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UTILIZING A FAST RECONFIGURATION ALGORITHM TO INCREASE THE EFFICIENCY OF PV SYSTEMS

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Abstract

Partial shading, in which some of a PV system is shaded while the rest is fully shaded lighted, is a major cause of energy loss for PV systems. Mismatch power losses are the manifestation of these wastes. Recent research has found that these losses may be reduced by rearranging the associations between PV modules in a PV framework. Existing reconfiguration approaches, however, are rooted on biological optimisation, which takes extensive computing effort to seek out the best configuration. This is a major drawback that prevents them from being widely used in huge scope PV frameworks. In this review, we present a reconfiguration method for finding the best possible setup with little computing effort. In order to find the optimal PV setup without having to tackle complex optimisation issues, simple principles are established. By comparing the suggested method's results with those of similar existing techniques under a number of different shading conditions, its validity and superiority are confirmed.

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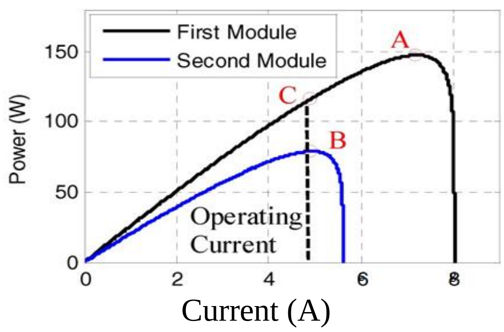
I. INTRODUCTION

There has been a worldwide increase in the use of electricity in recent years, leading to a number of regions facing energy shortages or outright energy crises. To solve this problem, significant efforts of research and development have been given in two areas: Firstly, improve the efficiency of present power conversion and utilization system. Second, create effective technologies for generating and converting renewable energy to complement and ultimately replace the current conventional fossil fuel based energy supply. A viable answer to the energy quandary is the utilization of sustainable energy sources. The renewable energy generation and conversion system has many advantages over conventional energy supply, e.g. the ability of regeneration, reusability and less pollution. However, the production and conversion technologies for renewable energies are still developing. There are still issues, such as poor efficiency and high cost, that need to be addressed. Principal Non-Fossil Fuel Energy Sources currently under development include solar, wind, hydropower and biomass. Alternatives to fossil fuels might be expensive, but renewable energy sources like solar and wind are showing promise. Solar energy is the most efficient and environmentally friendly alternative to wind power. The sun, geothermal forces, and the motion of planets in our solar system provide the basis of the vast majority of the world's renewable energy sources. Solar, wind, hydropower, wave energy, tidal power, ocean thermal energy conversion, and bio fuels are renewable whereas fossil fuels constitute non-renewables. Sun powered energy is the sun based radiation that reaches the earth. Every day Sun radiates or sends out an enormous amount of energy.

Broadly, following three approaches are generally followed for utilizing solar energy.

- Absorbing solar energy directly or by using concentrators and then converting into thermal energy for needed applications,
- Converting solar energy into electrical power using photovoltaic or thermoelectric devices, and
- Utilizing solar energy indirectly.

The sun based power framework can possibly become one of the main renewable energy sources due to the commercial availability of semiconductor-based photovoltaic devices, reduction in the system cost and development of power electronic technologies. In recent years, the solar power generation and conversion technology is developing rapidly. Improving the efficiency and dependability of solar power generating and conversion systems is an essential goal. A photovoltaic system uses solar cells to transform light from the sun into usable electricity. The high cost of installation and poor efficiency are the main issues with solar PV systems. The solar cell's efficiency also fluctuates with changes in the amount of available sunlight and the surrounding temperature. The efficiency of solar panels in converting sunlight into electrical power is currently only about 12–20%. Other variables, such solar panel temperature and load conditions, might further reduce efficiency. Fractional overshadowing, which happens when piece of a framework is concealed (because of passing mists, encompassing items and trees, adjoining PV modules, and so forth) while the rest of the framework is in full daylight, is the essential driver of force misfortunes in sun based PV frameworks [1-4]. When PV modules are linked in series and their power outputs don't match, a lot of juice is wasted. As a result of varying irradiance levels, PV modules linked in series may not produce the same maximum power point (MPP) currents, leading to a power mismatch [5, 6]. Since the MPP currents of the series PV modules are unique, greatest power point tracking is not achievable in this configuration [7-10]. Power discrepancy between two PV modules is displayed in Fig. l, which shows the power bends of the two modules. This is on the grounds that the greatest power from the second PV module (point B) must be removed by the functional current going through the two modules (shown by a ran line), however not the primary module (point A). Befuddle power misfortunes are characterized as the distinction between the influence separated (point C) and the most extreme accessible influence (point A) of the primary module. This exploration investigates the utilization of PV exhibit reconfiguration as a strategy for lessening jumble power misfortunes. The PV system may be thought of as having two distinct types, the fixed and the reconfigurable, as illustrated in Fig. 2. Each switch in the reconfigurable group repositions a PV module in a different row of the fixed group in real time while the system operates [l l]. To start with, voltage and current readings from sensors on the modules are utilized to decide the irradiance of every individual module [12]. A short time later, the modules are moved to stick to the irradiance balance standard [13], which specifies that confound power misfortunes are at any rate when the amounts of irradiances in all the PV columns are about equivalent. Having almost identical MPP currents across all rows helps reduce power losses caused by mismatch.



In Fig. I, we see the power curves of two PV modules wired in series.

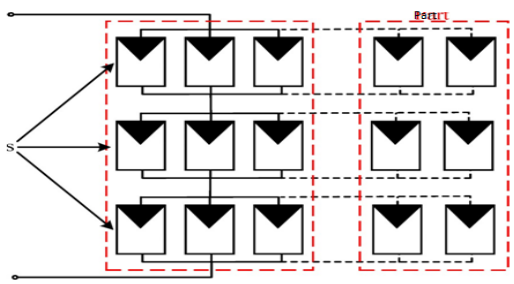


Figure 2: A photovoltaic (PV) system with both permanent and changeable components.

To reduce partial shading losses, [14] lays forth the simplest PV reconfiguration strategy possible. It is done by connecting the reconfigurable PV module with the most light to the decent PV column with the most un-light, etc, until all the reconfigurable PV modules are connected to the proper PV lines. This approach is inefficient due to the time needed to take measurements and analyse data after each PV module has been connected. The amounts of irradiances in the PV columns are computed for each conceivable arrangement, and the arrangement that results in the best equalisation is chosen using the method described in [13]. This approach is impractical because of the enormous number of feasible configurations for big PV systems, which necessitates an exorbitant amount of calculation time. In addition, [l l] proposes an optimization-based approach to PV reconfiguration. By modelling the optimal configuration selection as a quadratic programming problem, the branch and bound approach might be utilized to view as the ideal solution. The purpose of this strategy is to identify the arrangement that minimises the disparity between the PV rows' accumulated irradiance. Similar to other approaches, this research will demonstrate that the lengthy computing time required to address the optimisation issue renders this strategy unfeasible for big PV systems. As part of the reconfiguration strategy presented in [15], a quick and easy-to-understand algorithm was designed to locate the optimal setup with little computing effort. Unfortunately, it is not foolproof and cannot always locate the optimal setup. Using a simple methodology and little processing effort, this research suggests a novel reconfiguration approach.

II.PROPOSED METHOD

Fractional overshadowing, which happens when a part of a sun oriented photovoltaic framework is concealed (by passing mists, encompassing items and trees, adjoining PV modules, and so on) while the rest of the framework is in wide daylight, is the essential driver of force misfortunes in sun powered PV frameworks [1-4]. Because of the power difference between the series-associated PV modules, a huge amount of force is wasted under these circumstances. Because of variations in the amount of sunlight each PV module receives, a power mismatch occurs when their maximum power point (MPP) currents are not identical [5, 6]. Since the MPP currents of the series PV modules vary, it is impossible to extract the maximum power attainable from them [7-10]. Figure 1 displays the power curves of two PV modules that are out of phase with one another, illustrating the phenomenon of power mismatch. Point B addresses the most extreme power that can be separated from the second PV module when the operational current (shown by the dashed line) flows through both modules. Point A represents the most extreme power that can be removed from the primary module. Bungle power misfortunes are characterized as the distinction between the influence extricated (point C) and the greatest influence accessible (point A) of the primary module.

This research focuses on PV array reconfiguration as a proficient strategy for decreasing befuddle power misfortunes. Figure 2 depicts the PV system's organisational structure, which may either be fixed or flexible. During operation, each PV module in the reconfigurable gathering is continually moved to a new location, since it is linked by switches to all rows in the fixed group. To begin, voltage and current readings from sensors are utilized to decide the irradiance of each PV module [12]. The modules are then gotten to such an extent that the complete of irradiances across all PV lines is about the same [13], since this is when mismatch power losses are reduced to a minimum. Subsequently, the bungle power misfortunes are decreased and the MPP flows for all lines are practically equivalent.

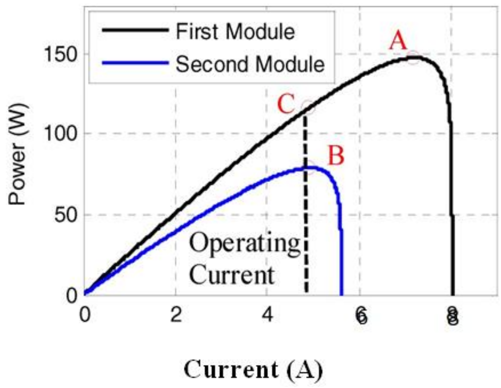


Figure I shows the power curves of the two PV modules wired in series.

Configurable PV rows with fixed parts

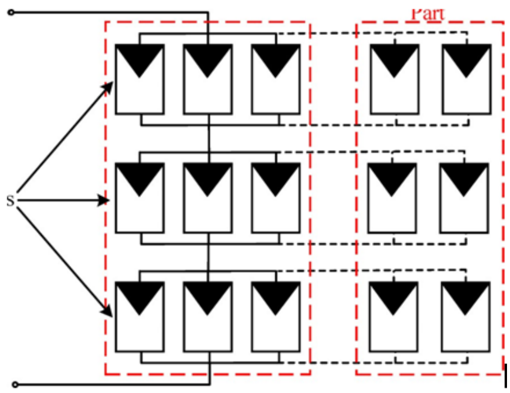


Figure 2: A photovoltaic (PV) system with both permanent and changeable components.

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PV reconfiguration. By modelling the optimal configuration selection as a quadratic programming problem, the branch and bound approach might be utilized to see as the ideal solution. The purpose of this strategy is to identify the arrangement that minimises the disparity between the PV rows' accumulated irradiance. Similar to other approaches, this research will demonstrate that the lengthy computing time required to address the optimisation issue renders this strategy unfeasible for big PV systems. As part of the reconfiguration strategy presented in [15], a quick and easy-to-understand algorithm was designed to locate the optimal setup with little computing effort. Unfortunately, it is not foolproof and cannot always locate the optimal setup. This research suggests a novel reconfiguration strategy, replete with a straightforward algorithm that, when given enough time, may rapidly determine the optimal PV configuration.

III. Proposed Algorithm for Finding the Best Reconfiguration

The best PV-locating algorithm is shown in this section. design and results in limited jumble power misfortunes. The proposed estimation relies upon the irradiance leveling guideline, which is like the accessible calculations in the writing, yet is recognized by its effortlessness and diminished computational time.

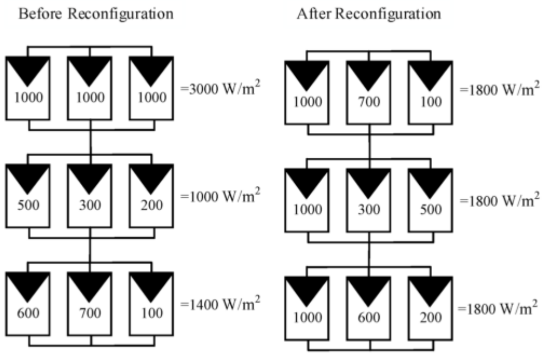

Figure 3: Before and after image of a rearranged PV system.

In order to determine the optimal PV setup, it is necessary to do the following:

Row irradiances are the total irradiances got by the PV modules in a given row, hence this is the first number to calculate.

Track down the columns with the best and least irradiances.

Start with the row that is getting the least amount of sunlight and work your way up to the row that is receiving the most.

After every substitution, the most reduced line irradiance of the two columns will be computed to see whether it is higher than it was before the replacement. whether it is, the replacement will be allowed.

If a replacement is accepted, steps 3 and 4 will be performed to determine which rows will now have the most reduced and most noteworthy line irradiances.

On the off chance that the substitutions are not generally acknowledged, stage 4 is rehashed between the PV line with the least column irradiance and the PV line with the second-generally raised (then third-generally important, fourth-most elevated, and so forth) line irradiance.

In the event that a substitution is acknowledged, Stage 7 will begin in the future between the columns with the most elevated and least irradiances.

When this interaction has been applied to all PV columns, another arrangement will arise that follows the irradiance evening out rule. Conversely, all PV columns in the new plan will consolidate the comparable reconfigurable PV modules. This recommends that if the amount of reconfigurable PV modules in the segments was permitted to be variable, there would be more replacements, leading to better setups. Here's how the algorithm will rearrange the PV panels to get a better layout that's not limited by the number of rows of panels:

Individually, move all PV modules from the PV column with the most noteworthy line irradiance to the PV line with the least line irradiance. Nine, on the off chance that the exchange further develops the line irradiances, the exchange is endorsed, and the system is rehashed with the new PV columns with the most noteworthy and least irradiances.

Assuming that no progressions were acknowledged, stage 10 will be rehashed between the PV columns with the most minimal line irradiance and the PV lines with the second-most elevated (third-most elevated, fourth-most elevated, and so forth) column irradiance.

By applying the method to Fig. 4's partly shaded PV system, we may get a clearer picture of how it works. Nine PV modules are permanently installed, and another nine may be arranged in various ways. Each PV module has an internal indicator that shows how much light hit it throughout the day. Clearly, there is a large disparity in the irradiance levels of different rows (4700 W/m2, 3200 W/m2, and 2600 W/m2). The reason for the proposed strategy is to level column irradiances by adjusting the reconfigurable PV modules displayed in Fig. 4.

The proposed approach starts off with the distinguishing proof of the top and base columns that give the most and least line irradiances, separately. These columns are the top line (4700 W/m2) and the base column (2600 W/m2), individually. The PV modules in the column with the least irradiance (2600 W/m2) will be traded out for the PV modules in the line with the most irradiance (4700 W/m2).The first table in Fig. 5 shows what would happen when the 100 W/m2 PV module is swapped out for a 1000 W/m2 PV module. Approval for this replacement is warranted since the most minimal column irradiance (3500 W/m2) after the installation of the new panels is greater than the irradiance (2600 W/m2) of the old panels (first table in Fig. 5). After the approval of the replacement, this procedure will be repeated to determine which rows of the new PV array will get the most minimal and most noteworthy line irradiances of 3800 W/m2 and 3200 W/m2 correspondingly. A PV module with a lower power yield (100 W/m2) will be introduced in the main column, taking the place of a more powerful (200 W/m2) unit.

Due to the lack of improved row irradiances, this replacement will not be authorised. When switching out a 100 W/m2 PV module with an 800 W/m2 PV module, the same effect happens. In contrast, switching out the PV module (200 W/m2) for the PV module (700 W/m2) will be conceded consent since the most minimal line irradiance (3300 W/m2) after the switch is more prominent than the least column irradiance (2300 W/m2) before the switch, as shown in the third table.

Rows of PV modules that get the least and most irradiance, as indicated in the third table, will be recognized and the methodology will be rehashed. In the third table, we see that the PV module (200 W/m2) will be traded out for the PV module (100 W/m2). The substitution will be approved since the new line irradiances (3400 W/m2 and 3600 W/m2) given in the fourth table are more prominent than the past most minimal column irradiance (3300 W/m2). All of the PV modules in Column 1 of Table IV will go through this system in the future, thus will those in Lines 2 and 3. All things considered, no substitution will be acknowledged. This implies that no further improvement is conceivable.

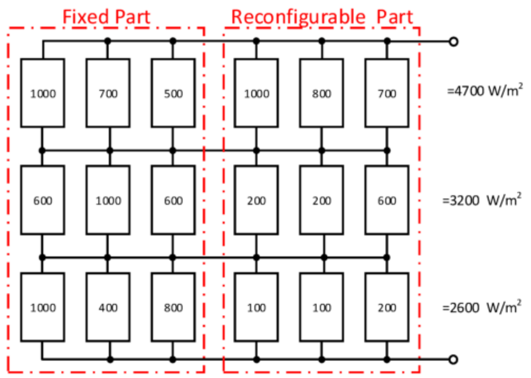

Figure 4: The investigated PV system with partial shading

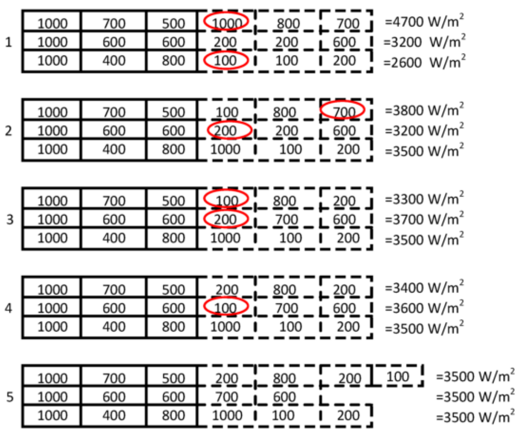

Figure 5 provides a thorough explanation of how the PV system works (Figure) 4 is altered by applying the proposed algorithm.

Now the algorithm enters its second phase. Table 4's second-row PV modules (which get the most irradiance) will be combined with the first-row PV modules (which get the least) to create a single array. As shown, there is no gain from relocating the PV modules (700 W/m2 and 600 W/m2), but the 100 W/m2 module will be relocated because of the gain it provides. The irradiance equalisation principle is met, as shown by Table V, which shows that the irradiance of each row is the same. With this second phase of the algorithm, we relax the requirement that each row include the same amount of PV modules. It's because of this that a superior setup may materialise, and the system is unaffected.

IV. TEST AND VALIDATION

A. Validation of the Suggested Approach

In this subsection, a MATLAB simulation is used to test the efficiency of the suggested reconfiguration process. As should be visible in Fig. 6(a), the researched PV framework is a 6>6 PV exhibit, which comprises of two fixed and four reconfigurable PV segments. The PV modules are fixed in place in the first two columns (shown by the solid line), and may be moved and rearranged in the remaining columns (marked by the dashed line). Two distinct shade conditions are used in the experiment.

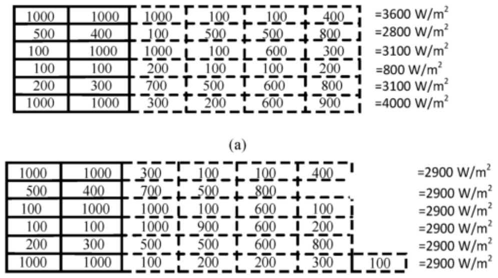

Figure 6: The PV system with the initial shade condition Before and after a configuration change

Figure 6(a) depicts the simplest case for shade. The large range in irradiance from lowest to highest row is evident from the data, which shows a minimum of 800 W/m2 and a maximum of 4000 W/m2. Because of this, the system suffers from power losses due to a mismatch. The suggested method is used to reorganise the system in order to cut down on these losses. As seen in Fig. 6(b), the resultant arrangement is shown. Mismatch power losses are reduced since the new setup results in uniform row irradiances, as indicated. For this PV system, the before and after power curves have been shown for your viewing pleasure in Fig. 7. Obviously subsequent to reconfiguring the framework, the most extreme power available to it is more (1950 W) than it was before (1750 W). As a result of reducing power losses caused by the mismatch.

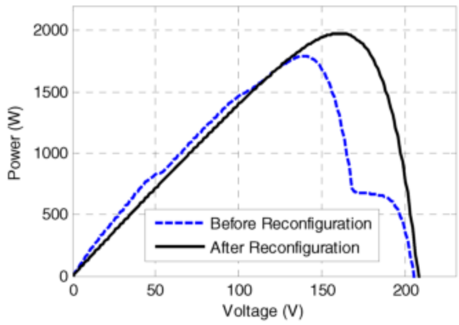

Figure 7: Power bends for the PV framework when reconfiguration, showing what is going on.

As was referenced in the presentation, the as of now accessible writing on PV reconfiguration offers either techniques with high precision yet lengthy computational time, (for example, the strategy introduced in [l l]) or techniques with quick computational time however no assurance of tracking down the best arrangement. The suggested approach is demonstrated to combine the benefits of existing methods, including high accuracy and low processing time, in this section.

We will first evaluate the suggested approach against the precision of the reconfiguration strategies portrayed in [l l] and [15].Since they are the most recent and successful approaches described in the literature, they serve as the standard against which other approaches are measured. The computing effort required by both the current and suggested strategies to zero in on the optimal design will next be compared. Because it is an earlier technique that calls for the PV modules to be actually connected and segregated during the quest for the ideal design, the procedure gave in [14] is left out of the comparison.

The photovoltaic system that was employed for this analysis is shown in Fig. 8(a). After using the reconfiguration techniques described in [I l] and [15], the PV configurations in Fig. 8(b) and Fig. 8(c) might be seen. In Fig. 8(d), we can see the PV arrangement that came about because of utilizing the proposed reconfiguration technique.

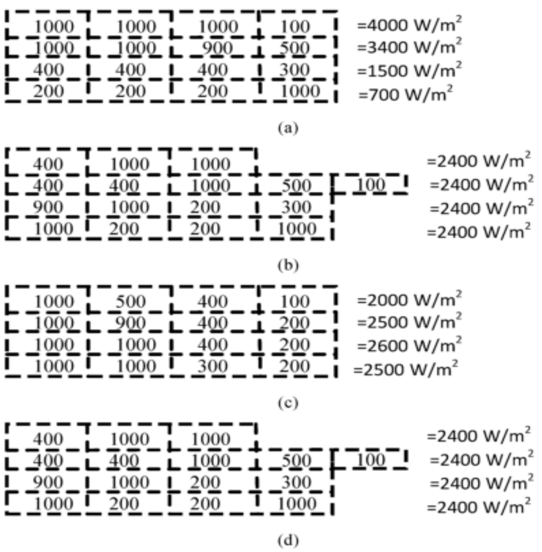

Figure 8: A PV structure under erratically covered conditions, a) first reconfiguration, b) after the reconfiguration uncovered in [11], b) after the reconfiguration depicted in [15], and d) after the suggested reconfiguration.

Row irradiances differ after using the approach in [15], but they are same after applying the suggested method and the one in [l l]. This shows that both the approach provided here and the way described in [l l] have smaller power jumble misfortunes than the technique depicted in [15]. In Fig. 9, we see the distinction between the power bends for the framework prior and then afterward it was reconfigured using the current techniques and the new way. The highest possible power may be generated using the suggested approach, much as the way in [l l]. However, as was mentioned in the introduction, the approach in [15] can't accomplish this greatest power attributable to wrong reconfiguration.

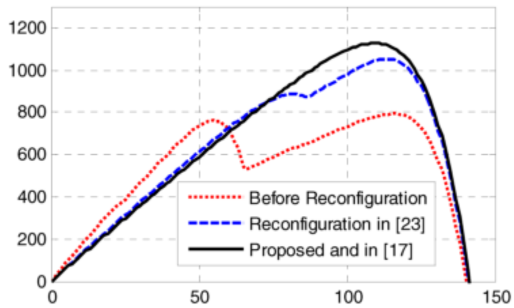

Figure 9 shows the PV system's power curves before and after a planned and existing configuration change.

Table I also summarises and compares the computing effort needed to decide the ideal setup for every one of the proposed and current methodologies. Like the procedure in [15], the figuring time expected by the suggested approach is proven to be very low, if not insignificant at all. The approach described in [l l], however, takes more time to compute due to the additional steps involved (as mentioned above).

V. CONCLUSION

Existing PV reconfiguration algorithms either guarantee the optimal configuration but take a long time to calculate, or they are very accurate but take too little time. This research offered a novel approach to PV reconfiguration that takes use of existing approaches while improving upon them in two key respects: computational efficiency and the ability to identify optimum configurations.

A MATLAB simulation was used to verify the efficacy of the suggested strategy. The strategy was put to the test under a variety of shade conditions, and it proved successful in determining the best setup. The suggested approach was also evaluated in terms of computing time and accuracy in comparison to preexisting configuration methods. High accuracy with little calculation time was shown for the suggested approach.

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