AGA_Results

In this document, we present the missing experimental results in our paper "AGA: An Accelerated Greedy Additional Algorithm for Test Case Prioritization" due to the space limit.

1 Subjects Information

1.1 Open-source Subjects

As we say in our paper, the first part of the subjects consist of 55 open-source projects. Among these projects, 33 are widely used in prior work, the others are the most popular subjects selected from GitHub according to the number of stars. Specifically, we target GitHub subjects whose primary programming language is *Java* and order them according to the number of stars in Jan 2019. Then, we check the first 100 subjects and keep only the ones that are code repository and the required tools (e.g., Maven, Clover, PIT) could work.

All the open-source projects used in this work are written in *Java*, whose number of lines of code is from 1,621 to 254,284. Each of these projects has a test suite written in JUnit Testing Framework. The detailed information is given in Table 1. It is worth noting that compared with the experimental dataset used in recent TCP work, our dataset is larger and contains more large-scale projects, which can make our experimental results more reliable and convincing.

1.2 Industrial Subjects

To show the practical usage of our approach, we collected industrial subjects from Baidu. Baidu is a famous Internet service provider with over 600M monthly active users. In their regression testing infrastructure, test case prioritization is frequently needed and they have been adopting Greedy Additional (GA) strategy for a long time because of its simple idea and relatively high effectiveness. However, they often complain about the long running time of GA, which deviates from the original intention of TCP, that is to accelerate the process of detecting faults.

To check the performance of our AGA approach in real-world scenarios, we collected 22 versions of five industrial projects from Baidu, each of which is taken as a subject in this study. More specifically, these subjects are collected from Dec. 2017 to Feb. 2018 and Oct. 2018 to Nov. 2018, and all of them are

Table 1: Basic information for open-source subjects

ID	Subjects	SLOC	TLOC	#Test Cases	#Mutants
$\mathcal{S}_1$	DiskLruCache	780	1,030	61	152
$\mathcal{S}_2$	gson-fire	895	726	36	520
$\mathcal{S}_3$	gson-fire-v2	1,178	952	47	202
$\mathcal{S}_4$	jumblr	1,489	1,243	103	167
$\mathcal{S}_5$	java-apns	1,503	1,724	87	412
$\mathcal{S}_6$	jasmine-maven-plugin	1,671	1,931	102	561
$\mathcal{S}_7$	java-uuid-generator	1,790	2,388	45	346
$\mathcal{S}_8$	gdx-artemis-master	1,851	1,492	35	961
$\mathcal{S}_9$	jopt-simple	1,924	5,903	727	1,677
$\mathcal{S}_{10}$	protoparser	2,153	3,227	171	864
$\mathcal{S}_{11}$	jackson-datatype-guava	2,217	1,035	73	845
$\mathcal{S}_{12}$	jackson-datatype-guava-v2	2,366	1,327	80	320
$\mathcal{S}_{13}$	JActor	2,542	4,418	65	56
$\mathcal{S}_{14}$	spring-retry	2,765	3,419	185	351
$\mathcal{S}_{15}$	scribe-java	2,808	2,536	99	563
$\mathcal{S}_{16}$	metrics-core	2,835	2,194	150	1,656
$\mathcal{S}_{17}$	javapoet	2,986	4,399	332	973
$\mathcal{S}_{18}$	low-gc-membuffers	3,184	9,782	51	780
$\mathcal{S}_{19}$	lambdaj-master	3,634	4,914	265	3,399
$\mathcal{S}_{20}$	LastCalc-0.1	4,522	581	32	2,499
$\mathcal{S}_{21}$	stream-lib	4,835	3,806	141	3,811
$\mathcal{S}_{22}$	webbit	4,914	8,463	131	349
$\mathcal{S}_{23}$	commons-pool	5,206	8,232	272	633
$\mathcal{S}_{24}$	redline-smalltalk-master	5,648	480	43	3,450
$\mathcal{S}_{25}$	la4j	7,086	4,050	625	5,023
$\mathcal{S}_{26}$	redline-smalltalk	7,212	2,414	240	833
$\mathcal{S}_{27}$	nv-websocket-client	7,351	657	73	277
$\mathcal{S}_{28}$	joss	8,078	6,035	531	1,289
$\mathcal{S}_{29}$	raml-java-parser-master	8,696	3,005	192	4,506
$\mathcal{S}_{30}$	raml-java-parser	8,788	5,061	197	1,288
$\mathcal{S}_{31}$	la4j-v2	9,272	4,035	799	3,141
$\mathcal{S}_{32}$	commons-io	9,980	19,189	1,081	7,773
$\mathcal{S}_{33}$	streamex	10,427	7,906	450	3,958
$\mathcal{S}_{34}$	jsoup	10,507	12,037	666	3,157
$\mathcal{S}_{35}$	commons-dbcp	11,592	8,752	560	2,601
$\mathcal{S}_{36}$	rome-1.5.0	11,647	2,705	475	4,929
$\mathcal{S}_{37}$	assertj-core	13,361	53,059	2,470	4,571
$\mathcal{S}_{38}$	vraptor-archive	16,910	16,213	1,130	7,245
$\mathcal{S}_{39}$	mapdb-mapdb-1.0.9	17,589	35,873	1,776	876
$\mathcal{S}_{40}$	RoaringBitmap	17,807	21,494	1,148	21,319
$\mathcal{S}_{41}$	blueflood	19,517	15,774	961	1,854
$\mathcal{S}_{42}$	lanterna	20,682	7,724	34	344
$\mathcal{S}_{43}$	jackson-core	21,320	10,924	376	6,215
$\mathcal{S}_{44}$	jsprit	23,073	18,373	1,250	12,350
$\mathcal{S}_{45}$	hivemall	28,569	3,975	150	6,557
$\mathcal{S}_{46}$	asterisk-java	30,495	4,263	217	3,226
$\mathcal{S}_{47}$	asterisk-java-v2	31,074	4,258	217	921
$\mathcal{S}_{48}$	restcountries	31,324	468	40	113
$\mathcal{S}_{49}$	chukwa	32,654	8,051	131	569
$\mathcal{S}_{50}$	ews-java-api	45,313	1,328	90	1,782
$\mathcal{S}_{51}$	languagetool	47,589	20,778	719	26,662
$\mathcal{S}_{52}$	OpenTripPlanner-otp-0.20.0	64,718	14,207	379	7,325
$\mathcal{S}_{53}$	hbase-1.2.2	66,630	17,385	434	1,781
$\mathcal{S}_{54}$	commons-math	86,748	90,798	5,082	84,476
$\mathcal{S}_{55}$	camel-core	120,248	134,036	5,623	13,005
	Total	912,045	633,085	31,454	262,295

Table 2: Results of Industrial Subjects

Subject[*]	Basic Information		Time cost (s)					
	SLOC[**]	#Test Cases	GA	AGA	*FAST*	ART-D	GA-S	GE
$\mathcal{I}_1$	>500K	4,246	29,278.9102	359.9679 ✓	1,860.1473	543,106.2852	2,680,036.2615	54,969.0830
$\mathcal{I}_2$	>200K	2,546	3,018.6473	89.9239 ✓	398.8814	32,938.6045	315,888.7090	13,887.3160
$\mathcal{I}_3$	>200K	2,566	3,228.2772	86.0066 ✓	417.8356	30,458.8672	304,555.6710	14,124.1435
$\mathcal{I}_4$	>200K	2,550	2,833.4841	80.5940 ✓	383.9494	24,944.4404	265,881.1139	19,345.1543
$\mathcal{I}_5$	>200K	2,556	3,289.5958	94.0641 ✓	428.5125	31,799.7539	366,902.7648	8,424.3798
$\mathcal{I}_6$	>500K	4,123	22,118.0296	329.4710 ✓	1,439.6848	402,039.4240	1,766,206.5003	49,274.3782
$\mathcal{I}_7$	>500K	4,139	21,963.5968	336.3432 ✓	1,600.3634	411,725.1937	2,390,410.2541	54,897.2351
$\mathcal{I}_8$	>200K	2,529	4,250.2729	89.2680 ✓	446.4625	36,610.5757	461,096.5509	3,857.2345
$\mathcal{I}_9$	>500K	4,134	22,057.8564	335.8682 ✓	1,450.5679	28,328.2207	2,091,910.4123	37,817.4141
$\mathcal{I}_{10}$	>200K	2,542	3,238.5423	96.6740 ✓	418.7254	769,960.0223	265,087.9653	7,134.1514
$\mathcal{I}_{11}$	>500K	4,133	23,749.9149	348.1437 ✓	1,531.0934	398,946.3216	2,537,854.1564	39,417.0345
$\mathcal{I}_{12}$	>500K	4,137	22,194.6776	342.6023 ✓	1,466.4241	398,254.6365	2,016,031.3451	38,741.9410
$\mathcal{I}_{13}$	>500K	4,128	22,545.8684	362.5389 ✓	1,470.3869	446,056.7049	2,018,768.3295	49,287.1451
$\mathcal{I}_{14}$	>200K	2,234	571.9417	22.2583 ✓	85.0108	4,999.5140	37,081.3254	487.0905
$\mathcal{I}_{15}$	>500K	2,201	6,517.1065	190.7537 ✓	926.5795	71,541.1456	513,769.5738	19,481.4108
$\mathcal{I}_{16}$	>20K	202	7.4382	3.5816 ✓	9.7204	87.4167	601.2848	42.7104
$\mathcal{I}_{17}$	>200K	2,216	599.1948	16.0822 ✓	85.3307	12,411.9608	32,268.7012	7,015.4581
$\mathcal{I}_{18}$	>20K	299	11.6980	2.2721 ✓	10.5942	83.9378	988.3095	38.6094
$\mathcal{I}_{19}$	>500K	3,993	21,482.4772	335.6216 ✓	1,750.2093	444,997.4857	2,295,089.0447	64,510.4519
$\mathcal{I}_{20}$	>200K	2,206	586.5093	18.7069 ✓	87.0280	6,905.6778	75,574.2453	1,048.8951
$\mathcal{I}_{21}$	>20K	281	8.0470	1.8397 ✓	9.1955	34.1523	610.4776	19.9627
$\mathcal{I}_{22}$	>500K	4,034	24,446.3671	335.9041 ✓	1,778.7107	466,512.4680	2,636,222.8890	52,941.8715
Total	>6,860K	61,995		22				

[*] We hide project names for the confidential policy.
[**] We report rough scale of SLOC due to the confidential policy.

written in *C*. As shown in the first three columns in Table 2, we summarize the SLOC and number of test cases of each subject. The SLOCs range from 20K to 500K while the numbers of test cases range from 202 to 4,246. Besides, we used C-Cover to collect statement coverage for each industrial subject.

2 Impact of iteration number on TCP effectiveness and efficiency

In our paper, we conduct an experiment to see whether the iteration number has large impact on TCP effectiveness and efficiency. Here, we present the complete results on each open-source project.

2.1 Effectiveness

In this section, for each project, we present the APFD values of $algo_1, algo_2, \ldots, algo_k$, respectively, where $algo_i$ means the Greedy Additional algorithm runs for i iterations and the remaining test cases are prioritized using Greedy Total.

$\mathcal{S}_1$: 0.8809, 0.9071, 0.9063, 0.9070, 0.9070, 0.9070, 0.9070, 0.9070, 0.9070
$\mathcal{S}_2$: 0.8369, 0.8381, 0.8380, 0.8380, 0.8380
$\mathcal{S}_3$: 0.8868, 0.8856, 0.8848, 0.8848, 0.8848
$\mathcal{S}_4$: 0.8505, 0.8509
$\mathcal{S}_5$: 0.8527
$\mathcal{S}_6$: 0.8101
$\mathcal{S}_7$: 0.9045, 0.9056, 0.9059, 0.9059, 0.9059

$\mathcal{S}_8$: 0.8913, 0.8888, 0.8898, 0.8898, 0.8898

$\mathcal{S}_9$: 0.9144, 0.9144

$\mathcal{S}_{10}$: 0.9514, 0.9516, 0.9517, 0.9517, 0.9518, 0.9518, 0.9518, 0.9518

$\mathcal{S}_{11}$: 0.8741, 0.8766, 0.8765, 0.8765, 0.8766, 0.8766, 0.8766, 0.8766, 0.8766, 0.8766

$\mathcal{S}_{12}$: 0.8854, 0.8864, 0.8864, 0.8864, 0.8864, 0.8864, 0.8864, 0.8864, 0.8864, 0.8864, 0.8864

$\mathcal{S}_{13}$: 0.8500, 0.8615, 0.8615, 0.8615, 0.8615, 0.8615, 0.8615, 0.8615, 0.8615, 0.8615

$\mathcal{S}_{14}$: 0.9188, 0.9199, 0.9214, 0.9206, 0.9203, 0.9199, 0.9195, 0.9191, 0.9188, 0.9188, 0.9188, 0.9188, 0.9188, 0.9188

$\mathcal{S}_{15}$: 0.8582

$\mathcal{S}_{16}$: 0.8010, 0.8021, 0.8025, 0.8031, 0.8031

$\mathcal{S}_{17}$: 0.9114, 0.9151, 0.9171, 0.9179, 0.9180, 0.9184, 0.9184, 0.9184, 0.9183, 0.9183, 0.9183, 0.9183, 0.9183, 0.9183

$\mathcal{S}_{18}$: 0.9026, 0.9028, 0.9028, 0.9028

$\mathcal{S}_{19}$: 0.9003, 0.9028, 0.9032, 0.9034, 0.9034, 0.9033, 0.9033, 0.9033, 0.9033, 0.9033, 0.9033

$\mathcal{S}_{20}$: 0.8014, 0.8013

$\mathcal{S}_{21}$: 0.8353, 0.8324, 0.8320, 0.8328, 0.8328, 0.8328

$\mathcal{S}_{22}$: 0.8642, 0.8654, 0.8647, 0.8644, 0.8643, 0.8642, 0.8642, 0.8642, 0.8642

$\mathcal{S}_{23}$: 0.8189, 0.8183, 0.8196, 0.8198, 0.8198, 0.8198, 0.8198, 0.8198, 0.8198, 0.8198

$\mathcal{S}_{24}$: 0.9850, 0.9856, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858, 0.9858

$\mathcal{S}_{25}$: 0.7135, 0.7612, 0.7544, 0.7507, 0.8120, 0.8082, 0.8073, 0.8273, 0.8306, 0.8401, 0.8391, 0.8399, 0.8393, 0.8383, 0.8377, 0.8382, 0.8398, 0.8391, 0.8390, 0.8409, 0.8434, 0.8442, 0.8435, 0.8432, 0.8436, 0.8433, 0.8434, 0.8428, 0.8455, 0.8452, 0.8450, 0.8447, 0.8446, 0.8442, 0.8439, 0.8438, 0.8447, 0.8444, 0.8455, 0.8461, 0.8462, 0.8461, 0.8461, 0.8460, 0.8458, 0.8458, 0.8457, 0.8456, 0.8456, 0.8455, 0.8454, 0.8454, 0.8453, 0.8453, 0.8452, 0.8452, 0.8451, 0.8451, 0.8450, 0.8450, 0.8449, 0.8453, 0.8453, 0.8452, 0.8452, 0.8451, 0.8451, 0.8450, 0.8450, 0.8449, 0.8449, 0.8449, 0.8449, 0.8448, 0.8448, 0.8448, 0.8448, 0.8447, 0.8447, 0.8447, 0.8448, 0.8448, 0.8448, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450, 0.8450

$\mathcal{S}_{26}$: 0.8322, 0.8331, 0.8337, 0.8339, 0.8339, 0.8339, 0.8339, 0.8339, 0.8339, 0.8339

$\mathcal{S}_{27}$: 0.9614, 0.9614, 0.9614, 0.9614, 0.9614, 0.9614, 0.9614, 0.9614, 0.9614, 0.9614, 0.9614, 0.9614

$\mathcal{S}_{28}$: 0.9153, 0.9153, 0.9165, 0.9164, 0.9164, 0.9164, 0.9164, 0.9164, 0.9164, 0.9164, 0.9164, 0.9164, 0.9164, 0.9164, 0.9164

$\mathcal{S}_{29}$: 0.9482, 0.9490, 0.9490, 0.9490, 0.9490, 0.9490, 0.9490, 0.9490, 0.9490

$\mathcal{S}_{30}$: 0.9620, 0.9616, 0.9617, 0.9617, 0.9617, 0.9617, 0.9617, 0.9617, 0.9617, 0.9617

$\mathcal{S}_{31}$: 0.9511, 0.9464, 0.9416, 0.9430, 0.9430, 0.9428, 0.9427, 0.9426

$\mathcal{S}_{32}$: 0.8889, 0.8906, 0.8909, 0.8909, 0.8909, 0.8911, 0.8911, 0.8911, 0.8911, 0.8911, 0.8911, 0.8911, 0.8911, 0.8911, 0.8911, 0.8911

$\mathcal{S}_{33}$: 0.8659, 0.8661, 0.8661, 0.8662, 0.8662, 0.8662, 0.8662

$\mathcal{S}_{34}$: 0.9277, 0.9320, 0.9324, 0.9327, 0.9327, 0.9328

$\mathcal{S}_{35}$: 0.9163, 0.9321, 0.9406, 0.9413, 0.9448, 0.9458, 0.9469, 0.9468, 0.9467, 0.9467, 0.9466, 0.9471, 0.9471, 0.9471, 0.9471, 0.9473

$\mathcal{S}_{36}$: 0.8644, 0.8833, 0.8970, 0.8966, 0.9138, 0.9208, 0.9320, 0.9340, 0.9347, 0.9371, 0.9398, 0.9395, 0.9394, 0.9393, 0.9398, 0.9405, 0.9417, 0.9417, 0.9418

$\mathcal{S}_{37}$: 0.8508, 0.8507,

0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507,
0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507, 0.8507

$\mathcal{S}_{38}$: 0.8657, 0.8657, 0.8657, 0.8657

$\mathcal{S}_{39}$: 0.8679, 0.9476, 0.9511, 0.9543, 0.9545

$\mathcal{S}_{40}$: 0.9198, 0.9233, 0.9242, 0.9243, 0.9244, 0.9244, 0.9244, 0.9244, 0.9244, 0.9244, 0.9244, 0.9244, 0.9244, 0.9244, 0.9244

$\mathcal{S}_{41}$: 0.9040, 0.9093, 0.9097, 0.9103, 0.9106, 0.9105, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106, 0.9106

$\mathcal{S}_{42}$: 0.8574, 0.8569, 0.8569, 0.8569, 0.8569, 0.8569, 0.8569, 0.8569, 0.8569

$\mathcal{S}_{43}$: 0.8913, 0.8923, 0.8924, 0.8924, 0.8924, 0.8924

$\mathcal{S}_{44}$: 0.9159, 0.9221, 0.9235, 0.9237, 0.9237, 0.9232, 0.9239, 0.9239, 0.9236, 0.9240, 0.9238, 0.9256, 0.9257, 0.9257, 0.9256, 0.9258, 0.9258, 0.9258, 0.9258, 0.9258, 0.9258, 0.9258, 0.9258, 0.9258, 0.9258, 0.9257, 0.9257, 0.9257, 0.9257, 0.9257, 0.9257, 0.9258, 0.9259, 0.9261

$\mathcal{S}_{45}$: 0.8466, 0.8464, 0.8464, 0.8464, 0.8464, 0.8464, 0.8464, 0.8464

$\mathcal{S}_{46}$: 0.8648, 0.8654, 0.8656, 0.8656, 0.8656, 0.8656, 0.8656, 0.8656, 0.8656, 0.8656

$\mathcal{S}_{47}$: 0.8751, 0.8750, 0.8750, 0.8750, 0.8750, 0.8750, 0.8750, 0.8750, 0.8750, 0.8750

$\mathcal{S}_{48}$: 0.7939, 0.7939, 0.7939, 0.7939, 0.7939

$\mathcal{S}_{49}$: 0.7997, 0.8010, 0.8009, 0.8009, 0.8009, 0.8009, 0.8009

$\mathcal{S}_{50}$: 0.8476, 0.8491, 0.8508, 0.8512, 0.8514, 0.8516, 0.8517, 0.8517, 0.8517, 0.8517, 0.8517, 0.8517, 0.8517

$\mathcal{S}_{51}$: 0.8571, 0.8647, 0.8657, 0.8666, 0.8668, 0.8671

$\mathcal{S}_{52}$: 0.9530, 0.9544, 0.9542, 0.9542, 0.9542, 0.9542, 0.9542, 0.9542, 0.9542, 0.9542, 0.9542, 0.9542, 0.9542

$\mathcal{S}_{53}$: 0.8673, 0.8706, 0.8709, 0.8710, 0.8710, 0.8710, 0.8710, 0.8710, 0.8710, 0.8710, 0.8710, 0.8710

$\mathcal{S}_{54}$: 0.9089, 0.9100, 0.9091, 0.9087, 0.9090, 0.9088, 0.9089

$\mathcal{S}_{55}$: 0.9516, 0.9539, 0.9540, 0.9541, 0.9543, 0.9544, 0.9544, 0.9544, 0.9544, 0.9544, 0.9543, 0.9544

From the data, we can see that the APFD values vary a little when the iteration number varies, which means a too large iteration number contributes little to the APFD value. This observation supports our claim that we can reduce the original iteration number to a relatively small number while preserving the high effectiveness.

2.2 Efficiency

In this section, for each project, we present the running time (in seconds) of $algo_1, algo_2, \ldots, algo_k$, respectively, where $algo_i$ means the Greedy Additional algorithm runs for i iterations and the remaining test cases are prioritized using Greedy Total.

$\mathcal{S}_1$: 0.0504, 0.0641, 0.0729, 0.0784, 0.0811, 0.0828, 0.0837, 0.0840, 0.0841

$\mathcal{S}_2$: 0.0116, 0.0146, 0.0157, 0.0162, 0.0163

$\mathcal{S}_3$: 0.0379, 0.0491, 0.0535, 0.0547, 0.0550

$\mathcal{S}_4$: 0.1880, 0.2045

$\mathcal{S}_5$: 0.0843

$\mathcal{S}_6$: 0.1394

$\mathcal{S}_7$: 0.0809, 0.1029, 0.1112, 0.1150, 0.1156

$\mathcal{S}_8$: 0.0237, 0.0315, 0.0339, 0.0344, 0.0344

$\mathcal{S}_9$: 14.6908, 15.2266, 15.6251, 15.9723, 16.2364, 16.4655, 16.6605, 16.7692, 16.8597, 16.9390, 17.0070, 17.0603, 17.0767, 17.0926, 17.1081, 17.1231, 17.1376, 17.1516, 17.1651, 17.1781, 17.1907, 17.2029, 17.2146, 17.2258, 17.2365, 17.2467, 17.2564, 17.2657, 17.2745, 17.2828, 17.2855

$\mathcal{S}_{10}$: 0.3590, 0.4801, 0.5353, 0.5646, 0.5859, 0.5937, 0.5978, 0.5985

$\mathcal{S}_{11}$: 0.0641, 0.0801, 0.0874, 0.0914, 0.0941, 0.0958, 0.0974, 0.0987, 0.0999, 0.1001

$\mathcal{S}_{12}$: 0.1331, 0.1659, 0.1825, 0.1922, 0.1985, 0.2034, 0.2067, 0.2097, 0.2123, 0.2145, 0.2149

$\mathcal{S}_{13}$: 0.1964, 0.2611, 0.2897, 0.3097, 0.3205, 0.3280, 0.3324, 0.3353, 0.3369, 0.3370

$\mathcal{S}_{14}$: 0.8414, 1.3185, 1.5495, 1.6882, 1.7633, 1.8179, 1.8517, 1.8754, 1.8912, 1.9004, 1.9059, 1.9101, 1.9130, 1.9135

$\mathcal{S}_{15}$: 0.0675

$\mathcal{S}_{16}$: 0.3380, 0.3416, 0.3440, 0.3454, 0.3456

$\mathcal{S}_{17}$: 1.9914, 2.9735, 3.5052, 3.7878, 3.9669, 4.0707, 4.1227, 4.1520, 4.1705, 4.1830, 4.1909, 4.1949, 4.1970, 4.1976

$\mathcal{S}_{18}$: 0.1527, 0.1671, 0.1702, 0.1707

$\mathcal{S}_{19}$: 2.3863, 3.1986, 3.5362, 3.7398, 3.8111, 3.8436, 3.8560, 3.8609, 3.8642, 3.8660, 3.8666

$\mathcal{S}_{20}$: 0.0271, 0.0285

$\mathcal{S}_{21}$: 0.8340, 1.0961, 1.1768, 1.2056, 1.2139, 1.2143

$\mathcal{S}_{22}$: 0.5849, 0.8163, 0.9193, 0.9644, 0.9832, 0.9927, 0.9982, 1.0024, 1.0029

$\mathcal{S}_{23}$: 4.7146, 6.2094, 6.7748, 7.0984, 7.2422, 7.3091, 7.3435, 7.3670, 7.3913, 7.3944

$\mathcal{S}_{24}$: 0.0293, 0.0491, 0.0622, 0.0713, 0.0796, 0.0913, 0.0984, 0.1038, 0.1086, 0.1126, 0.1160, 0.1186, 0.1211, 0.1226, 0.1232, 0.1237, 0.1238

$\mathcal{S}_{25}$: 1.2848, 2.4932, 3.6658, 4.7548, 5.7596, 6.6288, 7.3437, 7.9768, 8.5057, 8.9095, 9.3065, 9.6692, 10.0263, 10.3779, 10.7749, 11.0891, 11.3993, 11.7949, 12.0948, 12.3904, 12.6803, 12.9651, 13.2457, 13.5216, 13.7930, 14.0599, 14.3231, 14.5812, 14.8348, 15.0840, 15.3287, 15.5690, 15.8073, 16.0387, 16.2655, 16.4881, 16.7060, 16.9194, 17.1283, 17.3327, 17.5327, 17.7280, 17.9188, 18.1050, 18.2867, 18.4344, 18.5796, 18.7222, 18.8621, 18.9997, 19.1347, 19.2671, 19.3968, 19.5241, 19.6487, 19.7708, 19.8903, 20.0072, 20.1215, 20.2334, 20.3426, 20.4492, 20.5533, 20.6548, 20.7537, 20.8500, 20.9437, 21.0349, 21.1235, 21.2095, 21.2929, 21.3736, 21.4518, 21.5273, 21.6002, 21.6706, 21.7383, 21.8035, 21.8660, 21.9259, 21.9833, 22.0380, 22.0901, 22.1396, 22.1865, 22.2307, 22.2723, 22.3113, 22.3477, 22.3815, 22.4126, 22.4411, 22.4670, 22.4902, 22.5108, 22.5288, 22.5400, 22.5502, 22.5549

$\mathcal{S}_{26}$: 3.3623, 3.8165, 3.9018, 3.9339, 3.9454, 3.9513, 3.9563, 3.9594, 3.9615, 3.9620

$\mathcal{S}_{27}$: 0.4400, 0.6170, 0.7171, 0.7807, 0.8229, 0.8462, 0.8637, 0.8754, 0.8817, 0.8853, 0.8873, 0.8878

$\mathcal{S}_{28}$: 14.3927, 19.7917, 22.6283, 23.9404, 24.5570, 24.8224, 24.9380, 25.0118, 25.0643, 25.0975, 25.1161, 25.1302, 25.1430, 25.1564, 25.1586

$\mathcal{S}_{29}$: 3.2282, 4.7252, 5.3581, 5.6452, 5.8109, 5.8786, 5.9081, 5.9191, 5.9222

$\mathcal{S}_{30}$: 2.3742, 3.3614, 3.8224, 4.0232, 4.1435, 4.1981, 4.2209, 4.2336, 4.2390, 4.2395

$\mathcal{S}_{31}$: 25.1492, 42.4289, 54.9163, 63.8733, 68.8608, 72.6918, 75.5811, 77.6775, 78.7513, 79.7971, 80.6224, 81.2676, 81.7944, 82.3899, 82.8346, 83.2483, 83.5537, 83.7634, 83.9042, 84.0120, 84.0927, 84.1468, 84.1825, 84.2145, 84.2426, 84.2703, 84.2890, 84.3015, 84.3054

$\mathcal{S}_{32}$: 153.0957, 201.0579, 218.7986, 228.0523, 233.1286, 235.5030, 237.1574, 238.1448, 238.8023, 239.3401, 239.6719, 239.9191, 240.1302, 240.2296, 240.3084, 240.3205

$\mathcal{S}_{33}$: 30.5935, 33.3866, 33.7117, 33.7607, 33.7772, 33.7830, 33.7846

$\mathcal{S}_{34}$: 35.2755, 49.8249, 56.3072, 59.4785, 60.7809, 61.5248, 61.9220, 62.0839, 62.2000, 62.2684, 62.3323, 62.3854, 62.4366, 62.4858, 62.5332, 62.5786, 62.6222, 62.6638, 62.7036, 62.7414, 62.7773, 62.8113, 62.8434, 62.8736, 62.9018, 62.9283, 62.9527, 62.9753, 62.9960, 63.0147, 63.0316, 63.0350

$\mathcal{S}_{35}$: 11.1864, 18.6450, 25.2162, 30.2752, 34.5965, 37.7022, 39.9603, 41.6999, 43.2768, 44.5033, 45.5958, 46.3288, 47.0194, 47.6085, 48.0775, 48.5595, 48.9848, 49.3524, 49.6084, 49.8372, 50.0369, 50.2043, 50.3317, 50.4477, 50.5525, 50.6453, 50.7261, 50.7904, 50.8423, 50.8939, 50.9358, 50.9678, 50.9933, 51.0168, 51.0385, 51.0587, 51.0767, 51.0941, 51.0966

$\mathcal{S}_{36}$: 15.5974, 26.4010, 34.2673, 41.6620, 48.1831, 53.9740, 60.0339, 65.2927, 70.4275, 75.7401, 80.6256, 84.9370, 89.1388, 92.9175, 96.2393, 100.6009, 104.6002, 107.8779, 110.6553, 113.2206, 115.6184, 117.7884, 119.6572, 121.1277, 122.4974, 123.7275, 124.6721, 125.3627, 126.0210, 126.4629, 126.8797, 127.2838, 127.5417, 127.7382, 127.9308, 128.1156, 128.2947, 128.4695, 128.6374, 128.6612

$\mathcal{S}_{37}$: 348.6429, 425.8890, 426.7867, 427.4581, 428.1246, 428.7989, 429.4727, 430.2926, 431.0463, 431.8325, 432.5140, 433.1804, 433.8953, 434.6478, 435.3767, 436.0476, 436.7173, 437.3822, 438.0403, 438.6959, 439.3529, 440.1475, 440.8717, 441.5797, 442.2639, 442.9254, 443.6142, 444.2738, 445.0362, 445.7238, 446.3850, 447.0462, 447.7014, 448.3451, 449.0972, 449.9076, 450.6069, 451.3609, 452.0671, 452.7231, 453.3656, 454.1165, 454.7730, 455.4118, 456.0484, 456.6849, 457.3198, 457.9571, 458.5882, 459.2493, 459.8856, 460.5142, 461.1454, 461.7760, 462.4054, 463.0311, 463.6572, 464.2840, 464.9432, 465.6083, 466.2708, 466.9344, 467.5966, 468.2563, 468.9172, 469.5784, 470.2040, 470.8201, 471.4387, 472.0538, 472.6672, 473.2832, 473.9605, 474.5905, 475.2184, 475.8607, 476.5563, 477.2743, 477.9458, 478.6091, 479.2517, 479.9442, 480.6133, 481.2468, 481.9368, 482.6264, 483.3143, 483.9599, 484.6397, 485.3377, 485.9844, 486.6938, 487.3053, 487.9131, 488.6908, 489.4604, 490.1188, 490.8785, 491.5902, 492.2518, 492.8596, 493.5653, 494.2675, 494.9106, 495.5455, 496.1784, 496.8183, 497.4526, 498.0839, 498.7186, 499.3547, 499.9792, 500.6038, 501.2285, 501.8451, 502.4377, 503.0402, 503.6757, 504.3329, 504.9863, 505.6377, 506.2752, 506.8996, 507.5526, 508.2016, 508.8468, 509.4885, 510.1272, 510.7798, 511.3910, 511.9977, 512.5902, 513.1898, 513.7826, 514.3855, 514.9882, 515.5683, 516.1373, 516.7035, 517.3414, 517.9424, 518.5807, 519.1976, 519.7927, 520.3872, 520.9802, 521.5770, 522.2054, 522.8326, 523.4593, 524.0889, 524.6849, 525.2395, 525.8806, 526.5570, 527.1464, 527.7579, 528.4180, 529.0338, 529.6953, 530.2793, 530.8377, 531.3909, 531.9648, 532.5050, 533.0941, 533.7372, 534.2879, 534.8282, 535.3808, 536.0001, 536.5933, 537.2293, 537.7709, 538.3050, 538.8816, 539.4950, 540.1141, 540.7442, 541.2888, 541.8691, 542.4853, 543.0813, 543.7205, 544.2736, 544.8270, 545.3637, 545.9361, 546.5028, 547.0594, 547.6179, 548.1958, 548.7799, 549.3115, 549.8334, 550.3781, 551.0240, 551.5891, 552.1490, 552.6739, 553.1832, 553.6946, 554.2075, 554.7671, 555.3456, 555.9329, 556.4444, 556.9521, 557.4647, 557.9988, 558.5083, 559.0143, 559.5820, 560.1134, 560.6176, 561.1200, 561.6217, 562.1249, 562.6701, 563.2429, 563.7697, 564.2612, 564.8242, 565.3163, 565.8478, 566.3962, 566.8856, 567.4083, 567.9997, 568.5075, 569.0646, 569.5616, 570.1515, 570.6735, 571.2282, 571.7305, 572.2364, 572.7309, 573.3097, 573.8053, 574.2893, 574.7709, 575.2502, 575.7866, 576.3553, 576.8947, 577.4559, 577.9462, 578.4861, 579.0184, 579.5509, 580.0834, 580.6115, 581.1328, 581.6245, 582.0954, 582.5615, 583.0276, 583.4957, 583.9604, 584.4368, 584.9270, 585.3895, 585.8672, 586.3271, 586.7879, 587.2489, 587.7069, 588.1633, 588.6129, 589.0643, 589.5263, 590.0004, 590.4751, 590.9488, 591.4245, 591.8963, 592.3676, 592.8395, 593.3092, 593.7799, 594.2497, 594.7218, 595.2037, 595.6816, 596.1944, 596.6915, 597.1927, 597.6662, 598.1050, 598.5430, 598.9852, 599.4223, 599.8571, 600.2962, 600.7562, 601.2145, 601.6739, 602.1329, 602.5895, 603.0446, 603.4987, 603.9472, 604.3947, 604.8418, 605.2880, 605.7333, 606.1782, 606.6319, 607.0896, 607.5465, 608.0019, 608.4446, 608.8839, 609.3219, 609.7605, 610.1967, 610.6318, 611.1790, 611.7073, 612.1691, 612.6083, 613.1490, 613.6850, 614.1359, 614.5737, 615.0774, 615.4859, 616.0217, 616.4543, 616.8596, 617.2626, 617.6648, 618.0737, 618.5462, 618.9404, 619.3353, 619.7291, 620.1214, 620.5323, 620.9919, 621.4449, 621.8552, 622.2415, 622.6369, 623.1017, 623.5320, 623.9667, 624.4577, 624.8996, 625.3390, 625.7765, 626.2176, 626.6951, 627.1299, 627.5554, 628.0295, 628.4452, 628.8493, 629.2988, 629.7097, 630.1083, 630.5061, 630.9032, 631.4049, 631.8905, 632.2925, 632.7024, 633.1589, 633.5431, 633.9858, 634.3570, 634.7261, 635.0949, 635.4599, 635.8234, 636.1848, 636.5428, 636.9004, 637.2694, 637.7228, 638.1279, 638.5153, 638.8967, 639.2840, 639.6587, 640.0143, 640.3717, 640.7249, 641.0806, 641.4322, 641.7866, 642.1380, 642.4876, 642.8361, 643.1864, 643.6061, 644.0137, 644.3913, 644.7475, 645.0977, 645.5076, 645.8496, 646.1918, 646.5366, 646.8763, 647.2145, 647.5481, 647.8848, 648.2165, 648.5653, 648.9207, 649.2704, 649.6218, 649.9546, 650.2806, 650.6057, 650.9339, 651.2588, 651.5833, 651.9052, 652.2261, 652.5490, 652.8681, 653.1862, 653.5039, 653.8220, 654.1413, 654.4561, 654.7699, 655.0835, 655.3972, 655.7190, 656.0330, 656.3433, 656.6521, 656.9604, 657.2713, 657.5781, 657.8889, 658.1978, 658.5056, 658.8148, 659.1217, 659.4290, 659.7345, 660.0404, 660.3432, 660.6417, 660.9393, 661.2354, 661.5311, 661.8291, 662.1235, 662.4161, 662.7078, 662.9994, 663.2935, 663.5830, 663.8853, 664.1820, 664.4722, 664.7645, 665.0530, 665.3407, 665.6283, 665.9142, 666.1995, 666.4889, 666.7757, 667.0551, 667.3344, 667.6119, 667.8914, 668.1828, 668.4747, 668.7654, 669.0462, 669.3220, 669.5950, 669.8655, 670.1351, 670.4037, 670.6715, 670.9414, 671.2087, 671.4752, 671.7395, 672.0034, 672.2664, 672.5308, 672.7919, 673.0519, 673.3110, 673.5696, 673.8276, 674.0880, 674.3574, 674.6280, 674.8934, 675.1478, 675.4007, 675.6553, 675.9059, 676.1558, 676.4047, 676.6529, 676.9005, 677.1500, 677.3953, 677.6402, 677.8854, 678.1289, 678.3726, 678.6165, 678.8569, 679.0976, 679.3519, 679.6433, 679.8934, 680.1340, 680.3709, 680.6076, 680.8426, 681.0770, 681.3069, 681.5377, 681.7710, 682.0004, 682.2287, 682.4560, 682.6824, 682.9080, 683.1353, 683.3609, 683.5840, 683.8063, 684.0279, 684.2484, 684.4679, 684.6896, 684.9078, 685.1247, 685.3408, 685.5677, 685.7950, 686.0215, 686.2491, 686.4736, 686.6973, 686.9199, 687.1425, 687.3589, 687.5667, 687.7793, 687.9860, 688.1913, 688.3970, 688.6040, 688.8075, 689.0093, 689.2112, 689.4161, 689.6171, 689.8163, 690.0142, 690.2109, 690.4066, 690.6026, 690.7972, 690.9920, 691.1847, 691.3763, 691.5674, 691.7567, 691.9454, 692.1331, 692.3200, 692.5084, 692.6937, 692.8788, 693.0630, 693.2466, 693.4283, 693.6092, 693.7892, 693.9714, 694.1499, 694.3273, 694.5036, 694.6793, 694.8550, 695.0311, 695.2052, 695.3796, 695.5560, 695.7292, 695.9020, 696.0736, 696.2441, 696.4138, 696.5826, 696.7506, 696.9179, 697.0914, 697.2657, 697.4381, 697.6033, 697.7660, 697.9874, 698.1750, 698.3512, 698.5263, 698.7005, 698.8735, 699.0455, 699.2153, 699.3862, 699.5562, 699.7251, 699.8930, 700.0600, 700.2259, 700.3909, 700.5550, 700.7184, 700.8805, 701.0407, 701.2007, 701.3576, 701.5125, 701.6640, 701.8151, 701.9669, 702.1176, 702.2666, 702.4113, 702.5557, 702.7012, 702.8460, 702.9911, 703.1343, 703.2770, 703.4196, 703.5611, 703.7017, 703.8413, 703.9799, 704.1174, 704.2524, 704.3813, 704.5093, 704.6354, 704.7589, 704.8823, 705.0020, 705.1177, 705.2324, 705.3462, 705.4593, 705.5713, 705.6824, 705.7926, 705.9019, 706.0106, 706.1195, 706.2311, 706.3378, 706.4485, 706.5587, 706.6694, 706.7790, 706.8876, 706.9935, 707.0988, 707.2032, 707.3066, 707.4087, 707.4428

$\mathcal{S}_{38}$: 107.2255, 108.6407, 108.8885, 109.0394

$\mathcal{S}_{39}$: 170.0408, 269.1613, 340.3796, 395.4240, 433.2746, 467.8119, 492.9459, 511.4818, 528.6376, 543.2314, 554.2380, 564.2112, 573.3909, 580.9917, 587.0130, 591.8260, 596.6626, 600.6978, 604.2113, 607.3338, 610.0552, 612.9271, 615.6003, 618.1542, 620.6433, 622.1930, 623.5757, 624.9314, 626.2564, 627.5778, 628.8867, 630.3396, 631.5500, 632.6421, 633.7126, 634.9341, 636.1033, 637.1603, 638.1636, 638.9765, 639.8029, 640.6150, 641.3905, 642.3556, 643.3123, 644.1551, 644.9523, 645.6327, 646.3094, 646.9770, 647.6981, 648.6576, 649.3963, 649.9939, 650.5106, 651.0255, 651.5400, 652.0514, 652.6382, 653.2346, 653.7600, 654.3529, 655.0619, 655.6314, 656.1112, 656.5882, 656.6593

$\mathcal{S}_{40}$: 144.8071, 203.5979, 230.6923, 243.2056, 248.4747, 250.5133, 251.5861, 252.2128, 252.5334, 252.7727, 252.9300, 252.9951, 253.0272, 253.0491, 253.0558

$\mathcal{S}_{41}$: 104.3352, 143.9971, 162.6928, 174.4729, 181.1883, 185.4110, 188.0655, 189.8748, 191.1746, 192.0823, 192.6225, 192.9482, 193.2015, 193.3560, 193.4401, 193.4804, 193.5180, 193.5531, 193.5861, 193.5933

$\mathcal{S}_{42}$: 0.2544, 0.3268, 0.3490, 0.3646, 0.3773, 0.3870, 0.3937, 0.3975, 0.3979

$\mathcal{S}_{43}$: 32.1521, 37.5850, 38.4947, 38.6403, 38.6569, 38.6586

$\mathcal{S}_{44}$: 124.6057, 206.1989, 258.6179, 292.3406, 318.4573, 338.8340, 357.6794, 372.6274, 384.0906, 392.8428, 399.7534, 405.2201, 410.2681, 414.1381, 417.5244, 421.0558, 423.5546, 426.0039, 428.3116, 430.3889, 432.4392, 434.3951, 436.2013, 437.9293, 439.6121, 441.4132, 443.4237, 444.9808, 446.5019, 447.8638, 449.1986, 452.2697, 455.0118, 456.8946, 458.0750, 459.1645, 460.2211, 461.2608, 462.2504, 463.2032, 463.9739, 464.8663, 465.6153, 467.9212, 469.0643, 469.9781, 470.6567, 471.7226, 472.3642, 472.7605, 473.0732, 473.2894, 473.4241, 473.5281, 473.6399, 473.7013, 473.7470, 473.7977, 473.8341, 473.8433

$\mathcal{S}_{45}$: 5.3013, 6.4968, 6.7520, 6.8139, 6.8341, 6.8433, 6.8486, 6.8498

$\mathcal{S}_{46}$: 1.3324, 1.5251, 1.5718, 1.5879, 1.5966, 1.6028, 1.6061, 1.6083, 1.6101, 1.6105

$\mathcal{S}_{47}$: 16.7634, 19.2322, 19.7944, 19.9584, 20.0395, 20.0865, 20.1120, 20.1263, 20.1347, 20.1358

$\mathcal{S}_{48}$: 0.0357, 0.0389, 0.0402, 0.0408, 0.0409

$\mathcal{S}_{49}$: 5.0685, 5.9322, 6.1436, 6.2371, 6.2910, 6.3265, 6.3305

$\mathcal{S}_{50}$: 0.0324, 0.0384, 0.0421, 0.0445, 0.0461, 0.0475, 0.0487, 0.0494, 0.0499, 0.0504, 0.0507, 0.0510, 0.0511

$\mathcal{S}_{51}$: 158.8808, 226.7898, 251.1181, 263.5170, 269.9064, 274.0632, 277.4902, 278.7852, 279.6021, 280.2806, 280.8869, 281.3841, 281.7918, 282.1305, 282.4393, 282.6943, 282.9340, 283.1573, 283.3642, 283.5355, 283.6996, 283.8574, 284.0081, 284.1513, 284.2876, 284.4169, 284.5390, 284.6540, 284.7621, 284.8636, 284.9578, 285.0448, 285.1248, 285.1981, 285.2642, 285.3231, 285.3326

$\mathcal{S}_{52}$: 73.3657, 91.7328, 101.4404, 105.6360, 107.8175, 108.9070, 109.4403, 109.8443, 110.1497, 110.3997, 110.5926, 110.7068, 110.7226

$\mathcal{S}_{53}$: 127.0540, 160.7026, 170.2230, 174.6740, 176.7825, 177.8830, 178.3794, 178.7296, 179.0247, 179.3085, 179.5785, 179.6359

$\mathcal{S}_{54}$: 18629.9575, 26164.9477, 29666.8708, 31544.4487, 32638.3881, 33301.2351, 33731.4472, 34037.6406, 34249.1801, 34409.8976, 34524.7132, 34605.2745, 34670.0246, 34715.0275, 34745.2676, 34768.3418, 34791.8894, 34806.0601, 34819.4267, 34830.8051, 34840.4087, 34848.9924, 34856.1130, 34862.9495, 34870.0042, 34876.7258, 34881.2885, 34885.2692, 34888.2113, 34891.1196, 34893.9887, 34896.7631, 34899.6016, 34902.3937, 34905.1476, 34907.8593, 34910.5324, 34913.1689, 34915.7624, 34917.9242, 34920.0729, 34922.1959, 34924.1856, 34926.1803, 34928.1149, 34929.9520, 34931.9469, 34933.8678, 34935.8375, 34937.8476, 34939.8260, 34941.7851, 34942.1603

$\mathcal{S}_{55}$: 22606.1087, 32392.2527, 37798.7516, 41072.2083, 43149.7641, 44582.6927, 45635.4961, 46379.6898, 46950.6157, 47434.4500, 47794.4936, 48078.7050, 48309.3621, 48487.6458, 48648.9305, 48781.0347, 48892.7630, 48990.4820, 49059.3434, 49109.6972, 49155.4801, 49194.7795, 49224.1893, 49246.9715, 49264.0911, 49277.8622, 49293.3403, 49303.9250, 49311.6324, 49318.4052, 49324.9033, 49330.0864, 49333.6698, 49337.0947, 49340.8868, 49343.2418, 49346.0084, 49349.1518, 49352.2206, 49355.6237, 49358.1288, 49360.5859, 49363.0011, 49365.7545, 49368.4367, 49371.0541, 49373.2324, 49375.3677, 49377.4810, 49379.5384, 49381.5582, 49383.1409, 49384.7205, 49386.2954, 49387.8504, 49389.3883, 49390.9068, 49392.3923, 49393.8761, 49395.2923, 49396.7237, 49398.1487, 49399.5540, 49399.8693

From the data, we can see that along with the increase of the iteration number, the time cost also increases, indicating that the iteration number contributes much to the time cost. Therefore, it also supports our proposal to reduce iteration number to improve the efficiency.

3 Comparison with GA

3.1 Comparison based on adjacency list

Since adjacency list is more efficient than adjacency matrix as the algorithm input, we take adjacency list as input in the paper. Please refer to Section 6, 7, and 8 for the experimental results, interpretations, and analyses.

3.2 Comparison based on adjacency matrix

In this section, we present the results based on adjacency matrix, which is missing from the paper due to the space limit. Because the input format does not have any impact on the effectiveness of our algorithm, we only present the efficiency comparison results here.

We first compare the efficiency of GA-first, GA, and AGA, which is shown in Table 3. Each row represents a project and we report the running time of GA-first, GA, and AGA. Similar to the results in the paper, AGA, which has a much lower time complexity than GA, could reduce the time cost promisingly. The average speedup ratio of AGA over GA is 27.72X. Then, following the paper, we divide the projects into small-size projects, middle-size projects, and large-size projects. The average speedup ratio in the three categories is 5.84X, 35.47X, and 51.59X, respectively. Indeed, as adjacency matrix stores much more redundant information than adjacency list, it originally leads to very long running time. Therefore, the improvement that our approach achieves is larger, too. At the same time, on larger projects, the efficiency problem is more severe, and our AGA approach works better.

Then, we compare the efficiency of GA and AGA on industrial projects, which is shown in Table 4. Each row represents a project and we report the running time of GA and AGA. Similar to the results in the paper, AGA could reduce the time cost to a greater extent. The average speedup ratio of AGA over GA is 61.43X. This indicates that AGA is practical in real-world scenarios.

Table 3: Comparison of GA-first, GA, and AGA

ID	GA-first	GA	AGA
$\mathcal{S}_1$	0.0504	0.0841	0.0202
$\mathcal{S}_2$	0.0116	0.0163	0.0053
$\mathcal{S}_3$	0.0379	0.0550	0.0554
$\mathcal{S}_4$	0.1880	0.2045	0.0409
$\mathcal{S}_5$	0.0843	0.0843	0.0221
$\mathcal{S}_6$	0.1394	0.1394	0.0162
$\mathcal{S}_7$	0.0809	0.1156	0.0330
$\mathcal{S}_8$	0.0237	0.0344	0.0172
$\mathcal{S}_9$	14.6908	17.2855	0.6349
$\mathcal{S}_{10}$	0.3590	0.5985	0.0959
$\mathcal{S}_{11}$	0.0641	0.1001	0.0576
$\mathcal{S}_{12}$	0.1331	0.2149	0.0500
$\mathcal{S}_{13}$	0.1964	0.3370	0.1239
$\mathcal{S}_{14}$	0.8414	1.9135	0.2088
$\mathcal{S}_{15}$	0.0675	0.0675	0.0137
$\mathcal{S}_{16}$	0.3380	0.3456	0.0624
$\mathcal{S}_{17}$	1.9914	4.1976	0.3048
$\mathcal{S}_{18}$	0.1527	0.1707	0.0665
$\mathcal{S}_{19}$	2.3863	3.8666	0.7790
$\mathcal{S}_{20}$	0.0271	0.0285	0.0422
$\mathcal{S}_{21}$	0.8340	1.2143	0.1791
$\mathcal{S}_{22}$	0.5849	1.0029	0.1397
$\mathcal{S}_{23}$	4.7146	7.3944	0.5435
$\mathcal{S}_{24}$	0.0293	0.1238	0.0294
$\mathcal{S}_{25}$	1.2848	22.5549	1.0829
$\mathcal{S}_{26}$	3.3623	3.9620	0.3757
$\mathcal{S}_{27}$	0.4400	0.8878	0.1694
$\mathcal{S}_{28}$	14.3927	25.1586	1.1161
$\mathcal{S}_{29}$	3.2282	5.9222	2.2661
$\mathcal{S}_{30}$	2.3742	4.2395	0.5081
$\mathcal{S}_{31}$	25.1492	84.3054	2.0649
$\mathcal{S}_{32}$	153.0957	240.3205	5.1724
$\mathcal{S}_{33}$	30.5935	33.7846	1.6924
$\mathcal{S}_{34}$	35.2755	63.0350	2.5955
$\mathcal{S}_{35}$	11.1864	51.0966	1.7078
$\mathcal{S}_{36}$	15.5974	128.6612	19.3547
$\mathcal{S}_{37}$	348.6429	707.4428	4.0359
$\mathcal{S}_{38}$	107.2255	109.0394	2.1855
$\mathcal{S}_{39}$	170.0408	656.6593	8.0072
$\mathcal{S}_{40}$	144.8071	253.0558	4.3282
$\mathcal{S}_{41}$	104.3352	193.5933	3.6620
$\mathcal{S}_{42}$	0.2544	0.3979	0.2295
$\mathcal{S}_{43}$	32.1521	38.6586	2.1432
$\mathcal{S}_{44}$	124.6057	473.8433	7.2152
$\mathcal{S}_{45}$	5.3013	6.8498	1.0659
$\mathcal{S}_{46}$	1.3324	1.6105	0.2034
$\mathcal{S}_{47}$	16.7634	20.1358	2.0280
$\mathcal{S}_{48}$	0.0357	0.0409	0.0142
$\mathcal{S}_{49}$	5.0685	6.3305	1.1091
$\mathcal{S}_{50}$	0.0324	0.0511	0.0162
$\mathcal{S}_{51}$	158.8808	285.3326	7.5062
$\mathcal{S}_{52}$	73.3657	110.7226	6.8312
$\mathcal{S}_{53}$	127.0540	179.6359	9.7006
$\mathcal{S}_{54}$	18,629.9575	34,942.1603	154.0668
$\mathcal{S}_{55}$	22,606.1087	49,399.8693	164.2763

Table 4: Comparison of GA and AGA on industrial projects

ID	**GA**	**AGA**
$\mathcal{I}_1$	39,386.9529	705.3581
$\mathcal{I}_2$	8,707.1104	141.0114
$\mathcal{I}_3$	8,644.5796	112.5054
$\mathcal{I}_4$	9,144.3643	120.4061
$\mathcal{I}_5$	9,105.5180	127.5941
$\mathcal{I}_6$	35,021.6345	442.6086
$\mathcal{I}_7$	35,595.7667	523.4757
$\mathcal{I}_8$	8,860.3135	153.3128
$\mathcal{I}_9$	35,381.6218	388.7854
$\mathcal{I}_{10}$	9,267.9660	146.2093
$\mathcal{I}_{11}$	36,558.5647	450.7237
$\mathcal{I}_{12}$	35,918.4195	504.2236
$\mathcal{I}_{13}$	35,411.6647	487.3465
$\mathcal{I}_{14}$	1,278.2732	16.7977
$\mathcal{I}_{15}$	9,532.4880	219.6699
$\mathcal{I}_{16}$	4.9463	1.6006
$\mathcal{I}_{17}$	1,311.8609	17.4021
$\mathcal{I}_{18}$	12.1753	2.0372
$\mathcal{I}_{19}$	33,561.6102	456.4386
$\mathcal{I}_{20}$	1,312.5403	18.2663
$\mathcal{I}_{21}$	13.6631	1.7060
$\mathcal{I}_{22}$	34,293.2925	503.3268