TESTABILITY PATTERNS FOR PHP

The testability patterns for PHP are presented in Table I. This table groups together (by using horizontal lines) pattern instances which address similar aspects of the language and have the same response from SAST tools. For each instance (tarpit), the table reports its name, its properties with respect to the dimensions, and the tools that are affected by it (by using a sequence of letters, R for RIPS, S for PHPsafe, W for WAP, P for Progpilot, X for Comm_1 and Y for Comm_2). When a tool handles the pattern by means of an over-approximation, we mark its name with an overline. For instance, the string $----X\overline{Y}$ means that a tarpit is handled correctly only by Comm_1 and via over-approximation by Comm_2. The last fours sets of columns report the prevalence of each pattern instance in our four datasets – as expressed by the number of affected projects (prj column) and by the median number of occurrences of the pattern (med column).

Finally, when the same pattern has multiple instances (e.g., to describe tests belonging to different dynamic categories) that lead to the same result, we group them and report their number in the number of instances (*#i*) column.

TABLE I: Patterns

ID	Pattern	#i	API	SEC	Dyn	OOP	Neg	Tools	SC		G_L		G_M		G_H	
									prj	med	prj	med	prj	med	prj	med
1	static_variables	1			S			------	50	13	443	4	635	7	712	14.0
2	global_variables	1			S			-S--XY	89	10	203	7	213	10	210	12.0
3	global_array	1			S			--WP-Y	33	6	138	4.0	162	5.0	179	7
4	conditional_assignment	1			S			R-WPXY	221	74	795	18	890	31.5	908	59.0
5	combined_operator	1			S			R-WPXY	335	170	919	33	942	64.0	934	97.5
6	coalesce	1			S			RS--XY	0	0	0	0	280	6.0	433	11
7	string_arithmetic_operations	1		✓	S			RSW-XY	277	10	523	6	636	9.0	707	11
8	simple_reference	1			S			----X-	42	39	163	9	231	5	292	6.0
9	reference_argument	1			S			----XY	208	14	387	7	399	10	486	9.0
10	return_by_reference	1			S			------	19	11	83	4	95	4	132	4.0
11	foreach_with_reference	1			S			------	41	7	182	3.0	238	4.0	321	4
12	make_ref	2			S		✓	---P-$\overline{Y}$	25	6	116	6.0	134	4.0	180	4.0
13	assign_static_prop_ref	1			S			---PX-	9	1.0	19	1	10	1.0	17	1
14	object_assigned_by_reference	1			S			----X-	22	21	100	6.5	107	7	155	5
15	nested_function	1			S			-SWPX-	66	3.5	166	4.0	222	4.0	283	5
16	variadic_functions	1			S			----XY	1	12	59	3	143	3	239	3
17	get_arguments	1			S			R----Y	23	5.0	106	4.0	137	4	191	4
18	send_unpack	1			S			RS--X-	1	31	73	3	146	3.0	264	4.0
19	closures	2			D2			----XY	36	1	543	7	733	11	782	25.5
20	use_with_closures	2			D2		✓	----X$\overline{Y}$	25	1	321	4	524	5.0	614	12.0
21	simple_object	1			S	✓		---PXY	336	199	968	350.5	977	863	974	1536.5
22	assign_object	1			S	✓		--W-X-	30	3	138	4.0	212	4.0	325	4
23	object_argument	1			S	✓		----X-	119	30	591	23	718	53.5	804	79.5
24	new_self	1			S	✓		----X-	41	6	162	2.0	249	3	351	3
25	clone	1			S	✓		---PX-	41	6	147	3	238	5.0	338	5.0
26	late_static_binding	2			D2	✓	✓	----$\overline{X}$-	13	1.0	165	4	279	5	386	8.0
27	get_called_class	1			D2	✓		------	0	0	16	1.0	28	1.0	34	2.0
28	static_methods	1			S	✓		---PX-	119	17	792	29.0	865	61	898	126.5
29	static_properties	1			S	✓		---PX-	93	48	406	12.0	498	14.0	615	20
30	anonymous_classes	1			S	✓		----XY	1	6	30	2.0	81	3	174	3.0
31	static_method_variable	2			D2,D4	✓		------	1	1	23	1	51	2	68	2.0
32	set_overloading	1			S	✓		----X-	0	0	44	6.0	50	7.0	61	8
33	get_overloading	1			S	✓		------	1	1	56	6.5	70	7.0	81	8
34	isset_overloading	1			S	✓		------	1	1	32	6.5	34	7.0	49	7
35	unset_overloading	1			S	✓		----X-	0	0	24	5.5	23	8	29	7
36	call_overloading	1			S	✓		------	6	1.0	47	4	59	7	68	7.5
37	callstatic_overloading	1			S	✓		------	3	22	12	35.0	20	141.0	26	41.0
38	invoke	1			S	✓		----X-	1	21	6	1.5	9	3	11	4
39	serialize_unserialize	1			S	✓		---P--	42	1.5	135	5	143	8	188	6.0
40	trait	1			S	✓		----XC	87	6	800	13.0	881	26	907	43
41	self_methods	1			S	✓		---PX-	68	35	360	12.0	482	15.0	602	22.5
42	destructor	1			S	✓		------	102	1	59	4	78	5.5	88	7.0
43	tostring_echo_object	1			S	✓		----XY	9	12	76	14.5	86	25.0	108	16.0
44	verify_return_type	2			S	✓		---PX-	41	32	454	9.0	607	21	713	44
45	static_method_from_variable	1			D2	✓		---P-Y	23	3	98	2.0	166	4.0	235	4
46	object_to_array	1			D2	✓		------	50	13	290	4.0	405	4	475	5
47	Overriding	1			S	✓		---PXC	62	11	569	16	698	24	750	49
48	construct_with_inheritance	1			S	✓		---PX-	64	4.5	471	7	590	11	680	17
49	static_instance	1			S	✓		------	9	3	103	1	114	3	161	2
50	throw_exception	1			D2			------	84	24	610	9.0	739	13	810	21.0
51	catch_exception	1			S			RS---C	95	6	466	4.5	612	6.0	687	11
52	try_catch_finally	2			D2		✓	R---$\overline{XY}$	3	6	39	2	86	2.0	197	2
53	track_error	1			S			---P--	135	20	333	5	407	6	521	7
54	generators	1			S			R---X-	5	1.0	57	2	113	3	204	5.0
55	goto	1			S			----X-	3	8	68	8.0	95	4	155	5
56	exit	1		✓	S			RSWP--	261	3	182	2.0	185	4	226	4.0
57	JS_redirect	1			S			------	151	8	27	3.0	115	3	137	4.0
58	simple_array	2			D1		✓	R--PX$\overline{Y}$	338	336.5	973	120	970	224.5	963	439
59	foreach_with_array	1	✓		S			R----$\overline{Y}$	68	9.5	208	4.0	237	5	297	4
	foreach_with_array	1			S			R--PX$\overline{Y}$	262	21	831	10	883	21	917	29
60	array_walk	2	✓		D2,D4			------	19	1.0	43	1	60	2.0	74	2.0
61	array_map	2	✓		D2,D4			------	41	12	167	3	214	5.0	280	4.0
62	parse_str_function	1	✓		D4			R-----	17	4.0	76	1.0	88	3.0	112	2.0
63	substring_replace_function	1	✓		S			RS---Y	38	4.0	80	3.0	97	3	118	3.0
64	preg_match	1	✓		S			R---X-	100	6.0	277	6	279	9	355	6
65	system (system)	1	✓	✓	S			R--PXY	1	1	20	3.0	37	3	41	2
	system (exec)	1	✓	✓	S			R--PXY	20	3	78	2.0	100	3.0	130	3.0
	system (unlink)	1	✓	✓	S			R--PXY	101	3	159	4	181	6	237	5
66	superglobals	1		✓	S			-SWPX-	177	7.0	331	4	355	6	413	6

	superglobals	1		✓	S			R−W−X−	323	19	112	4.0	133	8	148	5.0
	superglobals	1		✓	S			−S−−X−	9	1	58	1.5	81	2	102	2.0
	superglobals	1		✓	S			RSWP−Y	240	9	90	4.0	120	4.0	124	4.0
67	odbc	1	✓	✓	S			RS−PXY	1	1	48	2.0	60	2.0	63	2
68	compact	2	✓		D2-D4			−−−−−−	1	1	48	2.0	60	2.0	63	2
69	create_function	1	✓		D1			−−−−−−	1	3	49	2	38	4.0	44	2.0
70	extract	1	✓		D2			−−−−−−	117	15	80	2.5	100	3.0	89	2
71	array_functions	1	✓		S			−−−−−$\overline{Y}$	23	1.0	86	2.0	114	2.0	155	3
	array_functions	1	✓		S			R−−−−$\overline{Y}$	10	1.0	23	2	37	1	40	2.0
72	procedural_queries	1	✓	✓	S			R−−PXY	187	26	30	2.5	33	4	24	4
	procedural_queries	2	✓	✓	S			−−−−XY	73	4	43	3	38	4	38	2.0
73	wrong_sanitizers	2	✓	✓	S			RS−PX−	174	5	242	3.0	303	5	332	5.0
74	dirname	1	✓	✓	D1			−−−−−−	23	3.0	101	4	111	4	131	4
75	buffer	1	✓		S			−−−−−−	27	2	150	2.5	190	3.0	181	4
76	function_variable	2			D2,D4			−−−−−−	40	2.5	315	3	465	4	602	7.0
77	object_callable	2			D2,D4			−−−−−−	12	6	89	2	141	3	252	4.0
78	autoloading_classes	1	✓		D2	✓		−−−P−−	50	1	123	1	138	1.0	150	2.0
79	dynamic_include	1			D1	✓		R−−PX−	337	44	549	5	600	5.0	636	6.0
	dynamic_include	1			D2	✓		R−−PX−	7	2	14	2.0	19	1	27	2
	dynamic_include	2			D3			−−−−−−	137	2	155	5	190	4.5	219	4
	dynamic_include	1			D4			−−−−−−	337	85.0	665	6	712	7.0	754	7.0
80	callback_functions	1			D1			−−−P−Y	41	2	128	3.0	159	3	208	2.5
	callback_functions	2			D2			−−−P−−	5	2	11	2	15	2	31	2
	callback_functions	1			D3			−−−−−−	8	7	17	2	29	1	38	1.5
	callback_functions	1			D4			−−−−−−	65	6	180	4.0	188	4.5	269	5
81	new_from_variable	1			D2	✓		−−−−−−	12	7	90	5.0	122	3.0	127	3
	new_from_variable	1			D3	✓		−−−−−−	0	0	0	0	0	0	0	0
	new_from_variable	1			D4	✓		−−−−−−	39	8	394	4.0	503	5	600	6.0
82	methods_variable	1			D2	✓		−−−−−−	14	4.0	99	4	163	4	211	4
	methods_variable	1			D4	✓		−−−−−−	46	3	223	3	351	3	448	4.0
83	array_variable_key	2			D2		✓	R−−−$\overline{XY}$	74	8.0	173	8	255	8	277	5
	array_variable_key	2			D4		✓	−−−−$\overline{XY}$	238	21	763	12	831	18	883	32
84	variable_variables	1			D2			−−−−−−	24	5.0	20	5.0	27	5	47	5
	variable_variables	1			D4			−−−−−−	123	5	81	4	108	4.5	147	3
	Total	122	26	16		39	7		7623	1716	22687	1031	27875	2004.5	32572	3097.5
	Average								74	16.66	220.2	10	270.6	19.5	316.23	30.07

Legenda for column Tools: RIPS (R), phpSAFE (S), WAP (W), Progpilot (P), Comm_1 (X), Comm_2(Y)