Implementation of Modified EPSO Technique in 69kV Distribution Network Reconfiguration for Losses Reduction

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Abstract—The implementation of meta-heuristic algorithm in defining the optimal solution for distribution network reconfiguration has been addressed by many researchers over the years. Nonetheless, the solution in minimizing the main objective which is total power losses could not be solved until today. In this study, the hybridization of evolutionary particle swarm optimization has been modified in order to reduce the losses problem in 69kV power distribution network. The adaptation of ranking concept towards combination elements from evolutionary programming and particle swarm optimization has contributed to find the optimal results significantly. The result by using proposed technique has been compared to the conventional PSO and EPSO respectively. Modified EPSO has shown the superior reduction in terms of percentage of losses reduction and it is hoped to solve many others problem in power system in the future research.

Keyword-Distribution Network Reconfiguration, Evolutionary Particle Swarm Optimization, Losses Reduction, Modified, Particle Swarm Optimization

I. INTRODUCTION

Presently, the dimension topology of power distribution network has got larger due to increased scale of demand for the energy. This phenomenon has contributed to the line losses significantly. Hence, many techniques have been identified in order to secure the planning due to the connection between the transmission network and consumers facilities. Since 1977, there are many researchers have done the investigation on various methods regarding to the topic of reducing the losses in the distribution network. But unfortunately, there is no absolute solution had been achieved by the researchers until today.

One of the techniques that have been applied to reduce the losses in large distribution network is reconfiguration system. Reconfiguration of the distribution network systems are meant for power losses mitigation. During normal operation of a distribution network, the energy flow has a radial path and passes the normally close switches [1], [2]. The network topologies in the distribution network reconfiguration change through the on/off of the sectionalizing and tie switches in order to get the optimal solution of the power losses. Over the years, many researchers have implemented Meta-heuristic methods in order to find the most suitable configuration which is consists of switches that will contribute in minimizing the power losses as well as would be considered as energy saving in the network respectively. Bio-inspired algorithm has been used by many researchers in order to achieve the objectives of the network reconfiguration. One of the most powerful algorithms that have been introduced is Particle Swarm Optimization (PSO) which is inspired by the process of birds schooling. Nevertheless, the performance of PSO has been improved recently by introduction of many hybridization PSO based methods with the goal to enhance the convergence time, accuracy and avoiding the trap problems accordingly.

As in [3], the Binary Particle Swarm Optimization (BPSO) had been introduced to a large scale of power system reconfiguration which was proposed to reduce the power losses. Meanwhile, Cui-ru wang and Yun-e Zhang has introduced the modified particle swarm optimization (MPSO) algorithm into the distribution network reconfiguration due the non-linear optimal problem which gives great impacts on economic benefit of power system [4]. Nevertheless, there were some constraint conditions that they had faced. First, the network must meet the power flow equations, secondly, the branch current and constraints of node voltages, third was the constraint of power up and lastly was the constraint of the various network topologies.

The application of hybrid genetic particle swarm optimization algorithm in the distribution network reconfigurations was introduced in [5]. The evolution idea of generic algorithm (GA) and the population intellectual technique of particle swarm optimization (PSO) algorithm had been combined together. However, the proposed algorithm had not performed well in terms of better convergence time compared to others hybridization methods. An approach of combination of binary particle swarm optimization (BPSO) with discrete particle swarm optimization (DPSO) and multi-agent system (MAS) had been introduced by the authors in [6]. When these three components were combined, a new method known as the Novel Hybrid Multi agent-Based particle Swarm Optimization Algorithm (NHMBPSO) was produced. The proposed method was successfully tested as to as to be able to undertake as a global search with a faster convergence rate and a feature of robust computation when evaluated on standard PG&E 69 nodes network system data. Unfortunately, when it was compared to other types of hybrid PSO based algorithms such as HPSO, BPSO and EPSO; it was still the weakest method in helping reducing the power losses in the distribution network system.

The implementation of Evolutionary Particle Swarm Optimization (EPSO) in power systems has been first introduced by [7]. They had verified that EPSO was very successful in solving the power system optimization of voltage control and the minimization of the losses. EPSO was also able to find the adequate solutions under a min-max criterion. By this approach, the first implementation of EPSO in more specific work in power system such as network reconfiguration system had been made by the authors in [8]. The work had proved that EPSO algorithm was better than conventional methods like PSO, GA and EP in reducing the power losses and improving the voltage profile congruently. Yet, there were still an improvement need to be done in order to enhance the performance of EPSO in terms of convergence time and global search scope. This is because EPSO does not reconsider the particles that ware rejected at the first initial population significantly. Therefore, this study will introduce the modification of EPSO by adding a ranking concept through the operational of global best in the evolutionary PSO process. The proposed method will react to the reduction of total power losses in 69kV distribution network and advance the computational time accordingly. Thus, the outline of this paper can be divided as follow; in the second section, the formula formulation for the objective will be represented while the proposed method will be explained in section three correspondingly. Section four will be a part of results and analysis while last section five can be considered as conclusion for this work.

II. FORMULA FORMULATION

The mathematical formulations for the expression that can relate with the objectives are as follows [9]-[11]:

$$\text{Minimize } f_1(x,v) = \sum_{i=1}^{n} Losses_i \quad (1)$$

Where,

n is the number of branches

x is the continuous control variable

v is the discrete control variable

Losses is the power losses as classified at i branch

Moreover, there are some constraints that should be considered during the process of analysis [12]-[16]. The constraints are:

A. The voltage constraints

In order to maintain the power quality of the system, the voltage magnitude should be based on within its particular limits.

$$V_{min} \leq V_{bus} \leq V_{max} \quad (2)$$

The particular limits for voltage at each bus are within 1.05 and 0.95 (±5).

B. Power flow constraints

Each and every branch in the power flow has its own permissible range. This range should be followed clearly and the constraints are strictly lies within it.

C. Radial configuration constraints

The constraints of the radial configuration should be considered to avoid any excess of current flow through the system. Therefore, in order to ensure the radial network to be maintained, several constraints must be taken into account. Several standard rules have been adopted for selection of switches. Those switches that do not belong to any loop, connected to the sources and contributed to a meshed network have to be closed.

III. MODIFICATION OF EPSO

In order to get faster solution for the proposed algorithm, there are involving the integrated process of inserting the combination, selection and ranking concept of the evolutionary programming (EP) into the traditional particle swarm optimization (PSO). In Modified EPSO, the best particles will move to the new position and the empty will be replaced by the other particles. The selected of the new position of these particles are much more different when it is compared to the PSO algorithm as they are being done by using the concept of combination and selection method in evolutionary programming. Meanwhile ranking concept is introduced which is different if to be compared to conventional EPSO and it is responsible to rank the possible optimal selection in order to get the best number before the convergence process is decided. Hence, the steps to implement the modified EPSO technique in 69kV distribution network reconfiguration system can be described as below while the summary of the proposed method is shown in Fig. 2 concurrently.

A. Initialization

All the input 69kV system data which is consist of network data, buses data, lines data and voltage limit are called to the based modification EPSO programming at the first stage. In order to determine the initialization population, the switches are selected from the set of its original tie switches. Through the random selection of the existing generator, those variables involved will be generated by the system in the program. Hence, in the next step, in order to compute the power losses, all the variables will be utilized. In this work, the particles are acted as the tie switches and the appropriate equation is represented as below:

$$X_{particles} = [\, S_1 , S_2 \, , S_3, \, ..., \, S_y \,] \qquad (3)$$

Where:

y = no of tie switches.

In this step, the parameters of modified EPSO that involved such as number of particles (N), weighting factor C_1 and C_2 and the maximum number of iteration as in equation (4) and (5) are analysed. There are several constraints that should be aware and considered to ensure the radial network is maintained.

$$v_{i+1} = \omega V_i + c_i r_i \, (P_{best} \text{ -} x_i) + c_2 r_2 \, (G_{best}\text{-}x_i) \qquad (4)$$

$$x_{i+1} = v_{i+1} + x_i \qquad (5)$$

For the selection of switches, there are several important rules that have been taken seriously.

Rule 1: All switches that do not belong to any loop are to be closed.

Rule 2: All switches are connected to the sources are to be closed.

Rule 3: All switches contributed to a method network need to be closed.

B. Fitness Calculation

In this study, the fitness function or also known as the objective function that needs to be optimized and hence solved is the power losses of the system. For this step, there are two random variables, those are position, X and velocities, Y which will randomly generated along with the initial populations of particles. For each and every particle that fulfils the requirements or constraints mentioned in section II, the power flow will be accomplished and by using the Newton-Raphson load flow technique, the total power losses will be calculated.

C. Determine P_{best} and G_{best}

These are the two values that need to be updated and recorded during this searching process. In the solution space, these values are related with the best solution that is has extended so far by each particles which retains path of its coordinate. These two best values are noted as the P_{best} and G_{best}. These P_{best} and G_{best} are important to represent the generation of the tie-switches and the power losses in the network system.

D. New Velocity and Position

In this step, by applying the equation (4) and (5), the particles' velocity and position are updated. The particle's velocity is signified as the switches while the total power losses of all switches are verified by using the new position.

E. Combination and Tournament Selection

After the new position, X_{new} is obtained, the values of the new position is used in determining the new fitness value or else know as the total power losses. Hence, both the set of the new position, X_{new} and the old set position, X will be combined together and this combination of new and old set position will be contested in a tournament. When the fitness is better than other contenders, a position gains the score and vice versa. This tournament is contested as randomly. The priority selection strategy is used throughout the selection strategy process. The old set position and the new set position were sorted in this technique in descending order according to power losses in the system.

F. Ranking Process

The modification of EPSO has been done by adding this ranking concept. In this process, the best ranking position is chosen according to the least values of power losses which have been sorted from the combination of the old and new set of the position. The best ranking position is set to be the new position set which will be tested for convergence. The best optimal value is selected as the best rank which used in the radial network system in order to help reducing the losses significantly. The illustration of modified EPSO by proposing a ranking concept can be described by the Fig. 1 as follow:

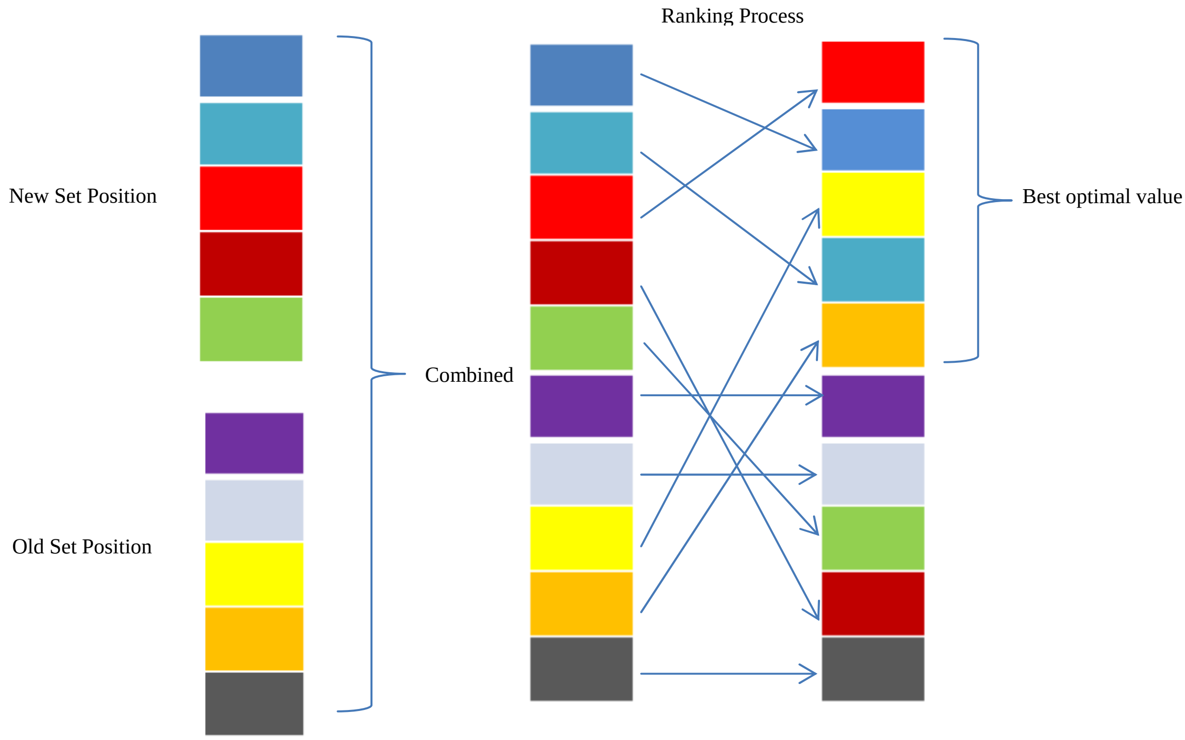

Fig. 1. Modification process of EPSO-Rank Concept

G. Convergence Test

If the convergence is not achieved, the process will be repeated from step B to F. Nevertheless, if the convergence has been achieved, then the optimization process is stopped.

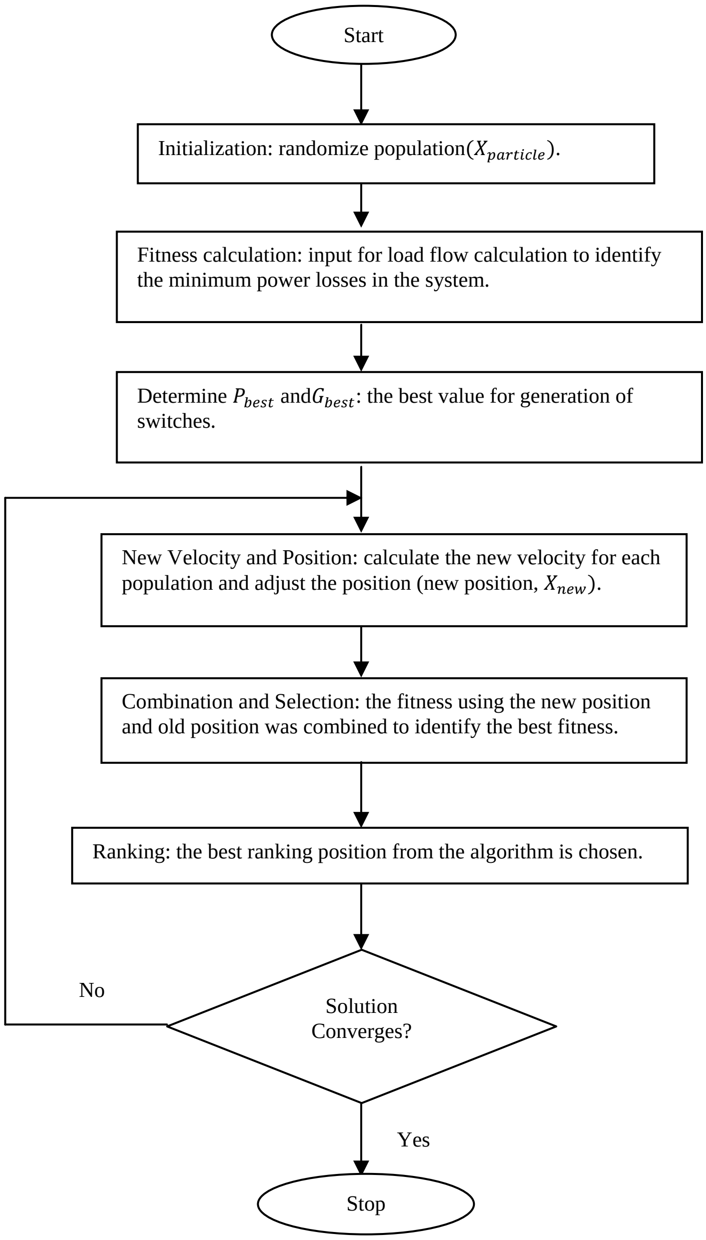

Fig. 2. Flow chart of proposed modification method

IV. RESULT AND ANALYSIS

The optimization programming has been written by using MATLAB (version 2010b) package in window based computer. The CPU was installed with 4.0GB of Ram while the processor used is Intel i5. The proposed algorithm was tested using a real 69-bust IEEE test system as in Fig. 3. Through the determination of the optimum switching configuration; the results of the study have been analysed in order to find the percentage of losses reduction correspondingly. In this section, the implementation of PSO, EPSO and modified EPSO algorithm for 69kV distribution network reconfiguration system will be discussed and the results will be compared according to the total power losses and percentage of losses reduction respectively.

Table I shows a summary of the results were obtained during the experimental process. It can be seen that modified EPSO has achieved the highest percentage of the power loss reduction if to be compared to the other methods, PSO and conventional EPSO. The proposed method is able to reduce the power loss from 0.0889MW to 0.0500MW with the percentage of reduction is approximately 43.76%. PSO is only able to reduce power loss from 0.0889MW to 0.0550MW while EPSO is able to reduce power loss from 0.0889MW to 0.0520MW respectively. If the comparison is made in terms of percentage of power losses reduction, modified EPSO has shown the highest percentage of reduction which is 43.76%, slightly higher than 38.13% and 41.51% for PSO and EPSO correspondingly. The combination and selection concept in EPSO and ranking concept in modified

EPSO has contributed to the great impact of the results taken for this study. The trapped consideration problem of population has been decreased so that the ability of the algorithm to find the best consideration of optimal solution is higher. Therefore, it can be concluded that the modified EPSO is superior in order to reduce power losses in power system compared to PSO and conventional EPSO techniques for 69kV bus test system. The summary graph of the result is shown in Fig. 5 while Fig. 4 represents the topology of the network after reconfiguration is done by using modified EPSO.

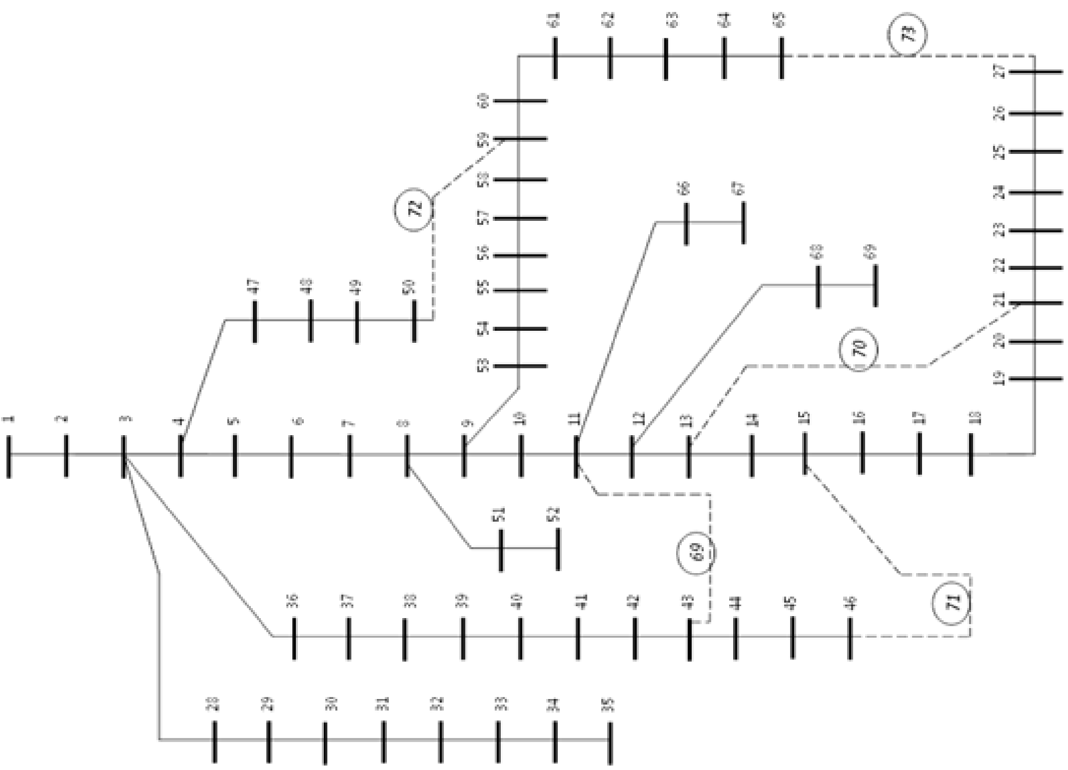

Fig. 3. Initial 69kV distribution network test system

TABLE I
Summary of the results

Parameters	Original initial network	By using PSO	By using EPSO	By Using Modified EPSO
Switch to be opened	69,70,71,72,73	8,57,22,12,19	38,3,69,22,54	69,20,56,14,72
Total Power Losses (MW)	0.0889	0.0550	0.0520	0.0500
Total Losses Reduction (MW)	-	0.0339	0.0369	0.0389
Percentage of Losses Reduction (%)	-	38.13%	41.51%	43.76%

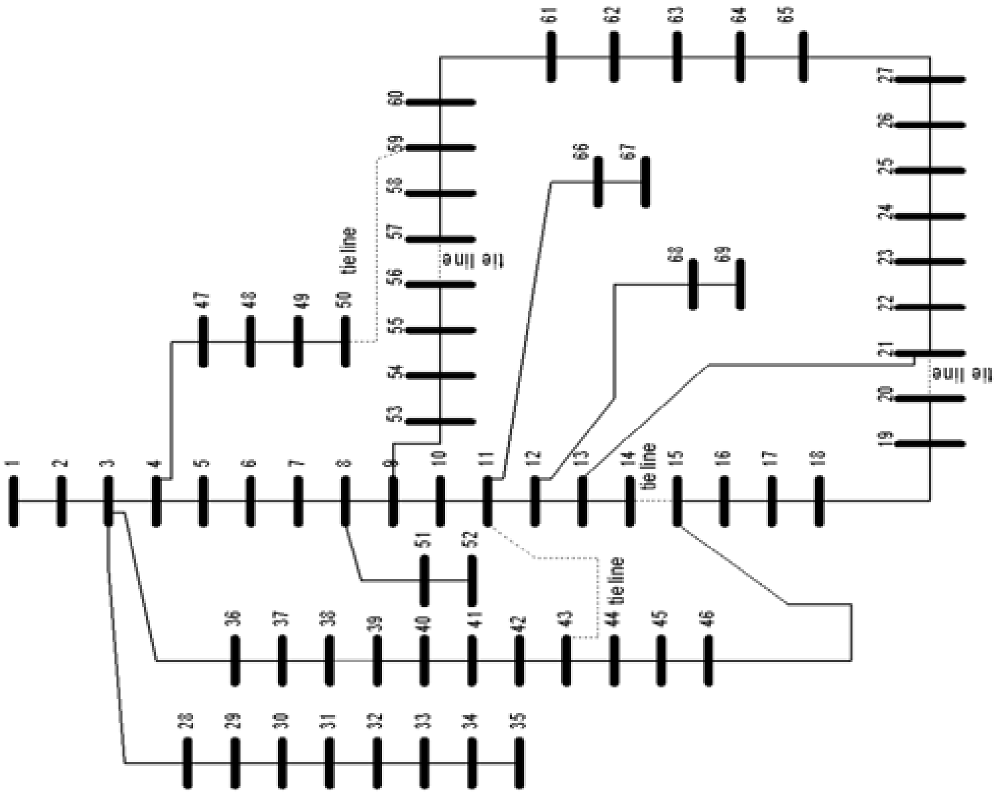

Fig. 4. Topology of the network after reconfiguration by using modified EPSO

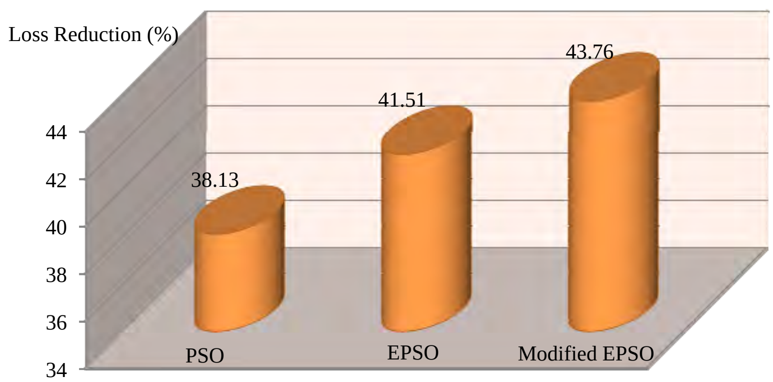

Fig. 5. Summary of the losses reduction

V. CONCLUSION

In this study, a distribution network reconfiguration method which is based on modified EPSO technique has been introduced. The main goal of this work is to minimize the total power losses is successfully validated by comprising of the proposed method with two conventional PSO and EPSO correspondingly. The power losses are positively being reduced and the best optimal value has been achieved by proposed modified algorithm. Thus, the implementation of modified EPSO is proved to give the great impact for the whole 69kV distribution network reconfiguration system.

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