b-connected subspace of X which contains a, b. Therefore either $D \subseteq A$ or $D \subseteq B$ which is a contradiction (since $A \cap B = \emptyset$). Then X is coc-b-connected space .

Proposition(15):

If A is coc-b-connected set then $\overline{A}^{b-coc}$ is coc-b-connected .

Proof:

Suppose A is coc-b-connected and $\overline{A}^{b-coc}$ is not coc-b-connected. Then there exist two coc-b-separated set D, E such that $\overline{A}^{b-coc} = D \cup E$. But $A \subseteq \overline{A}^{b-coc}$,then $A \subseteq D \cup E$ and since A is coc-b-connected set. Then either $A \subseteq D$ or $A \subseteq E$. If $A \subseteq D$ then $\overline{A}^{b-coc} \subseteq \overline{D}^{b-coc}$. But $\overline{D}^{b-coc} \cap E = \emptyset$, hence $\overline{A}^{b-coc} \cap E = \emptyset$ since $\overline{A}^{b-coc} = D \cup E$. Then $E = \emptyset$ which is a contradiction .If $A \subseteq E$ then $\overline{A}^{b-coc} \subseteq \overline{E}^{b-coc}$. But $\overline{E}^{b-coc} \cap D = \emptyset$,hence $\overline{A}^{b-coc} \cap D = \emptyset$ since $\overline{A}^{b-coc} = E \cup D$. Then $D = \emptyset$ which is a contradiction .Then $\overline{A}^{b-coc}$ is coc-b-connected.

Proposition(16):

If D is coc-b-connected set and $D \subseteq E \subseteq \overline{D}^{b-coc}$ then E is coc-b-connected .

Proof:

Let D be coc-b-connected set and $D \subseteq E \subseteq \overline{D}^{b-coc}$ .Suppose E is not coc-b-connected ,then there exist two sets A, B such that $\overline{A}^{b-coc} \cap B = A \cap \overline{B}^{b-coc} = \emptyset,\ E = A \cup B$, since $D \subseteq E$, thus either $D \subseteq A$ or $D \subseteq B$ .Suppose $D \subseteq A$ then $\overline{D}^{b-coc} \subseteq \overline{A}^{b-coc}$, thus $\overline{D}^{b-coc} \cap B = \overline{A}^{b-coc} \cap B = \emptyset$. But $D \subseteq E \subseteq \overline{D}^{b-coc}$,then $\overline{D}^{b-coc} \cap B = B$ .Therefore $B = \emptyset$ which is a contradiction, hence E is coc-b-connected set.

Proposition(17):

If a space X contains a coc-b-connected subspace E such that $\overline{E}^{bcoc} = X$ then X is coc-b-connected .

Proof:

Suppose E a coc-b-connected subspace of a space X such that $\overline{E}^{b-coc} = X$, since $E \subseteq X = \overline{E}^{b-coc}$ then by proposition (2.3.11) then X is coc-b-connected .

Lemma(18):

If A is subset of a space X which is both coc-b-open and coc-b-

closed sets, then any coc-b-connected subspace $C \subseteq X$ which meets A must be contained in A.

Proof:

If A is coc-b-open and coc-b-closed sets in X then $C \cap A$ coc-b-open and coc-b-closed in C ,if C is coc-b-connected this implies that $C \cap A = C$ which says that C is contained in A.

Proposition(19):

The coc-b-continuous onto image of coc-b-connected space is connected.

Proof:

Let $f: (X, \tau) \to (Y, \tau')$ be coc-b-continuous, onto function and X is coc-b-connected .To prove that Y is connected .Suppose Y is a not connected space . So $Y = A \cup B$ such that $A \neq \emptyset$, $B \neq \emptyset$ and $A \cap B = \emptyset$ and $A , B \in \tau'$ hence $f^{-1}(Y) = f^{-1}(A \cup B)$, then $X = f^{-1}(A) \cup f^{-1}(B)$. Since f is coc-b-continuous hence $f^{-1}(A)$ and $f^{-1}(B)$ are coc-b-open in X and sine that $A \neq \emptyset, B \neq \emptyset$ and f is onto .Then $f^{-1}(A) \neq \emptyset$, $f^{-1}(B) \neq \emptyset$ and $f^{-1}(A) \cap f^{-1}(B) = \emptyset$,hence X is not coc-b-connected space which is contradiction .Then Y is connected .

Corollary(20):

The coc'-b-continuous image of coc-b-connected space is coc-b-connected.

Proof:

Let $f: (X, \tau) \to (Y, \tau')$ be coc'-b-continuous, onto function and X is coc-b-connected. To prove Y is coc-b-connected. Suppose Y is not coc-b-connected space. So, $Y = A \cup B$ such that $A \neq \emptyset$, $B \neq \emptyset$ and $A \cap B = \emptyset$ and A, B are coc-b-open sets, hence $f^{-1}(Y) = f^{-1}(A \cup B)$ then $X = f^{-1}(A) \cup f^{-1}(B)$. Since that f coc'-b-continuous ,hence $f^{-1}(A)$ and $f^{-1}(B)$ are coc-b-open in X and since that $A \neq \emptyset$, $B \neq \emptyset$ then $f^{-1}(A) \neq \emptyset$, $f^{-1}(B) \neq \emptyset$ and $f^{-1}(A) \cap f^{-1}(B) = \emptyset$, hence X is not coc-b-connected space which is contradiction .Then Y is coc-b-connected .

Proposition(21):

Let X be topological space and let $Y = \{0,1\}$ have the discrete space. Then X is coc-b-connected iff there is no coc-b-continuous function from X onto Y.

Proof:

Suppose $f:(X,\tau)\to(Y,\tau')$ is coc-b-continuous onto function. So there exists $x, y \in X$ such that $x \neq y$, $f(x)=0, f(y)=1$. Then $f^{-1}(\{0\})=A$, $A\subseteq X$ and $f^{-1}(\{1\})=B$, $B\subseteq X$ therefore A and B are coc-b-open set in X .Since f is coc-b-continuous .Hence $X=A\cup B$ such that $A\neq\emptyset, B\neq\emptyset$. A , B are coc-b-open sets which is a contradiction .Since X is coc-b-connected .

Conversely, let X be not coc-b-connected. Then $X=A\cup B$ such that $A\neq\emptyset, B\neq\emptyset, A\cap B=\emptyset$ and A, B are coc-b-open sets. Define $g:(X,\tau)\to(Y,\tau')$ such that $g(x)=0$ $\forall x\in A$ and $g(x)=1$ $\forall x\in B$,hence g is coc-b-continuous ,which is contradiction .Then X is coc-b-connected.

Definition(22): [4]

Let $f: X\to Y$ be a function of a space X into a space Y. Then f is called a ω-continuous function if $f^{-1}(A)$ is an ω-open set in X for every open set A in Y.

Definition(23): [6]

A subset A of a space X is called an ω-set if $A=U\cup V$ when U is open set and $Int(V)=Int_{\omega}(V)$.

Definition(24): [7]

A space (X,τ) is said to be satisfy ω-condition if every ω-open is ω-set.

Lemma(25): [6]

A subset A of a space X is open iff A ω-open set and ω-set .

Definition(26): [1]

A space X is said to be ω-connected provided that X is not the union of two nonempty disjoint ω-open sets .

Proposition(27):

Let (X,τ) and (Y,τ') be two topological spaces. If satisfy ω- condition ,then the coc-b-continuous, onto image of coc-b-connected space is ω-connected .

Proof:

Let $f:(X,\tau)\to(Y,\tau')$ be coc-b-continuous, onto function and X be coc-b-connected. To prove Y is ω-connected. Suppose Y is not ω-connected space. So, $Y=\{A\cup B\}$ such that $A\neq\emptyset, B\neq\emptyset$ and $A\cap B=\emptyset$ and A , B ω-open sets since Y satisfy ω-condition , then A , B are open sets. Hence $f^{-1}(Y)=f^{-1}(A\cup B)$. Then $X=f^{-1}(A)\cup f^{-1}(B)$. Since that f coc-b-continuous hence $f^{-1}(A)$ and $f^{-1}(B)$ are coc-b-open in X .Since that $A\neq\emptyset, B\neq\emptyset$ and f is onto then $f^{-1}(A)\neq\emptyset, f^{-1}(B)\neq\emptyset$ and $f^{-1}(A)\cap f^{-1}(B)=\emptyset$, hence X is not coc-b-connected space which is contradiction .Then Y is ω-connected.

Definition(28): [3]

A space (X,τ) is said to be locally connected if for each point $x\in X$ and each open set U such that $x\in U$. There is a connected open set V ,$x\in V\subseteq U$.

Definition(29):

A space (X,τ) is said to be coc-b-locally connected if for each point $x\in X$ and each coc-b-open set U such that $x\in U$. There is a coc-b-connected open set V ,$x\in V\subseteq U$.

Proposition(30):

Every coc-b-locally connected space is locally connected space.

Proof: Clear

Remark(31):

The convers of the proposition (24) is not true in general.

Example(32):

Let $X=\{1,2,3\}$,$\tau=\{X,\emptyset,\{2,3\}\}$ .The coc-b-open sets are $X,\emptyset,\{1\},\{2\},\{3\},\{1,2\},\{1,3\},\{2,3\}$ then (X,τ) is locally connected but (X,τ) is not coc-b-locally. Since $1\in\{1,2\}$. There is no coc-b-connected open set V such that $1\in V\subseteq\{1,2\}$.

Remark(33):

If (X,τ) is a coc-b-locally connected space. Then it need not be coc-b-connected .

Example(34):

Let $X=\{1,2,3\}$, $\tau=\{X,\emptyset,\{1\},\{2\},\{3\},\{1,2\},\{1,3\},\{2,3\}\}$. The coc-b-open sets is discrete topology then (X,τ) is a coc-b-locally but (X,τ) is not coc-b-connected ,since $\{1\},\{2,3\}$ are coc-b-open sets in X such that $X=\{1\}\cup\{2,3\}$ and $\{1\}\cap\{2,3\}=\emptyset$.

Definition(35):

Let (X,τ) be any space, a maximal coc-b-connected of X is said to be coc-b-component of X.

Theorem(36):
For a space (X,τ). The following condition are equivalent:

1-X is a coc-b-locally connected.

2-Every coc-b-component of every coc-b-open set is open.

Proof:

(1)→(2) Let X be coc-b-locally connected and let C be coc-b-component of X such that $x \in C$. Let $x \in X$ and A is coc-b-open set in X such that $x \in C \subseteq A$. Then $x \in A$ and A is coc-b-open set in X . Since X is a coc-b-locally connected , then there exist coc-b-connected open set V in X such that $x \in V \subseteq A$,since that C is coc-b-component ,then $V \subseteq C$ and $\bigcup_{x\in C} V_x \subseteq C$,hence $C = \bigcup_{x\in X}\{V_x : x \in C\}$ therefore C is open set.

(2)→(1) Let $x \in X$ and U be coc-b-open set in X such that $x \in U$ and let C coc-b-component of U such that $x \in C \subseteq U$. Then C is open set in X by (2) . Since that C is coc-b-component, hence C is coc-b-connected .Therefore X is a coc-b-locally connected.

Proposition(37):
The coc-b-continuous, open, image of coc-b-locally connected space is locally connected.

Proof:

Let $f: (X,\tau) \to (Y,\tau')$ be coc-b-continuous open and onto function and (X,τ) is coc-b-locally connected space. To prove (Y,τ') is locally connected. Let $y \in Y$ and U be open set in $Y \ni y \in U$. Since f is onto there exist $x \in X$ such that $f(x) = y$, since f is coc-b-continuous then $f^{-1}(U)$ is coc-b-open set in X such that $x \in f^{-1}(U)$, since X is coc-b-locally connected then there exist V is coc-b-connected open set in X such that $x \in V \subseteq f^{-1}(U)$ since f open function, then $f(x) \in f(V) \subseteq U$ such that $f(V)$ is open and $f(V)$ is connected by corollary(14). Therefore Y is a locally connected .

Remark(38):
The coc-b-continuous image of coc-b-locally connected need not be coc-b-locally connected.

Example(39):
Let $X = \{1,2,3\}$, $Y = \{a,b,c\}$, $\tau = \{\emptyset, X, \{1\}, \{2\}, \{3\}, \{1,2\}, \{2,3\}, \{1,3\}\}$ and

$\tau' = \{\emptyset, Y, \{a\}\}$. The coc-b-open set in X and Y are discrete topology. Define $f: (X,\tau) \to (Y,\tau')$ such that $f(1) = a$, $f(2) = b$, $f(3) = c$ is coc-b-continuous, onto function .Then (X,τ) is coc-b-locally connected but (Y,τ') is not coc-b-locally connected since $b \in \{a,b\}$ and exists no coc-b-connected open set V in X such that $b \in V \subseteq \{a,b\}$.

Proposition(40):
The coc'-b-continuous, open, image of coc-b-locally connected space is coc-b-locally connected.

Proof:

Let $f: (X,\tau) \to (Y,\tau')$ be coc'-b-continuous, open and onto function and (X,τ) is coc-b-locally connected space . To prove (Y,τ') is coc-b-locally connected, let $y \in Y$ and U is coc-b-open set in Y, such that $y \in U$. Since f onto there exist $x \in X$ such that $f(x) = y$ for each $y \in Y$, since f is coc'-b-continuous, hence $f^{-1}(U)$ is coc-b-open set in X such that $x \in f^{-1}(U)$. Since X is coc-b-locally connected then $\exists$ V coc-b-connected open set in X such that $x \in V \subseteq f^{-1}(U)$, since f is open then $f(V)$ is open set in Y and $f(V)$ is coc-b-connected by proposition (15). Hence $f(V)$ is coc-b-connected open set in Y such that $y \in f(V) \subseteq U$. Therefore Y is a coc-b-locally connected space.

Definition(41):
Let X be a space ,$A \subseteq X$, A is called coc-b-dence set in X if $\overline{A}^{b-coc} = X$.

We recall that a space X is said to be hyper connected if for every nonempty open subset of X is dence see [5] .

Definition(42):
A space X is said to be coc-b-hyper connected if for every nonempty coc-b-open subset of X is coc-b-dence.

Now, we explain the relation between an coc-b-hyper connected space and hyper connected space .

Proposition(43):
Every coc-b-hyper connected space is hyper connected.

Proof:

Let X be coc-b-hyper connected space. Then every nonempty coc-b-open subset of X is coc-b-dence in X, hence every nonempty open subset of X is dence.

Therefore X is hyper connected (since every coc-b-dence set is dence).

Remark(44):

The convers of the proposition (43) is not true in general.

Example(45):

Let $X = \{1,2,3\}$, $\tau = \{X, \emptyset\}$. The coc-b-open sets $\{X, \emptyset, \{1\}, \{2\}, \{3\}, \{1,2\}, \{1,3\}, \{2,3\}\}$. Then (X, τ) is hyper connected but (X, τ) is not coc-b-hyper connected since $\{1\}$ is coc-b-open set and $\overline{\{1\}}^{b-coc} = \{1\} \neq X$.

Proposition(46):

Every coc-b-hyper connected space is coc-b-connected.

Proof:

Let X be coc-b-hyper connected space and suppose X is not coc-b-connected. Then there exists A is coc-b-clopen subset in X such that $A \neq \emptyset$ and $A \neq X$, hence $A = \overline{A}^{b-coc}$ which is a contradiction, since X is coc-b-hyper connected. Therefore X is coc-b-connected .

Definition(47): [2]

A space (X, τ) is said to be extremally disconnected if the closure of every open subset of X is open in X.

Definition(48):

A space (X, τ) is said to be coc-b-extremally disconnected if the closure of every open is coc-b-open.

Remark(49):

Every extremally disconnected space is coc-b-extremally disconnected space and the convers is not true in general.

Example(50):

Let $X = \{a, b, c\}$, $\tau = \{X, \emptyset, \{a\}, \{b\}, \{a, b\}\}$ .The coc-b-open set $\{X, \emptyset, \{a\}, \{b\}, \{c\}, \{a, b\}, \{a, c\}, \{b, c\}\}$ .Then (X, τ) is coc-b-extremally disconnected, but (X, τ) is not extremally disconnected since $\overline{\{a\}} = \{a, c\} \notin \tau$.

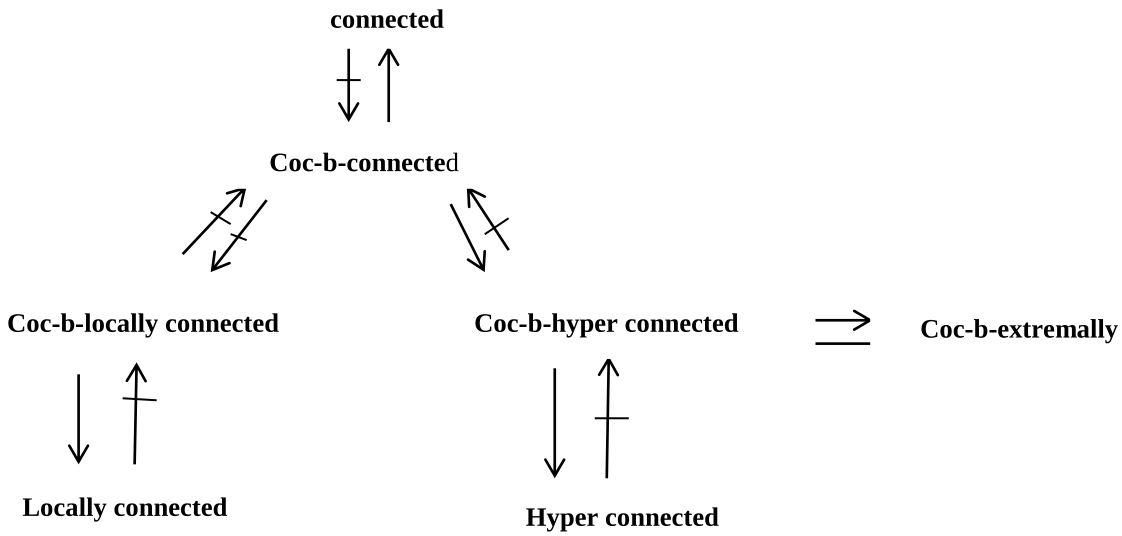
Remark(51):

Every coc-b-hyper connected is a coc-b-extremally disconnected space but the convers is not true in general.

Example(52):

Let $X = \{1,2,3\}$, $\tau = \{X, \emptyset, \{1\}, \{2\}, \{3\}, \{1,2\}, \{1,3\}, \{2,3\}\}$. The coc-b-open set $X, \emptyset, \{1\}, \{2\}, \{3\}, \{1,2\}, \{1,3\}, \{2,3\}$. Then (X, τ) is coc-b-extremally disconnected since the closure of every open subset of X is coc-b-open. But (X, τ) is not coc-b-hyper connected since $\overline{A}^{b-coc} = A \neq X \ \forall A$ coc-b-open.

The following diagram explain the relationship among these types of connected spaces



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الفضاءات المتصلة من النمط coc-b

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جامعة القادسية / كلية علوم الحاسوب وتكنلوجيا المعلومات / قسم الرياضيات

المستخلص :

نحن نقدم و ندرس الفضاء المتصل من النمط coc-b ،حيث نقدم عدد من المبرهنات والملاحظات حول هذا المفهوم والنتائج التي تخص ذلك و كذلك نقوم بمناقشة تعريف المتصل محليا من النمط coc-b أيضا نقدم بعض الملاحظات والمبرهنات حول المفهوم الجديد. في هذه الدراسة أيضا نقدم تعريف hyper connected باستخدام المجموعة المفتوحة من النمط coc-b ونعطي المبرهنات والملاحظات التي تخص ذلك المفهوم.