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# Factual power loss reduction by enriched black hole algorithm

**Kanagasabai Lenin**
Department of EEE, Prasad V. Potluri Siddhartha Institute of Technology,
Kanuru, Vijayawada, Andhra Pradesh, India

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**ABSTRACT**

This paper presents enriched black hole algorithm (EBHA) for solving optimal reactive power problem. In this work black hole algorithm based on membrane computing is projected. In black hole algorithm evolution of the population is through pushing the candidates in the course of the most excellent candidate in iterations and black hole which swap with those in the search space. Membrane computing is also branded as P system and it has multisets of objects with evolution rules in the membrane structure. Membrane structure is alike ingrained tree of section that demarcate the areas, and root is labelled as skin. Chemical substances (multisets of objects) are there inside the section (membranes) of a cell and the chemical reactions (evolution rules) that take place within the cell. Proposed enriched black hole algorithm (EBHA) has been evaluated in IEEE 14,300 bus test system. Loss reduction achieved.



***Corresponding Author:***

Kanagasabai Lenin
Department of EEE
Prasad V. Potluri Siddhartha Institute of Technology
Kanuru, Vijayawada, Andhra Pradesh, India
Email: gklenin@gmail.com

## 1. INTRODUCTION

Many methodologies and algorithms [1-16] have been applied to solve the Real power loss reduction problem. In this paper, enriched black hole algorithm (EBHA) has been applied to solve the problem. In this work black hole algorithm based on membrane computing is projected. In Black hole algorithm, evolution of the population is through pushing the candidates in the course of the most excellent candidate in iterations and black hole which swap with those in the search space. Excellent candidate amongst all the candidates in iterations is chosen as a black hole and remaining candidates structured as the standard stars. From the structure of the biological cell's membrane computing is planned by conceptual calculation of model from the hierarchy of the cells. Membrane computing is also branded as P system and it has multisets of objects with evolution rules in the membrane structure. Membrane structure is alike ingrained tree of section that demarcate the areas, and root is labelled as skin. Chemical substances (multisets of objects) are there inside the section (membranes) of a cell and the chemical reactions (evolution rules) that take place within the cell. Proposed enriched black hole algorithm (EBHA) validated in IEEE 14,300 bus system. Power loss reduction achieved.

## 2. RESEARCH METHOD

Objective function of the problem is;

$$F = P_L = \sum_{k \in Nbr} g_k \left(V_i^2 + V_j^2 - 2V_i V_j \cos\theta_{ij}\right) \quad (1)$$

$$F = P_L + \omega_v \times \text{VoltageDeviation} \quad (2)$$

$$\text{Voltage Deviation} = \sum_{i=1}^{Npq} |V_i - 1| \quad (3)$$

$$P_G = P_D + P_L \quad (4)$$

$$P_{gslack}^{min} \leq P_{gslack} \leq P_{gslack}^{max} \quad (5)$$

$$Q_{gi}^{min} \leq Q_{gi} \leq Q_{gi}^{max}, i \in N_g \quad (6)$$

$$V_i^{min} \leq V_i \leq V_i^{max}, i \in N \quad (7)$$

$$T_i^{min} \leq T_i \leq T_i^{max}, i \in N_T \quad (8)$$

$$Q_c^{min} \leq Q_c \leq Q_C^{max}, i \in N_C \quad (9)$$

## 3. ENRICHED BLACK HOLE ALGORITHM

In the black hole algorithm evolution of the population is through pushing the candidates in the course of the most excellent candidate in iterations and black hole which swap with those in the search space. Production of population is capricious and in the exploration space candidates, stars are present [17]. Incorporation of stars by the black hole is given as,

$$Z_i(t+1) = Z_i(t) + random \times \left(Z_{BH}, Z_i(t)\right) i = 1,2,..,N \quad (10)$$

$$HR = \frac{f_{bh}}{\sum_{i=1}^{N} f_i} \quad (11)$$

$$Z_i = (s_i, \ldots, s_N, bh_d) \quad (12)$$

$$G_{ij}^d = \xi(t_o) \frac{d_{pi}(t) \times d_{aj}(t) \times \left(s_j(t) - s_i(t)\right)}{\left(D_{ij}(t) + \varepsilon\right)^2 \times \left(d_{pi}(t) + d_{aj}(t)\right)} \times \left(\frac{t_o}{t - t_o}\right)^a \quad (13)$$

$$G_i^d(t) = \sum_{j=1\ J \neq i}^{N} r_i G_{ij}^d(t) \quad (14)$$

$$m_i^d(t) = \frac{g_i^d(t)}{d_{ii}(t)} \quad (15)$$

$$velocity_i^d(t+1) = r_i \times v_i^d(t) + m_i^d(t) \quad (16)$$

$$s_i(t+1) = s_i(t) + v_i^d(t+1) \quad (17)$$

With the steps as follows,

- Initialization
- Mutation and cross over are computed
- Position, velocity are calculated
- continued existence criterion calculated
- completion of Vector correction
- If maximum generation $g_{max}$is attained, then stop, or else, go to Step b

In the proposed enriched black hole algorithm (EBHA) from the structure of the biological cell's membrane computing is planned by conceptual calculation of model from the hierarchy of the cells. Membrane computing is also branded as P system and it has multisets of objects with evolution rules in the membrane structure. Membrane structure is alike ingrained tree of section that demarcate the areas, and root is labelled as skin. Chemical substances (multisets of objects) are there inside the section (membranes) of a cell and the chemical reactions (evolution rules) that take place within the cell.

Representation of membrane system as follows,

$$\Pi_{BH} = \left(O_{BH}, \mu_{BH}, \omega_{BH}^{1}, \omega_{BH}^{2}, .., \omega_{Bh}^{i}\omega_{BH}^{q}, R_{BH}\right) \quad (18)$$

Multi-set of the objects in every elementary membrane of the structure is given as,

$$\omega_i = \{O_1, O_2, .., O_n\} \quad (19)$$

An object in -dimensional vector of the form given by,

$$O_j = \{(Z_{11}, Z_{12}, .., Z_{id}), .., (Z_{i1}, Z_{i2}, .., Z_{id}), .., (Z_{k1}, Z_{k2}, .., Z_{kd})\} \quad (20)$$

$$\left|\omega_1 \cap \omega_2 \cap ... \cap \omega_i ... \cap \omega_q\right| \leq \delta \quad (21)$$

In the projected approach the fitness values of the objects are done by,

$$F(X, Z) = \sum_{j=1}^{k}\sum_{i=1}^{m} W_{ij}\left\|X_i - Z_j\right\| \quad (22)$$

$$Z_i(t+1) = Z_i(t) + r * \left(Z_{BH} - Z_i(t)\right) \quad (23)$$

Radius of the event horizon is found by,

$$HR = \frac{f_{Bh}}{\sum_{i=1}^{n} f_i} \quad (24)$$

With the steps as follows,
- Establish the elementary membrane numbers
- Initialize the population of stars for every elementary membrane, and choose the most excellent star
- Alter the location of every star
- Calculate the fitness of all stars for each elementary membrane again.
- In each elementary membrane, it will be swallowing by the black hole
- Until the end criterion is reached repeat the steps c to e.
- End

## 4. SIMULATION RESULTS

Enriched black hole algorithm (EBHA) validated in IEEE 14 and 300 bus systems [18]. Comparisons of results are presented in Tables 1 and 2. Graphical representation is shown in Figures 1 and 2.

Table 1. Comparison of loss

| Parameters | ABCO [19] | IABCO [19] | EBHA |
|---|---|---|---|
| V1 | 1.06 | 1.05 | 1.01 |
| V2 | 1.03 | 1.05 | 1.00 |
| V3 | 0.98 | 1.03 | 1.03 |
| V6 | 1.05 | 1.05 | 1.04 |
| V8 | 1.00 | 1.04 | 0.90 |
| Q9 | 0.139 | 0.132 | 0.100 |
| T56 | 0.979 | 0.960 | 0.900 |
| T47 | 0.950 | 0.950 | 0.900 |
| T49 | 1.014 | 1.007 | 1.000 |
| Power loss in MW | 5.92892 | 5.50031 | 4.0516 |

Table 2 Comparison of power loss

| Parameter | EGA [21] | EEA [21] | CSA [20] | EBHA |
|---|---|---|---|---|
| Power loss in MW | 646.299800 | 650.602700 | 635.894200 | 612.0914800 |

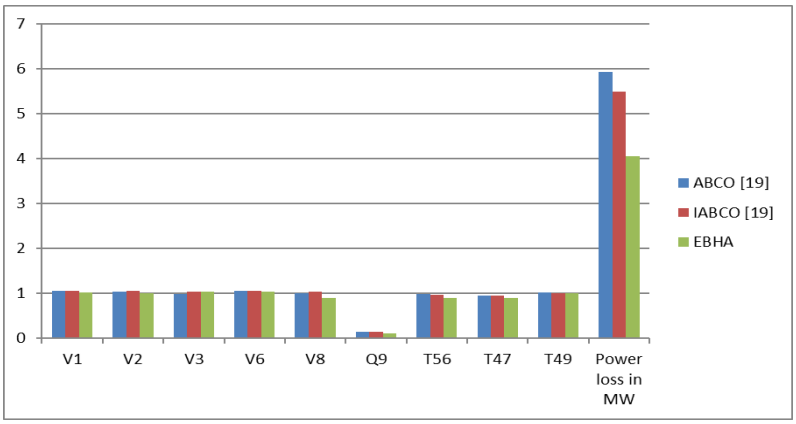


Figure 1. Comparison of parameters

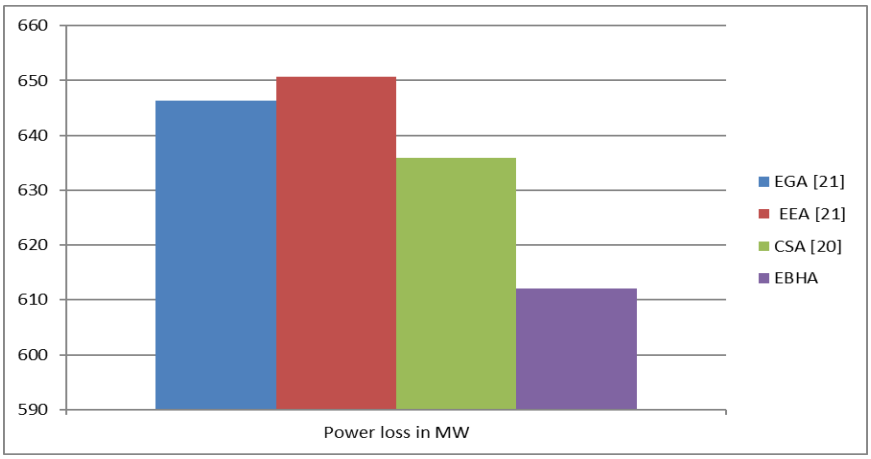


Figure 2. Comparision of power loss

## 5. CONCLUSION

Enriched black hole algorithm (EBHA) reduced the power loss effectively. Excellent candidate amongst all the candidates in iterations is chosen as a black hole and remaining candidates structured as the standard stars. From the structure of the biological cell's membrane computing is planned by conceptual calculation of model from the hierarchy of the cells. In IEEE 14 and 300 bus systems proposed enriched black hole algorithm (EBHA) performance has been validated. Power loss reduction has been achieved.

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