Table 1. Summary statistics on 61 projects that we evaluate: no. of test methods (#tests), test time w/o RV in seconds (t), relative JavaMOP overhead (t^{rv}/t), absolute JavaMOP overhead in seconds ($t^{rv}-t$), lines of code (SLOC), % statement coverage (cov^s), % branch coverage (cov^b), no. of GitHub commits (#SHAs), years since first commit (age), and no. of stars (#★).

	#tests	t	t^{rv}/t	$t^{rv}-t$	SLOC	cov^s	cov^b	#SHAs	age	#★
Mean	135.3	41.8	17.2	495.8	8,308.5	64.9	56.8	283.2	9.3	176.9
Med	32.0	8.8	10.7	87.1	3,475.0	71.1	58.2	112.5	8.0	49.0
Min	1	1.8	1.4	5.0	204	4.6	4.8	3	3	6
Max	2,737	1,449.7	107.3	17,223.0	99,521	95.8	92.2	4,643	22	2,448
Sum	8,117	2,551.9	n/a	n/a	5.0×10^5	n/a	n/a	n/a	n/a	10,612

Table 2. Results from our IMMs formative study showing number of methods with at least one event, number of IMMs, number of IMMs involves just one spec, number of IMMs involves less than five specs, the maximum number of specs in an IMM, number of traces, and the number of unique traces.

project	# methods	# IMMs methods	# IMMs with 1 spec	# IMMs with < 5 specs	IMM max specs	# traces	# unique traces
agarciadom-xeger	25	23	6	17	4	15784919	1687
albfernandez-javadbf	69	25	5	20	4	137584	271
almondtools-stringsearchalgorithms	188	156	44	95	8	71164581	4844
almson-almson-refcount	18	5	4	1	2	5000230	24
Antibrumm-jackson-antpathfilter	76	38	11	24	6	10630145	427
attoparser-attoparser	86	40	3	31	6	219116681	989
awslabs-route53-infima	41	21	2	15	9	7106092	774
cocolian-cocolian-nlp	136	80	21	51	8	25115363	28729
codelion-gramtest	72	24	4	18	7	25601108	1230
conveyal-osm-lib	208	93	49	44	4	16842895	3523
cowtowncoder-java-uuid-generator	32	25	3	22	3	20836588	120
dakusui-jcunit	385	116	32	65	8	136512454	7568
danieldk-dictomaton	153	88	34	43	6	42767533	13836
davidmoten-bplustree	49	32	14	18	4	63527267	189
davidmoten-rtree	349	154	19	119	6	33111143	2825
davidmoten-rtree2	295	126	19	95	6	16505411	1811
davidmoten-rtree-multi	301	124	20	93	6	19764129	38325
dperezcabrera-jpoker	224	89	21	66	6	96172485	1714
eightbitjim-cassette-nibbler	89	70	16	53	7	189045642	45365
f4b6a3-uuid-creator	75	69	29	40	3	602946	202
finmath-finmath-lib	1210	718	294	363	9	292561860	7034
flipkart-incubator-databuilderframework	158	83	25	48	6	51550176	1453
fraunhoferfokus-Fuzzino	361	168	42	113	8	503526	7001
fusion-jena-JaroWinklerSimilarity	43	18	3	11	7	137424739	11414
ghaffarian-progex	279	188	16	139	10	20492889	37675
Grundfleck-ASM-NonClassloadingExtensions	229	113	21	84	6	32050829	41819
hlavki-jlemmagen	27	14	2	11	6	1260566	2066
houbb-sensitive-word	32	21	8	11	5	99409238	309
huaban-jieba-analysis	16	8	1	6	6	18908475	1092
indeedeng-vowpal-wabbit-java	61	34	10	23	7	287481159	275
jahlborn-jackcess	744	435	142	267	8	39739951	38194
kapoorlabs-kiara	235	40	13	16	8	8700158	104731
lexburner-consistent-hash-algorithm	3	2	0	1	6	56100216	27
LiveRamp-HyperMinHash-java	9	6	0	5	5	33218916	72
lukfor-pgs-calc	355	230	56	160	7	55087678	7759
MezereonXP-AnomalyDetectTool	27	19	8	10	5	1323046	678
mimno-Mallet	341	162	34	124	6	62585384	1379
mocnik-science-geogrid	7	4	2	2	4	4000577	63
myui-btree4j	44	14	1	12	7	40361420	1546
octavian-h-time-series-math	220	121	6	105	6	1295220	542408
renfei-ik-analyzer	40	20	2	15	5	28817059	922
romix-java-concurrent-hash-trie-map	41	6	4	2	3	324715	2292
sbesada-java.math.expression.parser	21	14	3	11	4	328001872	135
solita-functional-utils	75	28	9	17	5	9896	927
spullara-java-future-jdk8	54	7	0	7	3	500133	121
StarlangSoftware-TurkishDeasciifier	51	34	11	22	5	1512396	5340
StarlangSoftware-TurkishMorphologicalDisambiguation	71	50	15	33	5	244001149	28275
StarlangSoftware-TurkishPropBank	15	10	6	4	3	36922516	93
StarlangSoftware-TurkishSentiNet	7	4	0	2	5	63329671	31
StarlangSoftware-TurkishSpellChecker	77	56	8	43	7	24542090	27692
Sweetiee-yi-Jaba	34	19	7	10	5	22132139	4969
wiqer-ef-redis	29	7	2	5	2	40000171	77
zhoujianling-PointCloudUtilities	139	69	26	38	5	6757171	40450
jingpeicomp-id-generator	37	22	1	20	5	97144739	354
palindromicity-simple-syslog	85	48	7	36	5	11170066	2461
graphstream-gs-core	250	81	22	53	7	6501917	818
jordw-heftydb	281	142	47	92	5	4987253	11656
StarlangSoftware-TurkishMorphologicalAnalysis	154	56	10	42	9	47373793	22862
houbb-segment	44	30	7	20	5	5913933	320
sangupta-bloomfilter	14	0	0	0	0	2000027	28
JetBrains-jetCheck	109	38	19	17	6	7921613	1692

IMMs Formative Study. We conduct the study using the same 61 projects as in our evaluation. Table 1 shows summary characteristics of these 61 monitoring-dominated projects. **Evaluation Subjects** in paper's §4 describes how to select these projects.

Table 3. Results from our IMMs formative study showing number of traces in IMMs, number of unique traces in IMM, number of intra-procedural repeatedly monitored identical traces, number of inter-procedural repeatedly monitored identical traces, number of IMMs in project's code, number of IMMs in test classes, and number of IMMs in third-party libraries.

| project	# traces in IMMs	# unique traces in IMMs	intra-procedural repeatedly monitored identical traces	inter-procedural repeatedly monitored identical traces	IMMs in CUT	IMMs in test	IMM in library
agarciadom-xeger	13172395	536	15328363	456556	2	2	19
albfernandez-javadbf	137227	194	137445	0	12	13	0
almondtools-stringsearchalgorithms	62242225	4135	71160836	2546	100	3	53
almson-almson-refcount	5000214	8	5000212	0	1	3	1
Antibrumm-jackson-antpathfilter	9324574	313	9864723	765253	4	2	32
attoparser-attoparser	209465643	715	209465940	9650570	22	16	2
awslabs-route53-infima	6313065	260	7100569	5079	12	7	2
cocolian-cocolian-nlp	24367223	13665	24618319	496565	51	11	18
codelion-gramtest	22904099	956	25319091	281664	5	0	19
conveyal-osm-lib	16842053	3218	16841217	519	19	2	72
cowtowncoder-java-uuid-generator	20836449	105	20836441	126	8	17	0
dakusui-jcunit	136440601	1901	136471278	37696	77	18	21
danieldk-dictomaton	30941264	8382	38609258	4153908	40	48	0
davidmoten-bplustree	63523753	135	63524133	3083	12	14	6
davidmoten-rtree	27288096	1320	32259854	850236	28	9	117
davidmoten-rtree2	12964835	1005	15481269	1023651	26	3	97
davidmoten-rtree-multi	15555409	1393	18352016	1382089	24	1	99
dperezcabrera-jpoker	96170960	363	96170971	48	6	21	62
eightbitjim-cassette-nibbler	188990387	253	188998046	11564	61	9	0
f4b6a3-uuid-creator	535526	190	602934	12	16	53	0
finmath-finmath-lib	280677585	5327	280717750	11842037	514	180	24
flipkart-incubator-databuilderframework	41717976	866	45000866	6549043	20	17	46
fraunhoferfokus-Fuzzino	467403	5202	483356	18686	107	61	0
fusion-jena-JaroWinklerSimilarity	112519668	1449	118216984	19206982	13	5	0
ghaffarian-progex	18755703	5687	19759844	730765	148	0	40
Grundlefleck-ASM-NonClassloadingExtensions	26724783	1304	29616378	2434146	1	1	111
hlavki-jlemmagen	1232092	223	1254496	4636	12	1	1
houbb-sensitive-word	99406611	239	99408191	982	18	0	3
huaban-jieba-analysis	18201569	509	18835886	72254	8	0	0
indeedeng-vowpal-wabbit-java	192702366	153	258995614	28485424	20	5	9
jahlborn-jackcess	17575161	4376	38424618	1300035	239	183	13
kapoorlabs-kiara	8687227	104130	8637936	4910	38	0	2
lexburner-consistent-hash-algorithm	56100200	11	56100200	0	1	1	0
LiveRamp-HyperMinHash-java	33218916	72	33218916	0	5	1	0
lukfor-pgs-calc	55049872	7334	55077099	6282	46	9	175
MezereonXP-AnomalyDetectTool	1319487	346	1321989	666	13	2	4
mimno-Mallet	62573441	993	62579835	5122	117	39	6
mocnik-science-geogrid	4000576	62	4000576	0	4	0	0
myui-btree4j	40317936	405	40360251	0	8	6	0
octavian-h-time-series-math	1286894	542119	749622	4566	2	0	119
renfei-ik-analyzer	28697627	889	28697617	119400	7	1	12
romix-java-concurrent-hash-trie-map	294133	15	294331	28212	3	3	0
sbesada-java.math.expression.parser	328001806	69	328001801	0	14	0	0
solita-functional-utils	4612	550	6360	2950	26	2	0
spullara-java-future-jdk8	500028	16	500028	0	1	6	0
StarlangSoftware-TurkishDeasciifier	997730	2983	1185632	325783	1	3	30
StarlangSoftware-TurkishMorphologicalDisambiguation	225834125	6534	229643909	14356821	4	3	43
StarlangSoftware-TurkishPropBank	36922494	76	36922494	0	5	2	3
StarlangSoftware-TurkishSentiNet	63329660	20	63329660	0	3	0	1
StarlangSoftware-TurkishSpellChecker	21477262	24259	22315282	2214120	22	3	31
Sweetiee-yi-Jaba	17289494	4237	18670048	3460539	11	0	8
wiqer-ef-redis	40000080	18	40000078	36	1	2	4
zhoujianling-PointCloudUtilities	6736648	39765	6737225	6240	63	5	1
jingpeicomp-id-generator	96944681	298	96944475	200004	15	6	1
palindromicity-simple-syslog	9892344	2083	11140891	28279	6	3	39
graphstream-gs-core	6498934	437	6500840	730	69	12	0
jordw-heftydb	4126760	7122	4477965	502505	58	47	37
StarlangSoftware-TurkishMorphologicalAnalysis	41748001	8818	44963937	2393243	43	7	6
houbb-segment	5913206	230	5913613	192	18	0	12
sangupta-bloomfilter	0	0	0	2000000	0	0	0
JetBrains-jetCheck	2908831	677	6740752	1180276	28	10	0
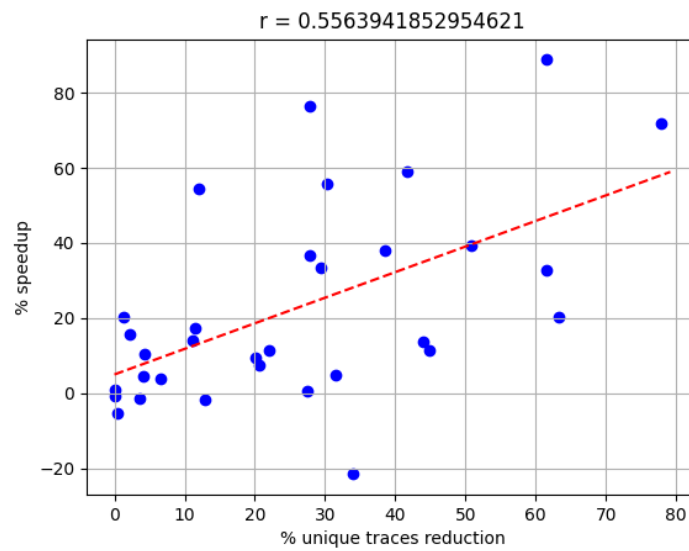
Fig. 1. A weak positive correlation between the percentage of unique traces reduced by LᴀᴢʏMOP^e 's optimization and performance gain (after removing outliers). The Pearson correlation coefficient (r) is 0.556.