Table 2. A comparison of the fault localization techniques. For each system, we show the technique with the best MFR in bold (the lower the better). DepGraph w/o Code Change shows the result after adopting Dependency-Enhanced Coverage Graph, and DepGraph shows the result of incorporating both Dependency-Enhanced Coverage Graph and Code Change Information. The number in the parentheses shows the percentage improvement over Grace [29]. The best result is marked in bold. Due to space constraints, the Tarantula results are not presented in the table but are available in our GitHub repository for reference [4].

Translate	System (# faults)	Techniques	Top-1	Top-3	Top-5	Top-10	MFR	MAR
Translate	Cli (39)		3	5	10	18		
CNN   14   24   26   30   7.04   9.09   7.04   9.09   7.04   9.09   7.04   9.09   7.04   9.09   7.04   9.09   7.04   9.09   7.04   9.09   7.04   9.09   7.04   9.09   9.					8	15	15.763	18.051
DepComph was Code Change								
Pop-Graph		DanGraph w/o Code Change						
Celus   Policy   Po		DepGraph  DepGraph						6.223 (32%)
Finanda	Closure (174)			39			98,652	110.348
CSN   CSN   PopCorph vo Code Change   24 (145)   77 (145)   122 (127)   148 (225)   424 (407)   720 (177)   721		Tarantula	20	37	68	70	97.745	109.634
DepCraph we Code Change		DeepFL						
rec (s)   DepCraph   60 (28%)   99 (27%)   126 (24%)   148 (22%)   4.542 (65%)   7.306 (13%)				78				
rec (18)		DepGraph DepGraph	60 (18%)	97 (24%)	123 (21%)	148 (22%)	4.544 (62%)	7.306 (51%)
Deepl	Codec (18)							
GNN	()	Tarantula	2	12	15	17		3.657
DepCopeny Nov Code Change   7 (1776)   12 (98)   14 (88)   16 (68)   3.111 (33)   3.256 (198   198 (198		DeepFL				16		
settons (4)					13			
Cohiai						16 (-6%)		4.327 (-8%)
DeepEl	Collections (4)		1	1			3.871	3.431
CNN   DepGraph w/o Code Change   1 (95)   1 (95)   2 (965)   2 (965)   2 (965)   1.51 (195)		Tarantula	1	1	2		3.001	8
DepGraph wo Cole Change   1 (09)   1 (09)   2 (09)   2 (09)   1.511		DeepFL						
press (47)   DepGraph   1 (08)   2 (08)   2 (08)   2 (08)   1.445 (48)   1.445 (48)								
Peres (47)								1.445 (4%)
Tarantula   6	Compress (47)			. ,	. ,	29		
GNN   23   29   34   42   5.383   6.987   1.200   1.		Tarantula	6	13	17	29	16.979	19.927
DepCraph v/o Code Change   24 (48)   32 (195)   36 (66)   42 (97)   4384 (197)   5.20 (255)		DeepFL	22	27	31	38	9.573	12.955
Deptocaph		GNN DanGraph w/o Code Character		29				6.987 5.200 (25%)
Chiai		DepGraph  DepGraph						4.245 (39%)
Tarantalla	Csv (16)				,			
DeepFL   7								
DepGraph w/o Code Change   8 (33%)   9 (13%)   10 (0%)   13 (8%)   5.582 (1%)   5.581 (6%)		DeepFL		8	9		5.623	5.971
DepGraph								
1		DepGraph DepGraph		9 (13%)	12 (20%)	13 (8%)	5.362 (1%) 4.813 (12%)	5.581 (6%)
Tarantula   4   9   10   13   9.956   9.667     DeepEl	<b>Gson</b> (18)							
GNN   DepGraph w/o Code Change   12 (9%)   14 (8%)   15 (7%)   15 (9%)   2,177 (66%)   2,278 (66%)   2,278 (66%)								
DepGraph wo Code Change   12 (9%)   14 (8%)   15 (7%)   15 (9%)   1.756 (8%)   2.477 (639)   2.477		DeepFL						
DepCraph   14 (27%)   15 (15%)   16 (14%)   16 (7%)   1.553 (79%)   1.755 (74%)								
SonCore (26)		DepGraph DepGraph			16 (14%)	16 (7%)	1.353 (79%)	2.4/1 (65%) 1.765 (74%)
Tarantula   6   12   14   16   4.368   16.892	JacksonCore (26)							
GNN   Pop	JacksonCore (26)				14		4.368	16.892
DepGraph w/o Code Change   9 (9%)   14 (8%)   15 (7%)   17 (13%)   3.474 (29%)   4.509 (28%)								9.711
DepGraph   12 (33%)   15 (15%)   15 (7%)   16 (7%)   3.052 (38%)   4.015 (367)		GNN						
SonXml (6)		DepGraph w/o Code Change DepGraph						
Tarantula	JacksonXml (6)							
GNN   DepGraph w/o Code Change		Tarantula	1	1	1	3	27.8	27.8
DepGraph w/o Code Change   4 (33%)   5 (67%)   5 (25%)   5 (0%)   0.411 (839)   0.411 (839)   0.490 (83%)   0.49		DeepFL						
DepGraph							2.401	2.401
p (93)			4 (33%)		5 (25%) 5 (25%)	5 (0%)	0.411 (83%)	0.411 (83%)
Tarantula 16 41 47 58 15 20.342  DeepFL 33 3 39 46 49 10.23 11.444  GNN 40 64 72 77 8.223 9.669  DepGraph w/o Code Change 59 (25%) 70 (9%) 77 (7%) 82 (6%) 4.022 (51%) 6.815 (90)  DepGraph by 53 (33%) 73 (14%) 78 (8%) 83 (8%) 3.023 (63%) 4.6174 (52  (64) Ochiai 25 45 51 59 4.68 5.15  Tarantula 32 55 56 59 2.613 2.993  DeepFL 42 53 55 57 2.833 3.08  GNN 45 53 55 57 2.833 3.08  DepGraph w/o Code Change 45 (5%) 55 (4%) 68 (5%) 51 59 2.6613 2.993  DepGraph w/o Code Change 45 (5%) 55 (4%) 60 (5%) 61 (5%) 1.564 (26%) 1.902 (23%)  DepGraph w/o Code Change 55 (4%) 60 (5%) 61 (5%) 1.153 (45%) 1.181 (24%)  DepGraph w/o Code Change 64 (7%) 90 (14%) 90 (9%) 100 (3%) 1.1155 (5%) 1.528 (5%)  DepGraph w/o Code Change DepGraph 72 (13%) 92 (16%) 97 (5%) 100 (3%) 1.1155 (5%) 1.528 (5%)  DepGraph w/o Code Change DepGraph 72 (13%) 92 (16%) 97 (5%) 100 (3%) 1.1155 (5%) 1.528 (5%)  DepGraph w/o Code Change DepGraph 72 (13%) 92 (16%) 97 (5%) 100 (3%) 1.1155 (5%) 1.528 (5%)  DepGraph w/o Code Change DepGraph 72 (13%) 92 (16%) 97 (5%) 100 (3%) 1.1155 (5%) 1.528 (5%)  DepGraph w/o Code Change DepGraph 72 (13%) 92 (16%) 97 (5%) 100 (3%) 1.1155 (5%) 1.528 (5%)  DepGraph w/o Code Change DepGraph 72 (13%) 92 (16%) 97 (5%) 100 (3%) 1.115 (3%) 1.528 (5%)  DepGraph w/o Code Change 20 (25%) 28 (17%) 34 (11%) 2.96 (15%) 3.307 (5%)  DepGraph w/o Code Change 20 (25%) 28 (17%) 34 (11%) 2.54 (17%) 2.99 (18%) 88  Ee (26) Ochiai 6 12 12 13 16 16.14 18.8 88  DepGraph w/o Code Change 21 (15%) 12 (15%) 13 (15%) 14 (15%) 19 (15%) 14 (16%) 15.354 17.170 11 (16%) 100 (16%) 11.15 (15%) 1.154 (15%) 11 (16%) 100 (16%) 11.534 17.170 11 (16%) 100 (16%) 11.534 17.170 11 (16%) 100 (16%) 11.534 17.170 11 (16%) 100 (16%) 11.534 17.171 11 (16%) 100 (16%) 11.534 17.171 11 (16%) 100 (16%) 11.534 17.171 11 (16%) 100 (16%) 11.54 (18%) 100 (16%) 11.54 (18%) 100 (16%) 11.55 (16%) 11.54 (18%) 100 (16%) 11.55 (16%) 11.54 (18%) 100 (16%) 11.55 (16%) 11.54 (18%) 100 (16%) 11.55 (16%) 11.54 (18%) 100 (16%) 11.55 (16%) 11.54 (18%) 100 (16%) 11.55 (16%) 11.54 (18%) 11.54 (18%) 11.	Jsoup (93)			. ,				
GNN DepGraph w/o Code Change 50 (25%) 70 (9%) 77 (7%) 82 (6%) 4.022 (51%) 6.815 (50%) DepGraph w/o Code Change 53 (33%) 73 (14%) 78 (8%) 83 (8%) 3.023 (63%) 4.6174 (52 (64)) Chiai 25 45 51 59 4.68 51.5   Tarantula 32 55 56 59 2.613 2.993 DepGraph w/o Code Change 45 (5%) 55 (4%) 58 (2%) 51 (5%) 1.564 (26%) 1.000 (26%)								
DepGraph w/o Code Change   50 (25%)   70 (9%)   77 (7%)   82 (6%)   4022 (51%)   6.815 (50°)		DeepFL	33	39	46			
DepGraph   53 (33%)   73 (14%)   78 (8%)   83 (8%)   3.023 (63%)   4.6174 (52 (64)								
(44) Ochiai 25 45 51 59 4.68 5.15 Tarantula 32 55 56 59 2.613 2.933 DeepFL 42 33 55 56 59 2.613 2.933 DeepFL 42 53 55 56 59 2.613 2.933 DeepFL 42 53 55 56 59 2.613 3.98 GNN 43 53 57 58 2.113 2.462 DepGraph w/o Code Change 45 (5%) 55 (4%) 60 (5%) 61 (5%) 1.564 (26%) 1.902 (27%) DepGraph w/o Code Change 48 (12%) 55 (4%) 60 (5%) 61 (5%) 1.155 (45%) 1.481 (40%)  (106) Ochiai 23 52 62 82 9.73 11.72 Tarantula 25 57 68 88 4.192 6.312 DeepFL 52 81 90 95 3.95 4.911 GNN 64 79 92 97 2.355 3.082 DepGraph w/o Code Change 67 (5%) 99 (14%) 96 (4%) 100 (3%) 1.185 (30%) 1.155 (35%) 1.528 (30%) DepGraph w/o Code Change 77 (13%) 92 (16%) 97 (5%) 102 (5%) 1.115 (35%) 1.528 (30%) DepGraph w/o Code Change 16 (16%) 16 24 26 29 9.611 DeepFL 10 18 23 20 22 24.77 Tarantula 9 17 20 26 16.861 21.81 DeepFL 10 18 23 26 13.541 17.001 GNN 16 24 26 29 9.611 13.542 DepGraph w/o Code Change 20 (25%) 28 (17%) 34 (31%) 34 (17%) 2.364 (75%) 3.307 (76%) DepGraph w/o Code Change 20 (25%) 28 (17%) 34 (31%) 34 (17%) 2.344 (77%) 2.998 (78%) Tarantula 7 12 14 16 15.354 17.121 DeepFL 12 15 18 20 12.72 1.342 DeepFL 12 15 18 20 12.72 1.342 DeepGraph w/o Code Change 16 (45%) 19 (19%) 20 (0%) 22 (5%) 3.331 (58%) 4.464 (456)		DepGraph w/o Code Change DepGraph	53 (33%)	73 (14%)	78 (8%)		3.023 (63%)	6.815 (30%) 4.6174 (52%
Tarantula   32   55   56   59   2.613   2.993     DeepFL   42   53   55   57   2.833   3.08     GNN	Lang (64)							
GNN		Tarantula		55	56	59	2.613	2.993
GNN		DeepFL						
DepGraph								
1(106)   Ochiai   23   52   62   82   9.73   11.72     Tarantula   25   57   68   88   4.192   6.312     DeepFL   52   81   90   95   3.95   4.911     GNN								
Tarantula	Math (106)							
DeepFL   52   81   90   95   3.95   4.911								
DepGraph w/o Code Change   67 (5%)   90 (14%)   96 (4%)   100 (3%)   1.1185 (50%)   1.528 (50%)		DeepFL	52	81	90	95	3.95	4.911
DepGraph   72 (13%)   92 (16%)   97 (5%)   102 (5%)   1.115 (53%)   1.454 (53%)		GNN					2.355	
kito (38)         Ochiai         7         14         18         23         20.22         24.77           Tarantula         9         17         20         26         16.861         21.81           DeepFL         10         18         23         26         13.541         17.901           GNN         16         24         23         29         9.611         11.601           DepGraph w/o Code Change         20 (25%)         28 (17%)         34 (31%)         34 (17%)         2.361 (75%)         3.307 (76%           Per (26)         Ochiai         6         12         13         16         16.14         18.98           Tarantula         7         12         14         16         15.354         17.121           DeepFL         12         15         18         20         12.722         13.746           GNN         11         16         20         21         7.842         8.448           DepGraph w/o Code Change         16 (45%)         19 (19%)         20 (9%)         22 (5%)         3.321 (58%)         4.465 (47%)		DepGraph w/o Code Change						
Tarantula   9   17   20   26   16.861   21.81	M - 1-1- (20)					()	, , ,	
DeepFL   10   18   23   26   13.541   17.001     GNN	Mockito (38)				18			
GNN 16 24 26 29 9.611 13.621 DepGraph w/o Code Change 20 (25%) 28 (17%) 34 (31%) 34 (31%) 2.361 (75%) 3.307 (76% DepGraph depGraph 21 (31%) 29 (21%) 32 (23%) 34 (11%) 2.194 (77%) 2.998 (78%) et (26) Ochiai 6 12 13 16 16.14 18.98 Tarantula 7 12 14 16 15.354 17.121 DeepFL 12 15 18 20 12.722 13.754 GNN 11 16 20 21 7.842 8.448 DepGraph w/o Code Change 16 (45%) 19 (10%) 20 (0%) 22 (5%) 3.321 (58%) 4.465 (45%)		DeepFL	10	18	23	26	13.541	17.001
DepGraph   21 (31%)   29 (21%)   32 (23%)   34 (17%)   2.194 (77%)   2.998 (78%)		GNN	16	24	26	29	9.611	13.621
e(26)		DepGraph w/o Code Change			34 (31%)		2.361 (75%)	3.307 (76%)
Tarantula         7         12         14         16         15.354         17.121           DeepFL         12         15         18         20         12.722         13.754           GNN         11         16         20         21         7.842         8.448           DeepGraph w/o Code Change         16 (45%)         19 (19%)         20 (0%)         22 (5%)         3.321 (58%)         4.465 (47%)								
DeepFL   12   15   18   20   12.722   13.754   GNN   11   16   20   21   7.842   8.448   DepGraph w/o Code Change   16 (45%)   19 (19%)   20 (0%)   22 (5%)   3.321 (5%)   4.465 (78)	Time (26)							
GNN 11 16 20 21 7.842 8.448 DepGraph w/o Code Change 16 (45%) 19 (19%) 20 (0%) 22 (5%) 3.321 (58%) 4.465 (47%)								
DepGraph w/o Code Change 16 (45%) 19 (19%) 20 (0%) 22 (5%) 3.321 (58%) 4.465 (47%)		GNN	11	16	20	21	7.842	8.448
DepGraph 17 (55%) 20 (25%) 21 (5%) 22 (5%) 3.044 (61%) 4 371 (48%)		DepGraph w/o Code Change	16 (45%)	19 (19%)	20 (0%)		3.321 (58%)	4.465 (47%)
		DepGraph	17 (55%)	20 (25%)	21 (5%)	22 (5%)	3.044 (61%)	4.371 (48%)
	Total (675)							
Tarantula 135 278 350 427 16.95 20.567								
DeepFL 257 353 427 468 8.726 10.338 GNN 98 416 486 541 5.678 6.851								

298

336 (13%)

359 (20%)

416

470 (13%)

481 (16%)

DepGraph

DepGraph w/o Code Change

486

534 (10%)

541 (11%)

541

588 (9%)

597 (10%)

5.678

3.049 (46%)

2.562 (55%)

6.851

3.957 (42%)

3,272 (52%)