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# Improvement of Voltage Profile and Loss Reduction Using Optimized Soft Computing Based Capacitor Placement Methodology

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*Abstract*—Significant exploration has been done on the arrangement of ideal capacitor arranging in the appropriation frameworks for the assignments of power factor adjustment, voltage profile improvement and misfortune decrease. Particularly, mechanical plant with variable load conditions has huge inductive loads and its power factor is exceptionally poor. These ventures advantage most capacitor banks. This bank gives improved power factor, expanded voltage level on the load and lessen the electric service bills. Moreover, programmed capacitor banks might be ready to dispose of kVAr stimulated at light-load periods and bothersome over-voltages. In most cases, the primary motivation behind why a client introduces a capacitor bank is to maintain a strategic distance from punishment in the power bill. Power factor is a proportion of the genuine power to evident power, and speaks to how a lot genuine power electrical gear uses. A power factor of any worth other than solidarity is brought about by inductive or capacitive reactance and harmonics in the circuit [2]. The expansion in power request and high load thickness in the urban zones makes the activity of power frameworks muddled. To fulfill the load need, the framework is required to extend by expanding the substation limit and the quantity of feeders. Notwithstanding, this may not be handily accomplished for some utilities because of different requirements. Along these lines, to give more limit edge for the substation to fulfil load need, framework misfortune minimization procedures are utilized. In addition, the impact of electric power misfortune is that heat energy is dispersed which builds the temperature of the related electric parts and can bring about protection disappointment. By limiting the power misfortunes, the framework may secure longer life expectancy and have dependability that is more prominent. Different techniques have been utilized to decrease power misfortunes financially by ideal choice of size, area and cost of capacitor bank.

**Index term:** DC-DC power converters, photovoltaic cells, maximum power point tracker, multilevel and single-phase inverter, Wind Energy, Solar PV, Grid Connected Energy System, Capacitor bank, GA

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## I. INTRODUCTION

Ideal capacitor arrangement is an improvement issue to upgrade the area of the capacitor bank and size of the capacitor banks on competitor transports to be put in the electrical and conveyance framework. Capacitor situation issue is a nonlinear enhancement problem.Optimization of capacitor situation can be accomplished for practically all kinds of circulation framework, for example, spiral framework or work interconnected framework. Ideal capacitor situation brings about decreased power misfortunes which may results to increment the framework life length. Significant examination has been done on the arrangement of ideal capacitor arranging in the circulation frameworks for the errands of power factor revision, voltage profile improvement and misfortune decrease. Particularly, mechanical plant with variable load conditions has enormous inductive loads and its power factor is extremely poor. These enterprises advantage most fi-om capacitor banks. This bank gives improved power factor, expanded voltage level on the load and lessen the electric service bills. Plus, programmed capacitor banks might be ready to dispose of kVAr empowered at light-load periods and bothersome over-voltages. In most cases, the fundamental motivation behind why a client introduces a capacitor bank is to stay away from punishment in the power bill. The establishments of the capacitor in dissemination framework need to pay an extremely true exertion to streamline the size and area utilizing various techniques. In this manner, in past the analyst has given the various strategies for capacitor situation by which the client what's more, the power utilities both are get profited at the same time [1-3].

Baran et al.[4] proposed ideal capacitor position on spiral conveyance frameworks. The issue of capacitor position on a spiral conveyance framework is defined and a arrangement algorithm is proposed. The area, type, and size of capacitors, voltage limitations, and load varieties are thought of. The goal of capacitor position is top power and energy misfortune decrease, considering the expense of the capacitors. The issue is planned as a blended whole number programming issue. The power streams in the framework are expressly spoken to, and the voltage limitations are consolidated. An answer strategy has been actualized that breaks down the issue into an ace issue and a slave issue. The ace issue is utilized to decide the area of the capacitors. The slave issue is utilized by the ace issue to decide the sort and size of the capacitors put on the framework.
Chang et al. [5] introduced another multitude insight algorithm that is subterranean insect state search algorithm (ACSA) to contemplate the electrical appropriation framework. This examination presents new algorithm for CPP and feeder reconfiguration issue. By considering both CPP furthermore, feeder reconfiguration issue together gives better outcomes in contrast with the results got from considering them independently.

Srinivas et al. [6] introduced a methodology for OCP in RDS, which comprises of two sections: in the initial segment misfortune affectability factors are determined to decide the ideal up-and-comer areas for capacitor arrangement and in the second section another algorithm which utilizes plant Growth Simulation Algorithm (PGSA) is utilized to decide the ideal size of capacitors to be set at competitor transports. It handles the imperatives and the goal work independently, and maintains a

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strategic distance from the trouble to decide the boundary factors. It doesn't require any outer boundary. The proposed technique has a controlling hunt course which changes persistently as the target work changes.

Murthy et al. [7] introduced a genuine and reactive joined power misfortune affectability (PLS) file based way to deal with decide the ideal areas for capacitor placement in the outspread dissemination framework (RDS). This methodology furnishes better outcome as contrasted and the current techniques for file vector (IV) and power misfortune list (PLI). Load development factor is basic for arranging and development of existing framework which is considered in this
approach. PLS gives best outcomes regarding power misfortune and by and large money saving advantage.

The OCP issue is to decide the best capacitor size and area in an electrical circulation framework by limiting the expenses brought about by power misfortune and capacitor establishment. To figure capacitor situation issue a few suspicions are made. There are different requirements has been talked about to acknowledge capacitor arrangement for example all out cost, voltage breaking point and power factor limit

## II. PROBLEM DEFINITION

TheThe OCP issue is to decide the best capacitor size and area in an electrical dissemination framework by limiting the expenses caused by power misfortune and capacitor establishment. To plan capacitor position issue a few suppositions are made. There are different requirements has been talked about to acknowledge capacitor situation for example all out cost, voltage breaking point and power calculate limit the capacitor situation issue there are numerous factors for example capacitor size, capacitor cost, capacitor area, voltage and all out consonant twisting on the framework.

There are diverse kind of capacitors accessible for example fixed capacitors, variable capacitors. To consider all the variable in a nonlinear way will make the enhancement issue ccomplicated. So a few suspicions are required to streamline the capacitor arrangement issue,

I) The three stage framework is taken to be adjusted and loads are time invariant

ii) Only fixed size capacitors are taken.

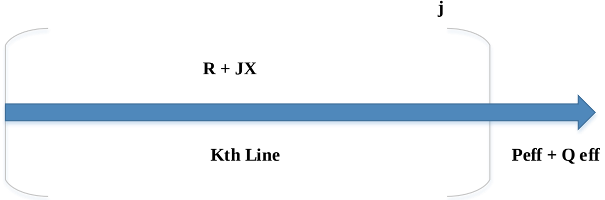


**Figure 1 .Structure of Bus System**

Power loss in the system is given as

$$PP_{Loss}(i, i+1) = i^2 R_{i.i+1} \qquad (2.1)$$

If power flow in the line is Pi+jQi

$$I = \frac{P_i^2 + Q_i^2}{V_i^2} \qquad (2.2)$$

where
Vi is the voltage of bus 'i'
Total power loss in the distribution grid is given by
n-l

$$P_{T,loss} = \sum_{i=0}^{n-1} P_{loss\,(i,i+1)} \qquad (2.3)$$

Where n is the number of buses.
If the total reactive power compensation exceeds the total reactive power load then
power factor will becomes leading which is undesirable, so there is a maximum limit for capacitor sizes to be imposed to avoid overcompensation.

$$Q_{max}^c \leq \sum_{i=1}^{n} Q_i \qquad (2.4)$$

Where,
*Qmax* is reactive power compensated and Qi is the reactive load power at bus ' i '.
Mathematical representation of capacitor placement problem is given by:

$$Total\ Cost = K_p P_{T,loss} + \sum_{i=1}^{n} k_{cf} + k_i^c Q_i^c \quad (2.5)$$

t=i
Where
*Kp*- Cost per unit power losses per year
*Ki*- Capacitor cost per kvar at bus i
*Kef*- Fixed capacitor installation cost
The maximum economic limit for power factor improvement depends upon the costsof installation of the capacitor and the demand charge in the region for particular time of operation i.e. if the demand charge varies the optimal size of the capacitor can vary at the same location. Therefore, the improvement in power factor to unity is not the only choice to improve the system power factor always.To improve our power factor from a certain low value to desired value the correction limits is to be decided and the corresponding size of the capacitor can be calculated as follow:
*VAr* = P • (tan α1- tan α2) (2.6)
Here, P is the active power at the respective node α1 is initial power factor angle and α2 is improved power factor angle at the same node. In power distribution the method of capacitor placement by developing the indices depends upon the overall improvement in the system parameters. These parameters may be considered as voltage profile or resultant power loss of the system under consideration.
Further, the implementation of these index based techniques do requires the imposition of constraint to find the size and location of the capacitor to be installed. The constraint could be voltage limit at particular node or in a group of node or the partial system configuration e.g.
Considering the voltage profile,
*Improvement in voltage profile of the nodes*
*OR*
*Maximizing the power loss reduction,*
*Subject to:*
*Vi, min<Vi<Vim,ax and*

*Ii<I limit*

Imposing the constraints considered above the optimal size or location of the capacitor placement may vary from one node to another node in the system considered [33].

## III. GENETIC ALGORITHM

Meta-heuristic improvement strategies are able to deal with intermittent issues and speak to the most generally utilized apparatuses for illuminating the ideal designation of DG. The Genetic Algorithm (GA) is one of the most powerful shrewd improvement strategies. It is a multipoint, probabilistic, arbitrary guided-search system. It is portrayed by its entangled computational model, which impersonates natural transformative speculations. Due to it's exceptionally resemble search ability, it tends to be applied to entangled improvement issues. The use of GA requires numerous means to arrive at the last ideal solution. Right off the bat, an underlying solution is detailed and an assessment work is applied. The assessment work is the best approach to quantify the fitness of every person (conceivable solution). At that point, the selection procedure is applied to choose the best people for propagation. At last, the genetic administrators are applied with two principle employments to make new people and get the genetic model last solution. The algorithm cycle, which is appeared in Fig. 2, comprises of four phases: Irregular introduction of chromosomes populace.

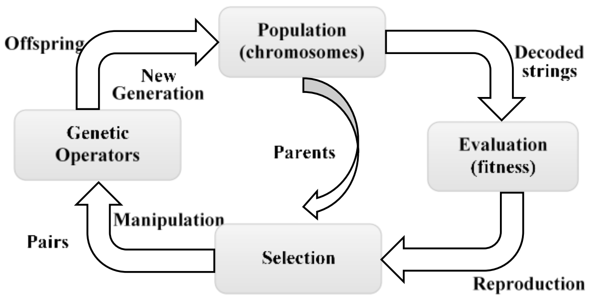


**Figure 2 Genetic Algorithm Cycle**

Fitness assessment everything being equal (chromosomes) in the populace. Selection of best chromosomes for multiplication process. Controlling and altering the chose people utilizing the genetic activities. This cycle characterizes one generation, which will be rehashed until the stop basis is reached. The primary favorable circumstances of the genetic algorithm can be summed up as follows: It can look at numerous solutions in equal in light of its multi-way ability and subsequently, it can lessen the chance of nearby least catching. The differing of boundary coding that GA works with gives greater adaptability to change the present status into the following state utilizing least calculations.

The fitness of each string can be determined and the objective capacity will be assessed to manage search process rather than the improvement work in traditional techniques. It doesn't require subordinates or other helper information.

It is productive in comprehending hard improvement, exceptionally compelled and enormous looking through space issues. Notwithstanding GA worthwhile, there are a few weaknesses, for example, the reliance of the genetic administrator on the difficult nature. Additionally, the crossover and mutation rates must be chosen autonomously. Up to late eighties of a century ago, GA applications are restricted to science, software engineering, activities research, picture handling and sociologies [58]. Then again, it has not been generally applied in electrical designing, most likely because of the requirement for over the top processing time. This is ascribed to the equal hunt course and the probabilistic change rules engaged with the algorithm.

For single-objective improvement issues, there is a novel ideal solution. Then again, in multi-objective issues, there is a somewhat set of various ideal solutions. At the point when all objectives are all the while thought of, these solutions are considered as ideal solutions from the point of perspective on the dynamic. There are no different solutions in the inquiry space that are better than them. The chief has adaptability to bargain between the various terms as per the system circumstance and prerequisites. This is known as distinguishing the Pareto-front (or Pareto wilderness). The objective capacity of the issue under examination fuses terms of various nature, for example, expanding the limit of capacitors, boosting voltage improvement, limiting power misfortunes and limiting deficiency current levels.

The maximum furthest reaches of capacitors limit is the fundamental objective to be characterized without influencing the security coordination. Subsequently, as far as possible in this examination isn't to choose for the capacitors limit however to characterize the limits that have not to be abused. Other specialized factors such, as voltage drop, issue current level, and power misfortunes, are thought of. This prompts the development of ideal areas of capacitors units close to the load area. Some other components can be presented yet the principle worry here is limited to the coordination issue. The financial matters of capacitors units are out of the extension in this investigation. Or maybe, this examination worries with evaluating the ideal capacitors limit that upgrades the exhibition with no extra security cost. As to capacitors areas, the capacitors ideal limit is assessed at various areas along the feeder including all accessible capacitors units at the particular area.

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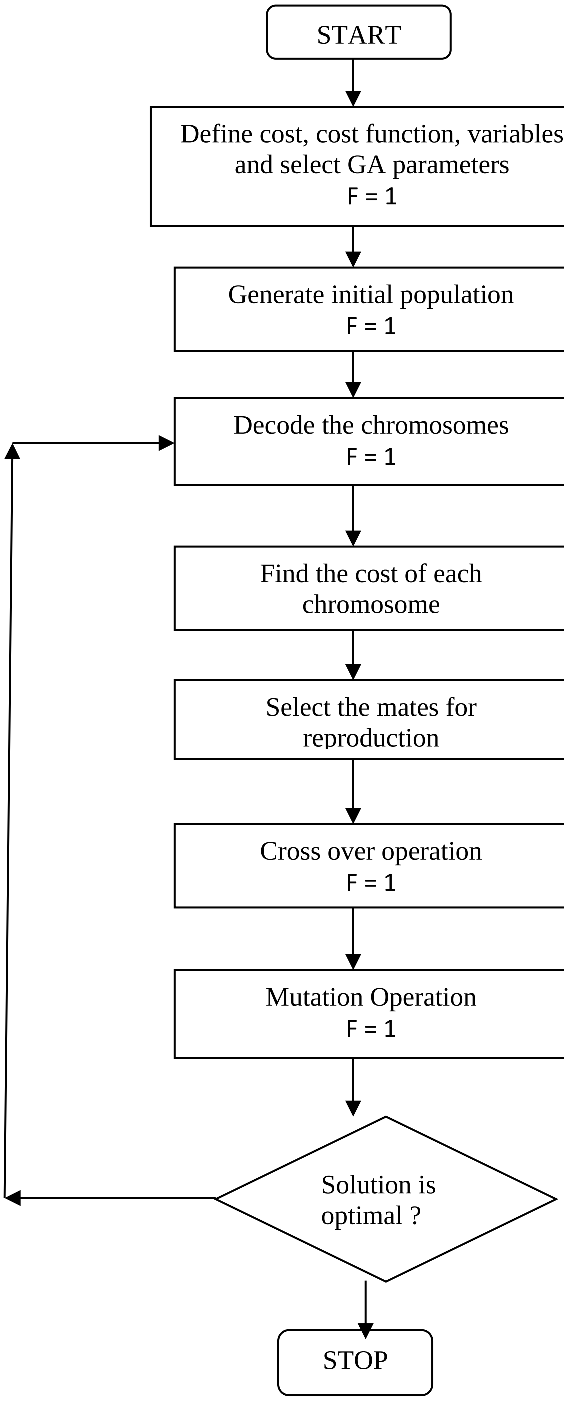


**Figure 3 .Flowchart of Genetic Algorithm**

**There are numerous varieties of the GA technique. These points of interest give genetic innovation extraordinary adaptability in tackling framework distinguishing proof issues. In any case, similar to any processing innovation, genetic algorithms have constraints.**
**The objective of advancement is improvement. GA's equal flavor makes it vigorous for worldwide enhancement and reasonable to take care of non-straight issues of power frameworks. GA codes its boundaries by and large in parallel structure as a limited length string, look from populace with rich database of points at the same time, utilizes target work (OF) and not derivates, less information ward and uses probabilistic progress rules [15].**

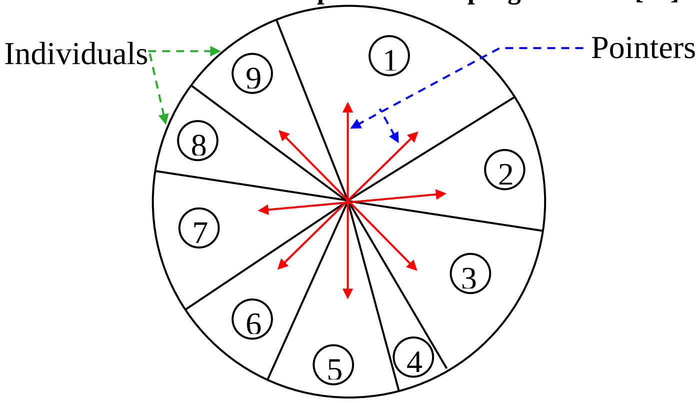


**Fig 4: The Roulette wheel selection**

Cross over is a procedure wherein singular strings are duplicated by their OF esteems and are consolidated to shape posterity.

OF is the last referee of string-animal's critical. Fitter off-springs are held and add to create off-springs of people to come.

Mutation chooses the people considered guardians that add to populace of people to come. Transformation applies arbitrary changes to singular guardians to shape youngsters. The procedure is exaplained as follows-
Step I) Read the transport, line information for the dissemination test framework from load stream investigation program, compute line flows and give it to GA.

Stage 2) Select introductory populace, wellness scaling, determination work, proliferation's world class tally and hybrid division, transformation, hybrid capacity, relocation and halting rules.

Stage 3) Calculate the wellness esteem for streamlining capacity which is to limit misfortune utilizing governing equations

Stage 4) Check imperative of power stream condition by governing equations

Stage 5) Check imperative of transport voltage constrains by governing equations

Stage 6) Check imperative of feeder current cutoff points by governing equations

Stage 7) Check imperative whether spiral arrangement group is kept up.

Stage 8) Check imperative whether any load point is interfered.

Stage 9) Report the ideal arrangement.

The algorithm is executed utilizing MATLAB streamlining tool stash, with MATLAB adaptation R2019a, with PC having Intel Pentium Quad-Core Processor, 3.0 GHz, 8 GB RAM. is utilized for load stream examination.

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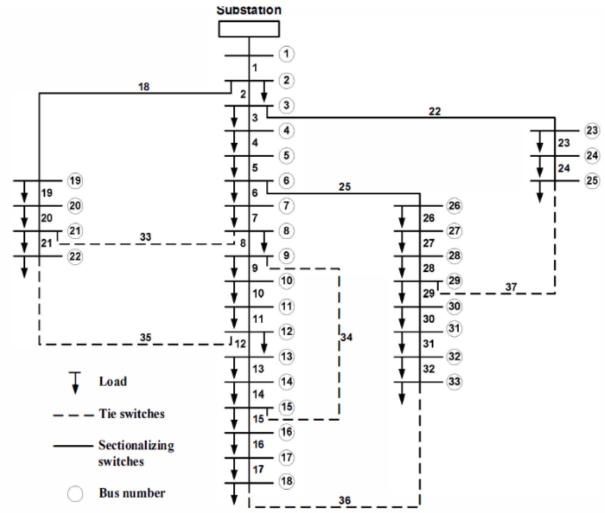


**Fig. 5 Proposed Test System Model**

The test system has been shown in fig 5. The test system is IEEE-33 bus test system having 33 nodes anb bus and line parameters. The IEEE 33 bus contains of different buses, tie switches, tie switches which are interconnected to each other for placement of capacitor.

## IV. RESULTS

For IEEE-33 bus system, a given soft computing technology based on genetic algorithm has been designed for the method of selecting capacitor position in power system. The optimal placement of capacitors has been achieved to minimize losses and improve voltage distribution. For the IEEE-33 bus system, the output and voltage curve have been improved to minimize loss. As shown in Figure 6. It can be seen from Figure 6 that by using an improved genetic algorithm method to optimally place capacitors, the fluctuation curve of the test system can be significantly improved.

**Table-1 (Genetic Algor Parameters)**

| Parameters | Values |
|---|---|
| **Maximum Iteration** | 150 |
| **Population Size** | 25 |
| **Crossover Frequency** | 0.9 |
| **Mutation Percentage** | 0.4 |
| **Mutation Rate** | 0.03 |
| **Type of Selection** | Tournament |

A given soft computing technique based on a genetic algorithm designed to select capacitor placement has also been implemented to improve the voltage curve. Figure 7 shows the loss reduction achieved for the IEEE-33 bus system. It can be clearly seen from the figure that after using the improved genetic algorithm to optimally place the capacitors, the active power loss in the test system is significantly reduced.

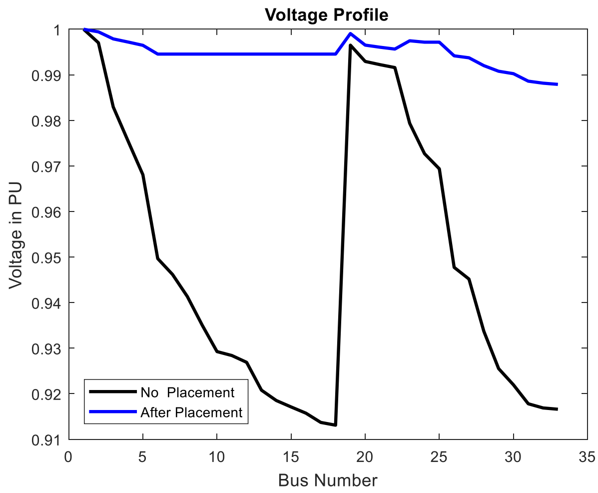


**Fig 6 Output analysis of Grid Voltage and Current**

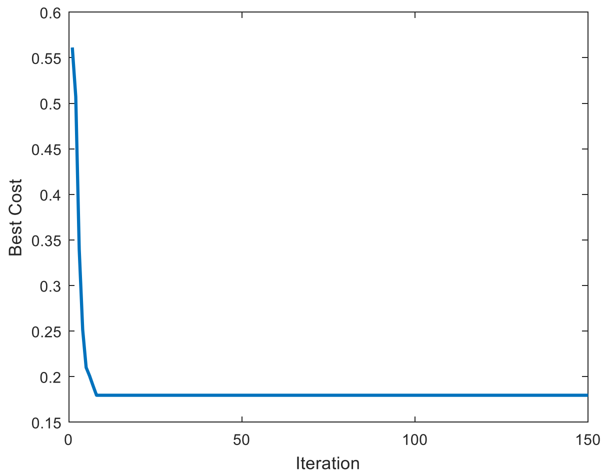


**Fig. 7 Output analysis of PV System**

**Table-2 (Comparative Analysis of Parameters)**

| Parameters | Before Placement | After Placement | Percent Change |
|---|---|---|---|
| **Voltage Profile** | 0.912 | 0.99 | **8.55 %** |
| **Power Losses** | 0.58 | 0.18 | **69 %** |

The given soft computing technology based on the genetic algorithm designed for capacitor placement selection in power systems has been successfully implemented to achieve the goal of minimizing reactive power loss and improving voltage distribution. Table 2 shows the comparative evaluation of voltage curve improvement and power loss minimization before and after placing capacitors in a given test system.
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## V. CONCLUSIONS

This article introduces the soft computing method of genetic algorithm for arranging and placing capacitors in the radial system of the IEEE-33 bus test case. The goal of consideration is to limit the true power failure and improve the voltage curve. Soft computing algorithms take advantage of this; it does not require any algorithms to control boundaries, and it is difficult to implement. The method proposed in this paper simultaneously solves two objective functions. The proposed strategy is applicable to the IEEE 33 bus test system test framework. The reformulation is done under MATLAB programming conditions. The entertainment results obtained show that the proposed procedure is sufficient in limiting misfortune and achieving goals. The introduced philosophy can be effectively implemented in a common-sense decentralized framework for scheduling and operational investigations.

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