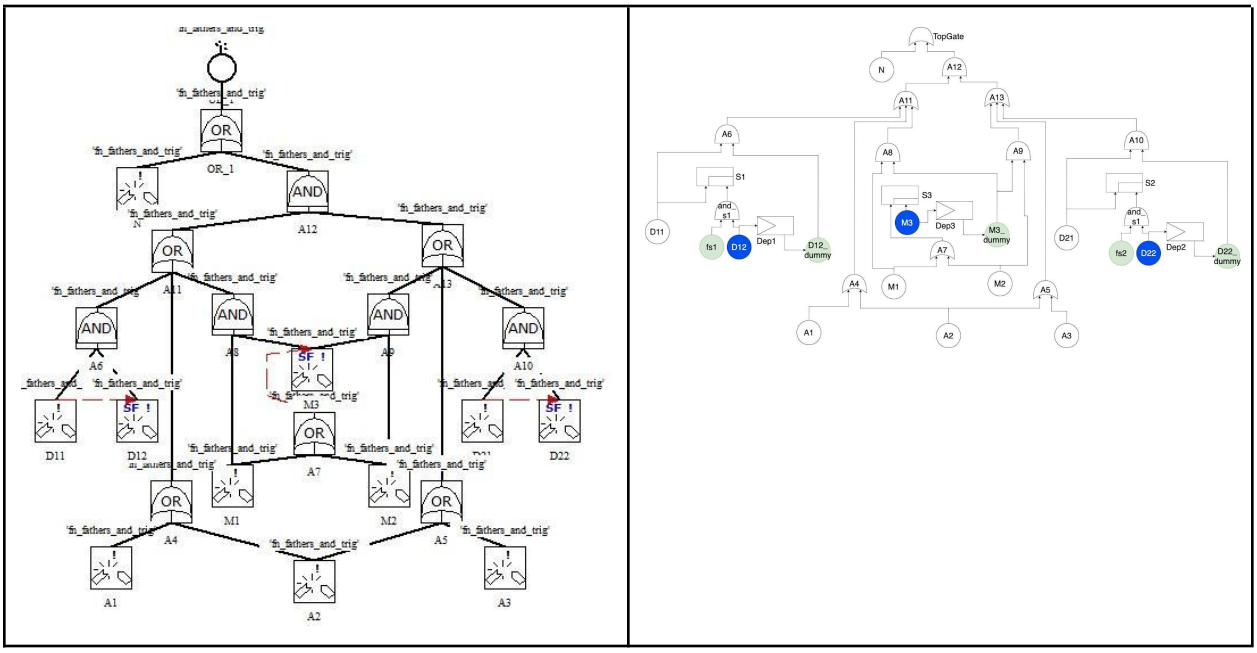
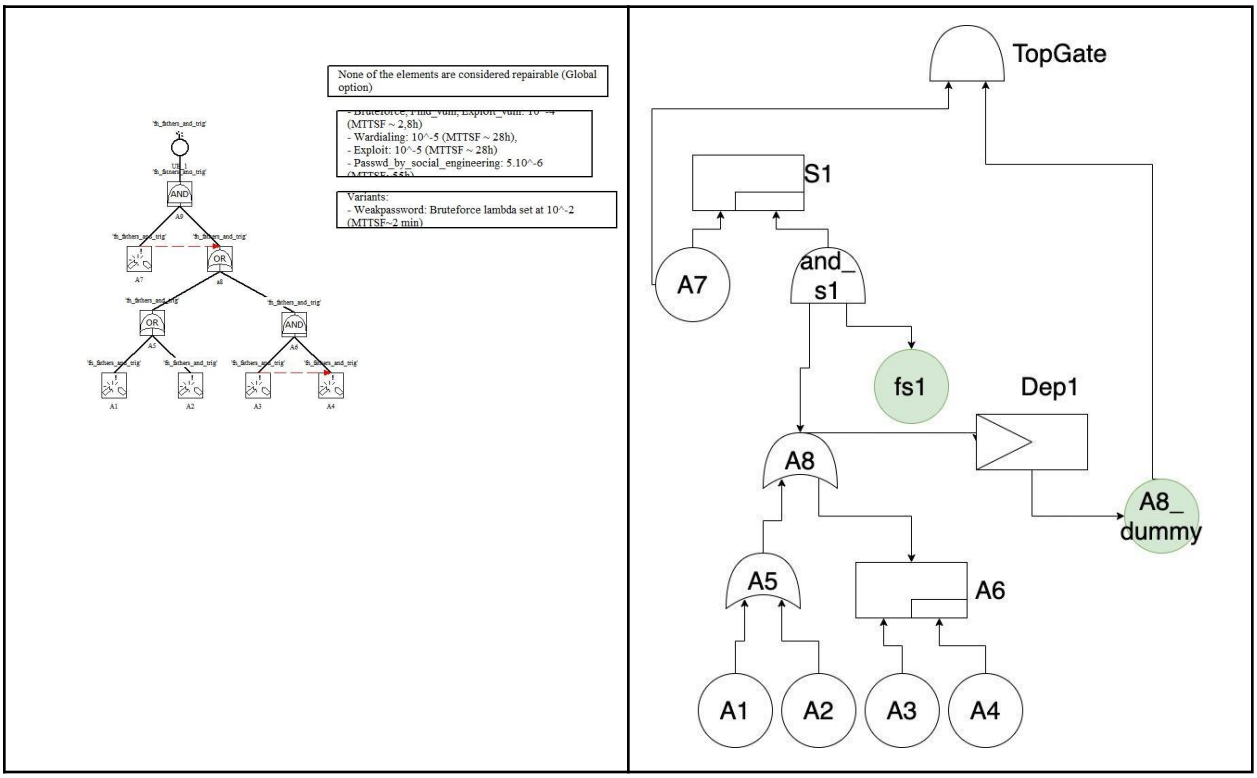
PRDC2021: Synergizing reliability Modeling Languages: BDMPs and Repairable DFTs

Benchmark 1: Multiprocessor computing system benchmark

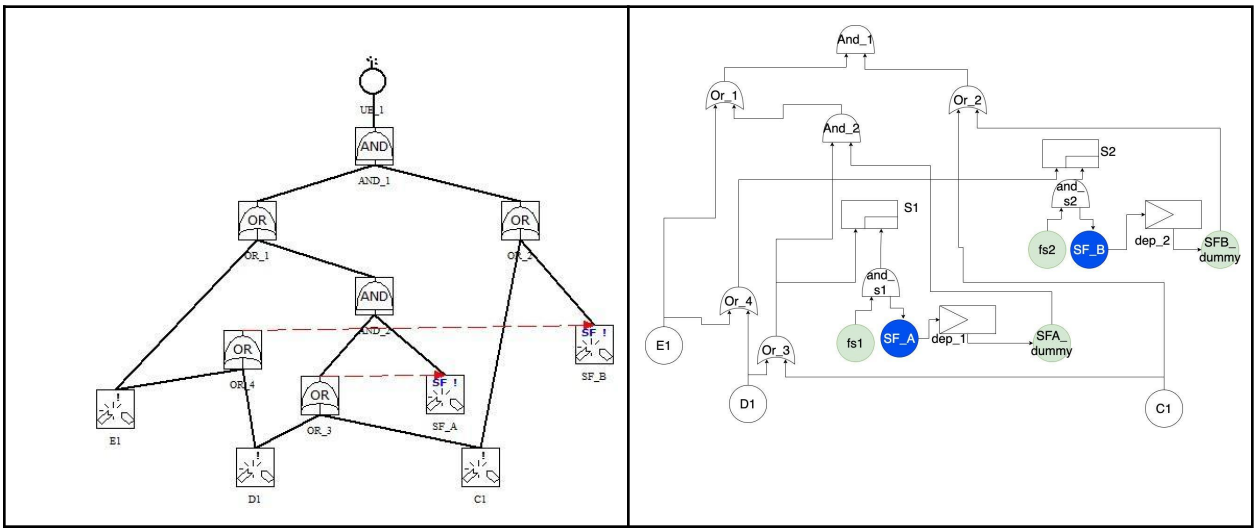


Benchmark 01: (17_21)



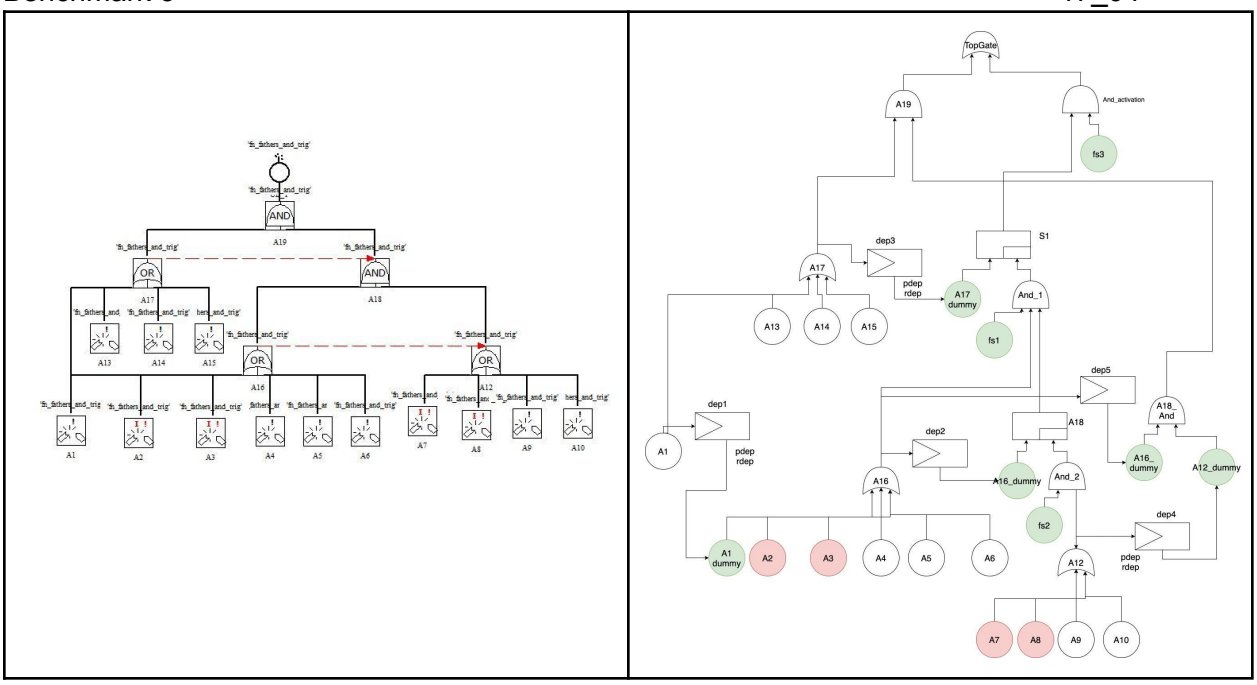
Unreliability: FigaroAPI= 0.338363 DftCalc= 0 Storm-RDFT= 0.3383632
DFTCalc Error= -0.338363 Storm-RDFT Error= 1.9e-07
Unavailability: FigaroAPI= 0.0281251 DftCalc= 0 Storm-RDFT= 0.0281251
DFTCalc Error= -0.0281251 Storm-RDFT Error= -1e-08

Benchmark 2 17_16



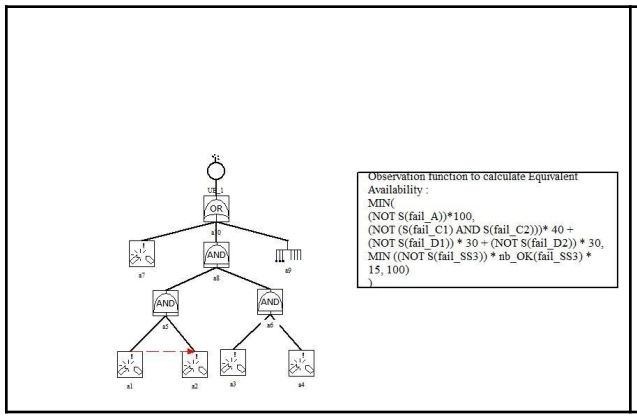
Unreliability: FigaroAPI= 0.257271 DftCalc= 0 Storm-RDFT= 0.2572713
DFTCalc Error= -0.257271 Storm-RDFT Error= 2.9e-07
Unavailability: FigaroAPI= 0.0180769 DftCalc= 0 Storm-RDFT= 0.0180769
DFTCalc Error= -0.0180769 Storm-RDFT Error= 4e-08

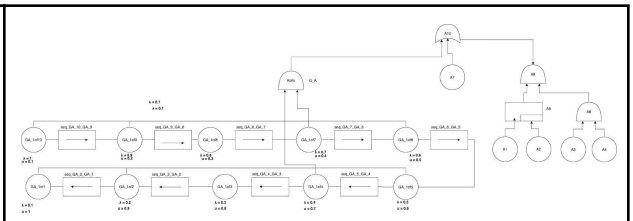
Benchmark 3 17_04



Unreliability: FigaroAPI= 0.21698 DftCalc= 0.32965 Storm-RDFT= 0.2169677 DFTCalc Error= 0.11267 Storm-RDFT Error= -1.229e-05

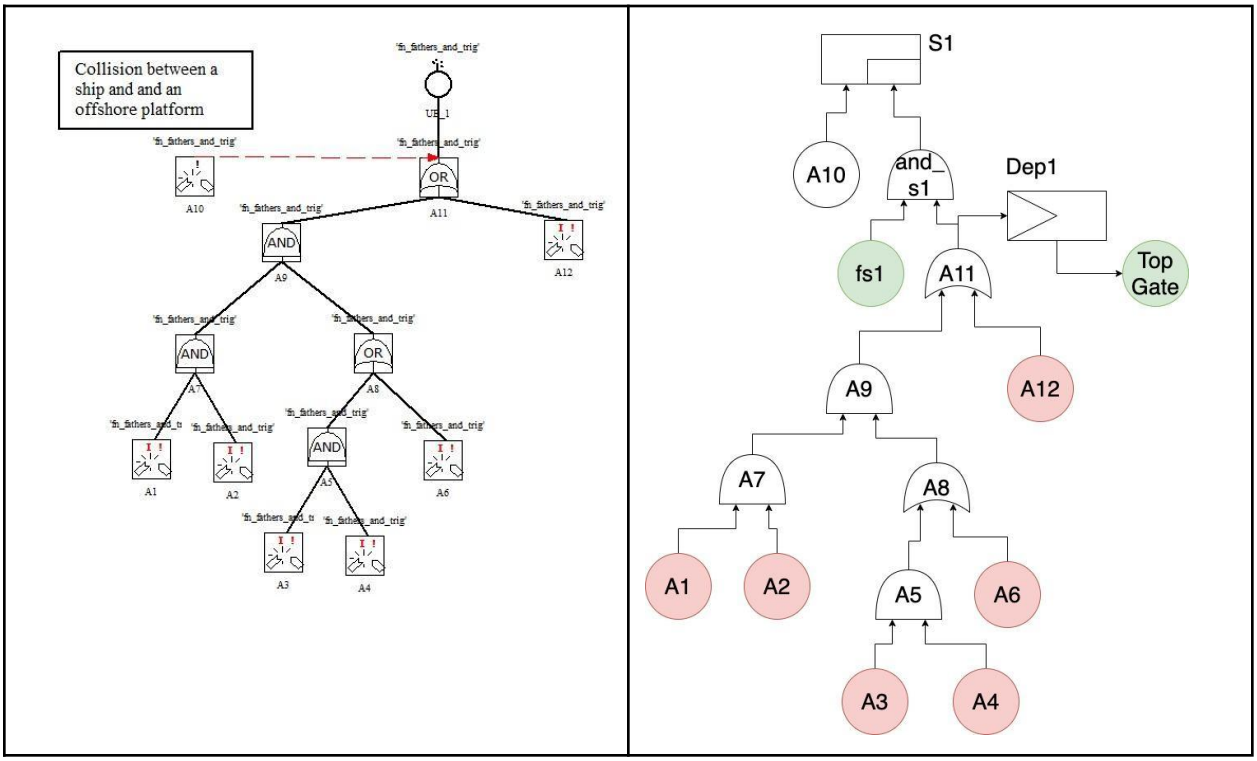
Unavailability: FigaroAPI= 0.0962907 DftCalc= 0 Storm-RDFT= 0.096261684 DFTCalc Error= -0.0962907 Storm-RDFT Error= -2.902e-05





17_20 @ 10

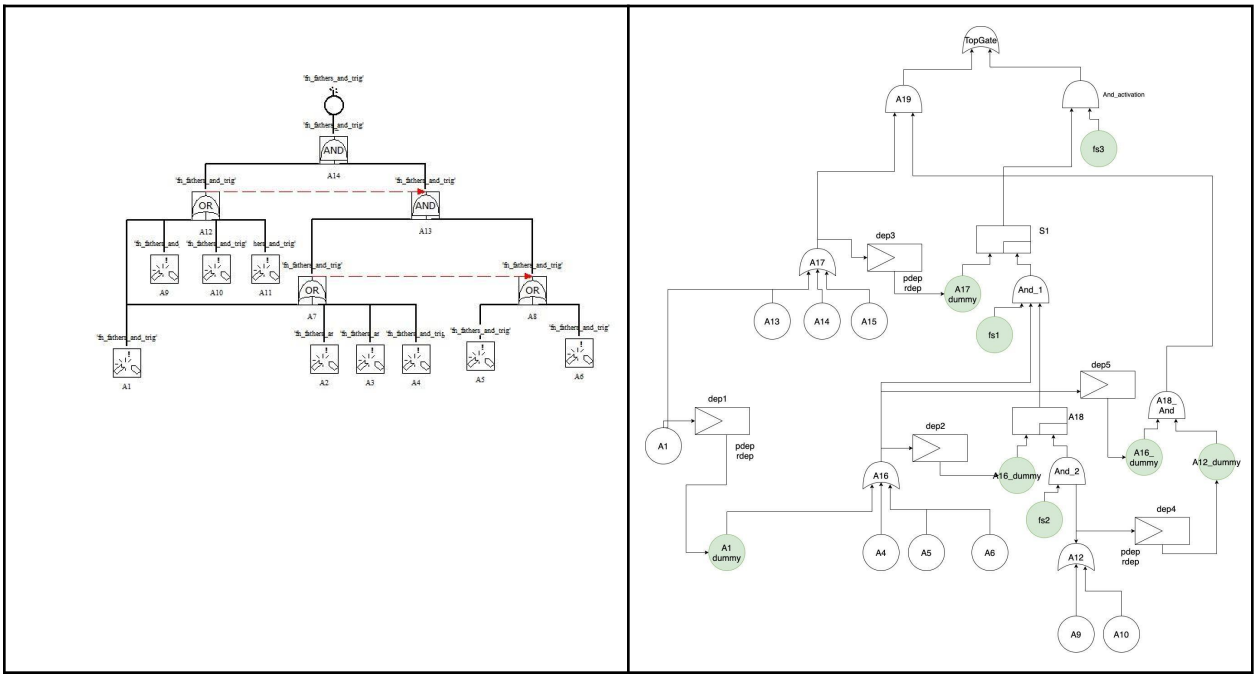
Unreliability: FigaroAPI= 0.92431 DftCalc= 0 Storm-RDFT= 0.9243097
DFTCalc Error= -0.92431 Storm-RDFT Error= -3.4e-07
Unavailability: FigaroAPI= 0.763649 DftCalc= 0 Storm-RDFT= 0.7636488
DFTCalc Error= -0.763649 Storm-RDFT Error= -1.8e-07



Unreliability: FigaroAPI= 0.00913958 DftCalc= 0 Storm-RDFT= 0.0091396 DFTCalc Error= -0.00913958 Storm-RDFT Error= 0.0

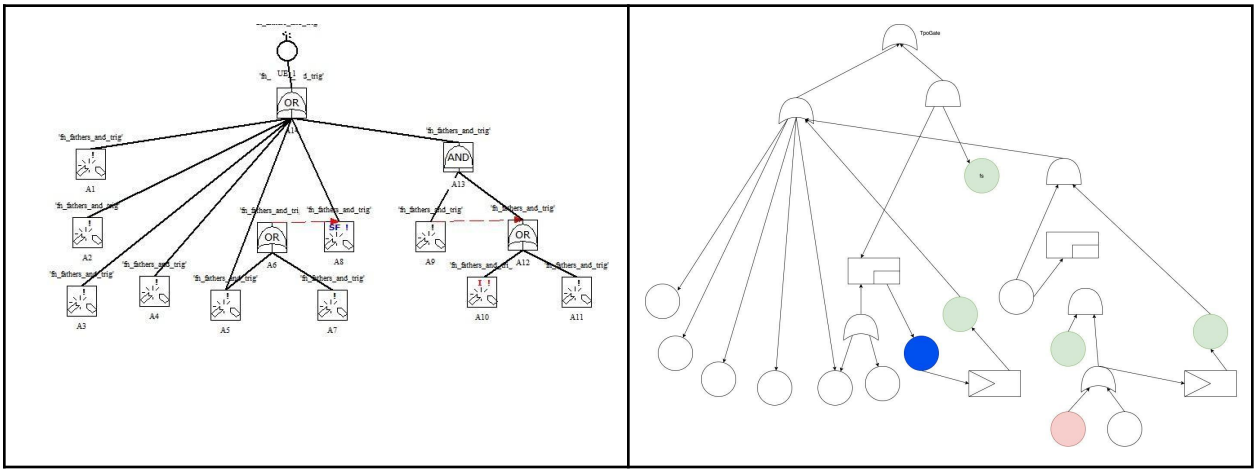
Unavailability: FigaroAPI= 0.000908896 DftCalc= 0 Storm-RDFT= 0.000908896 DFTCalc Error= -0.0009089 Storm-RDFT Error= -0.0

Benchmark 06: 17_05



Unreliability: FigaroAPI= 0.182051 DftCalc= 0 Storm-RDFT= 0.1820512
DFTCalc Error= -0.182051 Storm-RDFT Error= 2.4e-07
Unavailability: FigaroAPI= 0.0121088 DftCalc= 0 Storm-RDFT= 0.0121088
DFTCalc Error= -0.0121088 Storm-RDFT Error= 3e-08

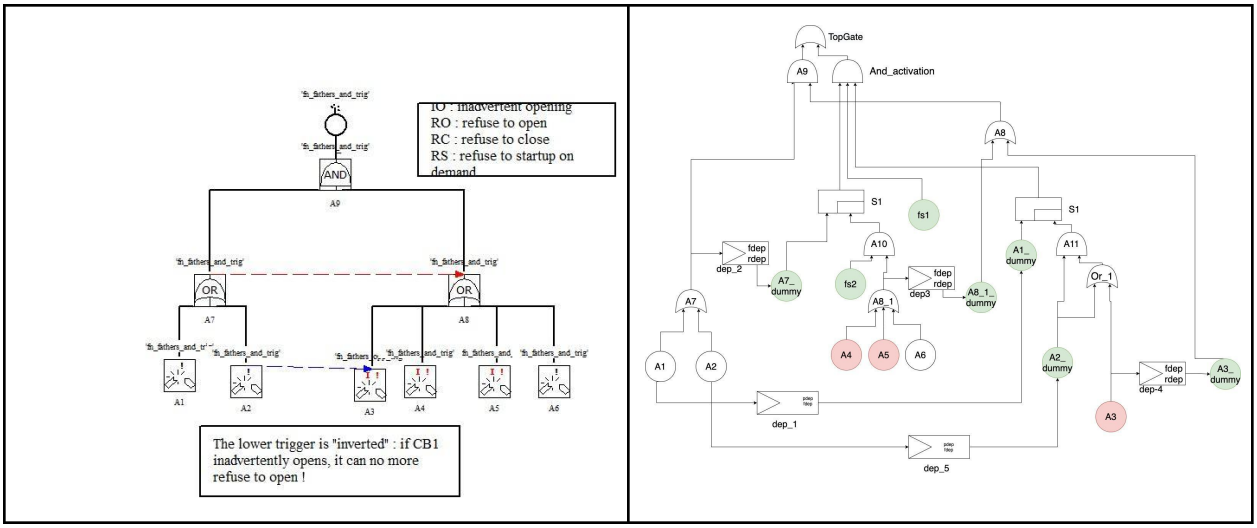
Benchmark 07 17_08



Unreliability: FigaroAPI= 0.994779 DftCalc= 0 Storm-RDFT= 0.9947791
DFTCalc Error= -0.994779 Storm-RDFT Error= 1.2e-07
Unavailability: FigaroAPI= 0.395239 DftCalc= 0 Storm-RDFT= 0.3952391
DFTCalc Error= -0.395239 Storm-RDFT Error= 1.1e-07

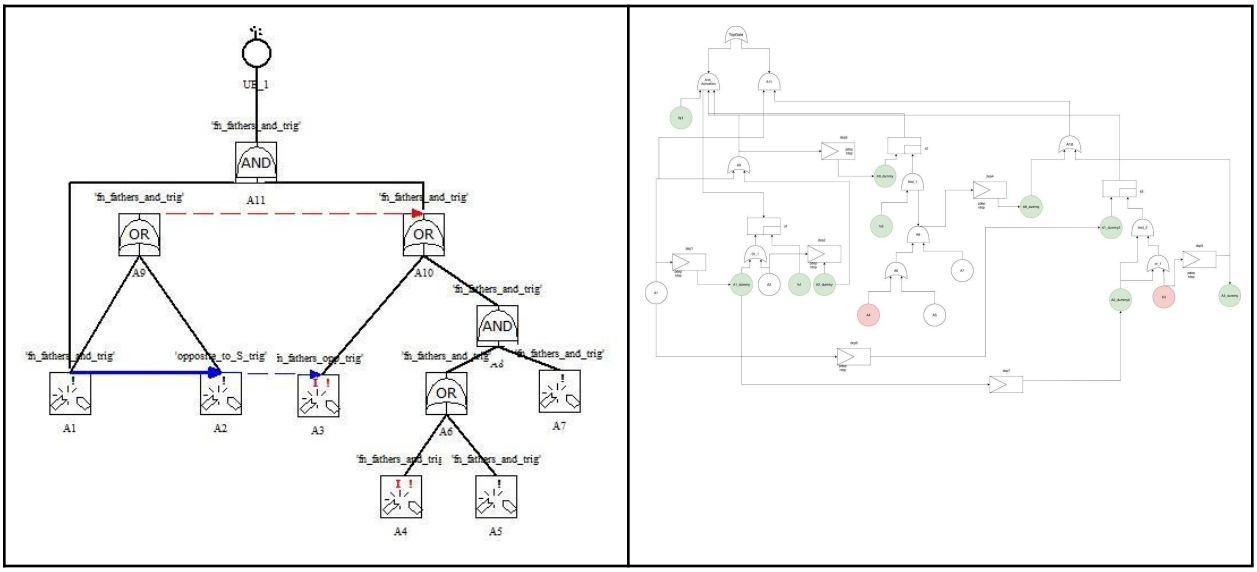
Several other test cases considered:
Marcs online english benchmarks start here

17_01



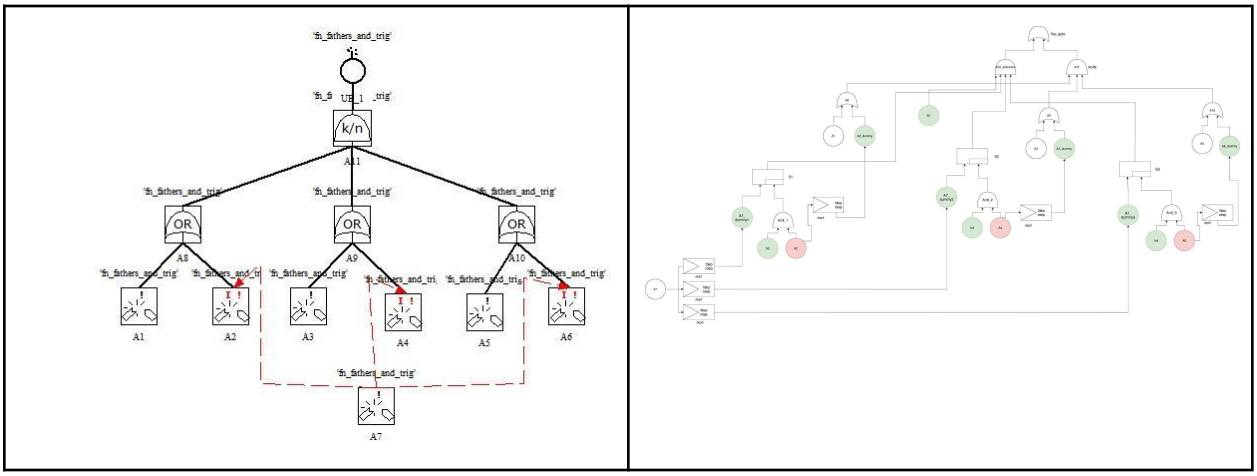
Unreliability: FigaroAPI= 0.800343 DftCalc= 0 Storm-RDFT= 0.8003433
DFTCalc Error= -0.800343 Storm-RDFT Error= 2.6e-07
Unavailability: FigaroAPI= 0.0909356 DftCalc= 0 Storm-RDFT= 0.0909356
DFTCalc Error= -0.0909356 Storm-RDFT Error= -1e-08

17_02



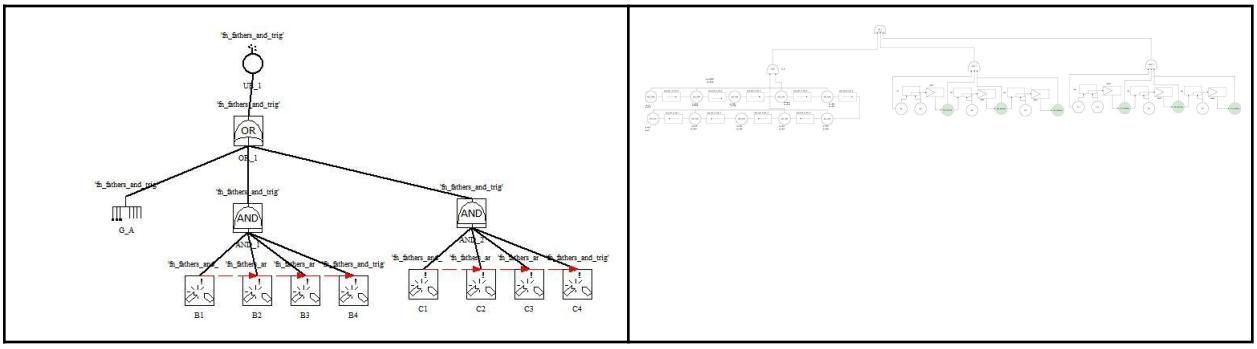
Unreliability: FigaroAPI= 0.0086668 DftCalc= 0 Storm-RDFT= 0.0086668
DFTCalc Error= -0.0086668 Storm-RDFT Error= 0.0
Unavailability: FigaroAPI= 0.000367203 DftCalc= 0 Storm-RDFT= 0.0003672
DFTCalc Error= -0.0003672 Storm-RDFT Error= 0.0

17_03



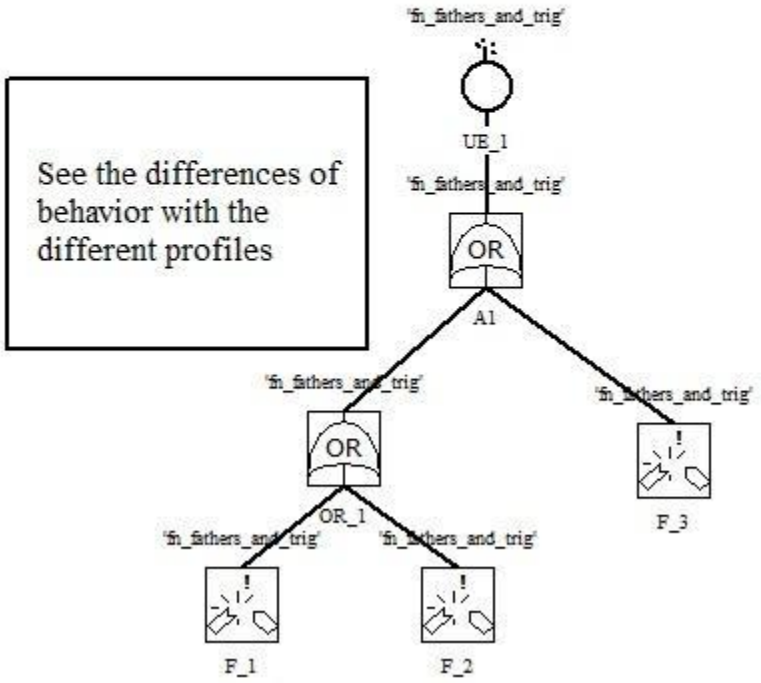
Unreliability: FigaroAPI= 0.322328 DftCalc= 0 Storm-RDFT= 0.3223278
DFTCalc Error= -0.322328 Storm-RDFT Error= -2.1e-07
Unavailability: FigaroAPI= 0.0237097 DftCalc= 0 Storm-RDFT= 0.0237097
DFTCalc Error= -0.0237097 Storm-RDFT Error= 4e-08

17_22



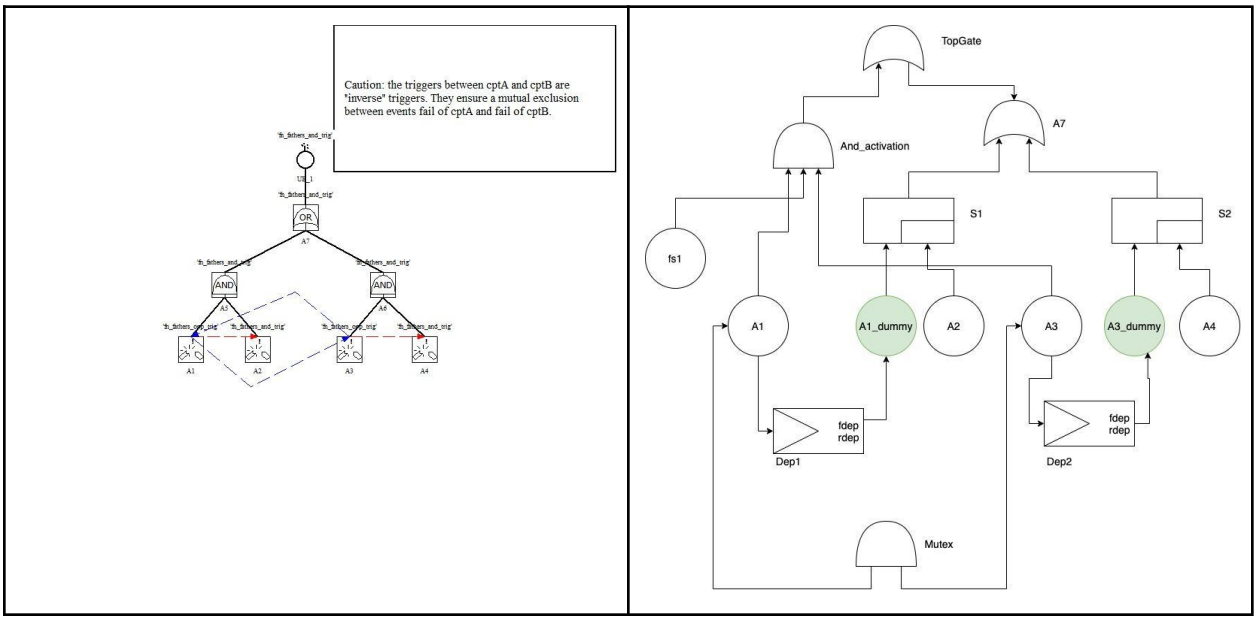
17_22 @ 10
Unreliability: FigaroAPI= 0.975491 DftCalc= 0 Storm-RDFT= 0.9754909
DFTCalc Error= -0.975491 Storm-RDFT Error= -1e-07
Unavailability: FigaroAPI= 0.879362 DftCalc= 0 Storm-RDFT= 0.8793618
DFTCalc Error= -0.879362 Storm-RDFT Error= -1.8e-07

17_06



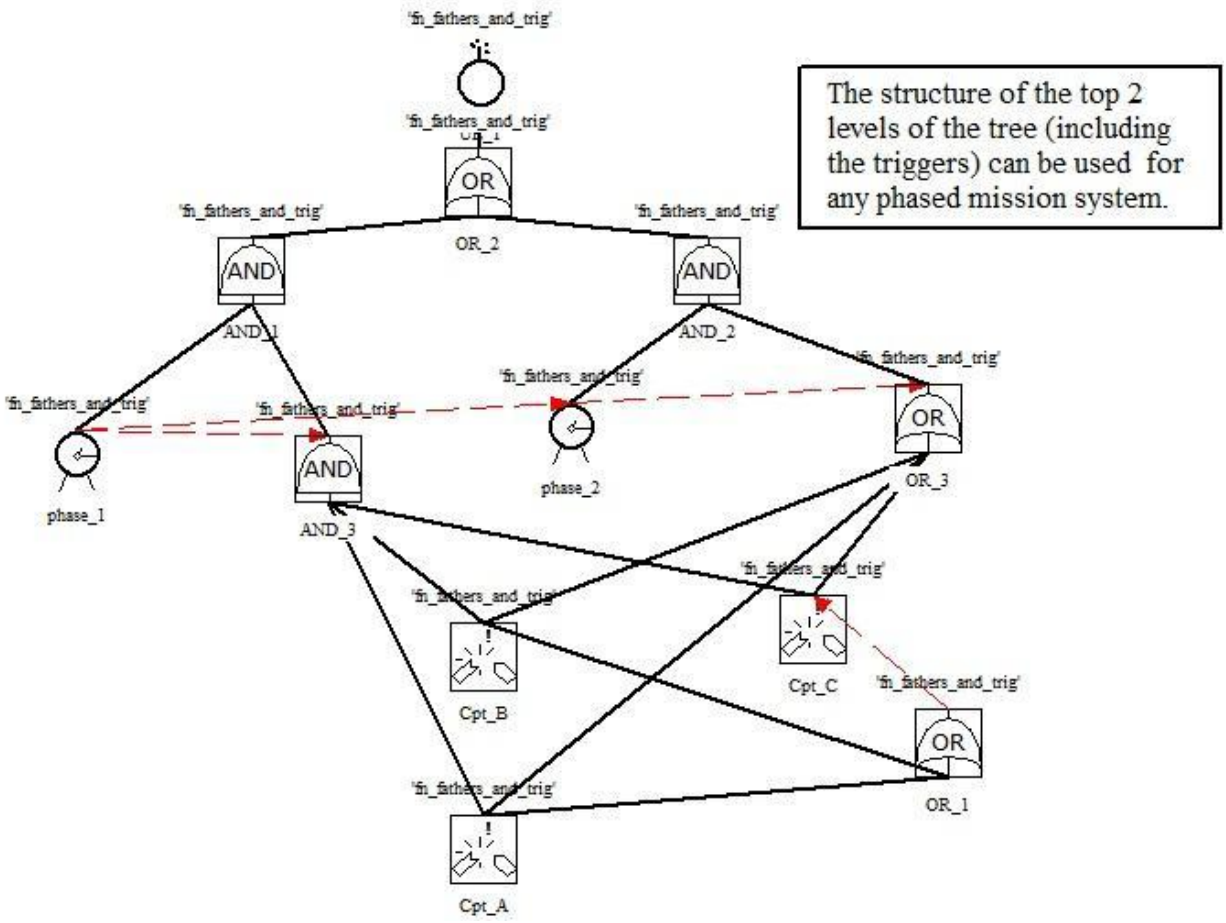
Unreliability: FigaroAPI= 0.950213 DftCalc= 0 Storm-RDFT= 0.9502129
DFTCalc Error= -0.950213 Storm-RDFT Error= -7e-08
Unavailability: FigaroAPI= 0.248681 DftCalc= 0 Storm-RDFT= 0.2486814 DFTCalc Error= -0.248681 Storm-RDFT Error= 4.3e-07

17_07 _7



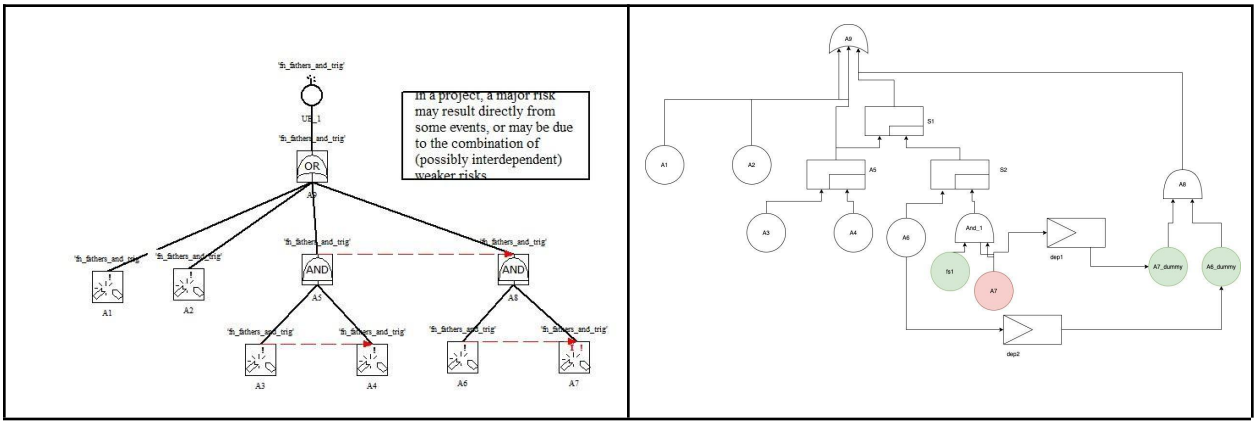
Unreliability: FigaroAPI= 0.133691 DftCalc= 0 Storm-RDFT= 0.1336915
DFTCalc Error= -0.133691 Storm-RDFT Error= 4.9e-07
Unavailability: FigaroAPI= 0.00827897 DftCalc= 0 Storm-RDFT= 0.008279
DFTCalc Error= -0.00827897 Storm-RDFT Error= 0.0

17_09



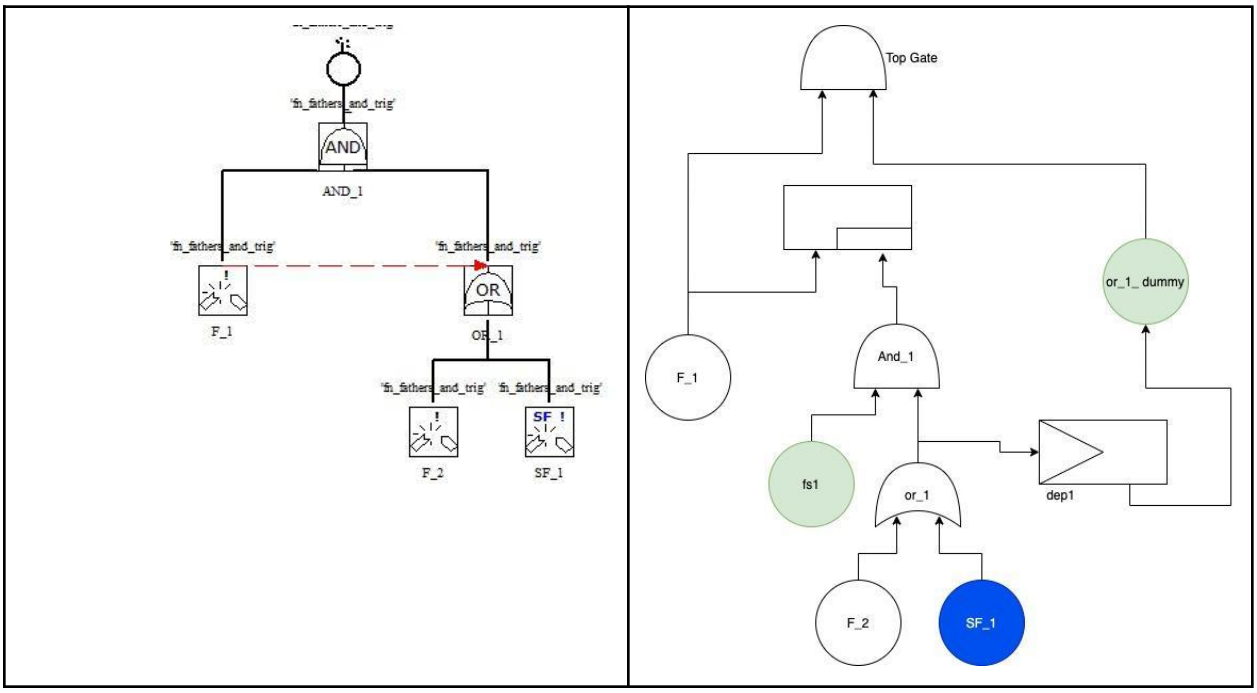
Unreliability: FigaroAPI= 0.115498 DftCalc= 0 Storm-RDFT= 0.1154987 DFTCalc Error= -0.115498 Storm-RDFT Error= 7e-07
Unavailability: FigaroAPI= 0.000872626 DftCalc= 0 Storm-RDFT= 0.000872626 DFTCalc Error= -0.00087263 Storm-RDFT Error= 0

17_10



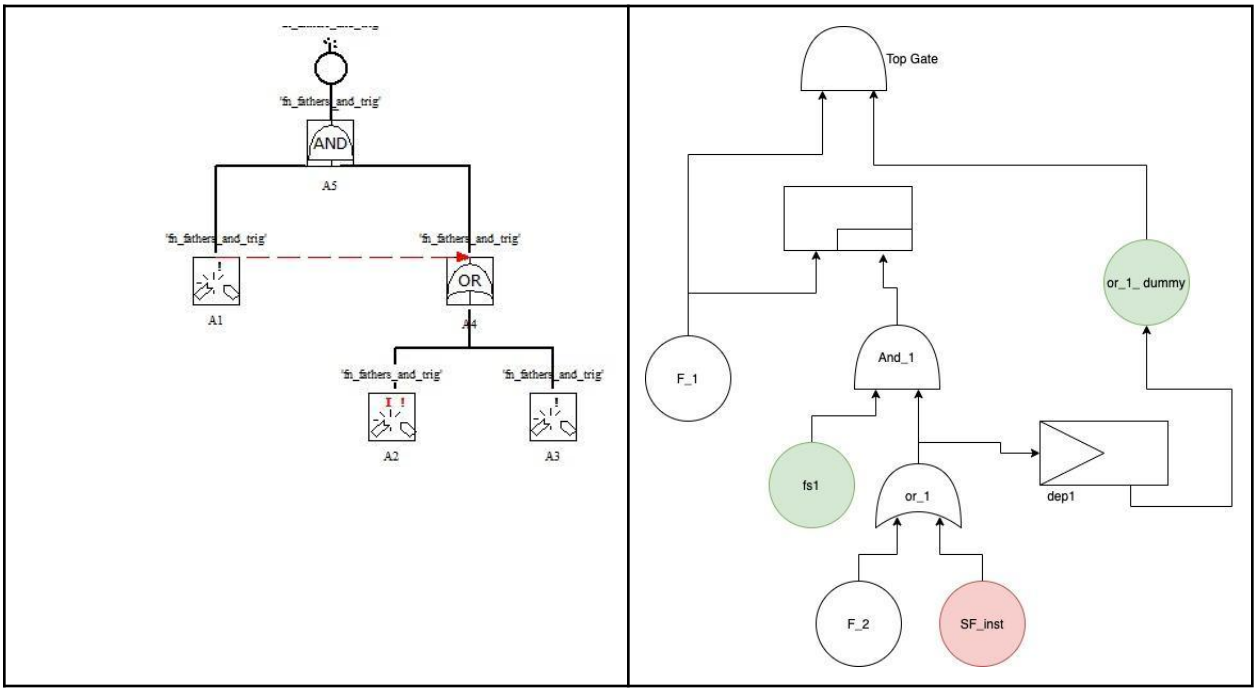
Unreliability: FigaroAPI= 0.874676 DftCalc= 0 Storm-RDFT= 0.874676
DFTCalc Error= -0.874676 Storm-RDFT Error= -2e-08
Unavailability: FigaroAPI= 0.177291 DftCalc= 0 Storm-RDFT= 0.1772912
DFTCalc Error= -0.177291 Storm-RDFT Error= 1.8e-07

17_11



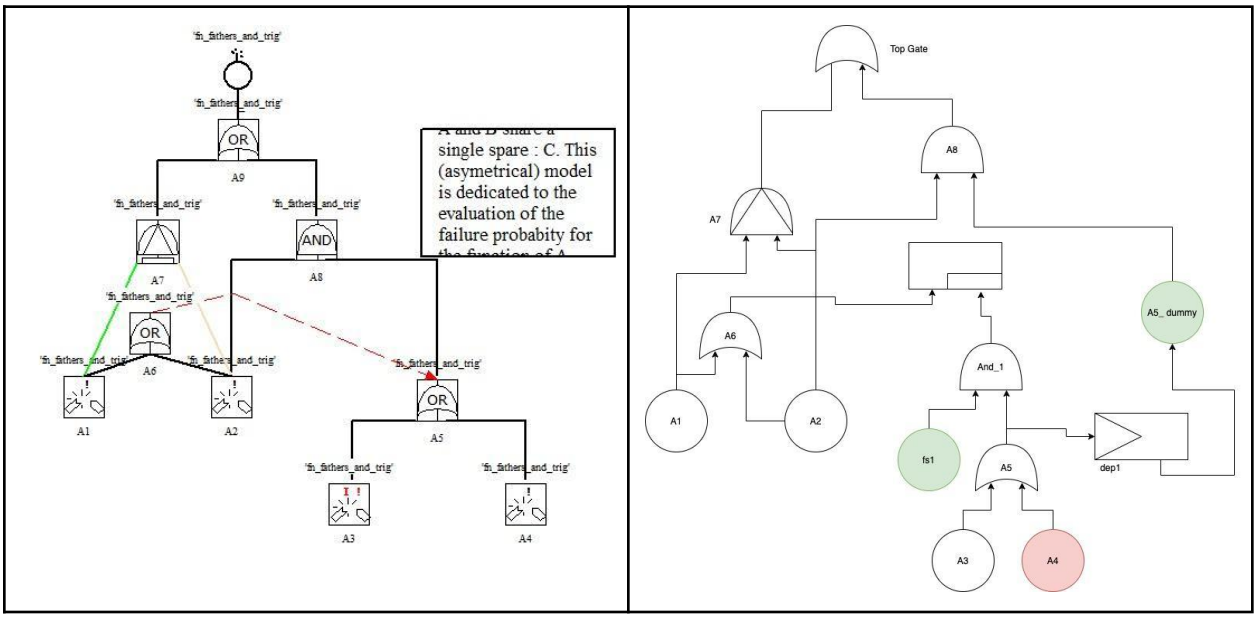
Unreliability: FigaroAPI= 0.139465 DftCalc= 0 Storm-RDFT= 0.1394652
DFTCalc Error= -0.139465 Storm-RDFT Error= 2.1e-07
Unavailability: FigaroAPI= 0.0091542 DftCalc= 0 Storm-RDFT= 0.0091542
DFTCalc Error= -0.0091542 Storm-RDFT Error= 0.0

17_12



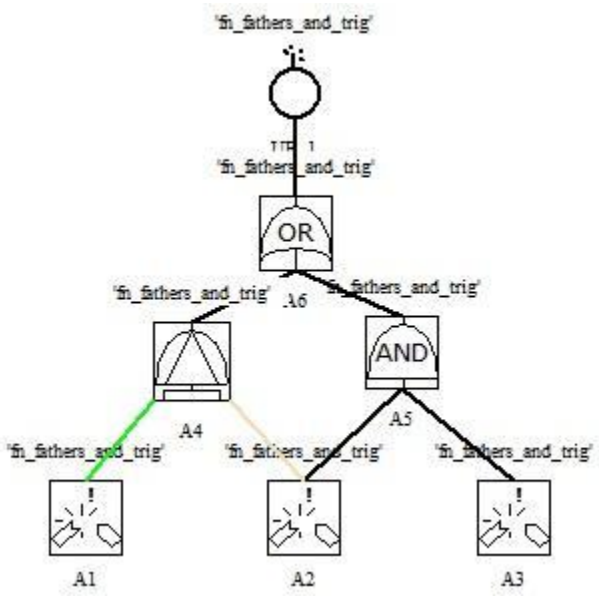
Unreliability: FigaroAPI= 0.0818825 DftCalc= 0 Storm-RDFT= 0.0818825
DFTCalc Error= -0.0818825 Storm-RDFT Error= -1e-08
Unavailability: FigaroAPI= 0.00498367 DftCalc= 0 Storm-RDFT= 0.0049837
DFTCalc Error= -0.00498367 Storm-RDFT Error= 0.0

17_13



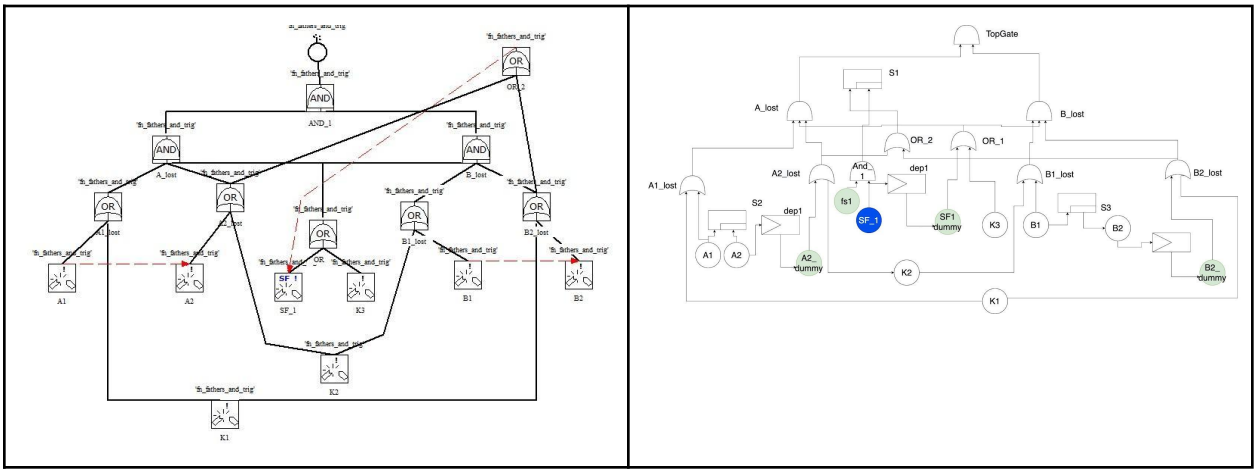
Unreliability: FigaroAPI= 0.14478 DftCalc= 0 Storm-RDFT= 0.1447798 DFTCalc Error= -0.14478 Storm-RDFT Error= -1.9e-07
Unavailability: FigaroAPI= 0.00917724 DftCalc= 0 Storm-RDFT= 0.0091772 DFTCalc Error= -0.00917724 Storm-RDFT Error= 0.0

17_14



Unreliability: FigaroAPI= 0.187691 DftCalc= 0 Storm-RDFT= 0.1876907
DFTCalc Error= -0.187691 Storm-RDFT Error= -3.4e-07
Unavailability: FigaroAPI= 0.0120206 DftCalc= 0 Storm-RDFT= 0.0120206
DFTCalc Error= -0.0120206 Storm-RDFT Error= 4e-08

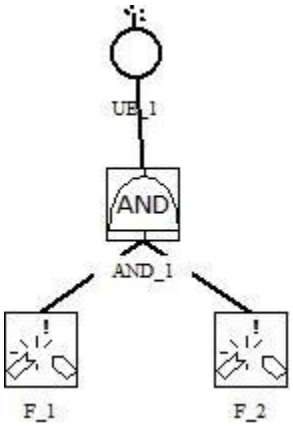
17_15



Unreliability: FigaroAPI= 0.0307718 DftCalc= 0 Storm-RDFT= 0.0307718
DFTCalc Error= -0.0307718 Storm-RDFT Error= -0.0
Unavailability: FigaroAPI= 0.0012933 DftCalc= 0 Storm-RDFT= 0.0012933
DFTCalc Error= -0.0012933 Storm-RDFT Error= -0.0

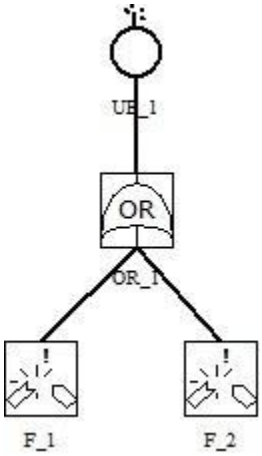
Various smaller test cases used to check correctness of translation

01_and



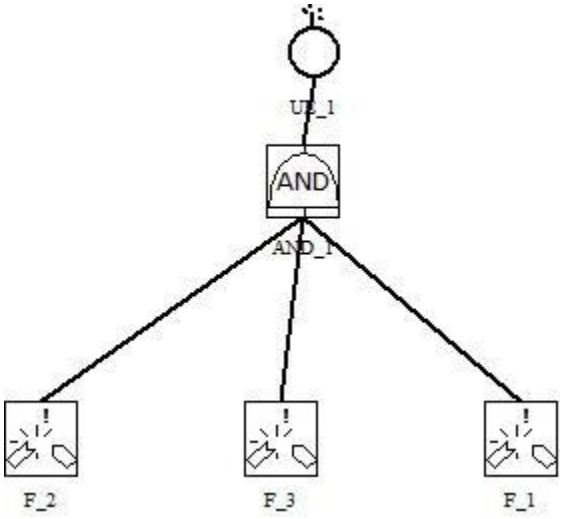
01_and @ 100
Unreliability: FigaroAPI= 0.133691 DftCalc= 0.13369 Storm-RDFT= 0.1336915
DFTCalc Error= -1e-06 Storm-RDFT Error= 4.9e-07
Unavailability: FigaroAPI= 0.00826419 DftCalc= 0.00826 Storm-RDFT= 0.0082642
DFTCalc Error= -4.19e-06 Storm-RDFT Error= -0.0

02_or



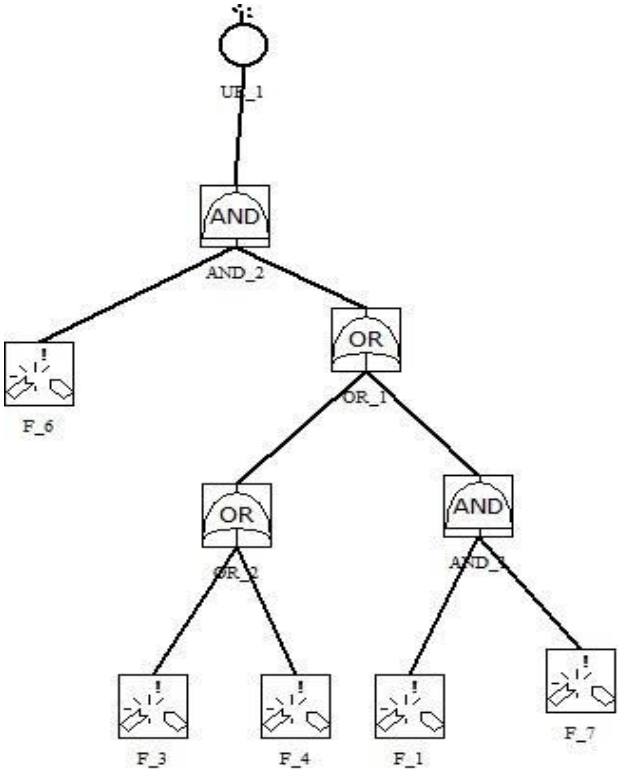
02_or @ 100
Unreliability: FigaroAPI= 0.864665 DftCalc= 0.86466 Storm-RDFT= 0.8646647
DFTCalc Error= -5e-06 Storm-RDFT Error= -2.8e-07
Unavailability: FigaroAPI= 0.173551 DftCalc= 0.17355 Storm-RDFT= 0.173551
DFTCalc Error= -1e-06 Storm-RDFT Error= -4e-08

03_and3



03_and3 @ 100
Unreliability: FigaroAPI= 0.0184869 DftCalc= 0.01848 Storm-RDFT= 0.0184869
DFTCalc Error= -6.9e-06 Storm-RDFT Error= 3e-08
Unavailability: FigaroAPI= 0.000751277 DftCalc= 7.5e-4 Storm-RDFT= 0.0007513
DFTCalc Error= -1.28e-06 Storm-RDFT Error= 0.0

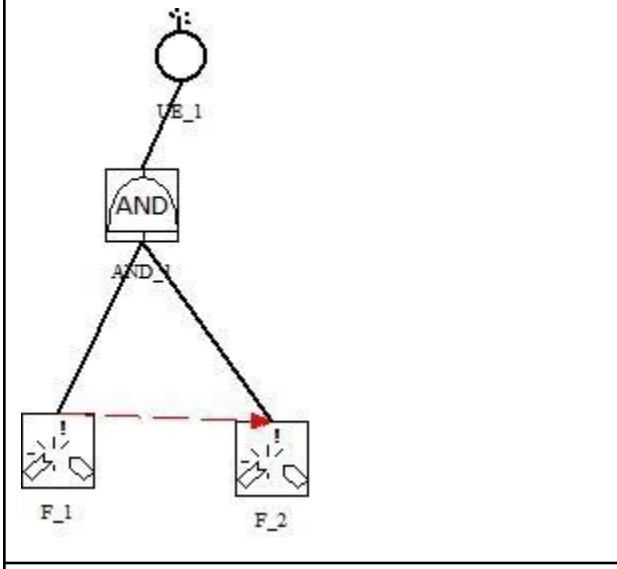
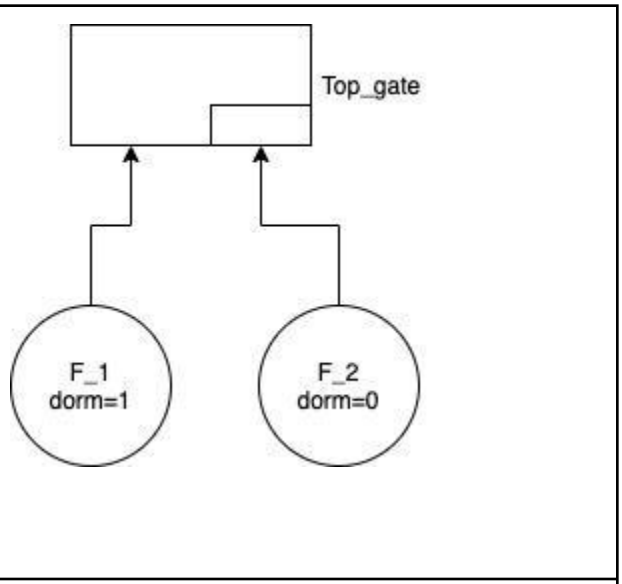
04_and_or



04_and_or @ 100

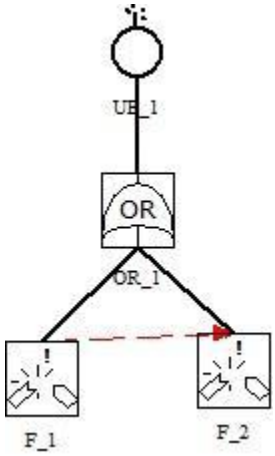
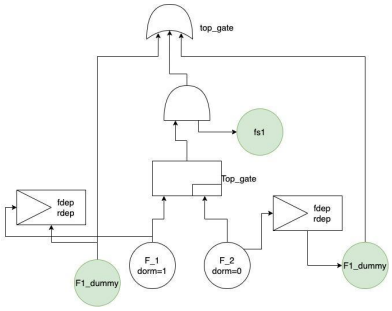
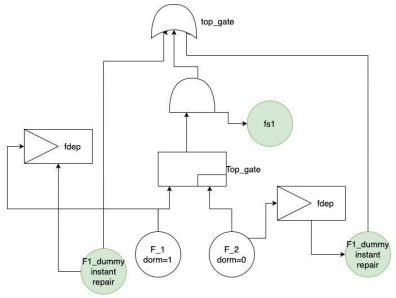
Unreliability: FigaroAPI= 0.242611 DftCalc= 0.24261 Storm-RDFT= 0.2426109
DFTCalc Error= -1e-06 Storm-RDFT Error= -1.4e-07
Unavailability: FigaroAPI= 0.016398 DftCalc= 0.01639 Storm-RDFT= 0.016398
DFTCalc Error= -8e-06 Storm-RDFT Error= -1e-08

05_and_trig

	
bdmp	Dftcalc / rdft

05_and_trig @ 1000
Unreliability: FigaroAPI= 0.564881 DftCalc= 0.56488 Storm-RDFT= 0.5648805
DFTCalc Error= -1e-06 Storm-RDFT Error= -4.7e-07
Unavailability: FigaroAPI= 0.00452489 DftCalc= 0.00452 Storm-RDFT= 0.0045249
DFTCalc Error= -4.89e-06 Storm-RDFT Error= -0.0

06_or_trig

		
bdmp	rdft	dftcalc

06_or_trig @ 100
Unreliability: FigaroAPI= 0.632121 DftCalc= 0.86466 Storm-RDFT= 0.6321206
DFTCalc Error= 0.232539 Storm-RDFT Error= -4.4e-07
Unavailability: FigaroAPI= 0.0950188 DftCalc= 0.86466 Storm-RDFT= 0.0950188
DFTCalc Error= 0.7696412 Storm-RDFT Error= 1e-08

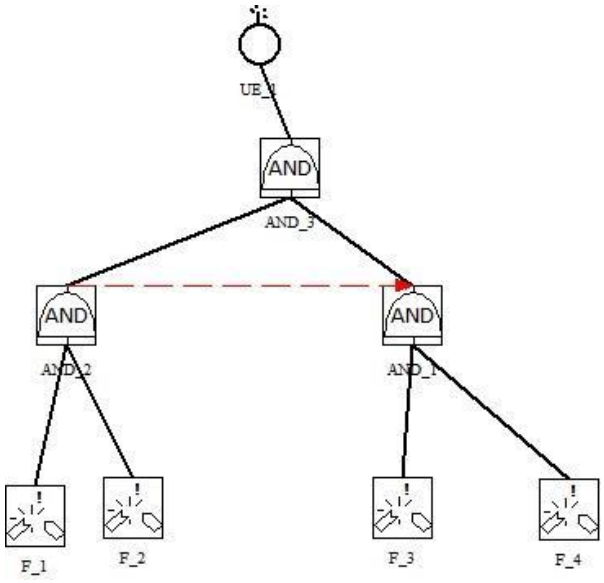
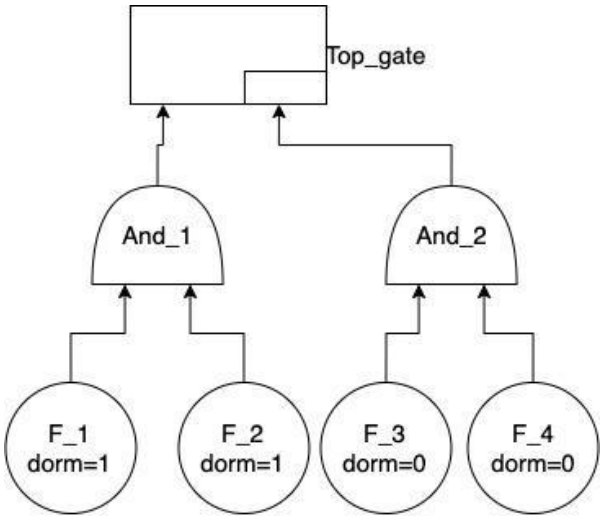
DFTcalc deviates in this test case due to two reasons: (1) Dftcalc can not propagate repair of components; therefore, we can not create a mirror image (w.r.t. both repair and failure) of a spare child out of a spare module.
(2) In Dftcalc the first child of an fdep is always active. Thus, the deactivation request of the spare gate is not entertained by the spare children. We validate point 2 by changing the dormancy factor of F_2 from 0 to 1, i.e., it will remain always active.

06_or_trig @ 100
Unreliability: FigaroAPI= 0.632121 DftCalc= 0.86466 Storm-RDFT= 0.8646647
DFTCalc Error= 0.232539 Storm-RDFT Error= 0.23254372
Unavailability: FigaroAPI= 0.0950188 DftCalc= 0.86466 Storm-RDFT= 0.173551
DFTCalc Error= 0.7696412 Storm-RDFT Error= 0.07853216

Storm-rdft and DFTcalc agree on the result of this varied model (obtained by changing dormancy of F_2 changed to 1).

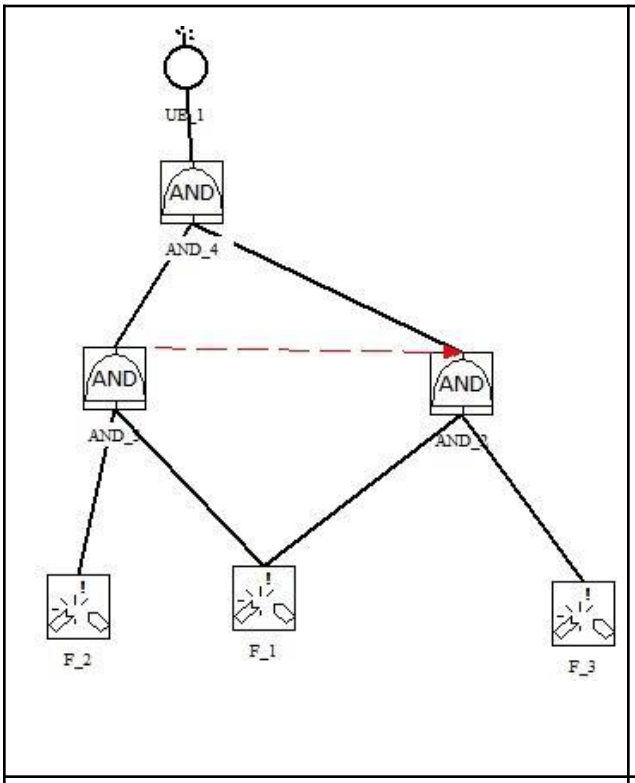
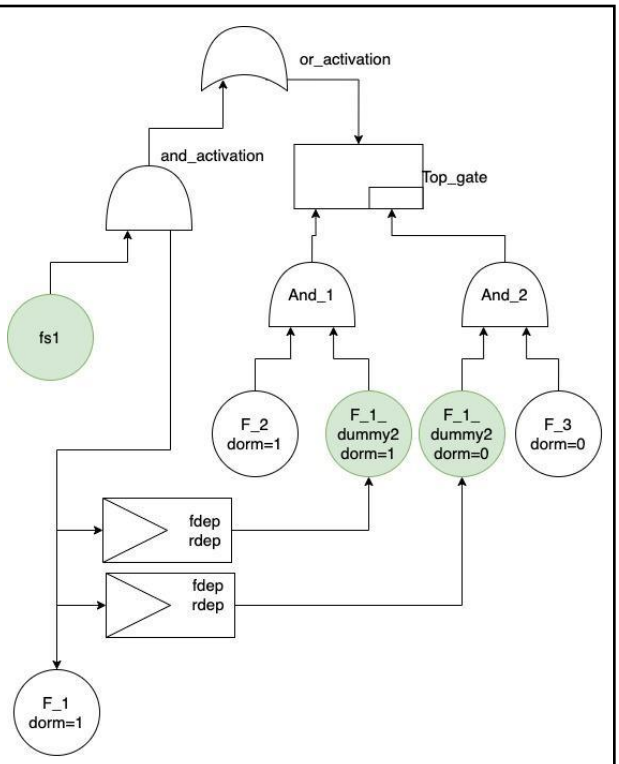
Thus we can not use DFTcalc in its present form to mimic the behavior of BDMPs.

07_and_and_trig
(Henceforth I do not compute unavailability for DFTclac because it is time consuming)

	
BDMP	Dftcalc / rdft

07_and_and_trig @ 1000
Unreliability: FigaroAPI= 0.00505394 DftCalc= 0.00505 Storm-RDFT= 0.0050539
DFTCalc Error= -3.94e-06 Storm-RDFT Error= 0.0
Unavailability: FigaroAPI= 1.33445e-05 DftCalc= 0 Storm-RDFT= 1.33e-05
DFTCalc Error= -1.334e-05 Storm-RDFT Error= -0.0
DFTcalc result corresponds to rdft and bdmp results.

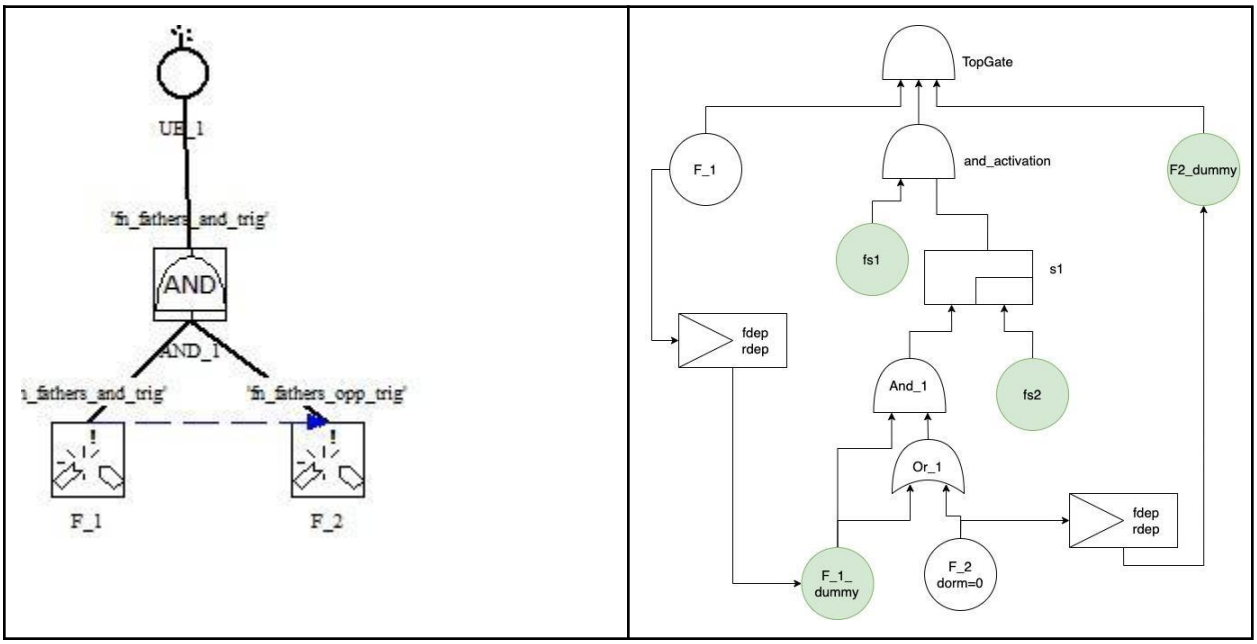
08_and_and_trig_common

	
bdmp	Dftcalc / rdft

08_and_and_trig_common @ 1000
Unreliability: FigaroAPI= 0.0745411 DftCalc= 0.52836 Storm-RDFT= 0.0745411
DFTCalc Error= 0.4538189 **Storm-RDFT Error= -2e-08**
Unavailability: FigaroAPI= 0.000275799 DftCalc= 0 Storm-RDFT= 0.0002758
DFTCalc Error= -0.0002758 Storm-RDFT Error= 0.0

I did not compute DFTCalc unavailability. DFTCalc unreliability error shows the effect of adding dummy elements.

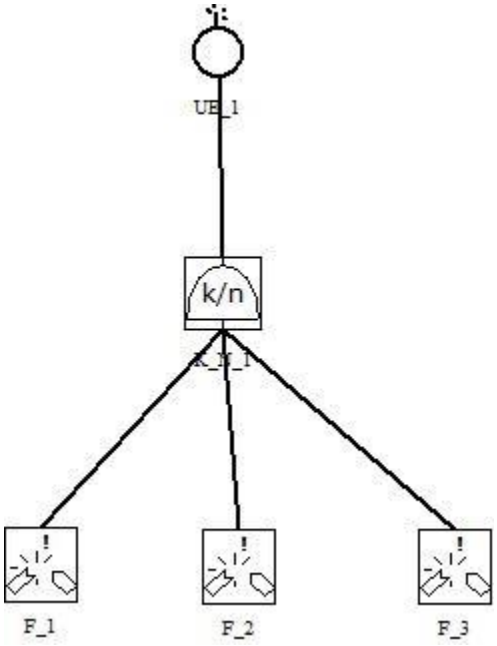
09_and_inv_trig



09_and_inv_trig @ 1000
Unreliability: FigaroAPI= 0.53325 DftCalc= 0.99954 Storm-RDFT= 0.5332498
DFTCalc Error= 0.46629 **Storm-RDFT Error= -1.8e-07**
Unavailability: FigaroAPI= 0.00395257 DftCalc= 0 Storm-RDFT= 0.0039526
DFTCalc Error= -0.00395257 **Storm-RDFT Error= -0.0**

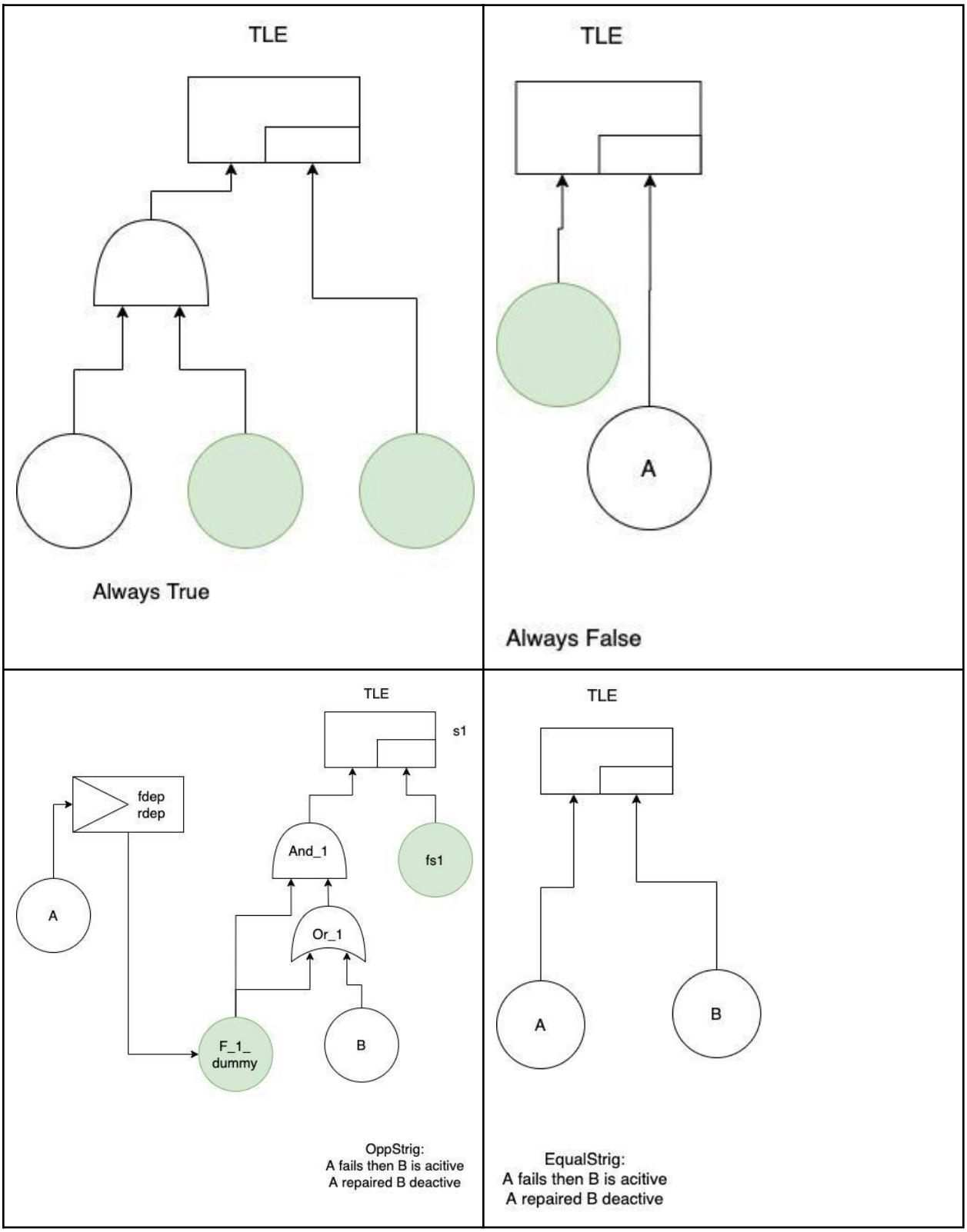
Whenever we introduce fdep gate in the dft, dftcalc result will diverge.

10_vot



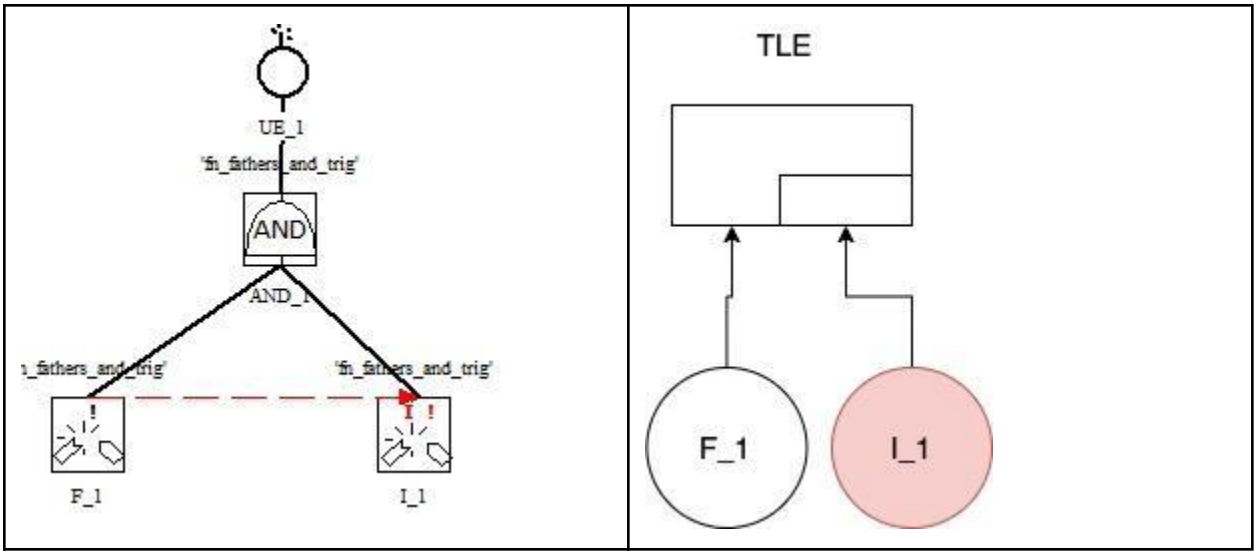
10_vot @ 1000
Unreliability: FigaroAPI= 0.983163 DftCalc= 0.98316 Storm-RDFT= 0.9831629
DFTCalc Error= -3e-06 Storm-RDFT Error= -1.2e-07
Unavailability: FigaroAPI= 0.0232908 DftCalc= 0 Storm-RDFT= 0.0232908
DFTCalc Error= -0.0232908 Storm-RDFT Error= -4e-08

Likewise we model other activation mechanism of BDMP



11_inst_and

(We can not model instantaneous leave of BDMP using existing components of Repairable DFTs. Because existing pdep gates can not remember one-order pending activation of basic events. Inst leaf of BDMPs must remember one activation to reproduce figaroAPI results. I must include inst leave to RDFTs)



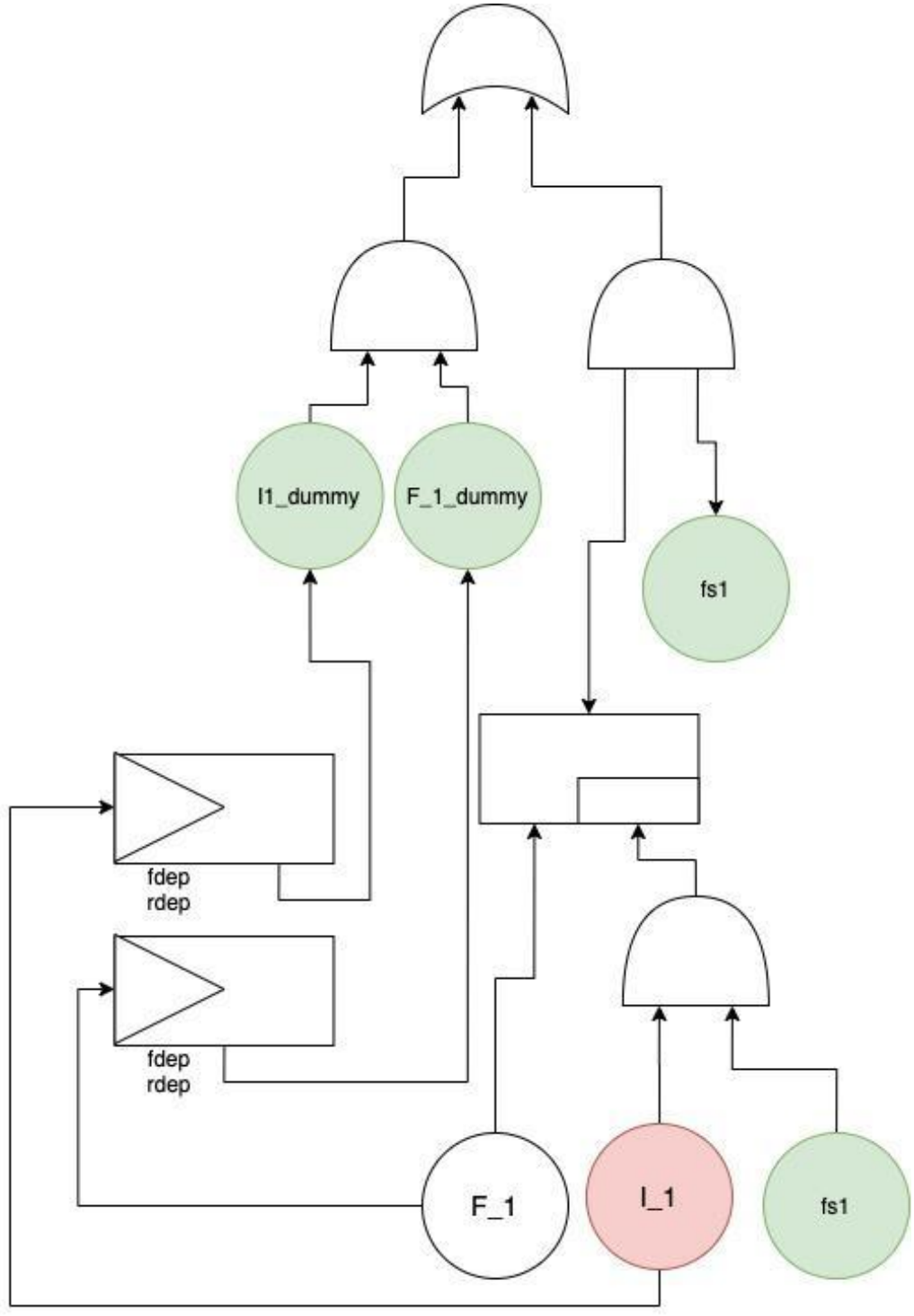
Unreliability: FigaroAPI= 0.991375 DftCalc= 0 Storm-RDFT= 0.9913751

DFTCalc Error= -0.991375 Storm-RDFT Error= 1.4e-07

Unavailability: FigaroAPI= 0.0235294 DftCalc= 0 Storm-RDFT= 0.03125

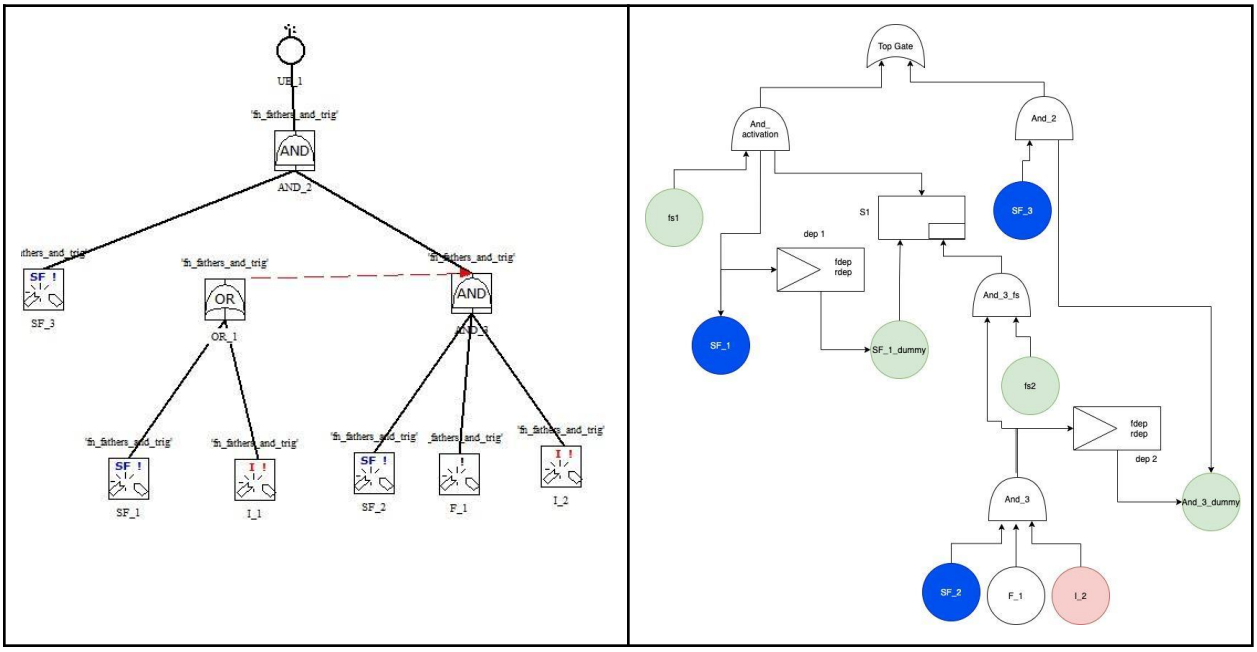
DFTCalc Error= -0.0235294 Storm-RDFT Error= 0.0077206

I_1 receive repeated activation requests in BDMPs. However in RDFTs spare does not claim a failed child therefore we need to include massive structure to mimic repeated activations (next page).



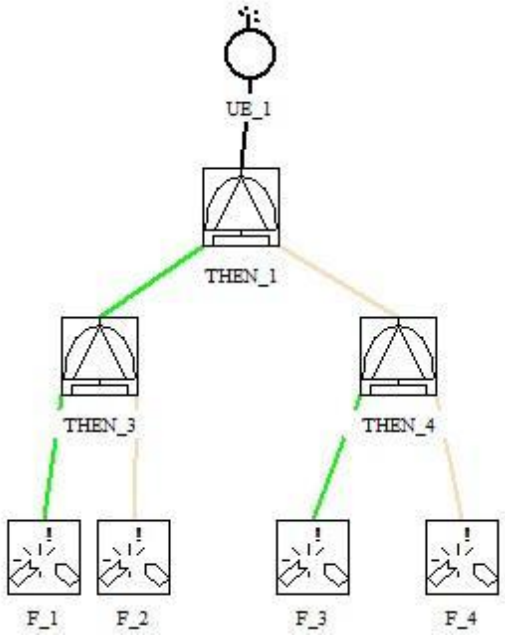
Unreliability: FigaroAPI= 0.991375 DftCalc= 0 Storm-RDFT= 0.9913751
DFTCalc Error= -0.991375 Storm-RDFT Error= 1.4e-07
Unavailability: FigaroAPI= 0.0235294 DftCalc= 0 Storm-RDFT= 0.0235294
DFTCalc Error= -0.0235294 Storm-RDFT Error= 1e-08

12_test



Unreliability: FigaroAPI= 0.0586378 DftCalc= 0 Storm-RDFT= 0.0586378
DFTCalc Error= -0.0586378 Storm-RDFT Error= 4e-08
Unavailability: FigaroAPI= 0.000549863 DftCalc= 0 Storm-RDFT= 0.0005499
DFTCalc Error= -0.00054986 Storm-RDFT Error= 0.0

13, 14, 15, 16



16_PAND_rep_last @ 10000
Unreliability: FigaroAPI= 0.0647566 DftCalc= 0 Storm-RDFT= 0.0647566
DFTCalc Error= -0.0647566 **Storm-RDFT Error= 1e-08**
Unavailability: FigaroAPI= 6.83013e-05 DftCalc= 0 Storm-RDFT= 6.83e-05
DFTCalc Error= -6.83e-05 **Storm-RDFT Error= 0.0**

15_PAND_rep_first @ 10000
Unreliability: FigaroAPI= 0.0601341 DftCalc= 0 Storm-RDFT= 0.0601341
DFTCalc Error= -0.0601341 **Storm-RDFT Error= 4e-08**
Unavailability: FigaroAPI= 6.21276e-05 DftCalc= 0 Storm-RDFT= 6.21e-05
DFTCalc Error= -6.213e-05 **Storm-RDFT Error= -0.0**

14_PAND_rep_any @ 10000
Unreliability: FigaroAPI= 0.0332326 DftCalc= 0 Storm-RDFT= 0.0332326
DFTCalc Error= -0.0332326 **Storm-RDFT Error= 0.0**
Unavailability: FigaroAPI= 8.53767e-06 DftCalc= 0 Storm-RDFT= 8.5e-06
DFTCalc Error= -8.54e-06 **Storm-RDFT Error= -0.0**

13_PAND_rep_all @ 10000
Unreliability: FigaroAPI= 0.0912194 DftCalc= 0 Storm-RDFT= 0.0912194
DFTCalc Error= -0.0912194 **Storm-RDFT Error= 4e-08**
Unavailability: FigaroAPI= 0.000192349 DftCalc= 0 Storm-RDFT= 0.0001923
DFTCalc Error= -0.00019235 **Storm-RDFT Error= -0.0**

As we did not have repair behaviors (rep-all, rep-first, rep-last) in storm-rdft implementation, I had to adopt the code of storm-rdft to include these repairs. FigaroAPI already has this behavior, thanks to KB3 export facility.