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ON SEMI GENERALIZED STAR b-CONTINUOUS MAP IN TOPOLOGICAL SPACES

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Abstract: In this paper, we introduce a new class of semi generalized star b-continuous map and study some of their properties as well as inter relationship with other continuous maps.

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Key Words: sg^*b-continuous map, b-continuous map, gb continuous map and rgb continuous map

1. Introduction

Continuous map was studied for different types of closed sets by various researchers for past many years. In 1996, Andrijevic [3, 4] introduced new type called b-open sets. A.A. Omari and M.S.M. Noorani [2] were introduced and studied b-continuous map and b-closed map.

The aim of this paper is to continue the study of semi generalized star b-continuous map, semi generalized star b-closed map have been introduced and studied their relations with various generalized closed maps. Through out this

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paper (X, τ) and (Y, σ) represent the non-empty topological spaces on which no separation axioms are assumed, unless otherwise mentioned.

Let $A \subseteq X$, the closure of A and interior of A will be denoted by $cl(A)$ and $int(A)$ respectively, union of all b - open sets X contained in A is called b - interior of A and it is denoted by $bint(A)$, the intersection of all b - closed sets of X containing A is called b - closure of A and it is denoted by $bcl(A)$.

2. Preliminaries

Definition 2.1. Let a subset A of a topological space (X, τ), is called

1) a pre-open set [16] if $A \subseteq int(cl(A))$.
2) a semi-open set [13] if $A \subseteq cl(int(A))$.
3) a α -open set [17] if $A \subseteq int(cl(int(A)))$.
4) a α generalized closed set (briefly αg- closed) [14] if $\alpha cl(A) \subseteq U$ whenever $A \subseteq U$ and U is open in X.
5) a generalized $*$ closed set (briefly g^{*}-closed)[20] if $cl(A) \subseteq U$ whenever $A \subseteq U$ and U is $\hat{g}$ open in X.
6) a generalized b- closed set (briefly gb- closed) [2] if $bcl(A) \subseteq U$ whenever $A \subseteq U$ and U is open in X.
7) a generalized semi-pre closed set (briefly gsp - closed) [9] if $spcl(A) \subseteq U$ whenever $A \subseteq U$ and U is open in X.
8) a generalized pre- closed set (briefly gp- closed) [10] if $pcl(A) \subseteq U$ whenever $A \subseteq U$ and U is open in X.
9) a generalized semi- closed set (briefly gs- closed) [9] if $scl(A) \subseteq U$ whenever $A \subseteq U$ and U is open in X.
10) a semi generalized closed set (briefly sg- closed) [6] if $scl(A) \subseteq U$ whenever $A \subseteq U$ and U is semi open in X.
11) a generalized pre regular closed set (briefly gpr-closed) [10] if $pcl(A) \subseteq U$ whenever $A \subseteq U$ and U is regular open in X.
12) a semi generalized b- closed set (briefly sgb- closed) [11] if $bcl(A) \subseteq U$ whenever $A \subseteq U$ and U is semi open in X.

13) a $\ddot{g}$ - closed set [19] if $cl(A) \subseteq U$ whenever $A \subseteq U$ and U is sg open in X.

14) a semi generalized star b - closed set (briefly $sg^{\star}b$ - closed)[20] if $bcl(A) \subseteq U$ whenever $A \subseteq U$ and U is semi open in X.

Definition 2.2. A function $f : (X, \tau) \to (Y, \sigma)$, is called

1) a pre continuous map [16] if $f^{-1}(V)$ is pre open in (X, τ) for every open set V of (Y, σ).

2) a semi continuous map [13] if $f^{-1}(V)$ is semi open in (X, τ) for every open set V of (Y, σ).

3) a continuous map [17] if $f^{-1}(V)$ is open in (X, τ) for every open set V of (Y, σ).

4) a generalized continuous map [14] if $f^{-1}(V)$ is generalized-closed in (X, τ) for every open set V of (Y, σ).

5) a generalized b continuous map [2] if $f^{-1}(V)$ is gb-open in (X, τ) for every open set V of (Y, σ).

6) a generalized semi-pre continuous map [9] if $f^{-1}(V)$ is gsp-open in (X, τ) for every open set V of (Y, σ).

7) a semi generalized continuous map [6] if $f^{-1}(V)$ is sg-open in (X, τ) for every open set V of (Y, σ).

8) a generalized pre regular continuous map [10] if $f^{-1}(V)$ is gpr-open in (X, τ) for every open set V of (Y, σ).

9) a semi generalized b continuous map [11] if $f^{-1}(V)$ is sgb-open in (X, τ) for every open set V of (Y, σ).

10) a regular generalized b continuous map [22] if $f^{-1}(V)$ is rgb-open in (X, τ) for every open set V of (Y, σ).

3. On Semi Generalized sg^*b-Continuous Map

In this section, we introduce semi generalized star b-continuous map ($sg^{\star}b$-continuous) in topological spaces by using the notions of $sg^{\star}b$-closed maps and study some of their properties.

Definition 3.1. Let X and Y be two topological spaces. A map $f : (X, \tau) \to (Y, \sigma)$ is called semi generalized star b-continuous map (briefly, $sg^{\star}b$-continuous map) if the image of every closed set in Y is $sg^{\star}b$-open in X.

Theorem 3.2. *If a map $f : (X, \tau) \to (Y, \sigma)$ from a topological space X into a topological space Y is continuous, then it is $sg^{\star}b$-continuous.*

Proof. Let V be an open set in Y. Since f is continuous, then $f^{-1}(V)$ is open in X. As every open set is $sg^{\star}b$-open, $f^{-1}(V)$ is $sg^{\star}b$-open in X. Therefore f is $sg^{\star}b$-continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.3. *Consider $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{b\}, \{a,\ b\}\}$ and $\sigma = \{Y, \phi, \{a\}, \{a, c\}\}$. Let $f : (X, \tau) \to (Y, \sigma)$ be defined by $f(a) = a, f(b) = b, f(c) = c$, then f is $sg^{\star}b$-continuous but not continuously as the inverse image of an open set $\{a, c\}$ in Y is $\{b, c\}$ which is not open set in X.*

Theorem 3.4. *Let X and Y be topological spaces. If a map $f : (X, \tau) \to (Y, \sigma)$ is $\ddot{g}$-continuous, then it is $sg^{\star}b$-continuous.*

Proof. Let us assume that $f : (X, \tau) \to (Y, \sigma)$ is b-continuous. Let V be an open set in Y, Since f is b-continuous then $f^{-1}(V)$ is b-open. Hence every b-open is $sg^{\star}b$-open in X. Therefore f is $sg^{\star}b$-continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.5. *Consider $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a, b\}\}$ and $\sigma = \{Y, \phi, \{a, c\}\}$. Let $f : (X, \tau) \to (Y, \sigma)$ be defined by $f(a) = c, f(b) = a, f(c) = b$. the f is $sg^{\star}b$-continuous but not $\ddot{g}$-continuous as the inverse image of an open set $\{a, c\}$ in Y is $\{a, b\}$ which is not $\ddot{g}$-open set in X.*

Theorem 3.6. *Let X and Y be topological spaces. If a map $f : (X, \tau) \to (Y, \sigma)$ is α-continuous then it is $sg^{\star}b$-continuous.*

Proof. Let us assume that $f : (X, \tau) \to (Y, \sigma)$ is α-continuous. Let V be an open set in Y, Since f is α-continuous then $f^{-1}(V)$ is α-open. Hence every α-open is $sg^{\star}b$-open in X. Therefore f is $sg^{\star}b$-continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.7. *Consider* $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a, b\}\}$ *and* $\sigma = \{Y, \phi, \{b\}, \{a, b\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = a, f(b) = c, f(c) = b$, *then* f *is* $sg^{\star}b$*-continuous but not* α*-continuously as the inverse image of an open set* $\{a, b\}$ *in* Y *is* $\{b, c\}$ *which is not* α*-open set in* X.

Theorem 3.8. *Let* X *and* Y *be topological spaces. If a map* $f : (X, \tau) \to (Y, \sigma)$ *is semi continuous, then it is* $sg^{\star}b$*-continuous.*

Proof. Let us assume that $f : (X, \tau) \to (Y, \sigma)$ is semi continuous. Let V be an open set in Y, Since f is semi continuous then $f^{-1}(V)$ is semi open. Hence every semi open is $sg^{\star}b$-open in X. Therefore f is $sg^{\star}b$-continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.9. *Consider* $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{b\}, \{a, b\}\}$ *and* $\sigma = \{Y, \phi, \{b\}, \{b, c\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = c, f(b) = a, f(c) = b$, *then* f *is* $sg^{\star}b$*-continuous but not semi-continuously as the inverse image of an open set* $\{b\}$ *in* Y *is* $\{c\}$ *which is not semi-open set in* X.

Theorem 3.10. *Let* X *and* Y *be topological spaces. If a map* $f : (X, \tau) \to (Y, \sigma)$ *is pre continuous, then it is* $sg^{\star}b$*-continuous.*

Proof. Let us assume that $f : (X, \tau) \to (Y, \sigma)$ is pre continuous. Let V be an open set in Y, Since f is pre continuous, then $f^{-1}(V)$ is pre open. Hence every pre open is $sg^{\star}b$-open in X. Therefore f is $sg^{\star}b$-continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.11. *Consider* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{b\}, \{a, b\}\}$ *and* $\sigma = \{Y, \phi, \{a\}, \{a, b\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = c, f(b) = b, f(c) = a$, *then* f *is* $sg^{\star}b$*-continuous but not pre-continuous as the inverse image of an open set* $\{a\}$ *in* Y *is* $\{c\}$ *which is not pre-open set in* X.

Theorem 3.12. *Let* X *and* Y *be topological spaces. If a map* $f : (X, \tau) \to (Y, \sigma)$ *is* αg *continuous, then it is* $sg^{\star}b$*-continuous.*

Proof. Let us assume that $f : (X, \tau) \to (Y, \sigma)$ is αg continuous. Let V be an open set in Y, Since f is αg continuous then $f^{-1}(V)$ is $g\alpha$-open. Hence every $g\alpha$-open is $sg^{\star}b$-open in X. Therefore f is $sg^{\star}b$-continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.13. *Consider* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{a, b\}\}$ *and* $\sigma = \{Y, \phi, \{a\}, \{a, c\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = b, f(b) = a, f(c) = c$, *then* f *is* $sg^{\square}b$*-continuous but not* αg*-continuous as the inverse image of an open set* $\{a, c\}$ *in* Y *is* $\{b, c\}$ *which is not* αg*-open set in* X.

Theorem 3.14. *Let* X *and* Y *be topological spaces. If a map* $f : (X, \tau) \to (Y, \sigma)$ *is* $sg^{\square}b$ *continuous then it is* gsp*-continuous.*

Proof. Let us assume that $f : (X, \tau) \to (Y, \sigma)$ is $sg^{\square}b$ continuous. Let V be an open set in Y, Since f is $sg^{\square}b$ continuous then $f^{-1}(V)$ is $sg^{\square}b$ open. Hence every $sg^{\square}b$ open is gsp open in X. Therefore f is gsp continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.15. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{b\}, \{b, c\}\}$ *and* $\sigma = \{Y, \phi, \{a\}, \{a, b\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = b, f(b) = c, f(c) = a$, *then* f *is* gsp *continuous but not* $sg^{\square}b$ *continuous as the inverse image of an open set* $\{a\}$ *in* Y *is* $\{c\}$ *which is not* $sg^{\square}b$ *open set in* X.

Theorem 3.16. *Let* X *and* Y *be topological spaces. If a map* $f : (X, \tau) \to (Y, \sigma)$ *is* $sg^{\square}b$*-continuous, then it is* gb*-continuous.*

Proof. Let us assume that $f : (X, \tau) \to (Y, \sigma)$ is $sg^{\square}b$-continuous. Let V be an open set in Y, since f is $sg^{\square}b$-continuous then $f^{-1}(V)$ is $sg^{\square}b$-open. Hence every $sg^{\square}b$-open is gb-open in X. Therefore f is gb-continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.17. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{c\}, \{b, c\}\}$ *and* $\sigma = \{Y, \phi, \{b\}, \{a, c\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = a, f(b) = b, f(c) = c$, *then* f *is* gb*-continuous but not* $sg^{\square}b$*-continuous as the inverse image of an open set* $\{b\}$ *in* Y *is* $\{b\}$ *is not* $sg^{\square}b$*-open set in* X.

Theorem 3.18. *Let* X *and* Y *be topological spaces. If a map* $f : (X, \tau) \to (Y, \sigma)$ *is* sg *continuous, then it is* $sg^{\square}b$*-continuous.*

Proof. Let us assume that $f : (X, \tau) \to (Y, \sigma)$ is sg continuous. Let V be an open set in Y, Since f is sg continuous then $f^{-1}(V)$ is sg open. Hence every sg open is $sg^{\square}b$ open in X. Therefore f is $sg^{\square}b$-continuous. □

The converse of above theorem need not be true as seen from the following example.

Example 3.19. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{a\}, \{c\}, \{a,\ c\}\}$ *and* $\sigma = \{Y, \phi, \{c\}, \{b, c\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = c, f(b) = a, f(c) = b$, *then* f *is* $sg^{\star}b$*-continuous but not* sg*-continuous as the inverse image of an open set* $\{b, c\}$ *in* Y *is* $\{a, b\}$ *which is not* sg*-open set in* X.

Remark 3.20. The following examples show that $sg^{\star}b$ - continuous and gp-continuous maps are independent.

Example 3.21. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{b\}, \{c\}, \{b,\ c\}\}$ *and* $\sigma = \{Y, \phi, \{a\}, \{a, c\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = c, f(b) = a, f(c) = b$, *then* f *is* $sg^{\star}b$*-continuous but not* gp*-continuous as the inverse image of an open set* $\{a, c\}$ *in* Y *is not* gp*-open set in* X.

Example 3.22. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{c\}\}$ *and* $\sigma = \{Y, \phi, \{c\}, \{a, c\}, \{b, c\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = a, f(b) = c, f(c) = b$, *then* f *is* gp*-continuous but not* $sg^{\star}b$*-continuous as the inverse image of* $\{c\}$ *in* Y *is* $\{b\}$ *which is not* $sg^{\star}b$*-open set in* X.

Remark 3.23. The following examples show that $sg^{\star}b$ - continuous and gpr-continuous maps are independent.

Example 3.24. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{b\}, \{a, b\}, \{b,\ c\}\}$ *and* $\sigma = \{Y, \phi, \{a\}, \{a, b\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = b, f(b) = c, f(c) = a$, *then* f *is* gpr*-continuous but not* $sg^{\star}b$*-continuous as the inverse image of* $\{a, b\}$ *in* Y *is* $\{a, c\}$ *not* $sg^{\star}b$*-open set in* X.

Example 3.25. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{a\}, \{b\}, \{a,\ b\}\}$ *and* $\sigma = \{Y, \phi, \{b\}, \{b, c\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = b, f(b) = a, f(c) = c$, *then* f *is* $sg^{\star}b$*-continuous but not* gpr*-continuous as the inverse image of* $\{b, c\}$ *in* Y *is* $\{a, c\}$ *which is not* gpr*-open set in* X.

Remark 3.26. The following examples show that $sg^{\star}b$ - continuous and rgb-continuous maps are independent.

Example 3.27. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{a\}, \{a, b\}, \{b,\ c\}\}$ *and* $\sigma = \{Y, \phi, \{a, c\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = b, f(b) = a, f(c) = c$, *then* f *is* rgb*-continuous but not* $sg^{\star}b$*-continuous as the inverse image of* $\{b, c\}$ *in* Y *is not* $sg^{\star}b$*-open set in* X.

Example 3.28. *Let* $X = Y = \{a, b, c\}$,$\tau = \{X, \phi, \{b\}, \{c\}, \{b,\ c\}\}$ *and* $\sigma = \{Y, \phi, \{a\}, \{a, b\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = b, f(b) = c, f(c) = a$, *then* f *is* $sg^{\star}b$*-continuous but not* rgb*-continuous as the inverse image of* $\{a, b\}$ *in* Y *is* $\{a, c\}$ *which is not* rgb*-open set in* X.

Remark 3.29. The following examples show that sgb - continuous and

$sg^{\star}b$-continuous maps are independent.

Example 3.30. *Let* $X = Y = \{a, b, c\}, \tau = \{X, \phi, \{a\}, \{c\}, \{a,\ c\}, \{b, c\}\}$ *and* $\sigma = \{Y, \phi, \{a, b\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = a, f(b) = c, f(c) = b$, *then* f *is* $sg^{\star}b$*-continuous but not sgb-continuous as the inverse image of* $\{a, b\}$ *in* Y *is not sgb-open set in* X.

Example 3.31. *Let* $X = Y = \{a, b, c\}, \tau = \{X, \phi, \{a\}, \{b\}, \{a,\ b\}, \{b, c\}\}$ *and* $\sigma = \{Y, \phi, \{a\}, \{a, b\}\}$. *Let* $f : (X, \tau) \to (Y, \sigma)$ *be defined by* $f(a) = b, f(b) = a, f(c) = c$, *then* f *is sgb-continuous but not* $sg^{\star}b$*-continuous as the inverse image of* $\{a, b\}$ *in* Y *is* $\{a, c\}$ *which is not* $sg^{\star}b$*-open set in* X.

4. Applications

Theorem 4.1. *If a map* $f : (X, \tau) \to (Y, \sigma)$ *then*

(i) the following are equivalent

- *(a)* f *is* $sg^{\star}b$ *- continuous*
- *(b) The inverse image of open set in* Y *is* $sg^{\star}b$ *- open in* X.

(ii) If $f : (X, \tau) \to (Y, \sigma)$*is* $sg^{\star}b$ *- continuous, then* $f(b^{\star}(A)) \subset cl(f(A))$ *for every subset* A *of* X

Proof. (i) Let us assume that $f : X \to Y$ be $sg^{\star}b$ - continuous. Let F be open in Y. Then F^c is closed in Y. Since f is $sg^{\star}b$ - continuous, $f^{-1}(F^c)$ is $sg^{\star}b$ - closed in X. But $f^{-1}(F^c) = X - f^{-1}(F)$. Thus $X - f^{-1}(F)$ is $sg^{\star}b$ - closed in X. So $f^{-1}(F)$ is $sg^{\star}b$ - open in X. Hence (a) $\Rightarrow$ (b).

Conversely, let us assume that the inverse image of each open set in Y is $sg^{\star}b$ open in X. Let G be closed in Y. Then G^c is open in Y. By assumption $X - f^{-1}(G)$ is open in X. So $f^{-1}(G)$ is $sg^{\star}b$ - closed in X. Therefore f is $sg^{\star}b$ - continuous. Hence (b) $\Rightarrow$ (a). We have (a) and (b) are equivalent.

(ii) Let us assume that f is $sg^{\star}b$ - continuous. Let A be any subset of X. Then $cl(f(A))$ is closed in Y. Since f is $sg^{\star}b$ - continuous, $f^{-1}(cl(f(A)))$ is $sg^{\star}b$ - closed in X and it contains A. But $b^{\star}(A)$ is the intersection of all $b^{\star}$ closed sets containing. Therefore $b^{\star}(A) \subset f^{-1}(cl(f(A)))$. So that $f(b^{\star}(A)) \subset cl(f(A))$. □

Theorem 4.2 (PASTING LEMMA for $sg^{\star}b$-continuous maps). *Let* $X = A \cup B$ *be a topological space with topology* τ *and* Y *be a topological space with topology* σ. *Let* $f : (A, \tau/A) \to (Y, \sigma)$ *and* $g : (B, \tau/B) \to (Y, \sigma)$ *be* $sg^{\star}b$ *- continuous map such that* $f(x) = g(x)$ *for every* $x \in A \cup B$. *Suppose that* A *and* B *are* $sg^{\star}b$ *- closed sets in* X, *then* $\alpha : (X, \tau) \to (Y, \sigma)$ *is* $sg^{\star}b$ *- continuous.*

Proof. Let F be any closed set in Y. Clearly $\alpha^{-1}(F) = f^{-1}(F) \cup g^{-1}(F) = C \cup D$, where $C = f^{-1}(F)$ and $D = g^{-1}(F)$. But C is $sg^{\star}b$ - closed in A and A is $sg^{\star}b$ - closed in X. So C is $sg^{\star}b$ - closed in X. Since we have prove the result, if $B \subseteq A \subseteq X$, B is $sg^{\star}b$ - closed in A and A is $sg^{\star}b$ - closed in X, then B is $sg^{\star}b$ - closed in X. Also $C \cup D$ is $sg^{\star}b$ - closed in X. Therefore $\alpha^{-1}(F)$ is $sg^{\star}b$ - closed in X. Hence α is $sg^{\star}b$ - continuous. □

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