



Figure 1: Pareto front for all subject systems.

Table 1: RQ1: effectiveness results for all subject systems. OO stands for Original Order, SA stands for String Analysis

	CLA	CLAROLINE			ADDE	Addressbook	ЭОК			1	$_{ m PPMA}$	1			COL	COLLABTIVE	IVE				M	$\overline{\mathrm{MRBS}}$				\mathbf{M}_{A}	MANTISBT	BT		
		Manifest Deps	it Deps.			Maı	Manifest Deps.	Deps.			M	Manifest Deps	·sde			M	anifes	Manifest Deps	s.			Ma	Manifest Deps)S.			N.	Manifest Deps.	est L)eps.
Extracted	Filtered To Validate False	Validated Recovered Recovered (Disc.)	WAAT IstoT	Extracted Filtered	oTsbilsV oT 921s4	Validated	Recovered Recovered (Disc.) Total PRAM		Extracted Filtered	To Validate	False Validated	Recovered (Disc.) Recovered (Disc.) Total PRAW	 Extracted	Filtered	oT Validate False	bətsbilsV	Recovered (Disc.)	Total PRAW	Extracted	Filtered	To Validate False	b∍tsbilsV	Recovered Recovered (Disc.) Total PRAW	Extracted	Filtered	osled	False Validated	Recovered	Recovered (Disc.) Total PRAW	
Baseline (OO) 73 String Analysis 66	780 - 780 738 42 0 601 406 195 153 40 2	738 42 0 0 153 40 2 0	42 42	351 - 351 284	- 351 3; 284 67 30	320 31 0 36 22 8	0 0 31 8 1 31		253 - 253 197	253 56	231 22 36 12	0 0 22 5 3 20	780 746	- 639	780 107	740 40 65 17	$40\ 0$ $17\ 24\ 1$	40	231	144	231 210 87 66	17	0 0 21 2 2 21	820 784	- 889	820 96	785 35 60 20	0	0 35 0 36),c ;c
NLP-Verb (OO) $780\ 219\ 561\ 519\ 42\ 0$	80 219 561 5	19 42 0 0	42	351 16	$351\ 164\ 187\ 156\ 31\ 0$	56 31 (0 0 31		253 162	91	69 22	22 0 0 22	78	82 082	702 6	702 662 40 0 0	0 0	40	231	71 1	160 139 21 0	9 21	0 0 21	82(820 24	796 761	761 3	35 0 (0 35	,0
NLP-Verb (SA) $601\ 182\ 419\ 377\ 40\ 2$ 0	01 182 419 37	77 40 2 0	42	$351\ 164$	$351\ 164\ 187\ 156\ 31\ 0$	56 31 (0 0 31		253 162	91	69 22	22 0 0 22	74	746 79	$667\ 627\ 40\ 0$	27 40	0 0	40	231	71 1	160 139 21 0 0	9 21	0 0 21	784	784 24	2 092	760 725 35 0		0 35	,0
NLP-Dobj (OO) 780 570 210 168 29 13 0	80 570 210 10	58 29 13 0	42	351 220	$351\ 220\ 131\ 99\ \ 32\ 0\ 0$	9 32 (0 0 32		253 202	51	29 17	4 1 22	78	780 595 185 144 33 8	185 1	44 33	8	41	231	231 141 9	29 06	18	3 2 23	82(0442	820 442 378 340 31	340 3.	7	0 38	~
NLP-Dobj~(SA)~~601~457~144~101~28~12~3	01 457 144 10	01 28 12 3	43	351 220	351 220 131 99	9 32 0 0	0 0 32		253 202	51	29 17	4 1 22	74	746 596 150 108 33	150 10	08 33	4 5	42	231	231 141 9	29 06	18	3 2 23	784	4 442	784 442 342 304	304 31	~	0 38	~
NLP-Noun (OO) 780 455 325 285 35 5	$80\ 455\ 325\ 28$	85 35 5 0	40	351 266	$266.85 5^{2}$	54 27 2	2 2 31		253 207	207 46	24 16	5 1 22	78	780 591 189 149 36 4	189 1.	49 36	4 0	40	231	231 147 84	34 59	22	2 1 25	82(0520	820 520 300 265	265 33	2	0 35	,,
NLP-Noun (SA) 601 379 222 182 33 6	01 379 222 18	82 33 6 1	40	351 266	266 85 5	54 27 2	2 2 31		253 207	207 46	24 16	5 1 22	74	746 592 154 114 35 5	154 1	14 35	5 0	40	231	231 147 84	34 59	22	2 1 25	784	4 520	784 520 264 229	229 33	2	0 35	,

Table 2: RQ2: performance results for all subject systems. OO stands for Original Order, SA stands for String Analysis

gai	Validation	- 1 2 K						1						+
3ui		Validation	ution	- Valid	Validation	Ä N	Validation			Validation		Va	Validation	
Extra Filter	Recovery (Disc.) Total Saving (%)	Extraction Filtering Val. and Recovery	Recovery (Disc.) Total Saving (%)	Extraction Filtering Val. and Recovery	Recovery (Disc.) Total Saving (%)	Extraction Filtering Val. and Recovery	Recovery (Disc.)	letoT (%) gniveS	Extraction Filtering Val. and Recovery	Recovery (Disc.)	TetoT (%) SariveS	Extraction Filtering Val. and Recovery	Rесоvету (Disc.)	IstoT (%) gaiveS
Baseline (OO) 0.00 - 614.40 -	40- 614.40-	0.00 - 88.20 -	- 88.20 -	0.00 - 79.80 -	- 08.80 -	0.00 - 121	1215.00 -	1215.00 -	7 - 00.0	- 09.82	- 09.82	0.00 - 472	472.20 -	472.20 -
String Analysis $0.110.00106.944.82111.8681.79\%0.090.0051.601.3253.0239.89\%0.080.00$	94 4.82 111.86 81.79	. 09.00 0.00 21.60	$1.32\ 53.02\ 39.86$	% 0.08 0.00 36.00	36.0017.0953.1733.37%0.120.00543.00	% 0.12 0.00 543	3.09	546.21 55.04% 0.08 0.00 36.00 1.28	0.08 0.00 3		37.36 52.40	$37.36\ 52.46\%\ 0.11\ 0.00\ 198.60\ 3.64\ 202.36\ 57.15\%$	3.60 3.64	202.36 57.159
$NLP-Verb\;(OO)\;\;0.00\;0.05\;228.60\;1.78\;\;230.43\;62.50\%\;0.00\;0.04\;34.20\;0.95\;\;35.19\;60.11\%\;0.00\;0.04\;18.00\;0.16$	301.78230.4362.50	1% 0.00 0.04 34.20 (0.95 35.19 60.11	% 0.00 0.04 18.00	0.16 18.20 77.20	$18.20\ 77.20\%\ 0.00\ 0.04\ 1065.60\ 2.08$		$1067.72\ 12.12\%$	0.00 0.04 4	5.00 0.11	45.15 42.55	1067.7212.12%0.000.0445.000.11 45.1542.55%0.000.05451.802.53454.393.77%	.80 2.53	154.39 3.77%
$NLP-Verb\;(SA) 0.10\;0.04\;183.60\;1.81 185.55\;69.80\%\;0.07\;0.03\;34.20\;0.95\;35.25\;60.03\%\;0.07\;0.03\;18.00\;0.16\;\;18.26\;77.12\%\;0.10\;0.04\;959.40$	301.81 185.55 69.80	1% 0.07 0.03 34.20 ($0.95\ 35.25\ 60.03$	% 0.07 0.03 18.00	0.16 18.26 77.12	% 0.10 0.04 959	.40 2.11	961.64 20.85%	0.07 0.03 4	5.00 0.11	45.21 42.49	$2.11\ \ 961.64\ \ 20.85\%\ 0.07\ 0.03\ 45.00\ 0.11\ \ 45.21\ 42.49\%\ 0.10\ 0.05\ 446.40\ 2.56\ 449.11\ 4.89\%$	3.40 2.56	49.114.89%
$NLP-Dobj\;(OO)\;\;0.00\;0.27\;132.00\;2.05\;\;134.32\;78.14\%\;0.00\;0.22\;27.00\;0.92\;\;28.14\;68.09\%\;0.00\;0.27\;29$	00 2.05 134.32 78.14	1% 0.00 0.22 27.00 0	0.92 28.14 68.09	_	$31.201.78\ \ 33.1958.41$	$33.19\ 58.41\%\ 0.00\ 0.26\ 342.00$	2.18	344.44 71.65%	0.00 0.22 3	3.00 11.56	44.78 43.02	$71.65\%\ 0.00\ 0.22\ 33.00\ 11.56\ 44.78\ 43.02\%\ 0.00\ 0.26\ 244.20\ 2.26\ 246.72\ 47.75\%$	1.20 2.26	346.72 47.759
$NLP-Dobj\ (SA)\ 0.10\ 0.25\ 96.60\ 16.24\ 113.19\ 81.58\%\ 0.08\ 0.22\ 27.00\ 0.92\ 28.21\ 68.01\%\ 0.06\ 0.22$) 16.24 113.19 81.58	1% 0.08 0.22 27.00 (0.92 28.21 68.01	% 0.06 0.22 31.20	31.201.78 $33.2658.32$	$33.26\ 58.32\%\ 0.10\ 0.26\ 354.60$		$21.83\ 376.79\ 68.99\%$	0.07 0.20 3	3.00 11.56	44.84 42.96	$68.99\%\ 0.07\ 0.20\ 33.00\ 11.56\ 44.84\ 42.96\%\ 0.10\ 0.26\ 232.80\ 2.28\ 235.44\ 50.14\%$	2.80 2.28	235.44 50.149
NLP-Noun~(OO)~0.00~0.06~147.00~1.58~148.64~75.81%~0.00~0.04~25.80~6.34~32.18~63.51%~0.00~0.04~30.60~1.61	00 1.58 148.64 75.81	% 0.00 0.04 25.80 ($6.34\ 32.18\ 63.51$	%0.000.0430.60		$32.25\ 59.58\%\ 0.00\ 0.05\ 275.40$	2.09	277.54 77.16%	$77.16\%\ 0.00\ 0.05\ 32.40\ 1.13$		33.58 57.28	$33.58\ 57.28\%\ 0.00\ 0.07\ 228.60\ 2.36\ 231.03\ 51.07\%$	3.60 2.36	31.03 51.07%
NLP-Noun~(SA)~0.10~0.04~103.80~10.93~114.87~81.30%~0.08~0.04~25.80~6.34~32.25~63.43%~0.06~0.04~30.60~1.61	30 10.93 114.87 81.30	1% 0.08 0.04 25.80	$6.34\ 32.25\ 63.43$	% 0.06 0.04 30.60		$32.31\ 59.51\%\ 0.10\ 0.04\ 288.00$	2.07	290.21 76.11%	$76.11\%\ 0.07\ 0.04\ 32.40\ 1.13$	2.40 1.13	33.63 57.21	$33.63\ 57.21\%\ 0.10\ 0.06\ 216.00\ 2.39\ 218.54\ 53.72\%$.00 2.39	218.54 53.72%

Table 3: RQ3: parallelization results for all subject systems. OO stands for Original Order, SA stands for String Analysis

		BASELINE (OO)	(00		STRI	STRING ANALYSIS	IS		NLP-1	NLP-Verb (OO)	(0(NLP-V	NLP-Verb (SA	2		NLP-Dobj (00)BJ (O	0		NLP-	NLP-Dobj (SA)	3A)		NLP-1	NLP-Noun (OO)	(C		NLP-N	NLP-Noun (SA	3A)
		Worst case	e Average	age.	M	Worst case A	Average	Work	Worst case	Average	ge	Wors	Worst case A	Average		Worst	Worst case	Average	že	Woi	Worst case	Average	'ge	Woı	Worst case	Average		Wors	Worst case	Average
	Isnigine original	schedules (#) speed-up (%)	əmitnur	(%) qu-bəəqs Isnigiro əmimur	schedules (#)	speed-up (%)	(%) qu-bəəqs	schedules (#)	(%) dn-pəəds	əmimur (%) qu-bəəds	(%) du boode	schedules (#) runtime	speed-up (%)	(%) dn-pəəds	lsnigiro əmitnur	schedules (#)	(%) du-bəəds	omitinut (%)	lsnigino əmitinu	schedules (#)	(%) dn-pəəds	əminurı (%) qu-booqs	speed-up (%) (%) speed-up (%) (%) rentime original	schedules (#)	speed-up (%)	(%) dn-pəəds	lsnigiro əmitnur	schedules (#) runtime	(%) dn-pəəds	runtime (%) qu-bəəqs
Claroline	75.08	36 28.37 2.65 9.10	5 9.10	8.25 78	75.08 36 30.31	0.31 2.55 10	2.55 10.32 7.49 75	75.08 36 76.76 2.66 9.41	3 2.66 9		8.16 75.08	3 36 28.75	2.66 9.25	25 8.26	90.22	35 28.38	2.65 9.60	9.60 7.83	83 75.08	08 35 28.94	2.63	9.72	7.84 75.	75.08 36 29.20	0 2.64 9.31	31 8.26	5 75.1	36 28.96	2.69 9.42	.42 8.26
Addressbook	40.23	Addressbook 40.23 24 20.47 1.96 9.41 4.27 40.23	3 9.41	4.27 40		9.61 1.83 10	.05 3.94 40	24 39.61 1.83 10.05 3.94 40.23 24 21.48	8 1.82 9.87		3.97 40.23	3 24 21.48	1.82 9.87	87 3.97	7 40.23	24 21.62	1.859.13	0.13 4.39	39 40.23	23 24 21.62	2 1.85 9.13		4.39 40.	40.23 24 20.15	5 1.98 8.76	76 4.55	5 40.2	24 20.15	1.98 8.76	3.76 4.55
PPMA	51.74	22 20.96 2.47	2.47 8.90	5.80 51	51.74 22 51.01		2.62 9.90 5.15 51	51.74 22 21.97 1.82 8.91	7 1.82 8		5.87 51.74	1 22 21.97	1.82 8.91	91 5.87	51.74	22 20.76	2.51 8.93	3.93 5.84	84 51.74	74 22 20.76	2.51	8.93	5.84 51.	51.74 22 21.14	4 2.45 8.92	92 5.80	51.7	22 21.14	2.45 8.92	3.92 5.80
Collabtive	297.71	$37\ 116.66\ 2.55\ 48.97\ 6.08$	5 48.97		97.71 37 11	297.71 37 116.36 2.62 50.00 6.11		297.71 37 121.31 2.61 50.14 6.31	31 2.61 5	50.146.	.31 297.71	71 37 120.4	37 120.41 2.55 50.07 6.14	.07 6.14	1 297.71	1 37 141.07 2.17 59.24 5.17	7 2.17 5	9.24 5.1	17 297.71		37 138.41 2.22	55.51 5.52		297.71 37 152.	37 152.43 1.99 61.77 4.92	1.77 4.92		297.7 37 133.13 2.28	3 2.28	53.18 5.71
MRBS	56.87	21 23.81 2.39	2.39 10.56 5.39		6.87 12 24	56.87 12 24.95 2.20 11.20 4.90		56.87 21 23.47 2.41 10.89 5.20	7 2.41 1	10.89 5.	.20 56.87	7 21 23.47		2.41 10.89 5.20	56.87	20 26.05		2.20 12.74 4.50	50 56.87	87 20 26.05		2.20 12.74 4.50		56.87 20 28.68		2.00 13.79 4.15	5 56.9	20 28.68		2.00 13.79 4.15
MantisBT	184.52	$184.52\ 37\ 133.48\ 1.38\ 14.30\ 12.90\ 184.52\ 37\ 71.76\ \ 2.57\ 12.42\ 14.86\ 184.52\ 37\ 133.96\ 1.38\ 14.26\ 12.96$	3 14.30	12.90 18	84.52 37 71	1.76 2.57 12	.42 14.86 18	4.52 37 133.9	36 1.38 1	14.26 1.	2.96 184.5	52 37 133.8	9 1.39 14	.28 13.6	5 184.5.	2 37 133.55	3 1.38 1	5.03 12	.28 184.	.52 37 133.	37 1.38	15.091	2.17 18	$184.52\ 37\ 133.89\ 1.39\ 14.28\ 13.05\ 184.52\ 37\ 133.53\ 1.38\ 15.03\ 12.28\ 184.52\ 37\ 133.37\ 1.38\ 15.09\ 12.17\ 184.52\ 37\ 133.59\ 1.38\ 14.82\ 12.44\ 184.5\ 37\ 133.79\ 1.39\ 15.12\ 12.30$	59 1.38 1.	1.82 12.4	14 184.5	37 133.7	9 1.39 1	5.12 12