On *Certain New Generalised* Closed set in Ideal Nano Topological Spaces

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Abstract
The purpose of this paper is to introduce some new classes of sets namely $\bar{\rho}gI$ - Closed set and $\bar{\rho}gI$ -Open sets in Ideal Nano topological space and investigate some basic topological properties and its characterizations. Also the relationship between these sets with some of the known closed sets are studied and analyzed.

Keywords: $\bar{\rho}gI$ - Closed set, $\bar{\rho}gI$ - Open set.

Introduction
Topological space is a set endowed with a structure called a topology. In 1930 we introduce the concept of Ideals in topological space. In 2013, Lellis Thivagar and Carmel Richard [8] established the field of nano topological spaces which was defined in terms of approximation and boundary region of a subset of an universe using an equivalence relation on it and also defined nano closed sets, nano interior and nano closure. K. Bhuvaneswari et al. [6] introduced and studied the concept of nano generalised closed sets in nano topological spaces. [18] J. Arul Jesti and J. Joycy Renuka introduced the concept of NIg semi*-closed sets in Nano Ideal topological space.
In this paper we introduce a new type of $\bar{\rho}gI$ -closed set and $\bar{\rho}gI$ - open set in Ideal Nano topological space and investigated the relationships between these sets in Nano topological spaces and Ideal Nano topological spaces. Characterizations and properties of $\bar{\rho}gI$ - closed set and $\bar{\rho}gI$ - open set are also studied.

1. Preliminaries
Definition 1.1 [8]
Let U be the universe, R be an equivalence relation on U and
τR(X) = {U, ϕ, LR(X), UR(X), BR(X)}, where X ⊆ U and τR(X) satisfies the following axioms
i) U and ϕ ∈ τR(X) .
ii) The union of the elements of any sub-collection of τR(X) is in τR(X).
iii)The intersection of the elements of any finite sub collection of τR(X) is in τR(X). Therefore, τR(X) as the nano topological space. The elements of τR(X) are called nano open sets(briefly n-open sets). The complement of a nano open set is called a nano closed set(briefly n-closed set)
Definition 1. 2[18] A nano topological space (U,N) with an ideal I on U is called an ideal nano topological space or nano ideal topological space and is denoted by (U,I,N).
Definition 1. 3[16]
Let (U, N, I) be a nano ideal topological space U, where N = τR(X) and $(.)_n{}^*$ be a set operator from P(U) → P(U). (P(U) is the set of all subsets of U). For a subset H ⊂ U, H_n^* (I,N) ={x ∈U: Gn ∩ H ∉ I, for every Gn ∈ Gn(x)}, where Gn(x) = {Gn | x ∈ Gn, Gn ∈ N} is called the nano local function (briefly, n-local function) of H with respect to I and N.
We simply write H_n^* for H_n^* (I,N). The set operator n-cl is called a nano*-closure and is defined as n-cl^*(H) = H∪H_n^* for H ⊆ X.
Definition 1.5 A subset A of a nano ideal topological space (U, N, I) is said to be
i) NIg semi*-closed if A_n^* ⊆ V whenever A ⊆ V and V is nano semi*-open [18]
ii) NI_g-closed if A_n^* ⊆ V whenever A ⊆ V and V is nano-open [5]
iii) $NI_{\hat{g}}$-closed if $(A^*)^N$ ⊆ V whenever A ⊆ V and V is nano semi-open [13]
iv)$NI_{\hat{g}\alpha}$-closed if NαIcl(A) ⊆ V whenever A ⊆ V and V is $NI_{\hat{g}}$-open [12]
v) $NI_{g\alpha}$-closed if NIαcl(A) ⊆ V whenever A ⊆ V, V is nano open [5]

vi) $*^N$ -closed if $(A)^{*N} \subseteq$ A [14]

Theorem 1.6 [18]
1) If (U,N,I) is a nano topological space with an ideal I and $A \subseteq A^*_n$,
then A^*_n= n-cl(A^*_n) = n-cl(A).
2) Every N_g closed set is NIg semi*-closed set.
3) Every nano semi open set is NIg semi*-open set.
Definition 1.7 [15] A subset A of a nano ideal topological space (U,N,I) is
n* dense itself(resp. n*-perfect and n*-closed)
if $A \subseteq A^*_n$(resp. $A = A^*_n$, $A^*_n \subseteq A$).

2. On $\bar{\rho}gI$ – Closed set in Ideal Nano Topological Space

Definition 2.1
A subset H of an Ideal Nano topological space *(U, I, N)* is said to be $\bar{\rho}gI$ - closed if $H^*_n \subseteq V$ whenever
$H \subseteq V$ and V is NIg semi* open.
Example 2.2 Let U = {a,b,c,d}, X = {a,b} ⊂ U and I = {ϕ, {a}}.
τ_R(X) = {U, ϕ, {a},{a,c,d},{c,d}},
$\bar{\rho}gI$cl*(U, I, N)* = {U,ϕ,{a},{b},{a,b},{b,c},{b,d},{a,b,c},{a,b,d},{b,c,d}.
Theorem 2.3 Every n*closed set is $\bar{\rho}gI$ – Closed but not conversely.
Proof : Let $H \subseteq X$ and H be n*closed set. Assume $H \subseteq V$ and V is NIg semi*-open. Since H is n*-closed,
$H^*_n \subseteq H$ also $H^*_n \subseteq H \subseteq V$. Therefore $H^*_n \subseteq V$
Hence H is $\bar{\rho}gI$ – Closed.
Example 2.4 Let U = {a,b,c,d}, X = {a,c} ⊂ U and I = {ϕ, {b,c}}.
$\bar{\rho}gI$cl*(U, I, N)* = {U,ϕ,{b},{a,b},{b,c},{b,d},{a,b,c},{a,b,d},{b,c,d}}.
n*-closed set = {ϕ, U, {a,b}}. The set {b,d} is $\bar{\rho}gI$ – closed but not n*-closed.

Theorem 2.5 Every N_g-closed set is $\bar{\rho}gI$ - closed.
Proof : Suppose H is N_g-closed. Let V be any nano-open set containing H.
By theorem 1.6(2), V is NIg semi*-open set Containing H. Also H is N_g-closed
we have ncl(H) ⊆ V. By1.6(1), H^*_n= ncl(H^*_n) = ncl(H) ⇒ H^*_n = ncl(H) ⊆ V
⇒ $H^*_n \subseteq V$. Thus H is $\bar{\rho}gI$- closed
Remark: The converse of the above theorem need not be true as given
in the following example. In Example 2.2 and
$N_g$cl*(U, I, N)*= {U, ϕ,{b},{a,b},{b,c},{b,d},{a,b,c},{a,b,d},{b,c,d}}.
The set {a} is $\bar{\rho}gI$- closed set but not Ng-closed set.

Theorem 2.6 Every $NI_{\hat{g}}$-closed set is $\bar{\rho}gI$- closed but not reversely.
Proof : Given H is $NI_{\hat{g}}$-closed and H ⊆ V where V is nano semi open.
Since by theorem[1.6(3)], V is NIg semi*open in H.
Therefore ${H_n}^* \subseteq$ V. Hence H is $\bar{\rho}gI$- closed.
Example 2.7 Let U = {a,b,c,d}, X = {c} ⊂ U and I = {ϕ, {c}}.
$\bar{\rho}gI$- closed set = {U,ϕ,{a}, {b},{c}, {a,c}, {a,b},{b,c},{a,b,c},{a,c,d},{b,c,d}}.
$NI_{\hat{g}}$cl*(U, I, N)*= {U,ϕ,{c},{a,b},{b,c},{a,b,c},{a,b,d}}.
Cleary the set {a,c,d} is $\bar{\rho}gI$- closed but it is not $NI_{\hat{g}}$-closed.

Theorem 2.8 Every $NI_{\hat{g}\alpha}$-closed set is $\bar{\rho}gI$- closed but not conversely.
Proof: Let H be $NI_{\hat{g}\alpha}$-closed. Since every $NI_{\hat{g}\alpha}$-closed set is $NI_{\hat{g}}$-closed. Therefore Nα*Icl*(H) ⊆
Ncl(H) ⊆ V. Also by definition 1.5 [vi],
we have $H^*_n \subseteq$ H = ncl(H) ⊆ V this implies that $H^*_n \subseteq V$.
In example 2.4 and $NI_{\hat{g}\alpha}$cl*(U,I,N)* = {U,ϕ,{a},{b},{a,c},{a,b},{b,c}{a,c,d},{a,b,c},{b,c,d}}.
The set {b,d} is $\bar{\rho}gI$- closed but not $NI_{\hat{g}\alpha}$-closed.

Theorem 2.9 Every $NI_{g\alpha}$-closed set is $\bar{\rho}gI$- closed but not conversely.
Proof: Given that H is $NI_{g\alpha}$-closed set we have NIαcl(H) ⊆ V where H ⊆ V,
V is nano open set, By theorem 1.6(3), V is NIg semi*-open set containing H. Also H^*_n = ncl(H)
⇒ H^*_n ⊆ NIαcl(H) ⊆ V

$\Rightarrow H_n^* \subseteq V$.
Thus H is $\bar{\rho}gI$- closed.
Example: In example 2.7, $NI_{g\alpha}$-closed set = {U,ϕ,{a},{b},{a,c},{a,b},{a,d},{b,c},{b,d},{a,b,d}, {a,c,d},{a,b,c},{b,c,d}}.
The set {c} is $\bar{\rho}gI$- closed but it is not $NI_{g\alpha}$-closed set.
Theorem 2.10 Every Nano I-closed set is $\bar{\rho}gI$- closed but not conversely.
Proof: Let H be Nano I-closed and V be NIg semi*-open in H.
By theorem 1.6(1), H_n^* = ncl(H_n^*) = ncl(H)
Take H ⊆ V , H_n^* = ncl(H_n^*) ⊆ H.
$H_n^* \subseteq H \subseteq V$. Thus H is $\bar{\rho}gI$- closed.
In example 2.7 & NI-closed set = {U,ϕ,{a},{b},{c},{a,c},{a,b},{a,d},{b,c},{a,b,c}}.
The set {a,c,d} is $\bar{\rho}gI$- closed but not NI-closed.

Theorem 2.11 If H is ng closed iff H is $\bar{\rho}gI$- closed. Where I = {ϕ} in *(U, I, N).*
Proof: Let I = {ϕ}, H be ng-closed. ⇔ $H_n^* \subseteq H \subset$ ncl(H) also every subset of V is n*dense in itself. Hence proved.

Theorem 2.12 Every Nano closed set is $\bar{\rho}gI$- closed but not conversely.
Proof: Let H be nano-closed set and H ⊆ V. where V is NIg semi*-open in H. Since H is nano -closed we have ncl(H) = H. But $H_n^* \subseteq$ ncl(H) = H ⊆ V
$\Rightarrow H_n^* \subseteq V$. Hence proved.
Example 2.13 Let U = {a,b,c,d}, X = {a,d} ⊂ U and
$\tau_R(X)$ = {U, ϕ, {d},{a,c},{a,c,d}},
$\bar{\rho}gI$- closed set = {U,ϕ, {b},{d},{a,b},{b,c},{b,d},{a,b,c},{a,b,d},{b,c,d}}.
Cleary the set {a,b,d} is $\bar{\rho}gI$- closed but not Nano-closed.
Theorem 2.14 A subset H of U in a space *(U, I, N)* is $\bar{\rho}gI$- closed iff ncl*(H) ⊆ V whenever H ⊆ V and V is NIg semi*-open.
Proof: Let H ⊆ V where V is NIg semi*-open.
Since H is $\bar{\rho}gI$- closed we have $H_n^* \subseteq V$.Thus H ⊆V and $H_n^* \subseteq V$
$\Rightarrow$ ncl(H_n^*) = H ∪ H_n^* ⊆ V. This proves necessary part.
Conversely, Suppose H ⊆ V where V is NIg semi*-open by assumption,
ncl*(H)⊆ V ⇒ H ∪ H_n^* ⊆ V ⇒ H_n^* ⊆ V. Hence H is $\bar{\rho}gI$- closed.
Remark: The intersection of two $\bar{\rho}gI$- closed set is need not be $\bar{\rho}gI$- closed as seen in the following:
Example 2.15 Let U = {a,b,c,d}, I = {ϕ, {c}} and
$\bar{\rho}gI$- closed set = {U,ϕ, {a},{b},{c},{a,b},{a,c},{b,c},{a,b,c},{a,c,d},{b,c,d}}.
Cleary the set {a,c,d}∩ {b,c,d} = {c,d} is not in $\bar{\rho}gI$- closed.
Theorem 2.16 If H and K are $\bar{\rho}gI$- closed set then H ∪ K is also $\bar{\rho}gI$- closed.
Proof. Given H and K are $\bar{\rho}gI$- closed set. Then $H_n^* \subseteq V$ where H ⊆ V and V is NIg semi*-open and $K_n^* \subseteq V$ where K ⊆ V and V is NIg semi*-open. Since H and K are subsets of V, ($H_n^* \cup K_n^*$) = $(H \cup K)_n^*$ is a subset of V and V is NIg semi*-open. Hence H ∪ K is $\bar{\rho}gI$- closed.

Theorem 2.17 If H ⊆ X, then H is $\bar{\rho}gI$ - closed iff n-cl*(H) ⊆ V whenever H ⊆ V and V is NIg semi*-open in V.
Proof : Assume H is a $\bar{\rho}gI$ - closed, we have $H_n^* \subseteq V$ where H ⊆ V and V is NIg semi*- open in U. Now n-cl*(H) = (H ∪ H_n^*) ⊆ V whenever H ⊆ V and V is NIg semi*-open.
Conversely, Let H ⊆ V and V be NIg semi*-open in U. By hypothesis n-cl*(H) ⊆ V.
Since n-cl*(H) = (H ∪ H_n^*), we have $H_n^* \subseteq V$.
Theorem 2.18 If (U, I, N) is any ideal nano topological space and H ⊆ U, then the following are equivalent.
1. H is $\bar{\rho}$gI – closed
2. n-cl*(H) ⊆ V whenever H ⊆ V and V is NIg semi*-open in U
3. For all h ∈ n-cl*(H), NIg semi*cl({h}) ∩ H ≠ ϕ
4. n-cl*(H) - H contains no nonempty NIg semi*-closed set
5. H_n^*- H contains no nonempty NIg semi*-closed set

Proof: (1) ⇒ (2) If H is $\bar{\rho}$gI - closed, then $H_n^* \subseteq V$ whenever H ⊆ V and
V is NIg semi*-open in U and so n-cl*(H) = H ∪ H_n^* ⊆ V whenever H ⊆ V and
V is NIg semi*-open in U.
(2) ⇒ (3) Suppose h ∈ n-cl*(H). If NIg semi*cl({h}) ∩ H = ϕ ,
then H ⊆ U- NIg semi*cl({h}). By (2), n-cl*({h}) ⊆ U - NIg semi*cl({h}) and
hence n-cl*(H) ∩ {h} = ϕ , a contradiction, since h ∈ n-cl*(H).

(3) ⇒ (4) Suppose F ⊆ n-cl*(H) - H, H is NIg semi*closed and h ∈ H.
Since H ⊆ U - H, F ∩ H = ϕ. We have NIg semi* cl({h}) ∩ H = ϕ
because H is NIg semi*-closed and h ∈ H. From (3), which is a contradiction. Therefore n-cl*(H) - H contains no nonempty NIg semi*-closed.
(4) ⇒ (5) Since n-cl*(H) - H =(H ∪ H_n^*) - H = (H ∪ H_n^*) ∩ H^c= (H ∩ H^c) ∪ (H_n^* ∩ H^c) = H_n^* - H. Therefore H_n^* - H contains no nonempty NIg semi*-closed set.
(5) ⇒ (1) Let H ⊆ V where V is NIg semi*-open set. Therefore U - V ⊆ U - H
and so H_n^* ∩ (U - V) ⊆ H_n^* ∩ (U - H) = H_n^* ∩ H^c = H_n^* - H.
Therefore H_n^* ∩ (U -V) ⊆ H_n^* - H. Since H_n^* is always n-closed set,
so H_n^* is NIg semi*-closed and so H_n^* ∩ (U -V) is a NIg semi*-closed set
contained in H_n^* - H. Therefore H_n^* ∩ (U - V) = ϕ and hence H_n^* ⊆ V.
Therefore H is NIg semi*-closed.

Theorem 2.19 Let H ⊆ U is an $\bar{\rho}gI$ - closed set then the followings are hold
1. H is an n*-closed set.
2. n-cl*(H) - H is NIg semi*-closed set.
3. H_n^* - H is NIg semi*-closed set.
Proof: (1) ⇒ (2) If H is n*-closed, then H_n^* ⊆ H and so n-cl*(H) - H = ϕ.
Therefore n-cl*(H) - H is NIg semi*-closed.
(2) ⇒ (3) since n-cl*(H) - H = H_n^* - H, it is clear.
(3) ⇒ (1) If H_n^* - H is NIg semi*-closed set and H is NIg semi*-closed set,
by theorem [3.18] H_n^*-H = ϕ and so H is n*-closed.

Theorem 2.20 Every subset of U is $\bar{\rho}gI$ - closed set iff every NIg semi*-open set is n*- closed.
Proof: suppose every subset of U is $\bar{\rho}gI$ - closed. If M ⊆ U, U is NIg semi*-open then M is $\bar{\rho}gI$ - closed and M_n^* ⊆ M. Hence M is n*-closed.
Conversely, Suppose that every NIg semi*-open set is n*-closed. If M is NIg semi*-open set such that H ⊆ M ⊆ U then H_n^*⊆ M_n^* ⊆ M and so H is $\bar{\rho}gI$ - closed.

Theorem 2.21 Let *(U, I, N)* be an ideal nano topological space and H ⊆ S.
Then H is $\bar{\rho}gI$ - closed iff H = F - M where F is n*-closed and M contains no nonempty NIg semi* closed set.
Proof: If H is $\bar{\rho}gI$ - closed, then M = H_n^* - H contains no nonempty NIg semi*-closed set. If F = ncl*(H), then F is n*-closed such that
F - M = (H ∪ H_n^*) - (H_n^* - H)
= (H ∪ H_n^*) ∩ (H_n^* ∩ $H^c)^c$ = (H ∪ H_n^*) ∩ (($H_n^*)^c$∪ H)
= H ∪ ((H_n^* ∩ H^c $)^c$ ∩ ($H_n^*)^c$) = H.
Conversely, suppose H = F - M where F is n*-closed and M contains no nonempty NIg semi*-closed set. Let V be NIg semi*-open set such that H ⊆ V.
Then F - M ⊆ V ⇒ F ∩ (U - V) ⊆ M. Now H ⊆ F and F_n^*⊆ F then H_n^* ⊆ F_n^* and so
H_n^* ∩ (U - V) ⊆ F_n^* ∩ (U - V) ⊆ F ∩ (U - V) ⊆ M. since H_n^* ∩ (U -V) is NIg semi*-closed, H_n^* ∩ (U - V) = ϕ so that H_n^* ⊆ V. Hence H is $\bar{\rho}gI$ – closed.

3. On $\bar{\rho}gI$ – Open set in Ideal Nano Topological Space

Definition 3.1
A subset H of an ideal nano topological space is called $\bar{\rho}gI$ – Open if its complement of $\bar{\rho}gI$ – closed set in *(U, I, N)*.
Theorem 3.2 Let *(U, I, N)* be an Ideal nano topological space then following statements are hold
i) Every Nano- open set is $\bar{\rho}gI$ – Open
ii) Every NanoI- open set is $\bar{\rho}gI$ – Open
iii) Every n*open set is $\bar{\rho}gI$ – Open
iv) Every N_g open set is $\bar{\rho}gI$ – Open
v) Every $NI_{\hat{g}}$ open set is $\bar{\rho}gI$ – Open
vi) Every $NI_{\hat{g}\alpha}$ open set is $\bar{\rho}gI$ – Open
vii) Every $NI_{g\alpha}$ open set is $\bar{\rho}gI$ – Open
Proof:
i) Let H be a nano-open then H^c is nano-closed.

By theorem[2.12], H^c is $\bar{\rho}gI$ – closed. Thus H is $\bar{\rho}gI$ – open.
ii) Given that H be a nanoI-open then H^c is nanoI-closed.
By theorem[2.10], H^c is $\bar{\rho}gI$ – closed. Thus H is $\bar{\rho}gI$ – open.
iii) Let H be a n*-open, then H^c is n*-closed.
By theorem[2.3], H^c is $\bar{\rho}gI$ – closed. Thus H is $\bar{\rho}gI$ – open.
iv) Assume that H is N_g -open. Then H^c is N_g-closed.
By theorem[2.5], H is $\bar{\rho}gI$ – open.
v) Let H be a $NI_{\hat{g}}$ open set. Then H^c is $NI_{\hat{g}}$-closed.
By theorem[2.6], H is $\bar{\rho}gI$ – open.
vi) Given that H is $NI_{\hat{g}\alpha}$ open. Then H^c is $NI_{\hat{g}\alpha}$-closed.
By theorem[2.8], H^c is $\bar{\rho}gI$ – closed. Thus H is $\bar{\rho}gI$ – open.
vii) Let H be $NI_{g\alpha}$ open. Then H^c is $NI_{g\alpha}$ -closed.
By theorem[2.9], H^c is $\bar{\rho}gI$ – closed. Hence H is $\bar{\rho}gI$ – open.
Remark : The converse of the above theorem is need not be true as shown in the examples [2.2, 2.4, 2.7, 2.13]

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