Paper No: 21ISGT1122

Toward Efficient Wide-Area Identification of Multiple Element Contingencies in Power Systems

Hao Huang (Presenter), Zeyu Mao, Mohammad Rasoul Narimani, and Katherine R. Davis

Texas A&M University

hao_huang@tamu.edu

Background

Line Outage Distribution Factors (LODFs)

Based on LODFs, we proposed a new metric *M* to represent the importance of branches in the system.

$$NLODF(i) = \frac{mean(abs(LODFs))}{std(abs(LODFs))}$$

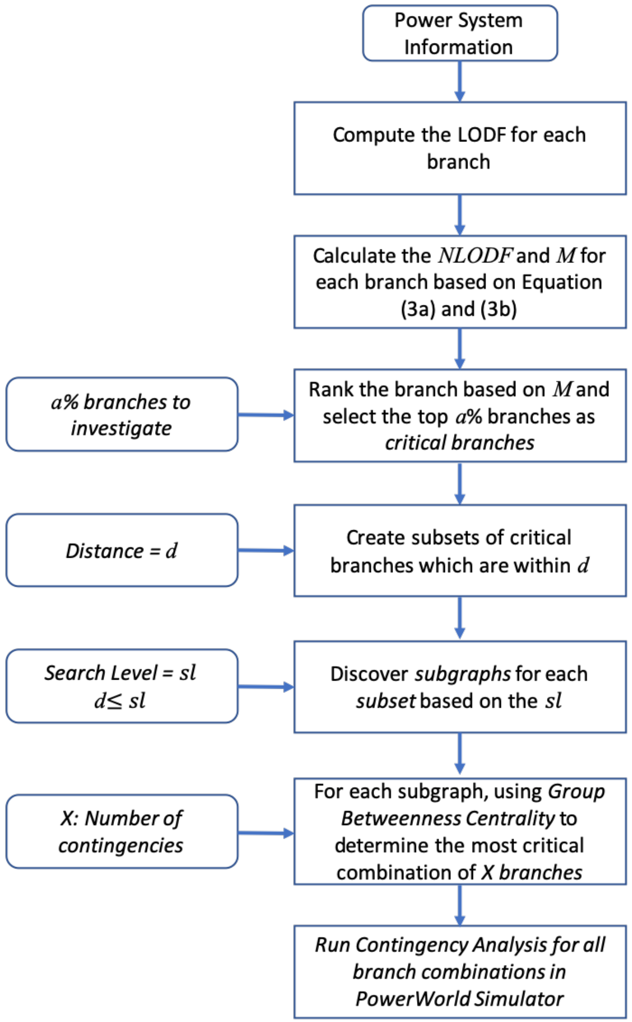
$$M(i) = PF(i) \times min\{NLODF(i), 1\}$$

Group Betweenness and Centrality (GBC)

GBC is to identify a set of the most important components whose loss has a severe impact on the network.

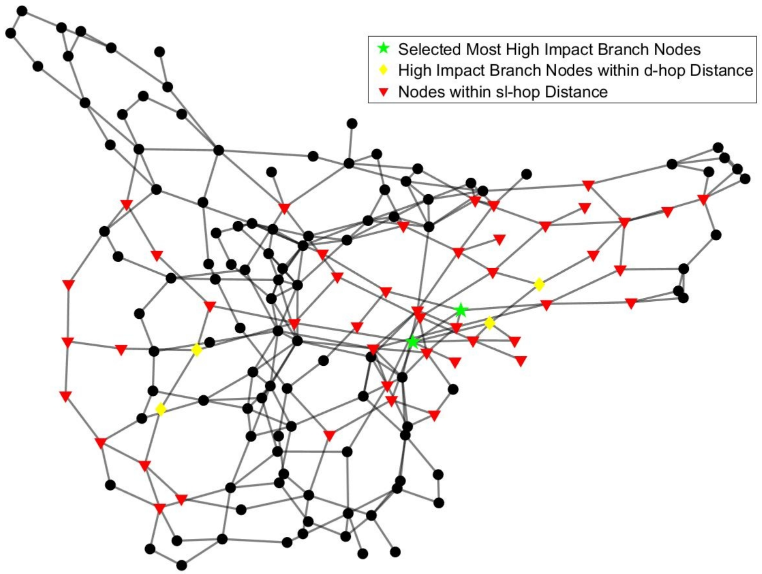
$$GBC(E) = \sum_{s=1}^{n} \sum_{t=1}^{n} \frac{\sigma(s,t|E)}{\sigma(s,t)}, s,t \notin E, s \neq t$$

Critical Branches Identification Framework



Example of Constructing Subgraph

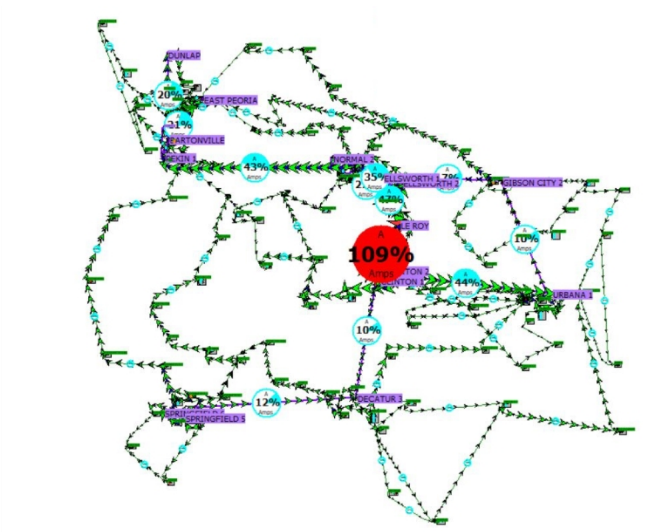
d=3 *sl*=3



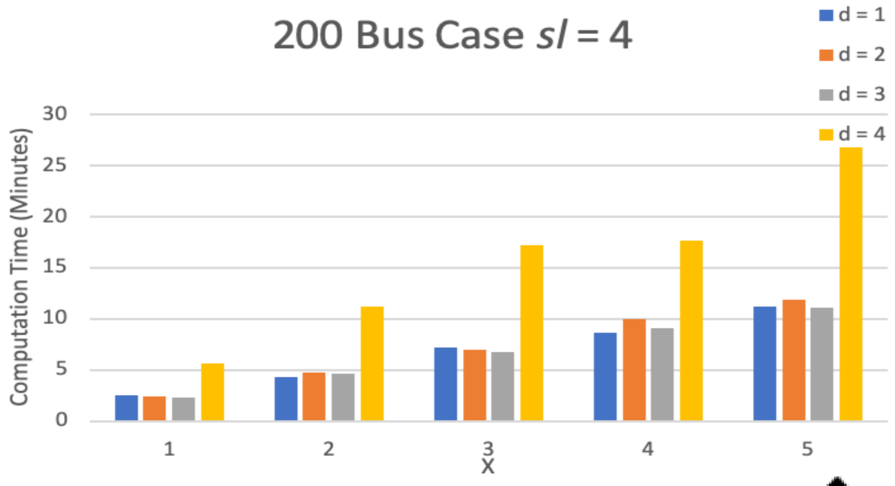
The green star nodes show both ends of the line whose outage has the highest *M*. The yellow diamond nodes show other high impact branches in the grid that are within 3 hop-distance to the green star nodes. The red triangle nodes are within 3-hop distance from the desired branches.

Results

200-Bus Synthetic Grid

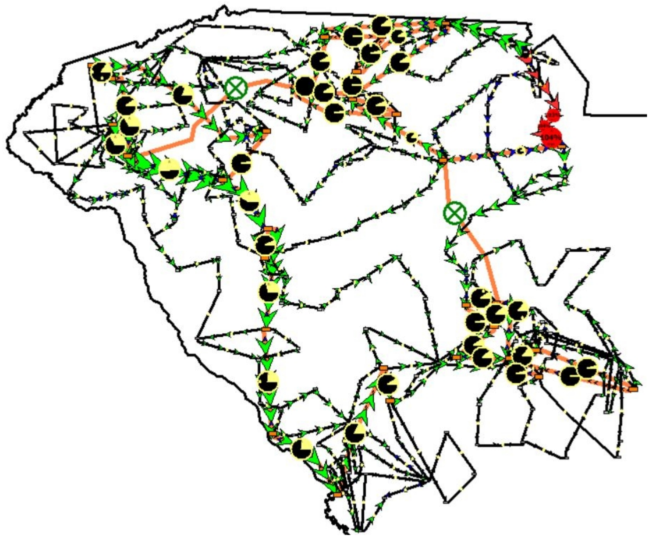


X	Critical Line	Contingency	Distance (*d*)	Searching Level (*sl*)	Computation Time (min)
1	[[189, 187]]	Reserve Limit	4	4	05:39.5
2	[[189, 187], [187, 121]]	Reserve Limit	4	4	11:14.1
2	[[189, 187], [136,133]]	Reserve Limit	4	4	11:14.1
2	[[136, 133], [135, 133]]	1 Overflow and Reserve Limit	4	4	11:14.1
3	[[189, 187], [187, 121], [154, 149]]	Reserve Limit	4	4	17:10.8
3	[[189,187], [136, 133], [135, 133]]	Unsolved	4	4	17:10.8
3	[[136, 133], [135, 133], [125, 123]]	2 Overflow, 18 Undervoltage, and Reserve Limit	4	4	17:10.8
4	[[189, 187], [136, 133], [135, 133], [125, 123]]	Unsolved	4	4	23:38.1
4	[[189, 187], [187, 121], [154, 149], [152, 149]]	2 Overflow	4	4	23:38.1
5	[[189, 187], [136, 133], [135, 133], [125, 123], [126, 123]]	Unsolved	4	4	26:47.6
5	[[189, 187], [187, 121], [154, 149], [152, 149], [153, 149]]	Unsolved	4	4	26:47.6
5	[[136, 133], [135, 133], [125, 123], [126, 123], [127, 123]]	Unsolved	4	4	26:47.6

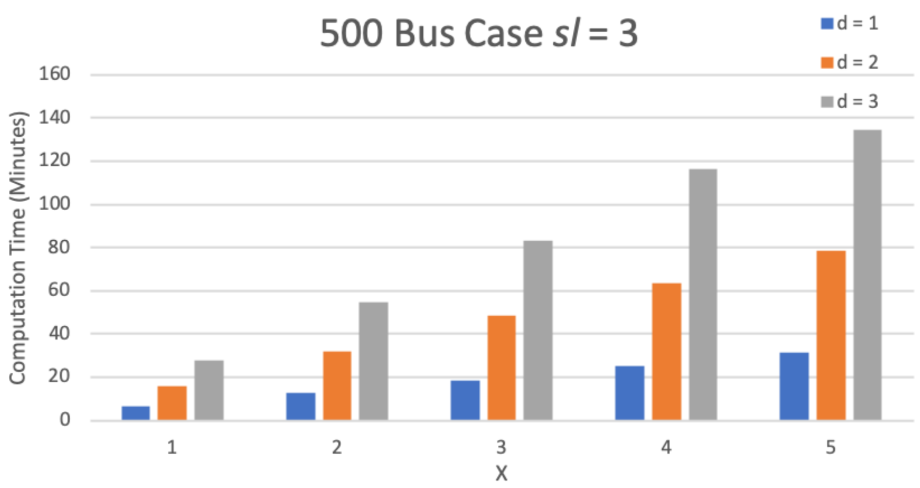


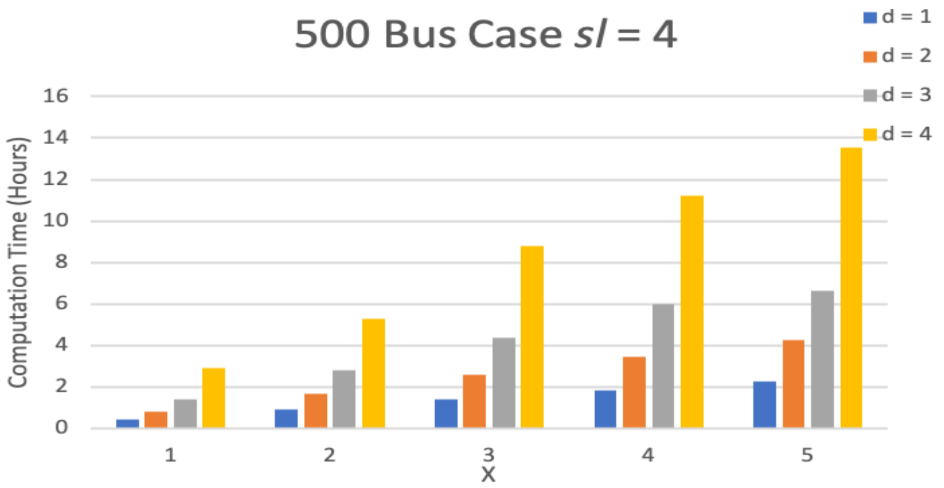
Results

500-Bus Synthetic Grid



X	Critical Line	Contingency	Distance (*d*)	Searching Level (*sl*)	Computation Time (h)
3	[[142, 141], [424, 423], [87, 141]]	3 Overflow	2	3	48:24.4
3	[[162, 220], [23, 386], [87, 141]]	1 Overflow	2	3	48:24.4
4	[[162, 220], [23, 386], [87, 141], [247, 246]]	Unsolved	2	3	1:03:41
4	[[142, 141], [424, 423], [87, 141], [247, 246]]	Unsolved	2	3	1:03:41
5	[[162, 220], [23, 386], [87, 141], [247, 246], [437, 428]]	Unsolved	2	3	1:18:36
5	[[162, 220], [23, 386], [142, 141], [424, 423], [87, 141]]	5 Overflow	2	3	1:18:36
5	[[142, 141], [424, 423], [87, 141], [247, 246], [402, 401]]	Unsolved	2	3	1:18:36
3	[[162, 220], [23, 386], [87, 141]]	1 Overflow	3	3	1:22:57
4	[[162, 220], [23, 386], [87, 141], [247, 246]]	Unsolved	3	3	1:56:23
5	[[162, 220], [23, 386], [142, 141], [424, 423], [87, 141]]	5 Overflows	3	3	2:14:41
3	[[142, 141], [424, 423], [87, 141]]	3 Overflow	1	4	1:23:54
4	[[142, 141], [424, 423], [87, 141], [247, 246]]	Unsolved	1	4	1:49:02
5	[[142, 141], [424, 423], [87, 141], [247, 246], [402, 401]]	Unsolved	1	4	31:18.0
5	[[268, 267], [213, 212], [105, 104], [408, 407], [36, 35]]	2 Overvoltage	1	4	2:16:34
3	[[142, 141], [424, 423], [87, 141]]	3 Overflow	2	4	2:36:06
4	[[162, 220], [23, 386], [87, 141], [247, 246]]	Unsolved	2	4	3:27:14
5	[[142, 141], [424, 423], [87, 141], [247, 246], [402, 401]]	Unsolved	2	4	4:15:18
5	[[268, 267], [213, 212], [105, 104], [408, 407], [36, 35]]	2 Overvoltage	2	4	4:15:18





Conclusions

- We provide a computationally tractable approach to identify critical multiple-element branch contingencies by exploiting the GBC and LODFs.
- For future work, we will improve the framework's efficiency and speed by choosing appropriate parameters and implementing parallel computing.