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New Dynamic Programming based Unit Commitment Technique by Reducing Paths

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***Abstract*— This project presents a new dynamic programming solution to the unit commitment problem. The unit commitment is the complex decision making process because of multiple constraints the Unit commitment which may not be violated while finding the optimal or suboptimal commitment schedule. Dynamic programming takes a lot of simulation time, so it is not optimal to use in a real power system for performing the unit commitment. Therefore, we need a new dynamic programming method to satisfy both the simulated and the real power system to get the optimal solution. A five generator system will be considered and the unit's commitment schedule will be found considering the demand for 24 hours. The goal of the objective function is in cost minimization, so we use the economic dispatch using the lambda iteration method when we calculate the production costs. Finally, we compare the UC solution by using both methods.**

Keywords- Start up cost, production cost,economic dispatch, feasible state, new dynamic programming constraints.

I. INTRODUCTION

A unit commitment (UC) process decides when to start and shutdown units according to the load status. The UC problem is well known in the power industry and it is important to save millions of dollars per year. Therefore the method of UC has been gradually studied. When we use the priority list method for the unit commitment, we can save simulation time and memory, and it can also be applied in a real power system. The priority list method has drawbacks that result in suboptimal solutions because it does not consider all the possible combinations of generation. Therefore, we have to find a method for always getting an optimal solution. Dynamic programming is the one of these methods. By using dynamic programming for unit commitment, we can get optimal solutions. However, it is well known that there is a problem in the number of combinations of units. When we decide for the optimal start and shutdown of the units, it will take considerable time and use a lot of memory to save all the paths. Because of these problems, dynamic programming can

II. UNIT COMMITMENT

Constraints

We considered three constraints the loading constraint, the unit limit constraint and the minimum-up/down time constraint.

A. Load Constraint

$$PD - \sum_{i=1}^{i=n} PG = 0$$

B. Unit Limit Constraint

$$P_{min} \le PG \le P_{max}$$

C. Minimum Up/Down Constraint

C(1) Minimum Up Time

Once starts the generator, it will take some time to shut down.

C(2) Minimum Down Time

Once shut down the generator, it will take some time to recommit.

III. PRODUCTION COST

After considering the constraints we need to calculate the Production cost for each generating unit. Before getting the Production cost, it is necessary to decide the generation of each unit by using the economic dispatch which is realized by the lambda iteration method. At first, we assumed lambda of any value. By applying this value, we could get the generation of each unit. We then could calculate the error that is difference between the demand and total generation. If the error is not satisfied, the value is smaller than the tolerance; the lambda would have to be updated by applying the projection method. Lastly, after getting the generation of each unit, we could then calculate the production cost by multiplying the fuel cost.

IV. AU POWER CALCULATION

Limits on unit generation

PGmin	PGmax
150.000	455.000
20.000	130.000
20.0000	130.000
20.0000	80.0000
10.0000	55.0000
TOTAL DEMAND:820.0000	

V. RESULTS

INCREMENTAL FUEL COST

dC1/dPG1	16.6268
dC2/dPG2	17.1200
dC3/dPG3	17.0486
dC4/dPG4	23.3992
dC5/dPG5	26.1265

VI. PRODUCTION COST

$$Pcost(k,I)= \sum_{i=1} P_i\lambda_i + \text{No load operating cost}$$

P_i - Generating power.

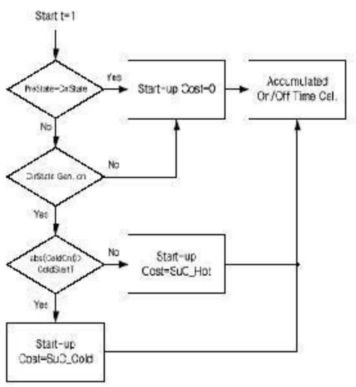
λ_i - Incremental fuel cost.

(i=1,2,…..,n)

VII. START UP COST

Another cost of UC is the start-up cost. Assume that, there is no cost associated with the shutting down of units is this paper. A simple practice is to assume a constant cost irrespective of the unit shut down time. However, if we are to get more accurate results in the unit commitment, a time dependent start-up cost is needed. Therefore, the start-up cost we considered in this paper is dividend of the cold start-up cost and the hot start-up cost.

A. Flow Chart



Pre State	:	Previous Generator State
Crr State	:	Current Generator State
Cold Cnt	:	Accumulated Generator State
Cold StartT	:	Generator Cooling Time
SuC_Hot	:	Hot Start-up Cost
SuC_Cold	:	Cold Start-up Cost

Each unit has an individual basis of cooling time. So by comparing between the accumulated status and the cooling time, we could decide the time dependent start-up cost.

VIII. OBJECTIVE FUNCTION

FCOST(K,I) = min [PCOST(K,I)+SCOST(K-1,L:K,I)+FCOST(K-1,L) where

$State(K,I)$: Combination I of Units at Time K

$F_{cost}(K,I)$: Least Total Cost to Arrive at State (K,I)

$P_{cost}(K,I)$: Production Cost for State (K,I)

$S_{cost}(K-1,L:K,I)$: Transition Cost from State (K-1,L) to State (K,I)

IX. NEW DYNAMIC PROGRAMMING

New dynamic programming, we mention the characteristics of dynamic programming. Dynamic programming is a methodical procedure which systematically evaluates a large number of possible decisions in a multi-step problem .When we utilize the existing dynamic programming method, although its solution is correct and has the optimal value; it takes a lot of memory and spends much time in getting an optimal solution. For example, assume that there are 4 units which can supply the 24 hour load. So, the total maximum path to satisfy the 24 hour load curve is calculated by:

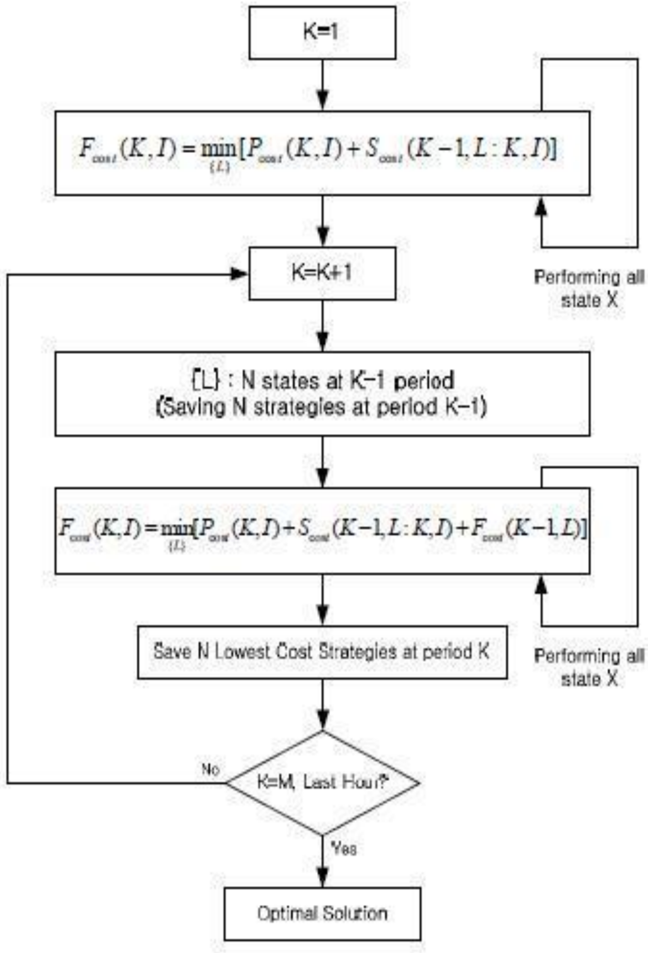
$$Total \quad Paths = (2^4 - 1)^{24}$$

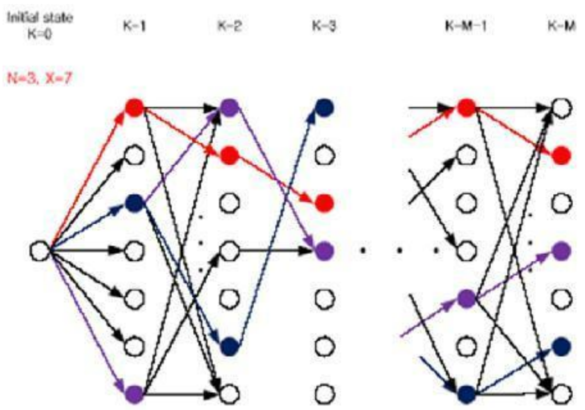
Because of this disadvantage, a better method of determining the optimum combination of units in service for any given system and load condition is desirable. Fortunately, there is such a method: modified dynamic programming. We already showed the standard dynamic programming method and we recognize the disadvantage a lot of paths. We

Total Paths = $(2^5-1)^{24}$

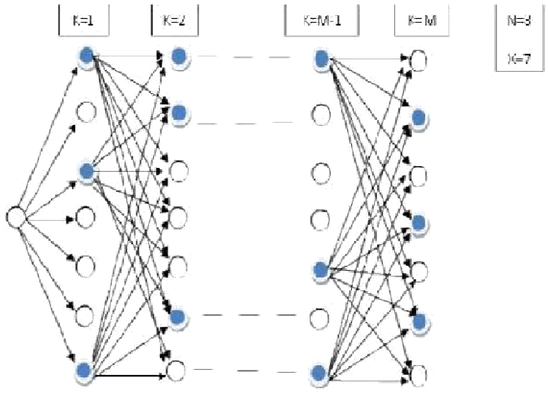
introduce the characteristics of modified dynamic programming. As shown in Figures, modified dynamic programming does not save all the paths in order to get the optimal solution. At K periods, we consider all the feasible states X which could be satisfied by demanding from N paths at the K-1 period. Continuously, we find the lowest new N paths and thereby save memory and time. Similarly, we iterate until the last period.

A.Flow Chart





The modified dynamic programming path saving.

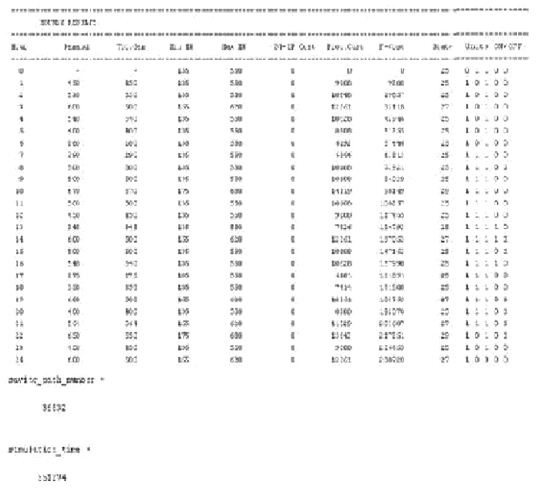


UNIT CHARACTERISTICS

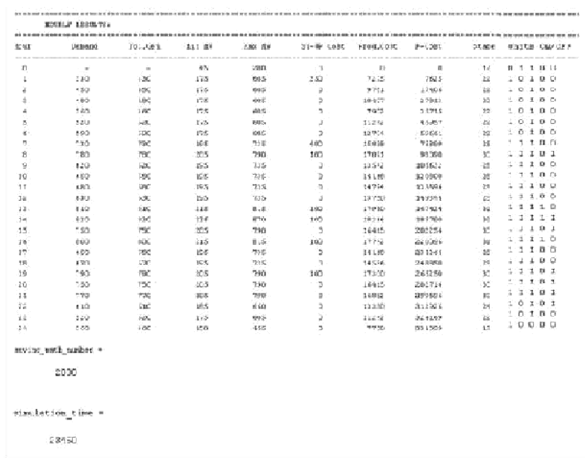
Parameter		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
MinOutput [MW]		150	20	20	20	10
MaxOutput [MW]		455	130	130	80	55
SuC_Cold [$]		9000	1100	1120	340	60
SuC_Hot [$]		4500	550	560	170	30
ColdStartT [h]		5	4	4	2	0
MinUpTime [h]		8	6	6	4	1
MinDownTime [h]		8	6	6	4	1
Heat rate curves	a	0.00048	0.002	0.00211	0.00712	0.00413
	b	16.19	16.6	16.5	22.26	25.92
	c	1000	700	680	370	660

24 HOURS LOAD DATA

Time (h)	Load (MW)	Time (h)	Load (MW)
1	330	13	810
2	450	14	820
3	480	15	750
4	360	16	800
5	520	17	650
6	590	18	670
7	730	19	790
8	780	20	750
9	620	21	770
10	650	22	610
11	680	23	520
12	630	24	360



DYNAMIC PROGRAMMING METHOD:



VII.COMPARISON O F DYNAMIC AND NEW DYNAMIC PROGRAMMING

Method	Savin g Path Num ber	Simulation Time
DYNAMIC PROGRAMMING	368 32	551274
NEW DYNAMIC PROGRAMMING	2000	23450

VIII. CONCLUSION

There is lot of method for solving the unit commitment problem and there are both advantage and disadvantages. One of the main problem of the do not get the optimal solution for performing the unit commitment. Dynamic programming was chosen to get an optimal solution despite being impossible to utilize in a real power system. Therefore, we needed to develop a dynamic programming system with that could be applied to a real power system. So introduced the new dynamic programming described in the paper and compare both applied to a real power system. So introduced the new dynamic programming described in the paper and compare both method.

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