$$\textbf{MR}: R^{*}_{C,AC} = Min \sum_{i \in B}\left(c_{B,i} \cdot \delta_{B,i}\right) + \sum_{l \in L}\left(c_{L,l} \cdot \delta_{L,l}\right)$$

subject to

$$\Delta PL_l^{(1)} = -\sum_{i \in B}\left(SF_{l,i} \cdot \Delta D_i^{(1)}\right) \qquad \forall l \in L$$

$$\Delta D_l = \omega_l^{*} \cdot \left(PL_l^{(0)} + \Delta PL_l^{(1)}\right) \qquad \forall l \in L$$

$$\Delta D_i^{(1)} = -\sum_{l \in L, E_l = i} \Delta D_l + \sum_{l \in L, S_l = i} \Delta D_l \qquad \forall i \in B$$

$$\Delta PL_l^{(2)} = -\sum_{i \in B}\left(SF_{l,i} \cdot \Delta D_i^{(2)}\right) \qquad \forall l \in L$$

$$\Delta D_i^{(1)} + \Delta D_i^{(2)} \geq \delta_{B,i} \cdot \alpha_{B,i} \cdot D_i^{(0)} \qquad \forall i \in B$$

$$\Delta D_i^{(1)} + \Delta D_i^{(2)} \leq \delta_{B,i} \cdot \beta_{B,i} \cdot D_i^{(0)} \qquad \forall i \in B$$

$$\Delta PL_l^{(1)*} + \Delta PL_l^{(2)} \geq \alpha_{L,l} \cdot \left|PL_l^{(0)}\right| \qquad \forall l \in L_M$$

$$\Delta PL_l^{(1)*} + \Delta PL_l^{(2)} \leq \beta_{L,l} \cdot \left|PL_l^{(0)}\right| \qquad \forall l \in L_M$$

$$\delta_{L,l} \geq \omega_l^{*} \qquad \forall l \in L$$

$$-\delta_{L,l} \cdot M \leq \Delta PL_l^{(2)} \leq \delta_{L,l} \cdot M \qquad \forall l \in L$$

$$\textbf{FC}: E^{*}_{AC} = Min \sum_{i \in B_B} \varepsilon_i$$

subject to

$$\omega_l = 1 \qquad \forall l \in AS$$

$$\omega_l = 0 \qquad \forall l \in L \setminus AS$$

$$\sum_{l \in L, S_l = r} f_l - \sum_{l \in L, E_l = r} f_l = N_B - 1 \qquad \forall i \in B \setminus \{r\}$$

$$\sum_{l \in L, S_l = i} f_l - \sum_{l \in L, E_l = i} f_l = -1 \qquad \forall l \in L$$

$$-(N_B - 1) \cdot (1 - \omega_l) \leq f_l \leq (N_B - 1) \cdot (1 - \omega_l) \qquad \forall l \in L$$

$$\Delta PL_l^{(1)} = -\sum_{i \in B}\left(SF_{l,i} \cdot \Delta D_i^{(1)}\right) \qquad \forall l \in L$$

$$-M \cdot \omega_l \leq \Delta D_l \leq M \cdot \omega_l \qquad \forall l \in L$$

$$\Delta D_l \leq PL_l^{(0)} + \Delta PL_l^{(1)} + M \cdot (1 - \omega_l) \qquad \forall l \in L$$

$$\Delta D_l \geq PL_l^{(0)} + \Delta PL_l^{(1)} - M \cdot (1 - \omega_l) \qquad \forall l \in L$$

$$PL_l^{(1)} = PL_l^{(0)} + \Delta PL_l^{(1)} - \Delta D_l \qquad \forall l \in L$$

$$\Delta D_i^{(1)} = -\sum_{l \in L, E_l = i} \Delta D_l + \sum_{l \in L, S_l = i} \Delta D_l \qquad \forall i \in B$$

$$\Delta T_i^{(1)} = -\sum_{l \in L, E_l = i} \Delta PL_l^{(1)} + \sum_{l \in L, S_l = i} \Delta PL_l^{(1)} \qquad \forall i \in B_B$$

$$\alpha_{T,i} \cdot \left|T_i^{(0)}\right| - \varepsilon_i \leq \Delta T_i^{(1)} \leq \beta_{L,l} \cdot \left|T_i^{(0)}\right| + \varepsilon_i \qquad \forall i \in B_B$$

$$\textbf{RC}: r^{*}_{AC} = Max \sum_{l \in L}\left\{\left[prob_l + \omega_l\right] \cdot \Delta PL_l^{(0)}\right\}$$

subject to

$$0 \leq prob_l \leq u_l \qquad \forall l \in L$$

$$prob_l \leq \frac{PL_l^{(1)+} + PL_l^{(1)-} - S_l^{LB} \cdot u_l}{S_l^{UB} - S_l^{LB}} \qquad \forall l \in L$$

$$PL_l^{(1)+} + PL_l^{(1)-} \geq S_l^{LB} \cdot u_l \qquad \forall l \in L$$

$$PL_l^{(1)+} - PL_l^{(1)-} = PL_l^{(0)} + \Delta PL_l^{(1)*} - \Delta D_l^* \qquad \forall l \in L$$
$$0 \le PL_l^{(1)+} \le M \cdot v_l \qquad \forall l \in L$$
$$0 \le PL_l^{(1)-} \le M \cdot (1 - v_l) \qquad \forall l \in L$$

Algorithm 1: Fast Screening Strategy

Input: original line set L
Return: attackable line set S
1: $S \leftarrow L$
2: **for** each $l \in L$ **do**
3: solve problem **MR** and its optimal value R_{AC}^*
4: **if** problem **MR** is infeasible or $R_{C,AC}^* > R_C$ **then**
5: $S \leftarrow S \setminus \{l\}$

Algorithm 2: Sequential Decomposition Strategy

Input: attacked line set: *AS*
Output: temporary set: *temp*
1: solve problem **FC** and obtain E_{AC}^*
2: **if** $E_{AC}^* = 0$ **then**
3: solve problem **MR** and obtain $R_{C,AC}^*$
4: **if** $R_{C,AC}^* \le R_C$ **then**
5: solve problem **RC** and obtain r_{AC}^*, $temp \leftarrow \{(AS, r_{AC}^*)\}$

Algorithm 3: Local Search Strategy

Input: attacked line set: *AS*, candidate line set: *CS*, attackable line set: *S*
Output: temporary set: *TEMP*, attackable line set: *S*
1: $TEMP \leftarrow \phi$, $BS \leftarrow AS$, $S \leftarrow S \setminus CS$
2: **for** each $l \in BS$ **do**
3: $AS \leftarrow CS \setminus \{l\}$
4: **for** each $m \in S$ **do**
5: $AS \leftarrow AS \cup \{m\}$, execute Algorithm 2 and obtain *temp*
6: $TEMP \leftarrow TEMP \cup temp$, $AS \leftarrow AS \setminus \{m\}$
7: **if** $TEMP = \phi$ **then**
8: terminate

Algorithm 4: Candidate Line Set Updating Strategy

Input: candidate line set: *CS*, temporary sets: *SAVE*, *TEMP*
Output: candidate line set: *CS*
1: $risk1 \leftarrow 0$, $risk1 \leftarrow 2$
2: $(cs1, risk1) \leftarrow max(TEMP)$, $(cs2, risk2) \leftarrow max(SAVE)$
3: $(cs2, risk2) \leftarrow max(SAVE \setminus \{(cs2, risk2)\})$
4: **if** $risk1 < risk2$ **then**
5: $CS \leftarrow CS \cup cs2$
6: **else**
7: $CS \leftarrow CS \cup cs1$

Algorithm 5: Greedy Search-Based Heuristic Method

Input: attackable line set: S

Output: optimal solution (FS, $RISK$)

$CS \leftarrow \phi$, $AS \leftarrow \phi$, $SAVE \leftarrow \phi$, $K \leftarrow 1$
while $K \leq R_P$ **do**
  if $R_P = 1$ **then**
    for each $l \in S$ **do**
      $AS \leftarrow AS \cup \{l\}$, execute Algorithm 2 and obtain $temp$
      $SAVE \leftarrow SAVE \cup temp$, $AS \leftarrow AS \setminus \{l\}$
    (FS, $RISK$) $\leftarrow max$($SAVE$)
  $K \leftarrow K$+1
  if $R_P > 1$ **then**
    while $CS = \phi$ **do**
      $AS \leftarrow \{m\}$ where m has the highest SCI in S, $S \leftarrow S \setminus \{l\}$
      for each $l \in S$ **do**
        $AS \leftarrow AS \cup \{l\}$, execute Algorithm 2 and obtain $temp$
        $SAVE \leftarrow SAVE \cup temp$, $AS \leftarrow AS \setminus \{l\}$
      if $SAVE = \phi$ **then**
        $AS \leftarrow \phi$
      else
        (FS, $RISK$) $\leftarrow max$($SAVE$), $CS \leftarrow FS$
        execute Algorithm 3 and Algorithm 4 to update CS
  if $K > 2$ **then**
    $AS \leftarrow CS$, execute Algorithm 2 and obtain $temp$
    if $temp = \phi$ **then**
      execute Algorithm 3 and obtain $TEMP$
      $SAVE \leftarrow TEMP$, (FS, $RISK$) $\leftarrow max$($SAVE$), $CS \leftarrow FS$
      execute Algorithm 3 and Algorithm 4 to update CS
    else
      $SAVE \leftarrow temp$, (FS, $RISK$) $\leftarrow temp$, $CS \leftarrow FS$
      execute Algorithm 3 and Algorithm 4 to update CS
    (FS, $RISK$) $\leftarrow max$($TEMP \cup SAVE$)
    if $RISK$ is decreased **then**
      terminate

TABLE S.I
BUS LOAD MEASUREMENTS

Bus	Net Power Injection Measurement / MW		
	t_1	t_2	t_3
1	50.000	60.000	70.000
2	13.039	11.340	3.782
4	-63.039	-71.340	-73.782

TABLE S.II
LINE FLOW MEASUREMENTS

Line	Line Flow Measurement / MW			
	t_1	t_2	t_3	t_3'
1-2	16.530	21.194	27.704	Outaged
1-4	33.470	38.806	42.296	70.000
2-4	29.569	32.534	31.486	16.504

TABLE S.III
PRE-SPECIFIED PARAMETERS

p	c_B	c_L	α_T	β_T	α_B	β_B	α_L	β_L
1	1	2	-20%	-20%	-20%	-20%	-20%	-20%

TABLE S.IV
EQUIVALENT LINE PARAMETERS

Equivalent Line	7-13	7-23	13-23
Susceptance / p.u.	1.959	1.675	4.928
Reactance / p.u.	0.510	0.597	0.203

*: all values are scaled to their actual values

TABLE S.V
MINIMUM RESOURCES AND SEVERITY-COST INDICES

Line	$R_{c,l}^{\min}$	$\left\|PL_l^{(0)}\right\|$	SCI	Line	$R_{c,l}^{\min}$	$\left\|PL_l^{(0)}\right\|$	SCI
1-2	17	12.4	0.73	11-13	/	88.6	/
1-3	21	11.3	0.54	11-14	/	178.5	/
1-5	36	63.0	1.75	12-13	/	69.7	/
2-4	27	37.2	1.38	12-23	/	218.9	/
2-6	27	50.2	1.86	13-23	/	206.1	/
3-9	24	29.1	1.21	14-16	/	372.5	/
3-24	/	220.4	/	15-16	41	116.0	2.83
4-9	27	36.8	1.36	15-21	41	438.4	10.69
5-10	13	8.0	0.62	15-24	/	220.4	/
6-10	36	85.8	2.38	16-17	34	328.6	9.66
7-8	/	86.8	/	16-19	/	127.1	/
8-9	/	52.8	/	17-18	25	186.6	7.46
8-10	/	31.3	/	17-22	20	142.0	7.10
9-11	/	112.4	/	18-21	20	119.6	5.98
9-12	/	123.2	/	19-20	/	53.9	/
10-11	/	154.7	/	20-23	/	181.9	/
10-12	/	165.5	/	21-22	20	158.0	7.90

TABLE S.VI
INJECTION AMOUNT IN BUS LOAD MEASUREMENTS

Bus	$\Delta D_i^{(1)}$	$\Delta D_i^{(2)}$	$\delta_{B,i}$	Bus	$\Delta D_i^{(1)}$	$\Delta D_i^{(2)}$	$\delta_{B,i}$
1	-168.7	168.7	0	13	0.0	0.0	0
2	-112.4	112.4	0	14	0.0	-26.8	1
3	-57.0	57.0	0	15	5596.7	-5596.7	0
4	112.4	-112.4	0	16	0.0	0.0	0
5	168.7	-168.7	0	17	7867.7	-7867.7	0
6	313.6	-313.6	0	18	-7867.7	7867.7	0
7	0.0	0.0	0	19	0.0	0.0	0
8	0.0	0.0	0	20	0.0	-24.3	1
9	57.0	-25.0	1	21	-5596.7	5596.7	0
10	-313.6	332.6	1	22	0.0	0.0	0
11	0.0	0.0	0	23	0.0	0.0	0
12	0.0	0.0	0	24	0.0	0.0	0

TABLE S.VII
INJECTION AMOUNT IN LINE FLOW MEASUREMENTS

Line	$\Delta PL_l^{(1)}$	$\Delta PL_l^{(2)}$	$\delta_{L,l}$	Line	$\Delta PL_l^{(1)}$	$\Delta PL_l^{(2)}$	$\delta_{L,l}$
1-2	48.6	-47.2	1	11-13	-1.3	0.0	0
1-3	14.3	-16.2	1	11-14	-22.2	0.0	0
1-5	105.7	-105.3	1	12-13	-7.2	0.0	0
2-4	75.2	-74.0	1	12-23	-9.6	0.0	0

2-6	85.8	-85.6	1	13-23	-6.8	0.0	0
3-9	27.9	-22.1	1	14-16	-22.2	26.8	1
3-24	43.4	-51.1	1	15-16	-395.0	388.8	1
4-9	-37.2	38.4	1	15-21	-5158.3	5156.9	1
5-10	-63.0	63.4	1	15-24	-43.4	51.1	1
6-10	-227.8	228.0	1	16-17	-438.4	439.9	1
7-8	3.1	0.0	0	16-19	21.2	-24.3	1
8-9	10.6	-8.4	1	17-18	-7681.1	7682.4	1
8-10	-7.5	8.4	1	17-22	-625.0	625.2	1
9-11	-29.5	16.4	1	18-21	186.6	-185.4	1
9-12	-26.2	16.4	1	19-20	21.2	-24.3	1
10-11	6.0	-16.4	1	20-23	21.2	0.0	0
10-12	9.4	-16.4	1	21-22	625.0	-625.2	1

TABLE S.VIII
COMPARISONS OF FINAL OBJECTIVE VALUES

R_C	R_P	*RISK* / MW		
		MIP 1	MIP 2	Serial 1,2 and Para. 1,2
20	1	158.0	158.0	158.0
	2	344.6	344.6	344.6
	3	344.6	344.6	344.6
30	1	186.6	186.6	186.6
	2	**344.6**	**344.6**	**336.6**
	3	523.2	523.2	523.2
	4	523.2	523.2	523.2
40	1	328.6	328.6	328.6
	2	917.8	917.8	917.8
	3	1124.7	1124.7	1124.7
	4	**1218.2**	**1218.2**	**1124.7**
	5	**1281.2**	**1281.2**	**1124.7**
50	1	888.7	888.7	888.7
	2	1095.6	1095.6	1095.6
	3	1181.4	1181.4	1181.4
	4	1244.4	1244.4	1244.4
	5	1281.2	1281.2	1281.2
	6	1310.3	1310.3	1310.3
	7	1310.3	1310.3	1310.3
60	1	888.7	888.7	888.7
	2	1095.6	1095.6	1095.6
	3	1181.4	1181.4	1181.4
	4	1244.4	1244.4	1244.4
	5	1281.6	1281.6	1281.6
	6	1310.7	1310.7	1310.7
	7	**1490.5**	**1310.7**	**1310.7**

TABLE S.IX
COMPARISONS OF EXECUTION TIME

R_C	R_P	Without Identification / *s*			With Identification / *s*		
		MIP1	Serial 1	Para. 1	MIP 2	Serial 2	Para. 2
20	1	714	7	0.3	28	3	0.3
	2	1121	27	1.2	77	12	1.2
	3	1579	44	2.0	63	17	2.0
30	1	203	7	0.3	10	3	0.3

	2	294	22	1	109	10	1
	3	1292	54	2.4	219	23	2.4
	4	6525	80	4.4	197	32	4.4
40	1	749	7	0.3	88	3	0.3
	2	192	15	0.6	84	7	0.6
	3	208	49	2.1	105	20	2.1
	4	1674	92	4.1	90	36	4.1
	5	2879	114	5.5	79	47	5.5
50	1	13	7	0.3	4	3	0.3
	2	22	15	0.6	4	7	0.6
	3	414	50	2.1	9	21	2.1
	4	911	94	4.1	62	37	4.1
	5	1696	167	6.7	67	55	6.7
	6	4280	208	9	75	71	9
	7	5418	262	13.5	60	85	13.5
60	1	12	7	0.3	3	3	0.3
	2	14	15	0.6	6	7	0.6
	3	185	50	2.1	30	21	2.1
	4	957	94	4.2	12	37	4.2
	5	890	168	6.7	36	55	6.7
	6	6253	208	8.9	29	72	8.9
	7	3564	263	13.4	17	86	13.4
Average		1618	81.8	3.7	60.1	29.7	3.7

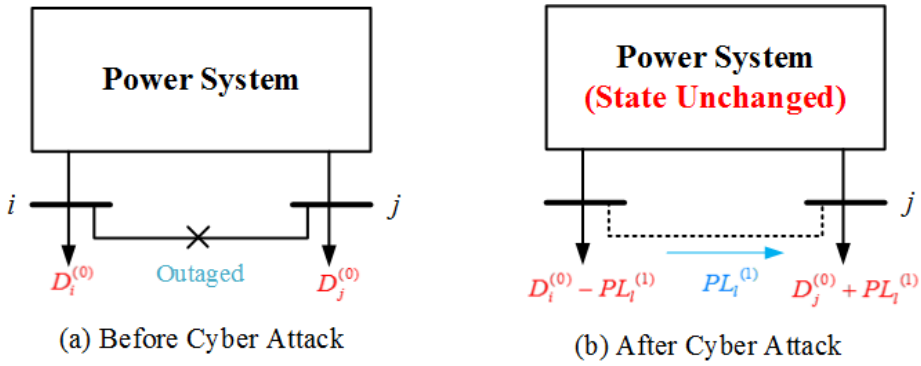


Fig. S.1 Topology preserving attack

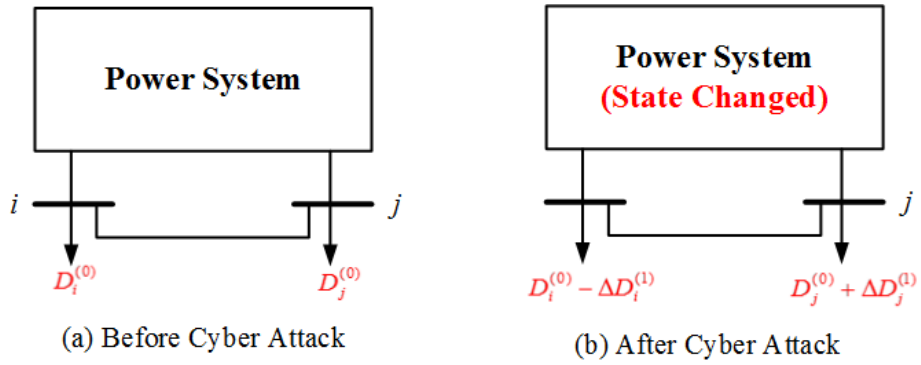
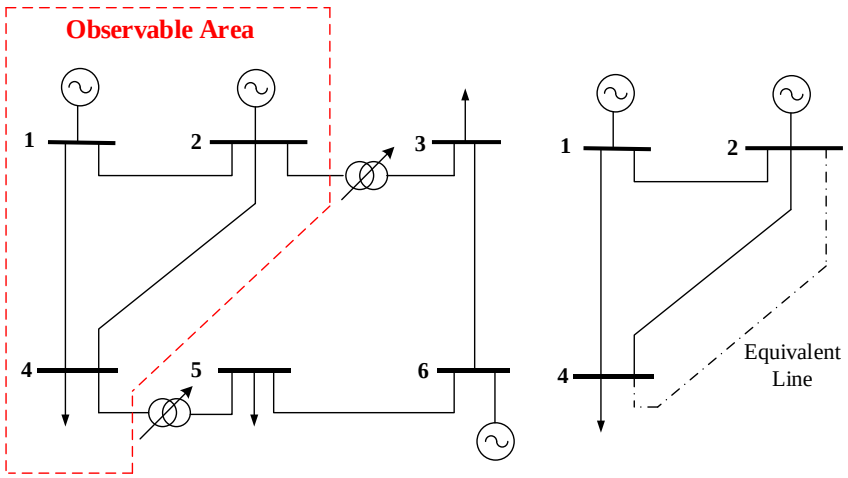


Fig. S.2 Load redistribution attack



(a) Original Network (b) Equivalent Network

Fig. S.3 Six-bus test system

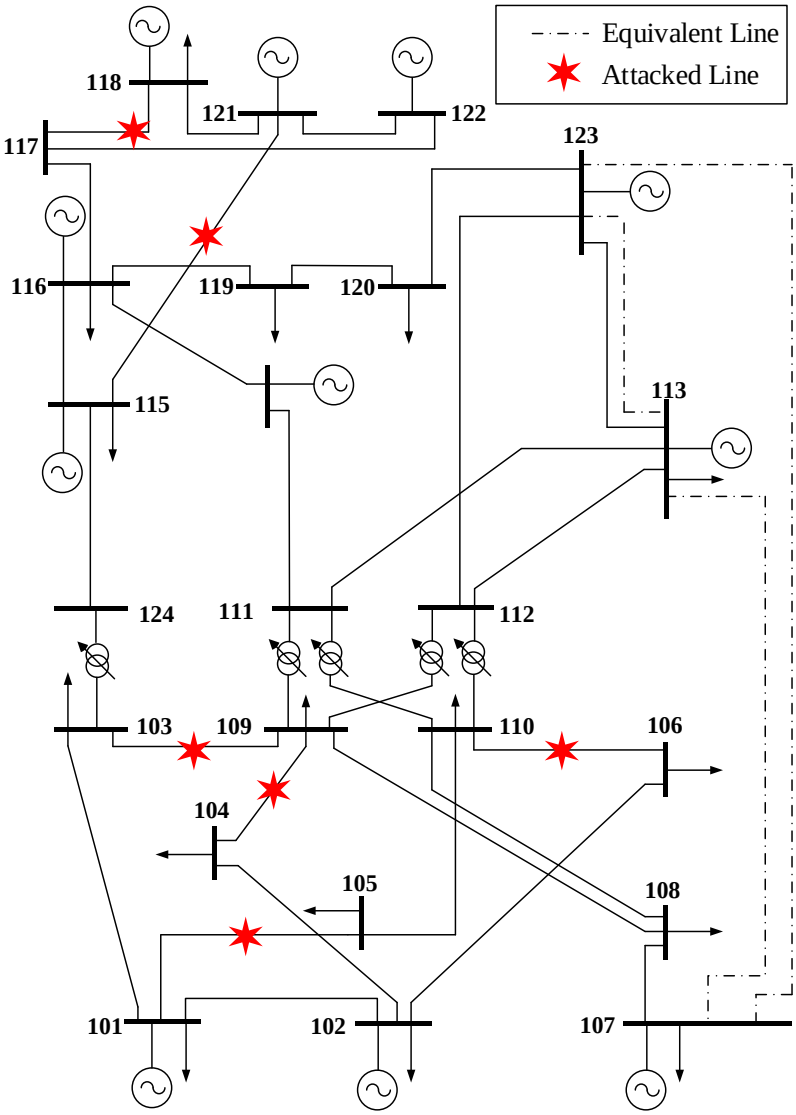


Fig. S.4 IEEE RTS-96 with equivalent lines in the most severe case when R_C = 60 and R_P = 6