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AN OPTIMAL ELECTRICITY DISTRIBUTION ALGORITHM FOR XYZ ELECTRICITY DISTRIBUTION ZONE

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Abstract

In this paper,an optimal electricity distribution algorithm was developed based on an earlier developed optimal electricity allocation model (OEAM) for efficient energy consumption. This was done by considering the optimal electricity results generated by the application of the OEAM model on the data obtained from the XYZ electricity distribution company and PQR transmission station.The electricity distribution algorithm optimizes the amount of energy to be delivered to various business units of the XYZ electricity distribution company based on the amount of electricity received by the XYZ electricity distribution zone. The algorithm developed was implemented using Java programming language on the JDK 1.7 platform.

Keywords: Algorithm; Fuzzy sets; Fuzzy Goal programming.

Introduction

Supply of adequate, reliable and economically priced power supply is vital for the socio-economic growth and development of any nation. It has been observed that the gross domestic product (GDP) growth rate of a nation has a direct relationship with the growth in the per capita electricity consumption.

The development of the various sectors of the economy, such as industry and commerce, agriculture, health, education, information, banking, tourism, etc depends heavily on reliable, adequate and economically priced power.

However, in rapidly developing economies where power is in short supply with increasing load demand from consumers, and where the load demand becomes in excess of what the generators can cope with, generator operators have adopted methods to save the power plants from damage which has in turn affected the quality of electricity delivered from the generators [1].

In some cases, with the understanding of the system, operator sequential load distribution and load allocation patterns are adopted, but these not only negate the purpose of providing good uninterrupted quality electricity to consumers, it is also unpredictable and does not allow the recognition of any pattern of allocation for the consumers to plan adequately[2].

An energy distribution algorithm would facilitate the effective utilization of the scare resource (electricity) in Nigeria. The pattern to optimally distribute the available electricity supply to the various districts of the XYZ electricity distribution zone which will improve the economy of Nigeria is hereby presented.

Problem Description

Nigeria like most developing economies has some common factors that militate against improved efficiency in electricity supply. Amongst these are: Weak and ageing infrastructure; inadequate transmission and transformation capacity at 330KV and 132KV voltage levels; inadequate protection systems; inadequate control and communication system; aged and obsolete switchgear and protection equipment; faulty lines and substations; overloaded distribution transformers; insufficient raw materials for Power plants; insufficiency of power supply; lack of proper maintenance culture; effect of vandalization; unplanned Network etc[3].

The problem of increasing energy demand by consumers has increased urgency in building new power plants by Independent Power Producers(IPPs) and the upgrading of the existing power plants by Power Holding Company of Nigeria (PHCN) Plcbecause of the socio-economic importance of electricity in the country.

The aforementioned factors amongst others, militating against providing good uninterrupted quality electricity to the consumers can be minimize if consistent load distribution patterns are adopted in which voltages that reaches the consumers are adequately utilized. In view of the inadequate electricity supply in Nigeria, an optimal electricity distribution pattern is developed in which consumers not only receive utilizable voltage but are able to predict the pattern of the electricity distribution which enables the consumers to plan adequately.

Review of Optimization Models

The roots of goal programming lie in the journal of management science by Charnes et al. [4]. Goal programming in fuzzy environment is further developed by Hannan[5], Tiwari [6], Mohamod [7] andBiswas and Pal, [8]. Fuzzy sets are mathematical concept proposed by Zadeh [9].

Bellman and Zadeh[10] defineda fuzzy decision as the fuzzy set of alternatives resulting from the intersection of the goals/objectives and constraints. The use of fuzzy set theory in goal programming was first considered by Narasimhan[11]. Zimmerman [12] extended his fuzzy linear programming approach to the multi objective linear programming problem. In the recent past, Mohamod[7] studied some fuzzy programming models by using the concept of conventional goal programming.

Afrati and Kolaitis[13]carried out a systematic investigation of the repair-checking problem for several different types of repairs and for various classes of integrity constraint encountered in database design, data integration, and data exchange. On the side of tractability, they gave a polynomial-time algorithm for the subset-repair checking problem with respect to every set of constraints that is the union of a weakly acyclic set of local-as-view(LAV)duple-generating dependencies (tgds)and a set of equality-generating dependencies (egds). This result significantly extends earlier tractability results for acyclic sets of inclusion dependencies and functional dependencies. They also gave a polynomial-time algorithm for the symmetric-difference repairs checking problem with respect to a weakly acyclic set of LAV tgds. These two tractability results turn out to be optimal because they found a weakly acyclic set of non-LAV tgds for which the subset-repair checking problem is co-non polynomial (NP)-complete. Furthermore, we found a set that is the union of a weakly acyclic set of LAV tgds with a set of edges for which the symmetric-difference repair checking problem is coNP-complete. They also studied the repair-checking problem for cardinality based repairs. Thus, their results reveal that testing a consistent instance repairs a database by minimizing the number of insertions and deletions is generally harder than testing that it is a subset-repair or a symmetric-difference repairs.

Saad and Schultz [14]present an iterative method for solving linear systems, which has the property of minimizing at every step the norm of the residual vector over a Krylovsubspace. The algorithm is derived from the Arnold process for constructing anl_2-orthogonal basis of Krylovsubspaces. It can be considered as a generalization of Paige and Saunders' MINRES algorithm and is theoretically equivalent to the Generalized Conjugate Residual (GCR) method and to ORTHODIR. The new algorithm presents several advantagesover GCR and ORTHODIR.

In this paper, an optimal electricity distribution algorithm was developed based on the earlier developed optimal electricity allocation model(OEAM) for efficient energy consumption. This was done by considering the optimal electricity results generated by the application of the OEAM model on the data obtained from the XYZ electricity distribution company and PQR transmission station. The electricity distribution algorithm optimizes the amount of energy to be delivered to various business units of the XYZ electricity distribution company based on the amount of electricity received by the XYZ electricity distribution zone.

The Energy Distribution Algorithm

Time An algorithm is a well-defined list of steps for solving a particular problem. The algorithm developed in this paper inputs the energy delivered (E) to XYZ electricity distribution zone, and the time (t_0) for the period to be utilize. As shown in figure1 below, the energy is delivered to all districts if it is sufficient. Districts with energy requirement less than or equal the amount of insufficient energy delivered to XYZ electricity distribution will be selected for distribution if time t_2 is equal for all the districts. However, districts with least time t_2 and energy requirement less than or equal the amount of insufficient energy delivered will be selected for

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Algorithm:  Distribute Energy to n districts for period t0
Input:      Amount of Energy E and period t0
Output:     distribute E to districts

    Main () {
        get Energy (E, t0);
        If (Energy E is sufficient for all districts n)
            distributeEnergyToAll (t0)
            indicate Districts All ()
        else
            t2 = checkTimeUtilizedForAllDistricts ()
            If (t2 is the same for all districts)
               districts = districts with energy requirement <= E
               distributeEnergy (districts, t0)
               IndicateDistricts (districts)
        Else
            districts = = districts with least t2 and energy requirement <=E
            distributeEnergy(districts, t0)
            IndicateDistricts (districts)
                    Record (Date, start time, end time, time utilized)
    }
```

Figure1. Electricity Distribution Algorithm

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distribution. In any case, the algorithm indicate the selected districts and record the current date, start-time, end-time and the period within which energy is been utilized by those districts.

Theorem: Polynomial Orders

Suppose $a_0, a_1, a_2, \ldots, a_n$ *are real numbers and* $a_n \neq 0$.
1. $a_n x^n + a_{n-1}x^{n-1} + \cdots + a_1 x + a_0$ *is* $O(x^s)$ *for all integers* $s \geq n$.

2. $a_n x^n + a_{n-1}x^{n-1} + \cdots + a_1 x + a_0$ *is* $\Omega(x^r)$ *for all integers* $r \leq n$.

3. $a_n x^n + a_{n-1}x^{n-1} + \cdots + a_1 x + a_0$ *is* $\Theta(x^n)$[15].

Efficiency Of The Algorithm

The analysis of algorithms is a major task in computer science. In order to compare algorithms, we must have some criteria to measure the efficiency of our algorithms. Accordingly, unless otherwise stated or implied, the term "complexity" shall refer to the running time of the algorithm [16]. Understanding the relative efficiencies of algorithms designed to do the same job is of much more than academic interest. In industries and scientific settings, the choice of an efficient over an inefficient program may result in the saving of many thousands of dollars or may make the difference between being able and not being able to do a project at all.
Two aspects of algorithm efficiency are important: the amount of time required to execute the algorithm and the amount of memory space needed when it is run. Occasionally, one algorithm may make more efficient use of memory space than another, forcing a trade-off based on the resources available to the user.
When algorithms are implemented in a particular programming language and run on a particular computer, some operations are executed faster than others, and, of course, there are differences in execution times from one machine to another. In certain practical situations these factors are taken into account when deciding which algorithm or which machine to use to solve a particular problem. In other cases, however, the machine is fixed, and rough estimates are all that we need to determine the clear superiority of one algorithm over another. Since each elementary operation is executed in time no longer than the slowest, the time efficiency of an algorithm is approximately proportional to the number of elementary operations required executing the algorithm. In sorting and searching algorithms, the number of comparisms that are required [15].

1. Computing an order of sum of time utilized t_2 nested loop segment. There are n additions for each loop. Therefore there are $13n$ additions for all the districts; by the theorem on polynomial orders $13n$ is $O(n^2)$ and so this algorithm segment is $O(n^2), 2 \geq 1$.

2. The complexity function $C(n)$ of the comparism of the time utilized t_2 when it is equal for all districts is $C(n) = n - 1$.

3. The complexity function $C(n)$ of the best case, worst case and average case for the comparism of the time utilized t_2 when it is not equal for all districts.

(a) Best case: $C(n) = 1$

(b)Worst case: $C(n) = n - 1$

(c) Average case:

$$C(n) = \left(1.\frac{1}{n-1} + 2.\frac{1}{n-1} + \cdots + (n-1).\frac{1}{n-1}\right)$$

$$C(n) = \left(1 + 2 + (n-1)\right)\frac{1}{n-1}$$

$$C(n) = (2 + 3 + \cdots + n)\frac{1}{n-1}$$

$$C(n) = \frac{n}{2n-2}(n+3)$$

Comparing with standard functions for all

n>2, ∃m∈ℤ$^+$/ | $C(n)$ |≤M|g (n) |

Therefore $C(n) = O(n^2)$ [16].

4. The complexity function $C(n)$ of the best case, worst case and average case for the distribution of electricity to districts when t_2 is equal for all districts and energy requirement less or equal to E.

(a) Best case: $C(n) = 1$

(b) Worst case: $C(n) = 13(n)$

(c) Average case:

$$C(n) = \left(1.\frac{1}{n} + 2.\frac{1}{n} + \cdots + (n).\frac{1}{n}\right)$$
$$C(n) = (1 + 2 + \cdots + n)\frac{1}{n}$$
$$C(n) = \frac{1}{2}(n + 1)$$

By the theorem on polynomial orders $\frac{1}{2}(n + 1)$ *is* $\Theta(n)$,hence, this algorithm segment is $\Theta(n)$.

5. The complexity function $C(n)$ of the best case, worst case and average case for the distribution of electricity to districts where t_2 is not equal for all districts and energy requirement less or equal to E.

(a) Best case: $C(n) = 1$

(b) Worst case: $C(n) = 13(n)$

(c) Average case:

$$C(n) = \left(1.\frac{1}{n} + 2.\frac{1}{n} + \cdots + (n).\frac{1}{n}\right)$$
$$C(n) = (1 + 2 + \cdots + n)\frac{1}{n}$$
$$C(n) = \frac{1}{2}(n + 1)$$

By the theorem on polynomial orders $\frac{1}{2}(n + 1)$ *is* $\Theta(n)$,hence, this algorithm segment is $\Theta(n)$.

Conclusion

In this paper, we demonstrated how an optimal electricity distribution algorithm can be used efficiently and effectively to distribute sufficient and insufficient electricity supply to XYZ electricity distribution zone comprising of 13 districts in order to obtain an optimal utilization of the scarce resource (electricity) based on the results generated from the applicability of the OEAM using Java programming language. The software developed provides a more flexible and realistic way for providing solutions to the electricity company energy distribution problems. While XYZ electricity distribution company has been selected for demonstrating the application of this algorithm, the algorithm is flexible enough to be extended to handle larger sizes electricity distribution problems.

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