CONTRA NANO α^*_{AS} CONTINUOUS FUNCTION IN NANO TOPOLOGICAL SPACE

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ABSTRACT

The purpose of this study is to introduce a new class of contra continuous function called Contra nano α^*_{AS}-continuous function in Nano topological spaces. Some of its properties are analysed. The equivalent condition for a function to be contra $N\alpha^*_{AS}$ -continuous function is established. Further Contra $N\alpha^*_{AS}$ -irresolute function is defined and few of its properties are discussed.

Keywords: Nano topological space, Nano contra continuous function, $N\alpha^*_{AS}$ -closed set, $N\alpha^*_{AS}$ -continuous function, $N\alpha^*_{AS}$ -irresolute function.

I.INTRODUCTION

The concept of topology was first developed in 17th century by Gottfried Leibniz. The concept of nano topology was introduced by Lellis Thivagar et all. We introduced $N\alpha^*_{AS}$ – closed set in nano topological space. $N\alpha^*_{AS}$ – closed map, open map, continuous and homeomorphism was also discussed in the previous papers and their properties were analysed. In this paper we introduce contra $N\alpha^*_{AS}$ – continuous and contra $N\alpha^*_{AS}$ – irresolute function, also some of their properties were discussed.

II.PRELIMINARIES

The following are the necessary concepts and definitions that are used in this work.

Definition 2.1:[1] Let U be a non-empty finite set of objects called the universe and R be an equivalence relation on U named as the indiscernibility relation. Elements belonging to the same equivalence class are said to be indiscernible with one another. The pair (U, R) is said to be the approximation space. Let $X \subseteq U$. Then,

1.The lower approximation of X with respect to R is the set of all objects, which can be for certain classified as X with respect to R and it is denoted by $L_R(X)$.

$L_R(X) = \bigcup_{x\in U}\{R(x): R(x) \subseteq X\}$, where R(x) denotes the equivalence class determined by $X \in U$.

2.The upper approximation of X with respect to R is the set of all objects, which can be possibly classified as X with respect to R and it is denoted by $U_R(X)$.

$U_R(X) = \bigcup_{x\in U} \{R(x): R(x)\cap X \neq \emptyset\}$.

3.The boundary region of X with respect to R is the set of all objects, which can be classified neither as X nor as not - X with respect to R and it is denoted by $B_R(X)$.

$B_R(X) = U_R(X) - L_R(X)$.

Definition 2.2:[1] Let U be the universe, R be an equivalence relation on U and $\tau_R(X) = \{U, \emptyset, U_R(X), L_R(X), B_R(X)\}$ where $X \subseteq U$. R(X) satisfies the following axioms:

1. U and $\emptyset \in \tau_R(X)$,

2. The union of the elements of any sub collection of $\tau_R(X)$ is in $\tau_R(X)$,

3. The intersection of the elements of any finite sub collection of $\tau_R(X)$ is in $\tau_R(X)$.

That is, $\tau_R(X)$ is a topology on U called the nano topology on U with respect to X. We call $(U,\tau_R(X))$ as the nano topological space. The elements of $\tau_R(X)$ are called as nano open sets. The complement of nano-open sets is called nano closed sets.

Remark 2.3:[1] If $\tau_R(X)$ is the nano topology on U with respect to X, then the set B = {U, ∅, $L_R(X)$, $B_R(X)$} is the basis for $\tau_R(X)$.

Definition 2.4:[1] A subset A of a nano topological space (U, $\tau_R(X)$) is called nano α^*_{AS} (briefly $N\alpha^*_{AS}$) closed sets if Nαcl(A) ⊆ Nint(V) whenever A ⊆ V and V is nano open.

Definition 2.5:[2] Let (U,τR(X)) and (V,σR(Y)) be a nano topological spaces. Then the function f :(U,τR(X))→(V,σR(Y)) is said to be nano continuous on U if the inverse image of every nano open set in V is nano open in U.

Definition 2.6:[2] A function f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) is called Nano α^*_{AS}-continuous (briefly $N\alpha^*_{AS}$ -continuous) if the inverse image of every Nano closed set in (V, $\sigma_R(Y)$) is $N\alpha^*_{AS}$-closed in (U, $\tau_R(X)$).

Definition 2.7:[4] A function f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) is called nano contra continuous if the inverse image of every nano open set in (V, $\sigma_R(Y)$) is nano closed set in (U, $\tau_R(X)$).

Definition 2.8:[5] A function f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) is called nano contra g - continuous if the inverse image of every nano open set in (V, $\sigma_R(Y)$) is nano g-closed set in (U, $\tau_R(X)$).

III.CONTRA $N\alpha^*_{AS}$ – CONTINUOUS

In this section, the notion of Contra $N\alpha^*_{AS}$ - continuous is introduced and its properties are investigated.

Definition 3.1: Let (U, $\tau_R(X)$) and (V, $\sigma_R(Y)$) be two nano topological spaces. A function f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) is called contra $N\alpha^*_{AS}$ - continuous if the inverse image of every nano open set in (V, $\sigma_R(Y)$) is $N\alpha^*_{AS}$ closed set in (U, $\tau_R(X)$).

Example 3.2: Let U= {a, b, c, d} with U/R = {{a}, {c}, {b, d}}. Let X= {a, b} ⊆ U and $\tau_R(X)$= {U, ∅. {a}, {b, d}, {a, b, d}}. Then $N\alpha^*_{AS}$ closed sets are = {U, ϕ,{c},{a ,c},{b ,c},{c, d},{a, b, c},{a ,c, d},{b, c, d}. Let V= {a, b, c, d} with V/R= {{a, b}, {c, d}}. Let Y= {a, b} ⊆V and $\sigma_R(Y)$ = {U, ∅. {a, b}}. Let f: U→V defined by f(a) = d, f(b) = c, f(c) = a, f(d) = b then $f^{-1}(a)$ = c, $f^{-1}(b)$ = d, $f^{-1}(c)$ = b, $f^{-1}(d)$ = a. Thus, the inverse image {a, b} in V i.e. $f^{-1}(a, b)$ = {c, d} which is a $N\alpha^*_{AS}$ closed set in U. Thus, f is contra $N\alpha^*_{AS}$ – continuous.

Theorem 3.3: Let U and V are any two Nano Topological spaces. Let f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$), f is contra $N\alpha^*_{AS}$ – continuous function if and only if inverse image of every Nano closed set in V is $N\alpha^*_{AS}$ open in U.

Proof: Let f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) and S be a Nano closed set in V. Since f is contra $N\alpha^*_{AS}$ – continuous function f^{-1}(V -S) = U - f^{-1}(S) is $N\alpha^*_{AS}$ closed in U. Hence f^{-1}(S) is $N\alpha^*_{AS}$ open set in V. Conversely, let S be a Nano open set in V. By assumption f^{-1}(V - S) is $N\alpha^*_{AS}$ open set. f^{-1}(V - S) = U - f^{-1}(S), f^{-1}(S) is $N\alpha^*_{AS}$ closed set in U. Hence f is Contra $N\alpha^*_{AS}$ - continuous function.

Theorem 3.4: Every Nano contra continuous function is contra $N\alpha^*_{AS}$ - continuous function.

Proof: Let f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) be a nano contra continuous function and S be a nano open set in V. Since f is nano contra continuous function f^{-1} (S) is closed set in U. Since every nano closed set is $N\alpha^*_{AS}$ closed f^{-1} (S) is $N\alpha^*_{AS}$ closed set in U. Hence f is contra $N\alpha^*_{AS}$ - continuous function.

Remark 3.5: The converse of the above theorem need not be true as shown in the following example.

Example 3.6: Let U= {a, b, c, d} with U/R = {{a}, {c}, {b, d}}. Let X= {a, b} ⊆ U and τ_R(X)= {U, ∅. {a}, {b, d}, {a, b, d}}. Then $N\alpha^*_{AS}$ closed sets are = {U, ϕ,{c},{a ,c},{b ,c},{c, d},{a, b, c},{a ,c, d},{b, c, d}. Let V= {a, b, c, d} with V/R= {{a, b}, {c, d}}. Let Y= {a, b} ⊆V and σ_R(Y) = {U, ∅. {a, b}}. Let f: U→V defined by f(a) = d, f(b) = c, f(c) = a, f(d) = b then f^{-1}(a) = c, f^{-1}(b) = d, f^{-1}(c) = b, f^{-1}(d) = a. Thus, the inverse image {a, b} in V i.e. f^{-1}(a, b) = {c, d} which is a $N\alpha^*_{AS}$ closed set in U. Thus, f is contra $N\alpha^*_{AS}$ – continuous. But {c, d} is not a nano closed set in U. Thus, f is not nano contra continuous function.

Theorem 3.7: Every nano contra α - continuous function is contra $N\alpha^*_{AS}$ - continuous function.

Proof: Let f: (U, τ_R(X)) → (V, σ_R(Y)) be a nano contra α - continuous function and S be a nano open set in V. Then the inverse image of S under the map f is nano α – closed set in U. Since every nano α – closed set is $N\alpha^*_{AS}$ closed, f^{-1} (S) is $N\alpha^*_{AS}$ closed set in U. Hence f is contra $N\alpha^*_{AS}$ - continuous function.

Remark 3.8: The converse of the above theorem need not be true as shown in the following example.

Example 3.9: Let U= {a, b, c, d} with U/R = {{a}, {c}, {b, d}}. Let X= {a, b} ⊆ U and τ_R(X)= {U, ∅. {a}, {b, d}, {a, b, d}}. Then $N\alpha^*_{AS}$ closed sets are = {U, ϕ,{c},{a ,c},{b ,c},{c, d},{a, b, c},{a ,c, d},{b, c, d}. Let V= {a, b, c, d} with V/R= {{a, b}, {c, d}}. Let Y= {a, b} ⊆V and σ_R(Y) = {U, ∅. {a, b}}. Let f: U→V defined by f(a) = d, f(b) = c, f(c) = a, f(d) = b then f^{-1}(a) = c, f^{-1}(b) = d, f^{-1}(c) = b, f^{-1}(d) = a. Thus, the inverse image {a, b} in V i.e. f^{-1}(a, b) = {c, d} which is a $N\alpha^*_{AS}$ closed set in U. Thus, f is contra $N\alpha^*_{AS}$ – continuous. But {c, d} is not a nano α- closed set in U. Thus, f is not nano contra α- continuous function.

Theorem 3.10: Let U and V are any two Nano Topological spaces. Let f: (U, τ_R(X)) → (V, σ_R(Y)) be nano contra continuous function. f is nano contra g - continuous iff it is contra $N\alpha^*_{AS}$ -continuous function.

Proof: Necessity: Let f: (U, τ_R(X)) → (V, σ_R(Y)) be a nano contra g - continuous function and S be a nano open set in V. Then the inverse image of S under the map f is nano g – closed set in U. We know that a set is nano g– closed set iff it is $N\alpha^*_{AS}$ closed, f^{-1} (S) is $N\alpha^*_{AS}$ closed set in U. Hence f is contra $N\alpha^*_{AS}$ - continuous function.

Sufficient: Assume f is contra $N\alpha^*_{AS}$-continuous. Let S be any Nano open set in (V, σ_R(Y)). Then f^{-1}(S) is $N\alpha^*_{AS}$- closed in (U, τ_R(X)). Since [6] A set is Nano g-closed set iff it is $N\alpha^*_{AS}$-closed. Then, f^{-1}(S) is Ng-closed in (U, τ_R(X)). Therefore, f is contra Ng-continuous.

Theorem 3.11: Every nano contra gα - continuous function is contra $N\alpha^*_{AS}$ - continuous function.

Proof: Let f: (U, τ_R(X)) → (V, σ_R(Y)) be a nano contra gα - continuous function and S be a nano open set in V. Then the inverse image of S under the map f is nano gα – closed set in U. Since every nano gα – closed set is $N\alpha^*_{AS}$ closed, f^{-1} (S) is $N\alpha^*_{AS}$ closed set in U. Hence f is contra $N\alpha^*_{AS}$ - continuous function.

Remark 3.12: The converse of the above theorem need not be true as shown in the following example.

Example 3.13: Let U= {a, b, c, d} with U/R = {{a, b}, {c, d}}. Let X= {a, b} ⊆ U and $\tau_R(X)$= {U, ∅, {a, b}}. Let V= {a, b, c, d} with V/R={{b}, {c}, {a, d}}. Let Y= {a, c} ⊆V and $\sigma_R(Y)$= {U, ∅, {c}, {a, d}, {a, c, d}. Let f: U→V defined by f(a) = b, f(b) = a, f(c) = d, f(d) = c then $f^{-1}(a)$ = b, $f^{-1}(b)$ = a, $f^{-1}(c)$ = d, $f^{-1}(d)$ = c. Then f is contra $N\alpha^*_{AS}$ -continuous but not contra nano gα-continuous.

Theorem 3.14: Let U and V are any two Nano Topological spaces. Let f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) be nano contra continuous function. f is nano contra αg - continuous iff it is contra $N\alpha^*_{AS}$ -continuous function.

Proof: Necessity: Let f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) be a nano contra αg - continuous function and S be a nano open set in V. Then the inverse image of S under the map f is nano αg – closed set in U. We know that a set is nano αg– closed set iff it is $N\alpha^*_{AS}$ closed, f^{-1} (S) is $N\alpha^*_{AS}$ closed set in U. Hence f is contra $N\alpha^*_{AS}$ - continuous function.

Sufficient: Assume f is contra $N\alpha^*_{AS}$-continuous. Let S be any Nano open set in (V, $\sigma_R(Y)$). Then $f^{-1}(S)$ is $N\alpha^*_{AS}$- closed in (U, $\tau_R(X)$). Since, [6] A set is Nano αg-closed set iff it is $N\alpha^*_{AS}$-closed. Then, $f^{-1}(S)$ is Nαg-closed in (U, $\tau_R(X)$). Therefore, f is contra Nαg-continuous.

Theorem 3.15: Every nano contra g* - continuous function is contra $N\alpha^*_{AS}$ - continuous function.

Proof: Let f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) be a nano contra g* - continuous function and S be a nano open set in V. Then the inverse image of S under the map f is nano g* – closed set in U. Since every nano g* – closed set is $N\alpha^*_{AS}$ closed, f^{-1} (S) is $N\alpha^*_{AS}$ closed set in U. Hence f is contra $N\alpha^*_{AS}$ - continuous function.

Remark 3.16: The converse of the above theorem need not be true as shown in the following example.

Example 3.17: Let U= {a, b, c, d} with U/R = {{a, b}, {c, d}}. Let X= {a, b} ⊆ U and $\tau_R(X)$= {U, ∅, {a, b}}. Let V= {a, b, c, d} with V/R={{b}, {c}, {a, d}}. Let Y= {a, c} ⊆V and $\sigma_R(Y)$= {U, ∅, {c}, {a, d}, {a, c, d}. Let f: U→V defined by f(a) = b, f(b) = a, f(c) = d, f(d) = c then $f^{-1}(a)$ = b, $f^{-1}(b)$ = a, $f^{-1}(c)$ = d, $f^{-1}(d)$ = c. Then f is contra $N\alpha^*_{AS}$ -continuous but not contra nano g*-continuous.

Remark 3.18: The composition of two contra N α^*_{AS} -continuous need not always be a contra N α^*_{AS} - continuous as seen from the following example.

Example 3.19: Let (U, $\tau_R(X)$), (V, $\sigma_R(Y)$) and (W, $\lambda_R(Z)$) be three nano topological spaces where U=V=W={a, b, c, d} then the nano open sets are $\tau_R(X)$= {U,∅,{a},{b, d},{a, b, d}}, $\sigma_R(Y)$ = {V,∅,{a, b}} and $\lambda_R(Z)$ = {W,∅,{c},{a, d},{a, c, d}}. Define two functions f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) and g: (V, σ_R (Y)) → (W, ($\lambda_R(Z)$). Clearly these two functions are contra N α^*_{AS} - continuous. But their composition g ₒ f: (U, $\tau_R(X)$) → (W, $\lambda_R(Z)$) is not contra N α^*_{AS} - continuous because for the nano open set {c} in (W, λ_R (Z)), $(g \circ f)^{-1} = f^{-1}(g^{-1}(c)) = f^{-1}(d)$ = {a} is not N α^*_{AS} – closed in (U, $\tau_R(X)$). Hence g ₒ f: (U, $\tau_R(X)$) → (W, $\lambda_R(Z)$) is not contra N α^*_{AS-} continuous. Thus, the composition of two contra N α^*_{AS} -continuous need not always be a contra N α^*_{AS} - continuous.

Remark 3.20: Contra N α^*_{AS} – continuous and N α^*_{AS} – continuous are independent.

Example 3.21: Let U = {a, b, c, d} with U/R = {{a, b}, {c, d}}. Let X= {a, b} ⊆ U and $\tau_R(X)$= {U, ∅, {a, b}}. Let V= {a, b, c, d} with V/R= {{b, {c}, {a, d}}. Let Y= {a, c} ⊆V and σ_R(Y)={U, ∅, {c}, {a, d}, {a, c, d}.Then nano closed set = { U, ∅, {c, d}}. Let f: U→V defined by f(a) = c, f(b) = d, f(c) = b, f(d) = a then f^{-1}(a) = d, f^{-1}(b) = c, f^{-1}(c) = a, f^{-1}(d) = b. Then f is Nα*$_{AS}$ - continuous. Since f^{-1}{c} = {a} is not Nα*$_{AS}$ closed set in U, f is not contra Nα*$_{AS}$ – continuous function.

Example 3.22: Let U= {a, b, c, d} with U/R = {{a}, {c}, {b, d}}. Let X= {a, b} ⊆ U and τ_R(X)= {U, ∅. {a}, {b, d}, {a, b, d}}. Then Nα*$_{AS}$ closed sets are = {U, ϕ,{c},{a ,c},{b ,c},{c, d},{a, b, c},{a ,c, d},{b, c, d}. Let V= {a, b, c, d} with V/R= {{a, b}, {c, d}}. Let Y= {a, b} ⊆V and σ_R(Y) = {U, ∅. {a, b}}. Then nano closed sets are = {U, ∅. {c,d}}. Let f: U→V defined by f(a) = d, f(b) = c, f(c) = a, f(d) = b then f^{-1}(a) = c, f^{-1}(b) = d, f^{-1}(c) = b, f^{-1}(d) = a. Thus, the inverse image {a, b} in V i.e. f^{-1}{a, b} = {c, d} which is a Nα*$_{AS}$ closed set in U. Thus, f is contra Nα*$_{AS}$ – continuous. But f^{-1}{c, d} = {a, b} is not a Nα*$_{AS}$ closed set in U. Thus, f is not Nα*$_{AS}$ – continuous.

IV.CONTRA Nα*$_{AS}$ – IRRESOLUTE FUNCTION

In this section we introduce Contra Nα*$_{AS}$ - irresolute function and discuss some of its properties.

Definition 4.1: Let (U, τ_R(X)) and (V, σ_R(Y)) be two nano topological spaces. A function f: (U, τ_R(X)) → (V, σ_R(Y)) is called contra Nα*$_{AS}$ - irresolute if the inverse image of every Nα*$_{AS}$ closed(open) set in (V, σ_R(Y)) is Nα*$_{AS}$ closed(open) set in (U, τ_R(X)).

Example 4.2: Let U= {a, b, c, d} with U/R = {{a, {c}, {b, d}}. Let X= {a, b} ⊆ U and τ_R(X)= {U, ∅. {a}, {b, d}, {a, b, d}}. Then Nα*$_{AS}$-closed = {U, ∅, {c}, {a, c}, {b, c}, {c, d}, {a, b, c}, {a, c, d}, {b ,c, d}}. Let V= {a, b, c, d} with V/R={{b}, {c}, {a, d}}. Let Y= {a, c} ⊆V and σ_R(Y) = {U, ∅, {c}, {a, d}, {a, c, d}}.Then Nα*$_{AS}$ closed set = {U, ∅, {b}, {a, b}, {b, c}, {b, d}, {a, b, c}, {a, b, d}, {b, c, d}}. Let f: U→V defined by f(a) = a, f(b) = d, f(c) = b, f(d) = c then f^{-1}(b) = c, f^{-1}{a, b} = {a, c} f^{-1}{b, c}= {c, d}, f^{-1}{b, d}= {b, c}, f^{-1}{a, b, c}= {a, c, d}, f^{-1}{a, b, d}= {a, b, c}, f^{-1}{b, c, d}= {b, c, d}. The inverse image of every Nano Nα*$_{AS}$-closed set in (V, σ_R(Y)) is Nα*$_{AS}$-closed in (U, τ_R(X)). Then f is contra Nα*$_{AS}$ - irresolute.

Theorem4.3: In a nano topological space, the composition of two contra Nα*$_{AS}$ - irresolute functions is also a contra Nα*$_{AS}$ - irresolute function.

Proof: Consider the contra Nα*$_{AS}$ - irresolute functions f: (U, τ_R(X)) → (V, σ_R(Y)) and g: (V, σ_R(Y) → (W, λ_R(Z)). Claim, g∘f: (U, τ_R(X)) → (W, λ_R(Z)) is a contra Nα*$_{AS}$ irresolute function. As g is considered to be a contra Nα*$_{AS}$ -irresolute function, by definition for every Nα*$_{AS}$ - closed set S of (W, λ_R(Z)), g−1(S) is a Nα*$_{AS}$ -closed set in (V, σ_R(Y)). Since f is Nα*$_{AS}$ -irresolute, $f^{-1}(g^{-1}(S))$ is Nα*$_{AS}$ - closed in (U, τ_R(X)). Hence (g∘f) is a contra Nα*$_{AS}$- irresolute.

Theorem 4.4: In a nano topological space, the composition of two contra Nα*$_{AS}$ - irresolute function is Nα*$_{AS}$ – irresolute function.

Proof: Consider the contra Nα*$_{AS}$ - irresolute functions f: (U, τ_R(X)) → (V, σ_R(Y)) and g: (V, σ_R(Y) → (W, λ_R(Z)). Claim, g∘f: (U, τ_R(X)) → (W, λ_R(Z)) is a Nα*$_{AS}$ irresolute function. Let S be a Nα*$_{AS}$ - open set in W. g-1(S) is a Nα*$_{AS}$ -closed set in V, since g is contra Nα*$_{AS}$ -irresolute function. Since f is also contra Nα*$_{AS}$ - irresolute, $f^{-1}(g^{-1}(S))$ is Nα*$_{AS}$ -closed in U. Hence (g∘f) is a Nα*$_{AS}$- irresolute function.

Theorem 4.5: Every contra Nα*$_{AS}$ - irresolute function is contra Nα*$_{AS}$ - continuous function.

Proof: Let f: (U, $\tau_R(X)$) → (V, $\sigma_R(Y)$) be a Contra Nα*$_{AS}$ -irresolute function. Let S a nano closed set in V. S is Nα*$_{AS}$ - closed in V, since every nano closed set is Nα*$_{AS}$ – closed. Hence $f^{-1}(S)$ is Nα*$_{AS}$ - open in U. Hence f is contra Nα*$_{AS}$ -continuous function.

Remark 4.6: Every contra Nα*$_{AS}$ - continuous function need not be contra Nα*$_{AS}$ - irresolute function as shown in the following example.

Example 4.7: Let U={a,b,c,d} with U/R = {{a,b},{c,d}}. Let X={a,b} ⊆ U and $\tau_R(X)$= {U,∅,{a,b}}. Let V={a,b,c,d} with V/R={{b},{c},{a,d}}. Let Y={a,c}⊆V and $\sigma_R(Y)$={U,∅,{c},{a,d}, {a,c,d}.Then nano closed set = { U,∅,{c,d}}. Let f: U→V defined by f(a) = c, f(b) = d, f(c) = b, f(d) = a then $f^{-1}(a)$ = d, $f^{-1}(b)$ = c, $f^{-1}(c)$ = a, $f^{-1}(d)$ = b. Then f is contra Nα*$_{AS}$ -continuous but not contra Nα*$_{AS}$ -irresolute.

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