A NEW APPROACH FOR NETWORK RECONFIGURATION USING A KNOWLEDGE BASE SYSTEM

فكره جديده لاعادة بناء الشبكه الكهربائيه باستخدام نظام المعرفه

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الخلاصة

تمثل مسألة الحفاظ علي أمان الشبكات الكهربيه في مواجهة الاحداث الطارئه أهميه عظمي في مجال تشغيل الانظمه الكهربيه. لذلك فمن الضروري أن يتوفر لدي مراكز التحكم برامج تعطي الحلول السريعه في مجال ازالة التحميل الزائد ومن هنا فقد تعددت الابحاث في هذا المضمار. وحديثا اتجهت الابحاث صوب الطرق التي تخلص الشبكه من التحميل الزائد عن طريق اعادة تغيير سريان القدره بتغيير شكل الشبكه. وقد استخدمت الطرق الرياضيه في ذلك اولا ، الا أنه في الاونه الاخيره قد تردد في الساحات العلميه ما يعرف باستخدام عنصر الذكاء الصناعي والاستفاده من الخبره البشريه في ايجاد نظام يمكن به حل مشاكل التحميل الزائد وبالتالي تجنب الكثير من العقبات التي تنجم عن استخدام الطرق الرياضيه. ولما كانت للطرق الرياضيه بعض المزايا مثل عنصر السرعه في ايجاد الحلول فانه في هذا البحث أمكن الجمع بينها وبين القواعد المستفاده من الذكاء الصناعي لعمل برنامج يفي بتلك المتطلبات مثل الحفاظ علي اقتصاديات التشغيل وأخذ القيود المختلفه في الاعتبار وكذلك عنصر السرعه في ايجاد الحلول.
وقد تم تطبيق الطريقه علي شبكة مصر الشماليه جهد ٢٢٠ ك.ف. وأكدت النتائج مصداقية وكفاءة هذه الطريقه.

Abstract:

This paper presents an approach to remove the overloads on an electrical transmission network by modification of its topology, the approach tries to impeds the algorithmic approaches with the heuristic techniques to benefit from both to build a knowledge based system. It allows the expression of the constraints to be taken into account.

The approach is implemented on the 220 kv network of Northern Egypt power system.

The results achieved proves the efficiency and validity of such approach to be implemented in the context of real time advanced applications in an Energy Management System.

I. Introduction:

No one can deny that the security of the power system is one of th important objectives, so many researches are continually offered to study this problem.

The problem becomes more difficult in case of accuring an unexpected event such as an outage of transmission line or generator. Particularly, if an overload appears on a transmission line, a corrective action must be quickly taken.

In the past, the corrective action was calculated using a linear programming solution and resulted in a shift in generation [1]. Because such shifts are generally in conflict with the carefully considered economic dispatch of the generation, the researches have gone along another type of the corrective actions that is a modification of the network topology through either line switching or busbar splitting. This actions affects neither the loads nor the cost of the operation and thus are interesting.

Reference [2] proposed an algorithm for automatic selection and ranking the possible lines to be switched to relieve line overload. The approach used the linear sensitivity factors which are calculated from relevant elements of the spars bus impedance matrix.

References [3,4] proposed a method to find the line to be switched by using the z matrix representation, if a line between buses P,Q is overloaded in the base case, then to check the effect of switching the line between buses R,S, the quantity/ $(Z_{PR}-Z_{QR})-(Z'_{PR}-Z'_{QR})$ is computed, if it is positive, then the overload will be reduced by switching the line R-S, where $Z_{PR}-Z_{QR}$ are the Z matrix elements of the base case while $Z'_{PR}-Z'_{QR}$ are the matrix elements after switching the line R-S.

References [5,6] proposed an approach to find the corrective topology by using the concept of current injection between the line to be switched, such current injection is distributed among the other lines of the network. The distribution of this current injection depends on the matrix of node branch distribution factors derived from the Z matrix of the base case and the branch currents in the overloaded case.

Reference [7] offered a fast algorithm to alleviate transmission lines overloads by changing the network topology. The algorithm used the concept of line outage distribution factors derived from the network admittance to solve the problem by either line switching or busbar splitting.

Nowdays, another way is used to find the corrective network topology, that is the "knowledge based system". The AMPERE system [8,9] which was started at the end of 1987 and was presented at Stockholm in 1988 is an example for this work. AMPERE system is designed on the basis of heuristic techniques and uses multiple search strategies and control strategies to find network reconfigurations to remove one or several overloads on the transmission lines.

The goal of this paper is to use the algorithm proposed in [7] which benefit of the heuristic techniques stated in [8] to find an approach can achieve the best results in the field of removing overloads and is the ground to a complete knowledge based system.

2. Problem formulation:

2.1. General:

Although algorithms are able to provide an answer to the question of how to modify the network topology to remove the overloads, they are generally limited in selecting the best corrective action.
Recently, the researches tend to use the heuristic knowledge obtained from the dispatcher's experience in this aspect. The problem will be solved with the best results if the algorithms are coupled to the heuristic techniques to benefit from the advantages of both.
In the next section an overview shows how the algorithm developed in Reference [7] can be used to build a knowledge based system.

2.2. Overview of the search process:

Fig. (1) gives the contingency list, the resulting overloaded lines list, and the corresponding corrective action list, this figure is formed as follows:

- The network lines are outaged one at a time, if overloads are detected, then the algorithm in [7] will find a list of corrective actions. If a candidate is chosen to remove the overloads, this candidate is passed into several rules:

a. Satisfaction of all the general or specific constraints.
b. Comparison between forecasted transit patterns in a given reconfiguration and the patterns required by the network.
c. Check of network connexity.
d. Satisfaction of all or some of the following rules gained from the operator's experience:
   - A reconfiguration has a stronger effect locally than on distant points of the network.
   - The direction of the power flow around a particular line can be used to select parts of the network interesting to alleviate the overload on that line.
   - The load on a line can be alleviated by the reduction of the impedance of the rest of the network.

   If the action is satisfying these rules, then the search is transferred to another outage, otherwise it continues to test another action.

2. Repeat this procedure over all the lines of the network and write down the results in a Figure such as Fig. (1).
3. Once Fig. (1) is formed, then the information in this Figure gives the solutions directly for future use by the system operators.

3. Test results:

An application on the 220 kv network of the Northern Egypt power system is carried out, the test system consists of 42 buses and 54 lines, Fig. (2) shows a single line diagram of the test system, the system data are shown in Table (1) and the base case data are shown in Table (2).

In this application, as an example:

- Due to the outage of line"3", line No. 10 is overloaded and the corrective action produced is splitting at bus 12.
- Also, if the line No. "17" is outaged, lines 18, 22 will be over loaded and then for relieving the overloads, the line No. 37 must be opened.
- The complete results are shown in Table (3).

4. Conclusions:

An approach is presented to build a knowledge based system for network reconfiguration (to alleviate line overloads). A preliminary work has been carried out to build a table look-up identifying necessary corrective actions for different line outages accompanied by different overloads.

The approach proposed allows to the algorithms to be coupled with the heuristic knowledge obtained from the operator's experience to build a knowledge based system to give a rapid solution in a short time.

The results confirmed that the approach proposed is confident and valid to be used in the energy control centers along with Artificial Intilleganee Techniques.

5. References:

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Contingency list	The resulting overloading lines	The corresponding Corrective action
Outage of line "1"		
"M"	Lines A,B	Opening line "F"

Figure (1): Towards building acknowledge based system.

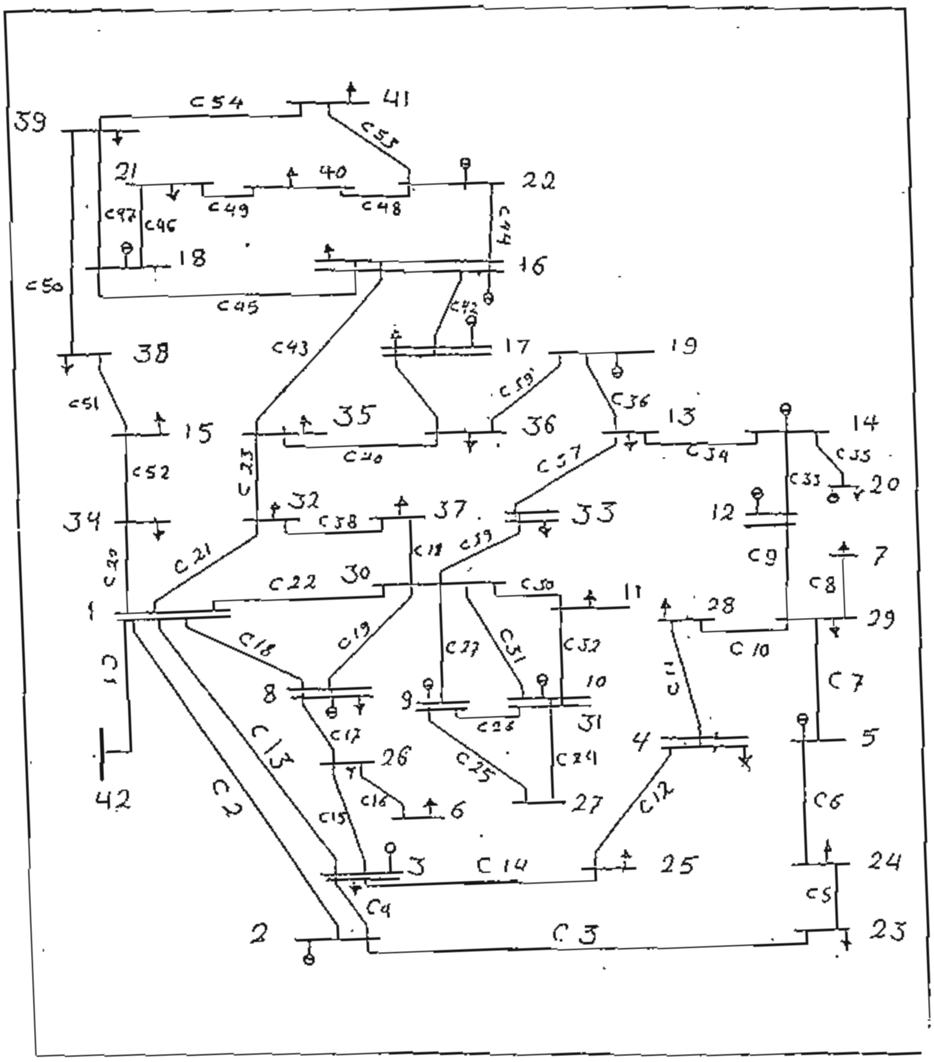

Fig. (2): Northern Egypt 220 Kv network.

Branch Num.	Branch From	Branch to	Xser (ohm/Km)	Lenght (Km)		Branch Rating (MW)
1 *	1	42				1500
2	1	2	0.410	43.0		230
3	2	23	0.418	50.0		300
4	2	3	0.410	3.0		230
5	23	24	0.3119	18.0		280
6	5	24	0.3119	28.0		360
7	5	29	0.4180	5.0		360
8	7	29	0.4180	5.0		360
9	12	29	0.4180	39.0		360
10	28	29	0.4180	45.0		280
11	4	28	0.4180	8.0		260
12	4	25	0.4180	6.0		260
13	1	3	0.4180	40.0		230
14	3	25	0.4180	10.0		260
15	3	26	0.4180	11.5		360
16	6	26	0.3020	91.0		360
17	8	26	0.4180	11.5		360
18	1	8	0.4180	5.5		380
19	8	30	0.4180	4.5		380
20	1	34	0.3920	35.5		460
21	1	32	0.4180	30.0		360
22	1	30	0.4180	10.0		380
23	32	35	0.4180	21.5		360
24	10	27	0.1344	5.0		500
25	9	27	0.0918	5.0		600
26	9	31	0.0918	4.0		600
27	9	30	0.0918	1.3		900
28	30	37	0.4180	20.0		360
29	30	33	0.4180	9.0		360
30	11	30	0.4180	10.0		400
31	31	30	0.4180	4.0		360
32	11	31	0.4100	9.5		600
33	12	14	0.4180	18.5		500
34	13	14	0.4180	37.5		460
35	14	20	0.4180	40.0		360
36	13	19	0.4180	60.0		180
37	13	33	0.4100	26.0		360
38	32	37	0.4180	21.0		360
39	19	36	0.4180	50.0		302
40	35	36	0.4180	43.0		180
41	17	36	0.3020	38.0		360
42	16	17	0.4180	7.0		360
43	16	35	0.4180	31.5		360
44	16	22	0.3119	20.0		360
45	16	18	0.4180	13.5		360
46	18	21	0.4180	11.5		360
47	18	39	0.4170	17.5		340
48	22	40	0.4170	8.5		360
49	21	40	0.4170	8.5		360
50	38	39	0.4100	2.5		360
51	15	38	0.3920	15.5		360
52	15	34	0.3920	26.0		460
53	41	22	0.4100	22.5		360
54	41	39	0.3020	2.5		360

Table (1): Test system data.

* Branch No. 1 is a transformer branch.

No.	Bus Gen	Bus Load
1	0	0
2	59	152
3	50	147
4	36	84
5	290	0
6	0	105
7	0	30
8	260	102
9	1140	0
10	0	138
11	0	168
12	555	36
13	77	114
14	19	48
15	0	36
16	136	45
17	119	33
18	279	45
19	125	279
20	34	36
21	120	132
22	600	15
23	0	18
24	0	9
25	0	114
26	0	84
27	0	126
28	0	24
29	0	15
30	0	0
31	0	0
32	0	78
33	0	105
34	0	6
35	0	18
36	0	123
37	0	78
38	0	36
39	0	114
40	0	84
41	0	126
42	0	1003
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		

Table (2): Data of test case

Contingency list	The resulting overloading lines	The corresponding corrective action
Outage of line "1"	-	-
Outage of line "2"	-	-
Outage of line "3"	line 10	Splitting at bus "12"
Outage of line "4"	-	-
Outage of line "5"	lines 10,11,12	Splitting at bus "29"
Outage of line "6"	lines 10,11,12	Splitting at bus "29"
Outage of line "7"	Line 5	Opening line 4
Outage of line "8"	-	-
Outage of line "9"	Line 22	Splitting at bus 30
Outage of line "10"	Line 5	Splitting at bus 3
Outage of line "11"	Line 5	Splitting at bus 3
Outage of line "12"	Line 5	Splitting at bus 3
Outage of line "13"	-	-
Outage of line "14"	-	-
Outage of line "15"	-	-
Outage of line "16"	-	-
Outage of line "17"	Lines 18,22	Opening line "37"
Outage of line "18"	Line 22	Splitting at bus 30
Outage of line "19"	Line 22	Splitting at bus 30
Outage of line "20"	Lines 18, 22	Opening line 38
Outage of line "21"	Lines 18, 22	Opening line 41
Outage of line "22"	Lines 18, 19	Splitting at bus 30
Outage of line "23"	-	-
Outage of line "24"	Line 27	Opening line 30
Outage of line "25"	Line 27	Splitting at bus 9
Outage of line "26"	Line 27	Splitting at bus 9
Outage of line "27"	Lines 24,26,31	Splitting at bus 9
Outage of line "28"	-	-
Outage of line "29"	-	-
Outage of line "30"	-	-
Outage of line "31"	-	-
Outage of line "32"	Line 27	Splitting at bus 28
Outage of line "33"	Line 5,10,11,12	Generation shift
Outage of line "34"	Line 5,10,11,12	Generation shift
Outage of line "35"	-	-
Outage of line "36"	-	-
Outage of line "37"	Lines 10, 11	Opening line 7
Outage of line "38"	-	-
Outage of line "39"	-	-
Outage of line "40"	-	-
Outage of line "41"	Line 43	Splitting at bus 16
Outage of line "42"	-	-
Outage of line "43"	-	-
Outage of line "44"	-	-
Outage of line "45"	-	-
Outage of line "46"	-	-
Outage of line "47"	Line 53	Opening line 51
Outage of line "48"	-	-
Outage of line "49"	-	-
Outage of line "50"	Lines 18,22	Opening line 38
Outage of line 51"	Lines 18,22	Opening line 38
Outage of line 52"	Lines 18,22	Opening line 38
Outage of line 53"	Line 47	Opening line 50
Outage of line 54"	-	-

Table (.3).: Using the algorithm to build a knowledge base system.