Supplemental material for:

Role Mining Heuristics for Permission-Role-Usage Cardinality Constraints

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December 2, 2020

Contents

1 Functions used by PRUCC_1 and PRUCC_2 **3**

2 Fixed *mru* **4**
2.1 Americas Large . . . 4
2.2 Americas Small . . . 6
2.3 Apj . . . 9
2.4 Emea . . . 12
2.5 Healthcare . . . 14
2.6 Domino . . . 16
2.7 Customer . . . 18
2.8 Firewall 1 . . . 21
2.9 Firewall 2 . . . 23
2.10 Heuristics' rank when fixing *mru* . . . 25

3 Fixed *mpr* **26**
3.1 Americas Large . . . 26
3.2 Americas Small . . . 29
3.3 Apj . . . 32
3.4 Emea . . . 35
3.5 Healthcare . . . 38
3.6 Domino . . . 41
3.7 Customer . . . 44
3.8 Firewall 1 . . . 47
3.9 Firewall 2 . . . 50
3.10 Heuristics' rank when fixing *mpr* . . . 53

4 Synthetic Datasets **55**
4.1 Paper's experiments data . . . 55
4.2 Constant nu/nr, varying permissions, and $mpr = np \cdot nr/nu$ . . . 56
4.3 Constant nu/nr and np/nr, $mru = nr/10$, $mpr = 5$, and $mru \cdot mpr = np/4$ . . . 58
4.4 Constant nu/nr and np/nr, $mru = nr/10$, $mru = 5$, and $mru \cdot mpr = np/4$ . . . 60
4.5 Constant number of ratio users/roles and varying permissions . . . 62
4.6 Constant number of the ratio permissions/roles and varying users . . . 64
4.7 Constant number of permissions and varying ratio users/roles . . . 66
4.8 Low `UPA` density - case 1 . . . 68
4.9 Low `UPA` density - case 2 . . . 74
4.10 Increasing (`UPA` density, from 1% to 4%) . . . 80

5 Reducing PRUCC to PUCC or RUCC **86**

1 Functions used by PRUCC_1 and PRUCC_2

The function `add`, used in `update1`, returns the updated matrix PA and the row index $found$ corresponding to the role *candidateRole*. The function `add` checks whether *candidateRole* appears in PA and, if it doesn't, it adds *candidateRole* to PA (see lines 9-13). Function `add` also returns the row index where *candidateRole* appears in PA (the last row if *candidateRole* is a new role).

FUNCTION 1: `add`

input : The $k \times m$ role-to-permission matrix PA and the candidate role *candidateRole*
output: The updated role-to-permission matrix PA and *candidateRole*'s index

```
1  found ← 0
2  for i ← 1 to k do                                   // Check whether candidateRole appears in PA
3  |  r ← {j : PA[i][j] = 1}
4  |  if r = candidateRole then
5  |  |  found ← i
6  |  |  break
7  |  end
8  end
9  if found = 0 then                                   // candidateRole does not appear in PA
10 |                                                   // Add the new role to PA
11 |  foreach j in candidateRole do PA[k + 1][j] ← 1
12 |  found ← k + 1
13 end
14 return (PA, found)
```

The function `fix` might unassign roles from a user making some roles useless (i.e, there could exist roles that are not anymore assigned to any user). Hence, heuristics PRUCC_1 and PRUCC_2 use the next function `removeUnassignedRoles` to remove *unassigned* roles. We do not describe the function `remove` as it simply sets to zero PA's entries associated to *candidateRole*.

FUNCTION 2: `removeUnassignedRoles`

input : The role-to-permission matrix PA
output: The *cleaned* role-to-permission matrix PA

```
1  k ← number of rows in PA                            // Number of mined roles
2  roles ← ∅
3  for i ← 1 to n do roles ← roles ∪ RolesU(u_i)       // Assigned roles
4  for j ← 1 to k do                                   // Remove unassigned roles
5  |  if j ∉ roles then PA ← remove(PA, k)
6  end
7  return PA
```

2 Fixed mru

2.1 Americas Large

mru	mpr		PRUCC$_1$ OF	PRUCC$_1$ OR	PRUCC$_1$ UF	PRUCC$_1$ UR	PRUCC$_2$ OF	PRUCC$_2$ OR	PRUCC$_2$ UF	PRUCC$_2$ UR
2	367	$\|\mathcal{R}\|$	504	549	505	547	506	552	505	550
		WSC	80013	97299	80291	96925	80748	98090	80893	97490
		time	305	423	353	506	432	456	362	535
2	458	$\|\mathcal{R}\|$	460	474	464	476	459	474	467	479
		WSC	91401	97943	92521	98177	91353	97854	92607	98618
		time	327	355	324	334	354	403	334	367
2	549	$\|\mathcal{R}\|$	443	447	445	448	442	448	443	449
		WSC	95220	97693	96037	98154	95469	98459	95168	98078
		time	278	378	373	344	327	366	371	357
2	640	$\|\mathcal{R}\|$	426	426	427	427	426	426	427	427
		WSC	101227	101230	101041	101039	101276	101275	101042	101035
		time	262	277	299	303	320	297	298	327
2	732	$\|\mathcal{R}\|$	422	422	423	423	421	420	423	423
		WSC	101267	101210	101023	101024	101255	101198	101024	101024
		time	291	284	303	300	267	290	313	317
3	245	$\|\mathcal{R}\|$	532	613	531	612	532	617	531	613
		WSC	73499	93181	73635	93161	73761	94037	73369	93365
		time	278	370	319	412	294	445	326	417
3	367	$\|\mathcal{R}\|$	500	545	501	543	499	549	503	547
		WSC	77754	95285	77395	95077	78055	96354	78195	95269
		time	292	373	305	394	322	488	330	456
3	489	$\|\mathcal{R}\|$	443	454	448	457	444	456	448	458
		WSC	90347	95619	91868	95938	90385	96439	91873	96141
		time	281	293	337	348	281	310	338	364
3	611	$\|\mathcal{R}\|$	426	426	427	427	426	426	427	427
		WSC	98116	98183	96175	96193	98067	98165	96174	96191
		time	271	300	378	279	292	309	335	290
3	732	$\|\mathcal{R}\|$	418	417	420	420	417	417	420	420
		WSC	98097	98087	96150	96149	98078	98053	96151	96152
		time	253	257	310	298	268	289	300	279

Table 1: Role-set size, WSC, and time value - Dataset Americas large

	$\|\mathcal{R}\|$ OF	$\|\mathcal{R}\|$ OR	$\|\mathcal{R}\|$ UF	$\|\mathcal{R}\|$ UR	WSC OF	WSC OR	WSC UF	WSC UR
PRUCC$_1$	8	4	1	0	5	0	3	2
PRUCC$_2$	7	4	2	0	4	0	5	2

	$\|\mathcal{R}\|$	WSC
better	2	5
equal	4	0
worse	4	5

Table 2: Minumum values - Dataset Americas large

$\mathcal{R}$	PRUCC$_1$ 0	1	2	3	4	PRUCC$_2$ 0	1	2	3	4
OF	2	5	3	0	0	3	4	3	0	0
OR	6	1	3	0	0	6	1	3	0	0
UF	9	1	0	0	0	8	2	0	0	0
UR	10	0	0	0	0	10	0	0	0	0

Table 3: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Americas large

WSC	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	5	5	0	0	0	6	4	0	0	0
OR	10	0	0	0	0	10	0	0	0	0
UF	7	3	0	0	0	5	4	1	0	0
UR	8	2	0	0	0	8	1	1	0	0

Table 4: Number of times variants reached minumum value for WSC - Dataset Americas large

	$\lvert\mathcal{R}\rvert$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	2.45	4.45	4.35	6.15	3.7	6.2	2.4	4.5
PRUCC_2	2.15	5.0	4.4	7.05	4.2	6.9	2.9	5.2

Table 5: Heuristics ranking - Dataset Americas large

$\mathcal{R}$	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	2.45	4.45	4.35	6.15	2.15	5.0	4.4	7.05

Table 6: Heuristics ranking on $\mathcal{R}$ - Dataset Americas large

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	3.7	6.2	2.4	4.5	4.2	6.9	2.9	5.2

Table 7: Heuristics ranking on WSC - Dataset Americas large

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	1.45	4.2	4.7	5.15	3.35	5.6	5.15	6.4

Table 8: Heuristics ranking on *time* - Dataset Americas large

2.2 Americas Small

			PRUCC$_1$				PRUCC$_2$			
mru	mpr		OF	OR	UF	UR	OF	OR	UF	UR
2	155	$\|\mathcal{R}\|$	283	288	283	288	286	299	288	299
		WSC	21903	22706	22147	22948	22435	24194	22773	24248
		time	203	201	225	267	231	250	293	266
2	193	$\|\mathcal{R}\|$	267	267	267	268	267	268	268	268
		WSC	24745	24712	24971	24978	24790	24825	24973	24960
		time	193	200	235	215	226	240	241	251
2	231	$\|\mathcal{R}\|$	263	263	263	263	263	263	264	264
		WSC	24881	24890	25121	25121	25011	24976	25123	25123
		time	193	212	223	222	232	251	247	251
2	269	$\|\mathcal{R}\|$	262	262	262	262	262	262	263	263
		WSC	25117	25096	25348	25348	25123	25113	25350	25350
		time	193	238	229	250	266	238	298	277
2	309	$\|\mathcal{R}\|$	260	260	260	260	260	260	261	261
		WSC	25112	25120	25344	25344	25118	25106	25346	25346
		time	211	192	215	224	224	228	245	271
4	78	$\|\mathcal{R}\|$	306	339	319	351	315	368	326	378
		WSC	15468	18073	16051	18554	16281	20387	16438	20466
		time	185	199	217	216	231	250	268	258
4	136	$\|\mathcal{R}\|$	287	299	297	308	286	305	299	318
		WSC	19683	21238	20196	21665	19504	22054	20205	22740
		time	176	187	211	209	209	240	232	244
4	194	$\|\mathcal{R}\|$	261	262	270	271	261	262	272	272
		WSC	22997	23008	23520	23523	22983	22990	23449	23391
		time	175	204	206	194	240	250	232	243
4	252	$\|\mathcal{R}\|$	256	256	265	265	256	256	266	266
		WSC	23376	23378	23892	23880	23169	23170	23629	23629
		time	180	173	197	198	229	209	235	242
4	309	$\|\mathcal{R}\|$	254	254	263	263	254	254	264	264
		WSC	23371	23374	23885	23888	23163	23165	23622	23619
		time	182	192	213	222	208	210	240	233
6	52	$\|\mathcal{R}\|$	320	374	352	400	341	424	365	440
		WSC	12946	15789	13960	16458	14094	18410	14901	18809
		time	178	193	224	219	217	235	245	256
6	116	$\|\mathcal{R}\|$	291	306	300	317	290	313	295	319
		WSC	17834	19613	18735	20554	17764	20538	18009	20909
		time	171	189	199	204	206	241	230	247
6	180	$\|\mathcal{R}\|$	258	258	268	269	258	258	265	265
		WSC	21862	21863	22883	22903	22043	22046	22522	22524
		time	176	146	160	175	198	172	192	190
6	244	$\|\mathcal{R}\|$	253	253	262	262	252	252	258	258
		WSC	22226	22222	23241	23217	22220	22224	22700	22700
		time	170	152	184	177	170	170	185	210
6	309	$\|\mathcal{R}\|$	251	251	260	260	250	250	256	256
		WSC	22222	22221	23239	23237	22219	22220	22701	22704
		time	136	138	160	171	158	167	204	193
8	39	$\|\mathcal{R}\|$	346	410	365	424	354	459	371	484
		WSC	12833	15300	13218	15557	13165	17259	13456	17928
		time	176	159	195	183	189	212	197	213
8	106	$\|\mathcal{R}\|$	290	310	302	321	295	326	305	339
		WSC	15942	18087	16687	18664	16420	19811	17048	20688
		time	139	173	179	190	164	182	211	221
8	173	$\|\mathcal{R}\|$	262	263	273	275	267	268	272	273
		WSC	20210	20378	21365	21582	20794	20907	21447	21631
		time	162	155	176	177	201	189	211	235
8	240	$\|\mathcal{R}\|$	252	252	263	263	253	252	258	258
		WSC	21395	21395	22603	22572	21281	21257	21936	21936
		time	153	139	161	185	165	168	186	200
8	309	$\|\mathcal{R}\|$	250	250	260	260	251	251	256	256
		WSC	21391	21390	22553	22535	21277	21280	21930	21932
		time	152	147	189	165	169	224	207	185

Table 9: Role-set size, WSC, and time value - Dataset Americas small

mru	mpr		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
11	29	$\|\mathcal{R}\|$	361	446	385	474	366	507	376	511
		WSC	12084	14584	12306	14796	12198	16431	12281	16316
		time	157	183	186	182	180	231	205	247
11	99	$\|\mathcal{R}\|$	271	294	306	330	269	300	282	308
		WSC	15043	17216	15323	17568	14895	17922	15060	17615
		time	152	183	171	189	186	176	186	204
11	169	$\|\mathcal{R}\|$	252	255	281	285	252	256	260	263
		WSC	18487	18655	20035	20221	18235	18719	18054	18361
		time	152	154	159	159	194	167	175	192
11	239	$\|\mathcal{R}\|$	242	242	273	273	240	241	246	247
		WSC	19815	19817	21379	21410	19284	19304	18788	18880
		time	163	138	157	204	167	154	186	205
11	309	$\|\mathcal{R}\|$	241	240	270	271	240	240	246	246
		WSC	19845	19803	21351	21380	19313	19314	18982	18997
		time	153	131	151	157	169	156	194	168

Table 10: Role-set size, WSC, and time value - Dataset Americas small

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	24	13	5	3	19	7	0	0
PRUCC$_2$	24	11	0	0	18	4	3	0

	$\|\mathcal{R}\|$	WSC
better	8	11
equal	11	0
worse	6	14

Table 11: Minumum values - Dataset Americas small

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	1	11	9	1	3	1	14	10	0	0
OR	12	1	8	1	3	14	1	10	0	0
UF	20	0	1	1	3	25	0	0	0	0
UR	22	0	0	0	3	25	0	0	0	0

Table 12: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Americas small

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	6	18	1	0	0	7	18	0	0	0
OR	18	6	1	0	0	21	4	0	0	0
UF	25	0	0	0	0	22	3	0	0	0
UR	25	0	0	0	0	25	0	0	0	0

Table 13: Number of times variants reached minumum value for WSC - Dataset Americas small

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	2.2	3.54	4.98	6.42	2.46	3.82	5.46	6.78
PRUCC$_2$	2.24	4.32	5.36	6.94	2.16	4.4	4.64	6.28

Table 14: Heuristics ranking - Dataset Americas small

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas small	2.2	3.54	4.98	6.42	2.24	4.32	5.36	6.94

Table 15: Heuristics ranking on $\mathcal{R}$ - Dataset Americas small

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas small	2.46	3.82	5.46	6.78	2.16	4.4	4.64	6.28

Table 16: Heuristics ranking on WSC - Dataset Americas small

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas small	1.72	1.86	3.78	4.46	4.66	5.32	6.82	7.38

Table 17: Heuristics ranking on *time* - Dataset Americas small

2.3 Apj

			PRUCC$_1$				PRUCC$_2$			
mru	mpr		OF	OR	UF	UR	OF	OR	UF	UR
2	29	$\|\mathcal{R}\|$	509	508	510	509	509	508	510	509
		WSC	5919	5918	5919	5918	5919	5918	5919	5918
		time	192	215	204	187	164	195	183	164
2	36	$\|\mathcal{R}\|$	506	506	507	507	506	506	507	507
		WSC	5913	5913	5913	5913	5913	5913	5913	5913
		time	211	190	184	185	223	181	168	156
2	43	$\|\mathcal{R}\|$	503	503	504	504	503	503	504	504
		WSC	5907	5907	5907	5907	5907	5907	5907	5907
		time	180	191	195	180	161	175	157	167
2	50	$\|\mathcal{R}\|$	501	501	502	502	501	501	502	502
		WSC	5903	5903	5903	5903	5903	5903	5903	5903
		time	202	183	181	184	173	164	171	163
2	57	$\|\mathcal{R}\|$	501	501	502	502	501	501	502	502
		WSC	5903	5903	5903	5903	5903	5903	5903	5903
		time	187	178	183	182	165	166	173	161
3	20	$\|\mathcal{R}\|$	516	524	518	527	513	521	516	523
		WSC	5737	5899	5730	5908	5694	5844	5690	5838
		time	181	177	173	173	162	164	157	157
3	29	$\|\mathcal{R}\|$	500	499	502	502	499	500	502	501
		WSC	5886	5884	5878	5878	5883	5886	5880	5879
		time	173	171	190	219	157	170	204	184
3	38	$\|\mathcal{R}\|$	496	497	499	499	496	497	499	499
		WSC	5877	5880	5872	5872	5878	5879	5874	5874
		time	206	205	283	227	197	240	281	178
3	47	$\|\mathcal{R}\|$	493	494	496	495	494	494	496	496
		WSC	5872	5874	5866	5866	5874	5873	5868	5868
		time	222	223	215	222	204	200	187	199
3	57	$\|\mathcal{R}\|$	493	493	495	495	492	493	495	495
		WSC	5871	5871	5864	5864	5870	5871	5866	5866
		time	222	217	224	227	213	202	204	197
4	15	$\|\mathcal{R}\|$	524	537	527	541	520	538	525	541
		WSC	5568	5769	5604	5815	5520	5785	5569	5816
		time	204	226	246	190	201	210	164	179
4	25	$\|\mathcal{R}\|$	492	493	495	496	492	493	495	496
		WSC	5739	5769	5793	5815	5741	5769	5788	5816
		time	196	180	170	174	178	170	154	148
4	35	$\|\mathcal{R}\|$	483	483	486	486	485	484	486	485
		WSC	5742	5753	5798	5798	5766	5756	5797	5787
		time	174	173	175	170	169	161	165	154
4	45	$\|\mathcal{R}\|$	482	481	484	484	482	481	483	484
		WSC	5752	5745	5794	5786	5754	5746	5783	5790
		time	178	196	174	181	182	171	202	175
4	57	$\|\mathcal{R}\|$	479	479	482	482	480	480	482	482
		WSC	5743	5747	5786	5790	5746	5752	5785	5786
		time	177	184	169	173	167	170	153	153
5	12	$\|\mathcal{R}\|$	505	536	505	543	504	551	503	544
		WSC	5181	5586	5184	5684	5167	5778	5169	5710
		time	175	175	230	183	156	166	154	162
5	23	$\|\mathcal{R}\|$	494	495	493	494	493	494	491	492
		WSC	5796	5820	5681	5702	5775	5820	5650	5697
		time	164	170	172	174	168	163	162	150
5	34	$\|\mathcal{R}\|$	479	479	478	478	479	479	477	477
		WSC	5788	5789	5667	5673	5788	5786	5670	5671
		time	170	173	169	171	164	149	153	148
5	45	$\|\mathcal{R}\|$	477	476	476	476	477	477	475	475
		WSC	5783	5785	5678	5668	5783	5784	5677	5679
		time	174	171	163	228	157	161	175	258
5	57	$\|\mathcal{R}\|$	475	475	474	474	475	475	473	473
		WSC	5779	5780	5658	5664	5781	5779	5675	5665
		time	285	186	224	170	217	164	162	174

Table 18: Role-set size, WSC, and time value - Dataset Apj

mru	mpr		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
7	9	$\|\mathcal{R}\|$	510	530	507	527	509	530	508	527
		WSC	5301	5492	5243	5439	5290	5497	5253	5434
		time	182	168	175	201	153	210	175	163
7	21	$\|\mathcal{R}\|$	475	478	474	478	475	478	474	478
		WSC	5389	5432	5329	5370	5395	5436	5321	5370
		time	170	237	167	169	195	199	174	154
7	33	$\|\mathcal{R}\|$	464	464	463	463	464	464	463	463
		WSC	5393	5388	5330	5336	5402	5392	5338	5339
		time	187	180	199	207	152	186	182	191
7	45	$\|\mathcal{R}\|$	463	463	462	462	463	463	462	462
		WSC	5387	5380	5316	5324	5379	5389	5323	5324
		time	176	179	215	198	240	182	190	233
7	57	$\|\mathcal{R}\|$	462	462	461	461	462	462	461	461
		WSC	5379	5380	5314	5317	5379	5379	5316	5313
		time	229	269	275	208	250	252	151	165

Table 19: Role-set size, WSC, and time value - Dataset Apj

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	13	11	10	6	9	6	17	10
PRUCC$_2$	12	9	10	6	8	7	15	11

	$\|\mathcal{R}\|$	WSC
better	4	14
equal	13	5
worse	8	6

Table 20: Minumum values - Dataset Apj

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	12	5	8	0	0	13	6	6	0	0
OR	14	3	7	1	0	16	3	6	0	0
UF	15	3	6	1	0	15	4	6	0	0
UR	19	0	5	1	0	19	0	6	0	0

Table 21: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Apj

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	16	5	0	0	4	17	4	0	0	4
OR	19	1	1	0	4	18	2	1	0	4
UF	8	9	4	0	4	10	8	3	0	4
UR	15	1	5	0	4	14	3	4	0	4

Table 22: Number of times variants reached minumum value for WSC - Dataset Apj

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	3.7	4.24	4.9	5.66	4.66	5.56	3.34	4.24
PRUCC$_2$	3.52	4.58	4.3	5.1	4.68	5.66	3.44	4.42

Table 23: Heuristics ranking - Dataset Apj

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Apj	3.7	4.24	4.9	5.66	3.52	4.58	4.3	5.1

Table 24: Heuristics ranking on $\mathcal{R}$ - Dataset Apj

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Apj	4.66	5.56	3.34	4.24	4.68	5.66	3.44	4.42

Table 25: Heuristics ranking on WSC - Dataset Apj

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Apj	5.66	5.74	5.82	5.7	3.74	3.74	3.14	2.46

Table 26: Heuristics ranking on *time* - Dataset Apj

2.4 Emea

mru	mpr		PRUCC_1				PRUCC_2			
			OF	OR	UF	UR	OF	OR	UF	UR
2	277	$\lvert\mathcal{R}\rvert$	45	47	45	46	45	47	45	47
		WSC	6750	7306	6750	7278	6750	7306	6750	7306
		time	6	10	4	8	5	11	5	9
2	346	$\lvert\mathcal{R}\rvert$	44	44	44	44	44	44	44	44
		WSC	7300	7300	7300	7300	7300	7300	7300	7300
		time	5	9	6	8	6	11	6	11
2	415	$\lvert\mathcal{R}\rvert$	39	39	39	39	39	39	39	39
		WSC	7290	7290	7290	7290	7290	7290	7290	7290
		time	4	6	4	6	4	6	4	6
2	484	$\lvert\mathcal{R}\rvert$	37	37	37	37	37	37	37	37
		WSC	7286	7286	7286	7286	7286	7286	7286	7286
		time	4	5	6	7	4	7	6	7
2	553	$\lvert\mathcal{R}\rvert$	35	35	35	35	35	35	35	35
		WSC	7282	7282	7282	7282	7282	7282	7282	7282
		time	6	6	6	6	6	6	6	6

Table 27: Role-set size, WSC, and time value - Dataset Emea

	$\lvert\mathcal{R}\rvert$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	5	4	5	4	5	4	5	4
PRUCC_2	5	4	5	4	5	4	5	4

	$\lvert\mathcal{R}\rvert$	WSC
better	0	0
equal	5	5
worse	0	0

Table 28: Minumum values - Dataset Emea

$\mathcal{R}$	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	0	0	1	0	4	0	0	1	0	4
OR	1	0	0	0	4	1	0	0	0	4
UF	0	0	1	0	4	0	0	1	0	4
UR	1	0	0	0	4	1	0	0	0	4

Table 29: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Emea

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	0	0	1	0	4	0	0	1	0	4
OR	1	0	0	0	4	1	0	0	0	4
UF	0	0	1	0	4	0	0	1	0	4
UR	1	0	0	0	4	1	0	0	0	4

Table 30: Number of times variants reached minumum value for WSC - Dataset Emea

	$\lvert\mathcal{R}\rvert$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	4.1	5.0	4.1	4.6	4.1	5.0	4.1	4.6
PRUCC$_2$	4.1	5.0	4.1	5.0	4.1	5.0	4.1	5.0

Table 31: Heuristics ranking - Dataset Emea

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Emea	4.1	5.0	4.1	4.6	4.1	5.0	4.1	5.0

Table 32: Heuristics ranking on $\mathcal{R}$ - Dataset Emea

WSC	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Emea	4.1	5.0	4.1	4.6	4.1	5.0	4.1	5.0

Table 33: Heuristics ranking on WSC - Dataset Emea

$time$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Emea	2.7	5.4	3.1	5.6	2.8	6.7	3.4	6.3

Table 34: Heuristics ranking on $time$ - Dataset Emea

2.5 Healthcare

mru	mpr		PRUCC_1				PRUCC_2			
			OF	OR	UF	UR	OF	OR	UF	UR
2	23	$\lvert\mathcal{R}\rvert$	21	23	21	24	20	27	20	26
		WSC	356	385	356	386	354	467	354	450
		time	3	3	3	3	4	4	4	4
2	28	$\lvert\mathcal{R}\rvert$	21	21	21	20	21	23	21	23
		WSC	401	401	401	395	401	459	401	459
		time	3	2	2	2	4	4	4	4
2	33	$\lvert\mathcal{R}\rvert$	21	20	21	20	21	20	21	21
		WSC	475	474	475	474	475	474	475	475
		time	2	2	2	2	4	4	4	4
2	38	$\lvert\mathcal{R}\rvert$	20	20	20	20	20	20	20	20
		WSC	468	468	468	468	468	468	468	468
		time	2	2	2	2	4	4	4	4
2	45	$\lvert\mathcal{R}\rvert$	18	18	18	18	18	18	18	18
		WSC	443	443	443	443	443	443	443	443
		time	2	2	2	2	4	4	4	4
3	16	$\lvert\mathcal{R}\rvert$	21	20	21	20	21	22	21	22
		WSC	329	327	329	325	329	346	329	346
		time	3	3	3	2	4	4	4	4
3	23	$\lvert\mathcal{R}\rvert$	17	17	17	17	17	20	17	20
		WSC	292	308	292	308	292	380	301	378
		time	2	2	2	2	3	3	3	3
3	30	$\lvert\mathcal{R}\rvert$	17	17	17	17	18	19	18	19
		WSC	286	286	286	286	317	372	317	375
		time	2	2	2	2	3	3	3	3
3	37	$\lvert\mathcal{R}\rvert$	17	17	17	17	17	17	17	17
		WSC	364	364	364	364	364	364	364	364
		time	2	2	2	2	3	3	3	3
3	45	$\lvert\mathcal{R}\rvert$	15	15	15	15	15	15	15	15
		WSC	338	338	338	338	338	338	338	338
		time	2	2	2	2	3	3	3	3
4	12	$\lvert\mathcal{R}\rvert$	20	20	20	20	20	23	20	23
		WSC	317	323	317	324	317	359	319	357
		time	2	2	2	2	4	4	4	4
4	20	$\lvert\mathcal{R}\rvert$	17	17	17	17	17	17	17	17
		WSC	285	285	285	285	285	285	285	285
		time	2	2	2	2	4	3	3	3
4	28	$\lvert\mathcal{R}\rvert$	18	17	18	17	18	20	18	20
		WSC	296	290	296	293	296	368	301	377
		time	2	2	2	2	3	4	3	3
4	36	$\lvert\mathcal{R}\rvert$	17	17	17	17	17	17	17	17
		WSC	365	365	365	365	365	365	365	365
		time	2	2	2	2	3	3	3	3
4	45	$\lvert\mathcal{R}\rvert$	15	15	15	15	15	15	15	15
		WSC	338	338	338	338	338	338	338	338
		time	2	2	2	2	2	2	3	3
5	10	$\lvert\mathcal{R}\rvert$	20	20	20	19	21	22	20	22
		WSC	326	326	326	325	337	354	334	352
		time	2	2	2	2	3	3	3	3
5	19	$\lvert\mathcal{R}\rvert$	18	18	18	17	18	17	18	17
		WSC	295	295	295	294	295	294	295	294
		time	2	2	2	2	3	3	3	3
5	28	$\lvert\mathcal{R}\rvert$	18	18	18	18	18	19	18	19
		WSC	307	307	307	307	312	361	327	362
		time	1	2	1	2	2	2	2	2
5	37	$\lvert\mathcal{R}\rvert$	17	17	17	17	17	17	17	17
		WSC	350	350	350	350	350	350	350	350
		time	1	2	1	2	2	2	2	2
5	45	$\lvert\mathcal{R}\rvert$	15	15	15	15	15	15	15	15
		WSC	324	324	324	324	324	324	324	324
		time	1	1	1	1	2	2	2	2

Table 35: Role-set size, WSC, and time value - Dataset Healthcare

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	14	16	14	19	14	13	14	16
PRUCC_2	17	11	18	10	17	11	14	10

	$\|\mathcal{R}\|$	WSC
better	5	6
equal	14	13
worse	1	1

Table 36: Minumum values - Dataset Healthcare

$\mathcal{R}$	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	6	0	1	0	13	3	0	8	0	9
OR	4	0	3	0	13	9	1	1	0	9
UF	6	0	1	0	13	2	1	8	0	9
UR	1	3	3	0	13	10	0	1	0	9

Table 37: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Healthcare

WSC	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	6	0	3	0	11	3	4	4	0	9
OR	7	1	1	0	11	9	1	1	0	9
UF	6	0	3	0	11	6	1	4	0	9
UR	4	4	1	0	11	10	0	1	0	9

Table 38: Number of times variants reached minumum value for WSC - Dataset Healthcare

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	4.275	3.85	4.275	3.425	4.025	3.95	4.025	3.6
PRUCC_2	4.45	5.625	4.325	5.775	4.35	5.625	4.65	5.775

Table 39: Heuristics ranking - Dataset Healthcare

$\mathcal{R}$	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Healthcare	4.275	3.85	4.275	3.425	4.45	5.625	4.325	5.775

Table 40: Heuristics ranking on $\mathcal{R}$ - Dataset Healthcare

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Healthcare	4.025	3.95	4.025	3.6	4.35	5.625	4.65	5.775

Table 41: Heuristics ranking on WSC - Dataset Healthcare

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Healthcare	2.55	2.85	2.45	2.75	6.3	6.3	6.4	6.4

Table 42: Heuristics ranking on *time* - Dataset Healthcare

2.6 Domino

			PRUCC$_1$				PRUCC$_2$			
mru	mpr		OF	OR	UF	UR	OF	OR	UF	UR
2	105	$\|\mathcal{R}\|$	24	24	25	24	24	24	25	24
		WSC	761	759	767	766	760	759	767	766
		time	2	2	1	2	2	2	2	2
2	131	$\|\mathcal{R}\|$	22	22	23	23	22	22	23	23
		WSC	757	757	763	763	754	757	763	763
		time	2	1	2	2	2	2	2	2
2	157	$\|\mathcal{R}\|$	22	22	23	23	22	22	23	23
		WSC	758	756	763	763	757	755	763	763
		time	1	2	1	2	2	2	2	2
2	183	$\|\mathcal{R}\|$	22	22	23	23	22	22	23	23
		WSC	755	756	763	763	756	757	763	763
		time	1	1	1	2	2	2	2	2
2	208	$\|\mathcal{R}\|$	22	22	23	23	22	22	23	23
		WSC	757	757	763	763	757	756	763	763
		time	1	2	1	2	2	2	2	2
4	53	$\|\mathcal{R}\|$	26	26	26	25	25	26	25	27
		WSC	713	711	722	711	659	761	668	776
		time	1	1	1	2	2	2	2	2
4	92	$\|\mathcal{R}\|$	25	24	25	24	24	25	24	25
		WSC	762	736	772	753	669	762	679	772
		time	1	2	1	2	2	2	2	2
4	131	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	758	753	764	764	752	755	764	764
		time	1	1	1	1	2	2	2	2
4	170	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	756	755	764	764	755	753	764	764
		time	1	1	1	2	2	2	2	2
4	208	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	754	753	764	764	754	758	764	764
		time	1	1	1	1	2	2	2	2
6	35	$\|\mathcal{R}\|$	31	29	31	29	28	32	28	31
		WSC	703	658	716	675	598	739	608	744
		time	1	2	1	2	2	2	2	2
6	78	$\|\mathcal{R}\|$	25	24	25	24	25	24	25	24
		WSC	761	745	772	740	763	755	772	756
		time	1	1	1	1	2	2	2	2
6	121	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	751	755	764	764	753	750	764	764
		time	1	1	1	1	1	1	1	1
6	164	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	755	756	764	764	752	752	764	764
		time	1	1	1	1	1	1	1	1
6	208	$\|\mathcal{R}\|$	21	21	21	20	21	21	21	20
		WSC	755	760	764	763	750	751	764	763
		time	1	1	1	1	1	1	1	1
8	27	$\|\mathcal{R}\|$	32	31	32	31	29	33	29	33
		WSC	647	631	655	629	559	691	571	699
		time	1	2	1	2	2	2	2	2
8	72	$\|\mathcal{R}\|$	25	24	25	24	25	24	25	24
		WSC	737	723	746	707	737	721	746	746
		time	1	1	1	1	1	2	1	2
8	117	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	755	754	763	763	750	749	763	763
		time	1	1	1	1	1	1	2	1
8	162	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	754	760	763	763	753	755	763	763
		time	1	1	1	1	1	1	1	1
8	208	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	20
		WSC	757	752	763	763	750	755	763	762
		time	1	1	1	1	1	1	1	1

Table 43: Role-set size, WSC, and time value - Dataset Domino

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	13	18	8	16	7	12	0	4
PRUCC_2	16	14	11	12	12	9	0	0

	$\|\mathcal{R}\|$	WSC
better	0	4
equal	17	1
worse	3	15

Table 44: Minumum values - Dataset Domino

$\mathcal{R}$	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	7	0	4	1	8	4	0	8	1	7
OR	2	0	9	1	8	6	0	6	1	7
UF	12	0	0	0	8	9	0	4	0	7
UR	4	2	5	1	8	8	2	2	1	7

Table 45: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Domino

WSC	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	13	5	2	0	0	8	11	1	0	0
OR	8	9	3	0	0	11	8	1	0	0
UF	20	0	0	0	0	20	0	0	0	0
UR	16	3	1	0	0	20	0	0	0	0

Table 46: Number of times variants reached minumum value for WSC - Dataset Domino

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	4.6	3.775	5.6	4.2	3.675	2.85	6.675	5.3
PRUCC_2	3.8	4.4	4.8	4.825	2.125	3.075	5.8	6.5

Table 47: Heuristics ranking - Dataset Domino

$\mathcal{R}$	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Domino	4.6	3.775	5.6	4.2	3.8	4.4	4.8	4.825

Table 48: Heuristics ranking on $\mathcal{R}$ - Dataset Domino

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Domino	3.675	2.85	6.675	5.3	2.125	3.075	5.8	6.5

Table 49: Heuristics ranking on WSC - Dataset Domino

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Domino	3.05	3.85	2.85	4.65	5.25	5.45	5.45	5.45

Table 50: Heuristics ranking on *time* - Dataset Domino

2.7 Customer

			PRUCC_1				PRUCC_2			
mru	mpr		OF	OR	UF	UR	OF	OR	UF	UR
2	13	$\lvert\mathcal{R}\rvert$	5393	5400	5394	5401	5396	5403	5397	5403
		WSC	50467	50498	50468	50505	50509	50532	50514	50528
		time	4953	4889	4961	5295	4855	4983	5020	5062
2	16	$\lvert\mathcal{R}\rvert$	5351	5353	5352	5353	5351	5354	5352	5353
		WSC	50423	50429	50424	50427	50434	50432	50432	50432
		time	5667	6797	6430	5682	5920	6123	5842	5678
2	19	$\lvert\mathcal{R}\rvert$	5332	5333	5333	5333	5333	5334	5333	5334
		WSC	50382	50384	50383	50384	50397	50405	50394	50397
		time	6235	6382	5759	4957	6356	6826	5716	4768
2	22	$\lvert\mathcal{R}\rvert$	5323	5324	5324	5324	5323	5324	5324	5324
		WSC	50401	50402	50402	50402	50402	50402	50402	50402
		time	5137	6348	5636	6398	5579	6030	6146	6091
2	24	$\lvert\mathcal{R}\rvert$	5323	5323	5324	5323	5324	5323	5324	5323
		WSC	50401	50401	50402	50400	50401	50400	50402	50400
		time	6209	4706	4665	4614	4803	4457	4476	4469
8	4	$\lvert\mathcal{R}\rvert$	1858	1953	1863	1970	1922	2031	1902	2012
		WSC	45315	45670	45347	45753	45672	46058	45556	45976
		time	1050	1094	1140	1040	1043	1054	1332	984
8	9	$\lvert\mathcal{R}\rvert$	1537	1581	1540	1582	1606	1664	1608	1658
		WSC	47048	47260	47092	47279	47904	48089	47942	48051
		time	855	819	987	954	829	843	982	989
8	14	$\lvert\mathcal{R}\rvert$	1314	1314	1317	1319	1316	1315	1317	1319
		WSC	47737	47733	47775	47791	47775	47747	47802	47801
		time	873	689	1071	1066	716	801	1085	957
8	19	$\lvert\mathcal{R}\rvert$	1275	1277	1280	1281	1277	1279	1279	1280
		WSC	47648	47662	47710	47713	47686	47700	47726	47732
		time	908	948	944	960	897	948	937	945
8	24	$\lvert\mathcal{R}\rvert$	1267	1268	1272	1272	1268	1268	1271	1271
		WSC	47675	47692	47731	47731	47698	47679	47728	47726
		time	959	932	993	935	930	891	1014	913
14	2	$\lvert\mathcal{R}\rvert$	519	523	521	520	531	525	521	524
		WSC	46036	46036	46074	46072	46077	46041	46075	46084
		time	750	746	793	750	694	715	748	696
14	7	$\lvert\mathcal{R}\rvert$	453	454	452	455	453	463	452	459
		WSC	46134	46151	46179	46198	46143	46212	46186	46239
		time	728	800	754	826	683	724	802	801
14	12	$\lvert\mathcal{R}\rvert$	418	420	418	420	422	424	420	421
		WSC	46159	46176	46205	46212	46194	46208	46244	46246
		time	741	716	749	719	676	653	708	695
14	17	$\lvert\mathcal{R}\rvert$	368	369	367	368	369	370	366	368
		WSC	46092	46091	46127	46130	46085	46097	46148	46157
		time	738	705	755	732	632	664	673	703
14	24	$\lvert\mathcal{R}\rvert$	350	349	348	348	349	349	347	347
		WSC	46071	46078	46122	46122	46084	46078	46120	46120
		time	701	752	725	733	665	682	676	703
20	2	$\lvert\mathcal{R}\rvert$	336	337	336	336	336	339	335	337
		WSC	45998	46010	46041	46041	46003	46016	46040	46047
		time	713	714	732	764	661	672	697	701
20	7	$\lvert\mathcal{R}\rvert$	308	310	306	307	308	309	306	307
		WSC	45960	45983	46002	46017	45977	45982	46008	46020
		time	793	752	742	866	770	695	783	730
20	12	$\lvert\mathcal{R}\rvert$	300	299	298	297	300	300	297	296
		WSC	45986	45970	46022	46015	45975	45960	46020	46016
		time	756	760	800	741	669	736	692	713
20	17	$\lvert\mathcal{R}\rvert$	298	299	298	298	298	300	297	297
		WSC	45978	45986	46022	46022	45983	45980	46020	46020
		time	707	733	709	709	666	677	685	675
20	24	$\lvert\mathcal{R}\rvert$	288	288	287	287	289	288	286	286
		WSC	45961	45959	46000	46000	45952	45967	45998	45998
		time	721	693	731	765	673	690	713	700

Table 51: Role-set size, WSC, and time value - Dataset Customer

mru	mpr		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
24	2	$\|\mathcal{R}\|$	289	290	288	288	290	290	288	288
		WSC	45985	45972	46002	46002	45971	45973	46002	46002
		time	741	699	756	742	664	668	716	697
24	7	$\|\mathcal{R}\|$	283	283	280	280	283	283	280	280
		WSC	45944	45929	45986	45986	45938	45952	45986	45986
		time	740	803	727	720	660	703	681	681
24	12	$\|\mathcal{R}\|$	280	281	278	278	281	281	278	278
		WSC	45947	45934	45982	45982	45938	45930	45982	45982
		time	706	723	778	722	665	649	706	675
24	17	$\|\mathcal{R}\|$	280	281	278	278	281	280	278	278
		WSC	45949	45929	45982	45982	45932	45955	45982	45982
		time	816	659	614	744	743	552	617	642
24	24	$\|\mathcal{R}\|$	280	280	277	277	279	279	277	277
		WSC	45934	45943	45980	45980	45944	45930	45980	45980
		time	712	715	718	744	651	661	665	676

Table 52: Role-set size, WSC, and time value - Dataset Customer

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	14	2	13	11	16	9	0	1
PRUCC$_2$	7	3	16	10	13	11	4	3

	$\|\mathcal{R}\|$	WSC
better	9	18
equal	10	1
worse	6	6

Table 53: Minumum values - Dataset Customer

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	11	9	2	3	0	18	5	2	0	0
OR	23	0	1	1	0	22	1	2	0	0
UF	12	3	8	2	0	9	7	9	0	0
UR	14	1	7	3	0	15	1	9	0	0

Table 54: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Customer

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	9	15	1	0	0	12	12	0	0	1
OR	16	8	1	0	0	14	8	1	1	1
UF	25	0	0	0	0	21	2	0	1	1
UR	24	1	0	0	0	22	0	1	1	1

Table 55: Number of times variants reached minumum value for WSC - Dataset Customer

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	3.5	5.32	3.48	4.28	1.94	2.74	5.28	5.7
PRUCC$_2$	5.14	6.5	3.22	4.56	3.64	4.1	6.06	6.54

Table 56: Heuristics ranking - Dataset Customer

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Customer	3.5	5.32	3.48	4.28	5.14	6.5	3.22	4.56

Table 57: Heuristics ranking on $\mathcal{R}$ - Dataset Customer

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Customer	1.94	2.74	5.28	5.7	3.64	4.1	6.06	6.54

Table 58: Heuristics ranking on WSC - Dataset Customer

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Customer	5.0	5.34	6.06	6.12	2.32	3.02	4.56	3.58

Table 59: Heuristics ranking on *time* - Dataset Customer

2.8 Firewall 1

			PRUCC$_1$				PRUCC$_2$			
mru	mpr		OF	OR	UF	UR	OF	OR	UF	UR
2	309	$\|\mathcal{R}\|$	90	90	92	91	90	90	91	91
		WSC	7116	7116	7123	7122	7116	7117	7121	7120
		time	45	44	41	41	94	95	94	98
2	386	$\|\mathcal{R}\|$	90	90	91	92	90	90	91	91
		WSC	7116	7116	7121	7123	7116	7116	7121	7121
		time	44	42	40	41	97	93	96	96
2	463	$\|\mathcal{R}\|$	90	90	92	92	90	90	91	91
		WSC	7116	7116	7123	7122	7116	7116	7120	7120
		time	47	43	43	42	105	96	93	98
2	540	$\|\mathcal{R}\|$	90	90	92	91	90	90	91	91
		WSC	7116	7116	7124	7122	7116	7116	7121	7120
		time	42	41	41	44	95	96	94	103
2	616	$\|\mathcal{R}\|$	90	90	92	92	90	90	91	91
		WSC	7117	7116	7122	7123	7116	7116	7120	7121
		time	41	41	42	44	95	99	94	96
4	155	$\|\mathcal{R}\|$	94	94	95	96	95	99	96	100
		WSC	5653	5777	5661	5819	5810	6557	5818	6535
		time	41	42	41	48	94	97	94	102
4	270	$\|\mathcal{R}\|$	87	87	88	88	87	87	88	88
		WSC	6988	6989	6997	6997	6990	6988	6996	6995
		time	41	41	43	42	95	97	93	98
4	385	$\|\mathcal{R}\|$	86	86	87	87	86	86	87	87
		WSC	6987	6987	6994	6995	6986	6986	6993	6994
		time	43	41	45	50	96	105	100	101
4	500	$\|\mathcal{R}\|$	86	86	87	87	86	86	87	87
		WSC	6988	6986	6995	6995	6987	6987	6993	6993
		time	43	50	41	40	96	103	97	108
4	616	$\|\mathcal{R}\|$	86	86	87	86	86	86	87	87
		WSC	6986	6988	6994	6995	6986	6987	6993	6995
		time	54	53	46	47	121	142	123	111
6	103	$\|\mathcal{R}\|$	95	98	96	99	109	113	110	114
		WSC	3502	3879	3512	3916	5178	5559	5053	5435
		time	59	49	50	47	88	80	81	91
6	231	$\|\mathcal{R}\|$	86	86	87	87	86	86	87	87
		WSC	6862	6862	6871	6869	6915	6915	6869	6867
		time	40	43	37	39	70	64	73	74
6	359	$\|\mathcal{R}\|$	84	84	85	85	84	84	85	85
		WSC	6857	6857	6865	6865	6911	6913	6864	6864
		time	38	38	38	39	64	67	75	73
6	487	$\|\mathcal{R}\|$	84	84	85	85	84	84	85	85
		WSC	6858	6858	6867	6865	6912	6912	6867	6865
		time	39	40	42	50	64	66	80	95
6	616	$\|\mathcal{R}\|$	84	84	85	85	84	84	85	85
		WSC	6858	6858	6865	6865	6912	6912	6865	6865
		time	50	48	51	37	81	88	87	77
8	78	$\|\mathcal{R}\|$	91	96	99	106	97	107	103	110
		WSC	4068	4551	4405	4959	4543	5372	4874	5499
		time	26	24	25	27	36	37	37	40
8	212	$\|\mathcal{R}\|$	83	83	86	86	85	86	86	87
		WSC	5403	5403	5394	5395	6029	6041	6017	6030
		time	19	20	23	25	26	27	36	47
8	346	$\|\mathcal{R}\|$	78	78	81	81	78	78	79	79
		WSC	6227	6228	6221	6219	6226	6226	6214	6214
		time	24	22	25	25	30	31	37	43
8	480	$\|\mathcal{R}\|$	78	78	81	81	78	78	79	79
		WSC	6226	6227	6218	6219	6227	6226	6214	6215
		time	25	18	22	25	37	27	33	37
8	616	$\|\mathcal{R}\|$	78	78	81	81	78	78	79	79
		WSC	6227	6228	6218	6219	6227	6227	6215	6214
		time	20	23	26	22	27	35	34	35

Table 60: Role-set size, WSC, and time value - Dataset Firewall 1

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	20	18	0	1	14	11	3	1
PRUCC_2	20	16	0	0	10	7	6	6

	$\|\mathcal{R}\|$	WSC
better	4	9
equal	16	7
worse	0	4

Table 61: Minumum values - Dataset Firewall 1

$\mathcal{R}$	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	0	2	17	1	0	0	4	16	0	0
OR	2	0	17	1	0	4	0	16	0	0
UF	20	0	0	0	0	20	0	0	0	0
UR	19	0	0	1	0	20	0	0	0	0

Table 62: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Firewall 1

WSC	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	6	5	9	0	0	10	4	6	0	0
OR	9	2	9	0	0	13	1	6	0	0
UF	17	3	0	0	0	14	3	3	0	0
UR	19	1	0	0	0	14	3	3	0	0

Table 63: Number of times variants reached minumum value for WSC - Dataset Firewall 1

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	2.275	2.425	6.35	6.35	2.75	3.3	5.15	5.725
PRUCC_2	2.75	3.35	6.0	6.5	4.425	5.025	4.625	5.0

Table 64: Heuristics ranking - Dataset Firewall 1

$\mathcal{R}$	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 1	2.275	2.425	6.35	6.35	2.75	3.35	6.0	6.5

Table 65: Heuristics ranking on $\mathcal{R}$ - Dataset Firewall 1

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 1	2.75	3.3	5.15	5.725	4.425	5.025	4.625	5.0

Table 66: Heuristics ranking on WSC - Dataset Firewall 1

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 1	2.6	2.2	2.425	2.775	5.875	6.55	6.2	7.375

Table 67: Heuristics ranking on *time* - Dataset Firewall 1

2.9 Firewall 2

mru	mpr		PRUCC_1				PRUCC_2			
			OF	OR	UF	UR	OF	OR	UF	UR
2	295	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1541	1541	1541	1541	1552	1552	1552	1552
		time	29	30	28	32	62	64	65	69
2	368	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1541	1541	1541	1541	1552	1552	1552	1552
		time	32	38	36	30	85	80	82	70
2	441	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1541	1541	1541	1541	1552	1552	1552	1552
		time	33	29	28	29	65	65	63	74
2	514	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1541	1541	1541	1541	1552	1552	1552	1552
		time	30	31	29	28	64	63	66	75
2	589	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1541	1541	1541	1541	1552	1552	1552	1552
		time	33	36	32	32	87	83	68	64

Table 68: Role-set size, WSC, and time value - Dataset Firewall 2

	$\lvert\mathcal{R}\rvert$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	5	5	5	5	5	5	5	5
PRUCC_2	5	5	5	5	5	5	5	5

	$\lvert\mathcal{R}\rvert$	WSC
better	0	5
equal	5	0
worse	0	0

Table 69: Minumum values - Dataset Firewall 2

$\mathcal{R}$	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	0	0	0	0	5	0	0	0	0	5
OR	0	0	0	0	5	0	0	0	0	5
UF	0	0	0	0	5	0	0	0	0	5
UR	0	0	0	0	5	0	0	0	0	5

Table 70: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Firewall 2

WSC	PRUCC_1					PRUCC_2				
	0	1	2	3	4	0	1	2	3	4
OF	0	0	0	0	5	0	0	0	0	5
OR	0	0	0	0	5	0	0	0	0	5
UF	0	0	0	0	5	0	0	0	0	5
UR	0	0	0	0	5	0	0	0	0	5

Table 71: Number of times variants reached minumum value for WSC - Dataset Firewall 2

	$\lvert\mathcal{R}\rvert$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC_1	4.5	4.5	4.5	4.5	2.5	2.5	2.5	2.5
PRUCC_2	4.5	4.5	4.5	4.5	6.5	6.5	6.5	6.5

Table 72: Heuristics ranking - Dataset Firewall 2

$\mathcal{R}$	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 2	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5

Table 73: Heuristics ranking on $\mathcal{R}$ - Dataset Firewall 2

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 2	2.5	2.5	2.5	2.5	6.5	6.5	6.5	6.5

Table 74: Heuristics ranking on WSC - Dataset Firewall 2

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 2	2.8	3.5	1.7	2.0	6.7	6.1	6.4	6.8

Table 75: Heuristics ranking on *time* - Dataset Firewall 2

2.10 Heuristics' rank when fixing mru

Dataset	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	2.45	4.45	4.35	6.15	2.15	5.0	4.4	7.05
Americas small	2.2	3.54	4.98	6.42	2.24	4.32	5.36	6.94
Apj	3.7	4.24	4.9	5.66	3.52	4.58	4.3	5.1
Customer	3.5	5.32	3.48	4.28	5.14	6.5	3.22	4.56
Domino	4.6	3.775	5.6	4.2	3.8	4.4	4.8	4.825
Emea	4.1	5.0	4.1	4.6	4.1	5.0	4.1	5.0
Firewall 1	2.275	2.425	6.35	6.35	2.75	3.35	6.0	6.5
Firewall 2	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Healthcare	4.275	3.85	4.275	3.425	4.45	5.625	4.325	5.775

Table 76: Heuristics ranking on $|\mathcal{R}|$ - fixed mru

Dataset	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	3.7	6.2	2.4	4.5	4.2	6.9	2.9	5.2
Americas small	2.46	3.82	5.46	6.78	2.16	4.4	4.64	6.28
Apj	4.66	5.56	3.34	4.24	4.68	5.66	3.44	4.42
Customer	1.94	2.74	5.28	5.7	3.64	4.1	6.06	6.54
Domino	3.675	2.85	6.675	5.3	2.125	3.075	5.8	6.5
Emea	4.1	5.0	4.1	4.6	4.1	5.0	4.1	5.0
Firewall 1	2.75	3.3	5.15	5.725	4.425	5.025	4.625	5.0
Firewall 2	2.5	2.5	2.5	2.5	6.5	6.5	6.5	6.5
Healthcare	4.025	3.95	4.025	3.6	4.35	5.625	4.65	5.775

Table 77: Heuristics ranking on WSC - fixed mru

Dataset	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	1.45	4.2	4.7	5.15	3.35	5.6	5.15	6.4
Americas small	1.72	1.86	3.78	4.46	4.66	5.32	6.82	7.38
Apj	5.66	5.74	5.82	5.7	3.74	3.74	3.14	2.46
Customer	5.0	5.34	6.06	6.12	2.32	3.02	4.56	3.58
Domino	3.05	3.85	2.85	4.65	5.25	5.45	5.45	5.45
Emea	2.7	5.4	3.1	5.6	2.8	6.7	3.4	6.3
Firewall 1	2.6	2.2	2.425	2.775	5.875	6.55	6.2	7.375
Firewall 2	2.8	3.5	1.7	2.0	6.7	6.1	6.4	6.8
Healthcare	2.55	2.85	2.45	2.75	6.3	6.3	6.4	6.4

Table 78: Heuristics ranking on $time$ - fixed mru

3 Fixed mpr

3.1 Americas Large

			PRUCC$_1$				PRUCC$_2$			
mpr	mru		OF	OR	UF	UR	OF	OR	UF	UR
2	367	$\|\mathcal{R}\|$	5915	8787	5902	8160	5927	8979	5912	8282
		WSC	113605	126713	113084	122883	113590	127307	113133	123170
		time	2298	4148	2246	3628	2275	4264	2260	3640
2	458	$\|\mathcal{R}\|$	5891	8528	5879	8078	5890	8551	5875	8086
		WSC	113620	128471	113082	123039	113595	128301	113122	123018
		time	2264	3910	2213	3565	2248	3868	2197	3506
2	549	$\|\mathcal{R}\|$	5894	8462	5876	8018	5894	8453	5875	8021
		WSC	113624	128237	113109	123072	113578	128119	113103	123089
		time	2287	3822	2224	3527	2252	3798	2200	3435
2	640	$\|\mathcal{R}\|$	5893	8414	5875	8041	5891	8400	5875	8003
		WSC	113637	128465	113090	123298	113612	128470	113131	123001
		time	2267	3800	2233	3534	2258	3766	2203	3715
2	732	$\|\mathcal{R}\|$	5894	8412	5875	8016	5894	8425	5874	8011
		WSC	113622	128283	113123	123072	113615	128441	113115	123052
		time	2682	4766	2705	4397	3400	4266	2478	4203
185	4	$\|\mathcal{R}\|$	600	733	596	736	602	735	597	738
		WSC	65907	91236	66209	91334	66278	91348	66282	91235
		time	311	467	300	534	378	455	325	501
185	186	$\|\mathcal{R}\|$	581	725	590	726	582	725	591	727
		WSC	61901	88424	63814	88124	61976	88416	63941	88122
		time	246	353	245	394	223	332	244	384
185	368	$\|\mathcal{R}\|$	582	723	591	727	582	725	591	729
		WSC	62010	88156	63903	88153	62082	88258	63813	88362
		time	242	359	269	410	234	366	281	375
185	550	$\|\mathcal{R}\|$	582	722	590	726	582	726	591	727
		WSC	62059	88075	63778	87984	61993	88486	63797	88191
		time	256	392	289	412	252	371	256	416
185	732	$\|\mathcal{R}\|$	582	723	591	725	582	724	591	727
		WSC	62053	88083	63979	87778	61957	88316	63811	88163
		time	248	380	254	356	246	343	238	366
368	2	$\|\mathcal{R}\|$	503	545	507	546	504	554	505	550
		WSC	80003	96650	80967	96810	80616	98661	80761	97537
		time	319	389	340	433	384	520	369	494
368	184	$\|\mathcal{R}\|$	493	537	499	540	493	538	499	540
		WSC	73904	90632	75164	90600	73814	90577	75199	90473
		time	263	356	325	385	280	414	278	397
368	366	$\|\mathcal{R}\|$	493	537	499	540	492	538	499	538
		WSC	73751	90646	75088	90701	73711	90662	75091	90113
		time	283	326	257	337	265	316	251	329
368	548	$\|\mathcal{R}\|$	492	538	499	540	493	537	499	540
		WSC	73808	90742	75163	90544	73797	90728	75165	90526
		time	254	323	284	348	252	330	271	330
368	732	$\|\mathcal{R}\|$	492	538	499	537	492	538	499	539
		WSC	73778	90752	75118	90189	73783	90773	75129	90396
		time	257	326	266	332	246	315	252	332
551	2	$\|\mathcal{R}\|$	443	445	445	448	442	448	445	449
		WSC	95883	97494	95962	97980	95971	98779	95803	98344
		time	298	309	327	338	340	357	358	376
551	184	$\|\mathcal{R}\|$	435	439	438	440	435	439	438	441
		WSC	91503	93010	91346	92854	91581	93038	91181	92885
		time	256	274	275	287	266	273	284	295
551	366	$\|\mathcal{R}\|$	434	439	438	441	434	439	438	441
		WSC	91502	92834	91126	92853	91482	92979	91237	92958
		time	257	275	270	288	269	280	272	295
551	548	$\|\mathcal{R}\|$	434	439	438	441	435	439	438	441
		WSC	91536	92954	91179	92883	91646	92877	91346	92894
		time	255	279	278	288	260	277	257	285
551	732	$\|\mathcal{R}\|$	434	440	438	440	434	440	438	440
		WSC	91442	93061	91126	92907	91288	93026	91072	92850
		time	278	283	289	290	258	269	256	275

Table 79: Role-set size, WSC, and time value - Dataset Americas large

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
732	2	$\|\mathcal{R}\|$	423	422	423	423	421	421	423	423
		WSC	101262	101218	101022	101024	101217	101249	101019	101021
		time	297	296	320	313	298	302	320	327
732	184	$\|\mathcal{R}\|$	414	414	415	415	415	414	415	415
		WSC	93242	93245	93141	93139	93263	93253	93139	93137
		time	261	261	285	273	268	266	263	263
732	366	$\|\mathcal{R}\|$	414	414	415	415	414	414	415	415
		WSC	93252	93267	93141	93141	93242	93266	93137	93140
		time	257	254	271	272	263	262	282	268
732	548	$\|\mathcal{R}\|$	415	414	415	415	414	414	415	415
		WSC	93291	93264	93137	93140	93227	93226	93138	93137
		time	257	257	271	271	250	263	282	278
732	732	$\|\mathcal{R}\|$	415	414	415	415	414	415	415	415
		WSC	93306	93222	93139	93134	93281	93284	93137	93136
		time	259	261	289	279	255	257	265	269

Table 80: Role-set size, WSC, and time value - Dataset Americas large

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	16	5	6	0	11	0	12	3
PRUCC$_2$	18	4	6	0	10	0	12	3

	$\|\mathcal{R}\|$	WSC
better	6	11
equal	13	1
worse	6	13

Table 81: Minumum values - Dataset Americas large

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	9	14	2	0	0	7	15	3	0	0
OR	20	3	2	0	0	21	1	3	0	0
UF	19	6	0	0	0	19	6	0	0	0
UR	25	0	0	0	0	25	0	0	0	0

Table 82: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Americas large

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	14	11	0	0	0	15	10	0	0	0
OR	25	0	0	0	0	25	0	0	0	0
UF	13	11	1	0	0	13	12	0	0	0
UR	22	2	1	0	0	22	3	0	0	0

Table 83: Number of times variants reached minumum value for WSC - Dataset Americas large

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	2.52	5.12	3.54	6.42	3.44	6.72	2.56	5.28
PRUCC$_2$	2.26	5.72	3.54	6.88	3.16	7.24	2.5	5.1

Table 84: Heuristics ranking - Dataset Americas large

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	2.52	5.12	3.54	6.42	2.26	5.72	3.54	6.88

Table 85: Heuristics ranking on $\mathcal{R}$ - Dataset Americas large

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	3.44	6.72	2.56	5.28	3.16	7.24	2.5	5.1

Table 86: Heuristics ranking on WSC - Dataset Americas large

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	2.5	5.2	3.92	6.68	2.64	5.34	3.22	6.5

Table 87: Heuristics ranking on *time* - Dataset Americas large

3.2 Americas Small

			PRUCC$_1$				PRUCC$_2$			
mpr	mru		OF	OR	UF	UR	OF	OR	UF	UR
2	155	$\|\mathcal{R}\|$	996	1087	992	1058	1000	1092	992	1064
		WSC	58065	59347	58332	59264	58021	59321	58356	59326
		time	417	441	492	502	394	423	474	497
2	193	$\|\mathcal{R}\|$	981	1069	979	1043	981	1068	980	1040
		WSC	58140	59401	58374	59290	58060	59480	58418	59296
		time	407	435	475	489	394	415	479	493
2	231	$\|\mathcal{R}\|$	981	1064	979	1036	981	1065	979	1037
		WSC	58089	59362	58413	59180	58106	59400	58407	59224
		time	383	426	489	483	405	426	491	491
2	269	$\|\mathcal{R}\|$	980	1070	979	1033	980	1068	980	1040
		WSC	58049	59415	58401	59191	58055	59481	58439	59322
		time	393	436	502	497	389	424	479	486
2	309	$\|\mathcal{R}\|$	981	1071	979	1037	981	1064	979	1039
		WSC	58108	59516	58394	59244	58116	59374	58407	59302
		time	403	443	491	485	388	421	491	499
67	5	$\|\mathcal{R}\|$	311	343	329	363	313	379	337	396
		WSC	14909	17077	15480	17803	15133	19500	16050	19998
		time	163	161	203	185	183	200	207	215
67	81	$\|\mathcal{R}\|$	206	205	216	215	206	206	216	215
		WSC	11296	11332	11662	11631	11291	11309	11660	11640
		time	113	140	125	131	106	112	122	120
67	157	$\|\mathcal{R}\|$	206	206	216	214	206	206	216	215
		WSC	11316	11390	11653	11639	11296	11390	11669	11640
		time	117	120	128	129	137	110	129	121
67	233	$\|\mathcal{R}\|$	206	206	216	214	206	206	215	215
		WSC	11297	11360	11668	11640	11309	11404	11639	11644
		time	134	116	126	130	118	110	121	139
67	309	$\|\mathcal{R}\|$	206	206	216	215	206	206	216	215
		WSC	11294	11371	11662	11656	11300	11327	11655	11647
		time	128	120	134	146	110	106	132	133
132	3	$\|\mathcal{R}\|$	292	303	300	311	288	312	299	316
		WSC	20675	22103	20895	22365	20152	23298	20877	23039
		time	164	174	186	193	186	193	232	220
132	79	$\|\mathcal{R}\|$	196	196	207	207	196	196	207	207
		WSC	11163	11158	11623	11637	11160	11135	11616	11641
		time	115	111	137	133	111	121	133	122
132	155	$\|\mathcal{R}\|$	196	196	206	207	196	196	206	207
		WSC	11149	11146	11639	11648	11138	11153	11639	11643
		time	117	129	140	128	107	126	125	130
132	231	$\|\mathcal{R}\|$	196	196	207	207	196	196	207	207
		WSC	11152	11172	11629	11636	11134	11151	11640	11624
		time	114	139	133	127	110	116	122	133
132	309	$\|\mathcal{R}\|$	196	196	206	207	196	196	207	207
		WSC	11163	11137	11609	11651	11131	11144	11637	11646
		time	113	112	126	141	140	114	126	128
197	2	$\|\mathcal{R}\|$	267	268	267	268	267	268	268	269
		WSC	24721	24722	24967	24970	24860	24823	24969	24972
		time	194	177	198	205	202	188	204	228
197	79	$\|\mathcal{R}\|$	196	196	207	207	196	196	207	207
		WSC	11126	11143	11631	11634	11153	11137	11630	11643
		time	117	113	125	164	110	110	120	122
197	156	$\|\mathcal{R}\|$	196	196	207	206	196	196	207	207
		WSC	11136	11137	11621	11632	11141	11166	11626	11634
		time	113	112	126	139	106	109	152	133
197	233	$\|\mathcal{R}\|$	196	196	207	207	196	196	207	207
		WSC	11131	11139	11650	11641	11139	11159	11649	11635
		time	111	111	146	126	111	106	137	121
197	309	$\|\mathcal{R}\|$	196	196	207	207	196	196	207	207
		WSC	11171	11137	11647	11631	11146	11145	11643	11637
		time	110	111	144	125	106	125	128	127

Table 88: Role-set size, WSC, and time value - Dataset Americas small

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
262	2	$\|\mathcal{R}\|$	262	262	262	262	262	262	263	263
		WSC	25104	25112	25348	25348	25124	25110	25350	25350
		time	173	185	194	193	185	200	202	205
262	79	$\|\mathcal{R}\|$	196	196	206	207	196	196	207	207
		WSC	11155	11167	11635	11633	11159	11156	11630	11653
		time	116	112	125	126	134	110	123	121
262	156	$\|\mathcal{R}\|$	196	196	207	207	196	196	207	207
		WSC	11155	11143	11642	11640	11148	11145	11650	11646
		time	131	112	123	137	118	108	126	142
262	233	$\|\mathcal{R}\|$	196	196	207	207	196	196	207	207
		WSC	11156	11137	11643	11645	11142	11162	11654	11632
		time	124	114	129	144	108	109	123	134
262	309	$\|\mathcal{R}\|$	196	196	207	207	196	196	207	207
		WSC	11153	11138	11636	11639	11139	11157	11633	11652
		time	112	109	126	137	111	109	144	123

Table 89: Role-set size, WSC, and time value - Dataset Americas small

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	19	17	7	1	18	7	0	0
PRUCC$_2$	21	17	5	0	18	7	0	0

	$\|\mathcal{R}\|$	WSC
better	4	16
equal	20	0
worse	1	9

Table 90: Minumum values - Dataset Americas small

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	6	2	16	0	1	4	3	18	0	0
OR	8	1	15	0	1	8	0	17	0	0
UF	18	5	1	0	1	20	4	1	0	0
UR	24	0	0	0	1	25	0	0	0	0

Table 91: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Americas small

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	7	18	0	0	0	7	18	0	0	0
OR	18	7	0	0	0	18	7	0	0	0
UF	25	0	0	0	0	25	0	0	0	0
UR	25	0	0	0	0	25	0	0	0	0

Table 92: Number of times variants reached minumum value for WSC - Dataset Americas small

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	2.62	3.82	4.96	5.86	2.0	3.68	5.56	6.1
PRUCC$_2$	2.66	4.02	5.48	6.58	2.14	4.18	5.64	6.7

Table 93: Heuristics ranking - Dataset Americas small

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas small	2.62	3.82	4.96	5.86	2.66	4.02	5.48	6.58

Table 94: Heuristics ranking on $\mathcal{R}$ - Dataset Americas small

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas small	2.0	3.68	5.56	6.1	2.14	4.18	5.64	6.7

Table 95: Heuristics ranking on WSC - Dataset Americas small

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas small	2.88	3.16	6.0	6.36	2.64	2.7	5.82	6.44

Table 96: Heuristics ranking on *time* - Dataset Americas small

3.3 Apj

			PRUCC$_1$				PRUCC$_2$			
mpr	mru		OF	OR	UF	UR	OF	OR	UF	UR
2	29	$\|\mathcal{R}\|$	782	805	784	802	782	807	785	803
		WSC	6720	6727	6666	6708	6725	6720	6668	6714
		time	219	219	208	217	201	212	194	197
2	36	$\|\mathcal{R}\|$	780	808	783	799	781	804	783	798
		WSC	6730	6735	6670	6710	6730	6752	6671	6707
		time	216	225	209	210	202	207	198	198
2	43	$\|\mathcal{R}\|$	780	805	784	800	781	804	783	798
		WSC	6725	6733	6671	6709	6730	6728	6669	6705
		time	219	223	203	209	201	212	193	203
2	50	$\|\mathcal{R}\|$	781	803	784	801	781	804	784	799
		WSC	6730	6722	6670	6712	6729	6725	6670	6706
		time	216	222	206	210	207	208	198	200
2	57	$\|\mathcal{R}\|$	781	807	783	799	781	802	783	801
		WSC	6727	6730	6669	6706	6728	6726	6670	6716
		time	219	218	210	209	206	206	196	207
14	5	$\|\mathcal{R}\|$	527	544	520	535	525	545	518	537
		WSC	5593	5841	5462	5672	5551	5860	5445	5727
		time	176	182	175	179	177	169	162	166
14	18	$\|\mathcal{R}\|$	469	469	470	470	469	469	470	470
		WSC	5193	5194	5150	5152	5196	5188	5152	5150
		time	166	171	184	194	154	160	176	206
14	31	$\|\mathcal{R}\|$	469	469	470	470	469	469	470	470
		WSC	5196	5192	5150	5157	5192	5192	5145	5146
		time	203	176	167	171	173	170	161	161
14	44	$\|\mathcal{R}\|$	469	469	470	470	469	469	470	470
		WSC	5195	5193	5147	5144	5195	5197	5143	5146
		time	168	171	171	173	164	161	158	162
14	57	$\|\mathcal{R}\|$	469	469	470	470	469	469	470	470
		WSC	5194	5190	5156	5150	5195	5198	5144	5144
		time	173	173	174	174	157	162	153	170
26	3	$\|\mathcal{R}\|$	507	508	509	509	506	508	509	509
		WSC	5882	5908	5874	5898	5879	5909	5876	5900
		time	199	189	193	193	178	179	176	179
26	16	$\|\mathcal{R}\|$	458	458	459	459	458	458	459	459
		WSC	5168	5171	5121	5124	5171	5170	5122	5126
		time	173	169	167	165	163	157	155	158
26	29	$\|\mathcal{R}\|$	458	458	459	459	458	458	459	459
		WSC	5165	5168	5130	5121	5169	5164	5120	5123
		time	171	166	166	169	157	157	154	156
26	42	$\|\mathcal{R}\|$	458	458	459	459	458	458	459	459
		WSC	5171	5165	5120	5121	5172	5169	5126	5126
		time	169	169	166	175	156	156	159	158
26	57	$\|\mathcal{R}\|$	458	458	459	459	458	458	459	459
		WSC	5171	5169	5121	5121	5170	5167	5126	5120
		time	171	170	186	169	156	162	168	156
38	2	$\|\mathcal{R}\|$	505	505	506	506	505	505	506	506
		WSC	5911	5911	5911	5911	5911	5911	5911	5911
		time	193	196	199	190	173	175	170	171
38	16	$\|\mathcal{R}\|$	454	454	455	455	454	454	455	455
		WSC	5161	5159	5113	5112	5158	5163	5112	5120
		time	167	169	168	166	156	157	159	156
38	30	$\|\mathcal{R}\|$	454	454	455	455	454	454	455	455
		WSC	5159	5159	5117	5112	5161	5157	5110	5116
		time	166	166	165	165	161	163	156	157
38	44	$\|\mathcal{R}\|$	454	454	455	455	454	454	455	455
		WSC	5160	5161	5111	5114	5161	5156	5114	5113
		time	166	165	164	165	157	159	153	155
38	57	$\|\mathcal{R}\|$	454	454	455	455	454	454	455	455
		WSC	5162	5162	5118	5113	5157	5158	5113	5118
		time	172	172	167	168	156	158	156	159

Table 97: Role-set size, WSC, and time value - Dataset Apj

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
51	2	$\|\mathcal{R}\|$	501	501	502	502	501	501	502	502
		WSC	5903	5903	5903	5903	5903	5903	5903	5903
		time	191	197	197	195	173	173	175	172
51	16	$\|\mathcal{R}\|$	454	454	455	455	454	454	455	455
		WSC	5161	5159	5112	5118	5164	5161	5110	5112
		time	167	171	167	166	158	160	159	156
51	30	$\|\mathcal{R}\|$	454	454	455	455	454	454	455	455
		WSC	5161	5162	5113	5114	5162	5159	5109	5115
		time	167	169	166	172	156	156	158	157
51	44	$\|\mathcal{R}\|$	454	454	455	455	454	454	455	455
		WSC	5160	5160	5110	5112	5160	5157	5116	5111
		time	166	165	163	165	156	157	156	171
51	57	$\|\mathcal{R}\|$	454	454	455	455	454	454	455	455
		WSC	5160	5163	5117	5118	5159	5161	5117	5111
		time	172	165	166	166	160	157	155	154

Table 98: Role-set size, WSC, and time value - Dataset Apj

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	24	18	1	0	2	2	19	9
PRUCC$_2$	24	18	1	0	2	2	20	9

	$\|\mathcal{R}\|$	WSC
better	2	8
equal	21	6
worse	2	11

Table 99: Minumum values - Dataset Apj

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	1	6	18	0	0	1	6	18	0	0
OR	7	0	18	0	0	7	0	18	0	0
UF	24	1	0	0	0	24	1	0	0	0
UR	25	0	0	0	0	25	0	0	0	0

Table 100: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Apj

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	23	0	0	0	2	23	0	0	0	2
OR	23	0	0	0	2	23	0	0	0	2
UF	6	16	1	0	2	5	16	2	0	2
UR	16	6	1	0	2	16	5	2	0	2

Table 101: Number of times variants reached minumum value for WSC - Dataset Apj

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	2.3	3.74	5.72	6.26	6.08	6.5	2.36	3.26
PRUCC$_2$	2.3	3.74	5.68	6.26	6.38	6.08	2.16	3.18

Table 102: Heuristics ranking - Dataset Apj

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Apj	2.3	3.74	5.72	6.26	2.3	3.74	5.68	6.26

Table 103: Heuristics ranking on $\mathcal{R}$ - Dataset Apj

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Apj	6.08	6.5	2.36	3.26	6.38	6.08	2.16	3.18

Table 104: Heuristics ranking on WSC - Dataset Apj

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Apj	6.72	6.76	5.58	6.12	2.78	3.28	1.96	2.8

Table 105: Heuristics ranking on *time* - Dataset Apj

3.4 Emea

			PRUCC$_1$				PRUCC$_2$			
mpr	mru		OF	OR	UF	UR	OF	OR	UF	UR
2	277	$\|\mathcal{R}\|$	1694	2133	1688	2137	1694	2135	1691	2145
		WSC	8774	10107	8736	10107	8774	10106	8745	10129
		time	131	190	122	190	127	195	126	199
2	346	$\|\mathcal{R}\|$	1673	2079	1669	2084	1673	2076	1669	2081
		WSC	8773	10044	8720	10015	8773	10030	8720	10020
		time	118	177	115	177	117	177	114	177
2	415	$\|\mathcal{R}\|$	1673	2075	1669	2085	1673	2072	1669	2077
		WSC	8773	10051	8720	10030	8773	10030	8720	10005
		time	117	178	116	184	116	178	116	177
2	484	$\|\mathcal{R}\|$	1673	2075	1669	2080	1673	2078	1669	2075
		WSC	8773	10038	8720	10022	8773	10044	8720	10011
		time	117	179	117	178	116	180	115	177
2	553	$\|\mathcal{R}\|$	1673	2065	1669	2078	1673	2073	1669	2083
		WSC	8773	10012	8720	10016	8773	10032	8720	10025
		time	117	181	116	178	117	180	119	182
140	4	$\|\mathcal{R}\|$	65	69	65	69	65	69	65	69
		WSC	6619	7218	6619	7280	6619	7299	6619	7207
		time	6	10	6	10	7	12	6	12
140	141	$\|\mathcal{R}\|$	65	69	65	69	65	69	65	69
		WSC	6618	7156	6618	7168	6618	7178	6618	7164
		time	5	9	5	9	5	9	5	9
140	278	$\|\mathcal{R}\|$	65	68	65	69	65	69	65	69
		WSC	6618	7116	6618	7163	6618	7194	6618	7160
		time	5	9	5	9	5	9	5	9
140	415	$\|\mathcal{R}\|$	65	69	65	69	65	69	65	69
		WSC	6618	7198	6618	7195	6618	7173	6618	7205
		time	5	9	5	9	5	9	5	9
140	553	$\|\mathcal{R}\|$	65	68	65	69	65	69	65	69
		WSC	6618	7146	6618	7200	6618	7166	6618	7191
		time	5	9	5	9	5	9	5	9
278	2	$\|\mathcal{R}\|$	45	47	45	47	45	47	45	47
		WSC	6748	7306	6748	7306	6748	7306	6748	7306
		time	5	8	5	9	5	8	5	8
278	140	$\|\mathcal{R}\|$	45	46	45	47	45	46	45	47
		WSC	6748	7233	6748	7218	6748	7225	6748	7227
		time	5	7	5	7	5	7	5	7
278	278	$\|\mathcal{R}\|$	45	47	45	47	45	46	45	47
		WSC	6748	7235	6748	7203	6748	7235	6748	7236
		time	5	7	5	7	5	8	5	8
278	416	$\|\mathcal{R}\|$	45	47	45	47	45	47	45	47
		WSC	6748	7229	6748	7223	6748	7248	6748	7230
		time	5	7	5	7	5	7	5	7
278	553	$\|\mathcal{R}\|$	45	47	45	47	45	47	45	47
		WSC	6748	7253	6748	7257	6748	7230	6748	7230
		time	5	7	5	7	5	7	5	8
416	2	$\|\mathcal{R}\|$	39	39	39	39	39	39	39	39
		WSC	7290	7290	7290	7290	7290	7290	7290	7290
		time	4	6	4	6	5	6	5	6
416	140	$\|\mathcal{R}\|$	39	39	39	39	39	39	39	39
		WSC	7290	7290	7290	7290	7290	7290	7290	7290
		time	5	6	5	6	4	6	5	6
416	278	$\|\mathcal{R}\|$	39	39	39	39	39	39	39	39
		WSC	7290	7290	7290	7290	7290	7290	7290	7290
		time	5	6	5	6	5	6	5	6
416	416	$\|\mathcal{R}\|$	39	39	39	39	39	39	39	39
		WSC	7290	7290	7290	7290	7290	7290	7290	7290
		time	5	6	5	6	5	6	4	6
416	553	$\|\mathcal{R}\|$	39	39	39	39	39	39	39	39
		WSC	7290	7290	7290	7290	7290	7290	7290	7290
		time	5	6	4	6	5	6	4	6

Table 106: Role-set size, WSC, and time value - Dataset Apj

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
553	2	$\|\mathcal{R}\|$	35	35	35	35	35	35	35	35
		WSC	7282	7282	7282	7282	7282	7282	7282	7282
		time	4	5	4	5	4	5	4	5
553	140	$\|\mathcal{R}\|$	35	35	35	35	35	35	35	35
		WSC	7282	7282	7282	7282	7282	7282	7282	7282
		time	4	5	4	5	4	5	4	5
553	278	$\|\mathcal{R}\|$	35	35	35	35	35	35	35	35
		WSC	7282	7282	7282	7282	7282	7282	7282	7282
		time	4	5	4	5	4	5	4	5
553	416	$\|\mathcal{R}\|$	35	35	35	35	35	35	35	35
		WSC	7282	7282	7282	7282	7282	7282	7282	7282
		time	5	5	4	5	4	5	4	5
553	553	$\|\mathcal{R}\|$	35	35	35	35	35	35	35	35
		WSC	7282	7282	7282	7282	7282	7282	7282	7282
		time	4	5	4	5	4	5	5	5

Table 107: Role-set size, WSC, and time value - Dataset Emea

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	20	10	25	10	20	10	25	10
PRUCC$_2$	20	10	25	10	20	10	25	10

	$\|\mathcal{R}\|$	WSC
better	1	1
equal	24	24
worse	0	0

Table 108: Minumum values - Dataset Emea

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	5	0	10	0	10	5	0	10	0	10
OR	15	0	0	0	10	15	0	0	0	10
UF	0	5	10	0	10	0	5	10	0	10
UR	15	0	0	0	10	15	0	0	0	10

Table 109: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Emea

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	5	0	10	0	10	5	0	10	0	10
OR	15	0	0	0	10	15	0	0	0	10
UF	0	5	10	0	10	0	5	10	0	10
UR	15	0	0	0	10	15	0	0	0	10

Table 110: Number of times variants reached minumum value for WSC - Dataset Emea

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	3.5	5.36	3.08	6.02	3.5	5.66	3.08	5.58
PRUCC$_2$	3.5	5.5	3.12	5.92	3.5	5.88	3.12	5.68

Table 111: Heuristics ranking - Dataset Emea

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Emea	3.5	5.36	3.08	6.02	3.5	5.5	3.12	5.92

Table 112: Heuristics ranking on $\mathcal{R}$ - Dataset Emea

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Emea	3.5	5.66	3.08	5.58	3.5	5.88	3.12	5.68

Table 113: Heuristics ranking on WSC - Dataset Emea

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Emea	2.86	6.34	2.28	6.36	2.56	6.56	2.46	6.58

Table 114: Heuristics ranking on *time* - Dataset Emea

3.5 Healthcare

			PRUCC_1				PRUCC_2			
mpr	mru		OF	OR	UF	UR	OF	OR	UF	UR
2	23	$\lvert\mathcal{R}\rvert$	34	33	33	33	35	35	34	34
		WSC	879	875	879	876	882	881	880	884
		time	3	3	3	3	4	5	4	4
2	28	$\lvert\mathcal{R}\rvert$	33	30	28	31	33	31	28	29
		WSC	955	940	936	944	955	940	937	932
		time	2	2	2	2	2	2	2	2
2	33	$\lvert\mathcal{R}\rvert$	29	29	28	30	29	28	28	29
		WSC	955	954	942	948	955	950	936	945
		time	2	2	2	2	3	2	2	2
2	38	$\lvert\mathcal{R}\rvert$	29	29	28	29	29	28	28	29
		WSC	955	952	940	942	955	949	940	948
		time	2	2	2	2	2	2	2	2
2	45	$\lvert\mathcal{R}\rvert$	29	29	28	29	29	28	28	30
		WSC	955	952	936	937	955	949	936	944
		time	2	2	2	2	2	2	2	2
9	6	$\lvert\mathcal{R}\rvert$	22	21	22	21	22	23	22	24
		WSC	342	337	342	337	342	360	344	365
		time	2	2	2	2	3	3	3	3
9	16	$\lvert\mathcal{R}\rvert$	16	16	16	16	16	16	16	16
		WSC	477	477	447	448	477	477	449	449
		time	1	1	1	1	1	1	1	1
9	26	$\lvert\mathcal{R}\rvert$	16	16	16	16	16	16	16	16
		WSC	477	477	449	448	477	477	452	449
		time	1	1	1	1	1	1	1	1
9	36	$\lvert\mathcal{R}\rvert$	16	16	16	16	16	16	16	16
		WSC	477	477	447	449	477	477	451	452
		time	1	1	1	1	1	1	1	1
9	45	$\lvert\mathcal{R}\rvert$	16	16	16	16	16	16	16	16
		WSC	477	477	447	452	477	477	452	451
		time	1	1	1	1	1	1	1	1
16	3	$\lvert\mathcal{R}\rvert$	21	20	21	20	21	21	21	22
		WSC	329	325	329	327	329	344	329	346
		time	2	2	2	2	3	3	3	3
16	13	$\lvert\mathcal{R}\rvert$	17	17	15	15	17	17	15	15
		WSC	285	285	401	405	285	300	403	408
		time	1	2	1	1	2	2	1	1
16	23	$\lvert\mathcal{R}\rvert$	15	15	15	15	15	15	15	15
		WSC	431	431	403	401	431	431	405	405
		time	1	1	1	1	1	1	1	1
16	33	$\lvert\mathcal{R}\rvert$	15	15	15	15	15	15	15	15
		WSC	431	431	405	406	431	431	403	405
		time	1	1	1	1	1	1	1	1
16	45	$\lvert\mathcal{R}\rvert$	15	15	15	15	15	15	15	15
		WSC	431	431	403	403	431	431	403	402
		time	1	1	1	1	1	1	1	1
23	2	$\lvert\mathcal{R}\rvert$	21	24	21	23	20	27	22	27
		WSC	356	386	356	385	354	467	391	469
		time	2	2	2	2	3	3	3	3
23	13	$\lvert\mathcal{R}\rvert$	16	16	14	14	16	16	14	14
		WSC	409	409	356	360	409	409	356	357
		time	1	1	1	1	1	1	1	1
23	24	$\lvert\mathcal{R}\rvert$	14	14	14	14	14	14	14	14
		WSC	385	385	359	355	385	385	355	360
		time	1	1	1	1	1	1	1	1
23	35	$\lvert\mathcal{R}\rvert$	14	14	14	14	14	14	14	14
		WSC	385	385	359	355	385	385	355	359
		time	1	1	1	1	1	1	1	1
23	45	$\lvert\mathcal{R}\rvert$	14	14	14	14	14	14	14	14
		WSC	385	385	355	356	385	385	355	356
		time	1	1	1	1	1	1	1	1
31	2	$\lvert\mathcal{R}\rvert$	21	21	21	21	21	22	21	21
		WSC	449	449	449	449	449	481	449	480
		time	2	2	2	2	3	3	3	3

Table 115: Role-set size, WSC, and time value - Dataset Healthcare

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
31	13	$\|\mathcal{R}\|$	16	16	14	14	16	16	14	14
		WSC	409	409	356	359	409	409	355	355
		time	1	1	1	1	1	1	1	1
31	24	$\|\mathcal{R}\|$	14	14	14	14	14	14	14	14
		WSC	385	385	360	356	385	385	359	356
		time	1	1	1	1	1	1	1	1
31	35	$\|\mathcal{R}\|$	14	14	14	14	14	14	14	14
		WSC	385	385	356	357	385	385	356	357
		time	1	1	1	1	1	1	1	1
31	45	$\|\mathcal{R}\|$	14	14	14	14	14	14	14	14
		WSC	385	385	359	360	385	385	355	355
		time	1	1	1	1	1	1	1	1

Table 116: Role-set size, WSC, and time value - Dataset Healthcare

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	15	17	23	20	3	5	16	8
PRUCC$_2$	17	17	24	18	5	0	17	9

	$\|\mathcal{R}\|$	WSC
better	3	8
equal	21	10
worse	1	7

Table 117: Minumum values - Dataset Healthcare

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	10	0	1	0	14	8	1	1	2	13
OR	8	0	2	1	14	8	0	3	1	13
UF	2	4	4	1	14	1	1	8	2	13
UR	5	0	5	1	14	7	0	4	1	13

Table 118: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Healthcare

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	22	0	2	0	1	20	3	2	0	0
OR	20	2	2	0	1	25	0	0	0	0
UF	9	13	2	0	1	8	11	6	0	0
UR	17	5	2	0	1	16	5	4	0	0

Table 119: Number of times variants reached minumum value for WSC - Dataset Healthcare

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	4.94	4.56	3.66	4.2	5.9	5.36	2.56	3.04
PRUCC$_2$	4.98	4.98	3.84	4.84	5.98	6.24	2.92	4.0

Table 120: Heuristics ranking - Dataset Healthcare

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Healthcare	4.94	4.56	3.66	4.2	4.98	4.98	3.84	4.84

Table 121: Heuristics ranking on $\mathcal{R}$ - Dataset Healthcare

WSC	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Healthcare	5.9	5.36	2.56	3.04	5.98	6.24	2.92	4.0

Table 122: Heuristics ranking on WSC - Dataset Healthcare

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Healthcare	4.02	4.18	4.02	4.02	5.12	5.04	4.8	4.8

Table 123: Heuristics ranking on *time* - Dataset Healthcare

3.6 Domino

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
2	105	$\|\mathcal{R}\|$	141	143	142	144	141	144	142	143
		WSC	850	856	857	863	849	859	857	859
		time	3	4	3	4	4	4	4	4
2	131	$\|\mathcal{R}\|$	134	136	134	135	134	136	134	135
		WSC	841	847	843	847	840	847	843	848
		time	3	3	3	3	3	3	3	3
2	157	$\|\mathcal{R}\|$	134	136	134	135	134	136	134	135
		WSC	840	843	843	848	841	847	843	847
		time	3	4	3	4	3	4	3	4
2	183	$\|\mathcal{R}\|$	134	135	134	135	134	136	134	135
		WSC	841	845	843	846	841	845	843	845
		time	3	3	3	3	3	3	3	3
2	208	$\|\mathcal{R}\|$	134	136	134	135	134	135	134	135
		WSC	840	846	843	846	840	843	843	846
		time	3	3	3	3	3	3	3	3
52	5	$\|\mathcal{R}\|$	28	27	28	27	27	28	27	28
		WSC	714	687	727	710	663	763	674	763
		time	1	2	1	2	2	2	2	2
52	56	$\|\mathcal{R}\|$	24	24	24	24	24	25	24	24
		WSC	617	640	629	647	620	647	629	647
		time	1	1	1	1	1	1	1	1
52	107	$\|\mathcal{R}\|$	24	24	24	24	24	25	24	24
		WSC	617	620	629	655	619	643	629	636
		time	1	1	1	1	1	1	1	1
52	158	$\|\mathcal{R}\|$	24	24	24	24	24	24	24	24
		WSC	620	632	629	645	616	638	629	651
		time	1	1	1	1	1	1	1	1
52	208	$\|\mathcal{R}\|$	24	24	24	24	24	24	24	24
		WSC	620	640	629	642	617	627	629	641
		time	1	1	1	1	1	1	1	1
102	3	$\|\mathcal{R}\|$	25	25	26	26	25	25	26	25
		WSC	761	767	774	774	764	763	774	773
		time	1	2	2	2	2	2	2	2
102	54	$\|\mathcal{R}\|$	22	22	22	22	22	22	22	22
		WSC	758	750	765	761	754	749	765	761
		time	1	1	1	1	1	1	1	1
102	105	$\|\mathcal{R}\|$	22	22	22	22	22	22	22	22
		WSC	754	753	765	760	758	752	765	760
		time	1	1	1	1	1	1	1	1
102	156	$\|\mathcal{R}\|$	22	22	22	22	22	22	22	22
		WSC	752	751	765	759	755	746	765	762
		time	1	1	1	1	1	1	1	1
102	208	$\|\mathcal{R}\|$	22	22	22	22	22	22	22	22
		WSC	756	754	765	757	755	749	765	758
		time	1	1	1	1	1	1	1	1
152	2	$\|\mathcal{R}\|$	22	22	23	23	22	22	23	23
		WSC	757	754	763	763	755	756	763	763
		time	1	2	1	2	2	2	2	2
152	53	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	753	752	763	763	750	753	763	763
		time	1	1	1	1	1	1	1	1
152	104	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	757	750	763	763	750	750	763	763
		time	1	1	1	1	1	1	1	1
152	155	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	755	755	763	763	752	752	763	763
		time	1	1	1	1	1	1	1	1
152	208	$\|\mathcal{R}\|$	21	21	21	21	21	21	21	21
		WSC	752	749	763	763	752	754	763	763
		time	1	1	1	1	1	1	1	1

Table 124: Role-set size, WSC, and time value - Dataset Domino

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
200	2	$\|\mathcal{R}\|$	22	22	23	23	22	22	23	23
		WSC	756	758	763	763	758	756	763	763
		time	1	2	1	2	2	2	2	2
200	53	$\|\mathcal{R}\|$	20	20	20	20	20	20	20	20
		WSC	752	755	761	761	749	751	761	761
		time	1	1	1	1	1	1	1	1
200	104	$\|\mathcal{R}\|$	20	20	20	20	20	20	20	20
		WSC	749	752	761	761	754	752	761	761
		time	1	1	1	1	1	1	1	1
200	155	$\|\mathcal{R}\|$	20	20	20	20	20	20	20	20
		WSC	750	752	761	761	752	755	761	761
		time	1	1	1	1	1	1	1	1
200	208	$\|\mathcal{R}\|$	20	20	20	20	20	20	20	20
		WSC	753	752	761	761	750	751	761	761
		time	1	1	1	1	1	1	1	1

Table 125: Role-set size, WSC, and time value - Dataset Domino

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	24	20	20	17	15	11	0	0
PRUCC$_2$	25	17	21	17	18	9	0	0

	$\|\mathcal{R}\|$	WSC
better	0	8
equal	25	4
worse	0	13

Table 126: Minumum values - Dataset Domino

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	1	1	7	0	16	0	1	7	3	14
OR	5	0	4	0	16	8	0	2	1	14
UF	5	0	4	0	16	4	0	5	2	14
UR	8	0	1	0	16	8	0	0	3	14

Table 127: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Domino

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	10	14	1	0	0	7	16	2	0	0
OR	14	10	1	0	0	16	7	2	0	0
UF	25	0	0	0	0	25	0	0	0	0
UR	25	0	0	0	0	25	0	0	0	0

Table 128: Number of times variants reached minumum value for WSC - Dataset Domino

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	3.88	4.64	4.44	4.96	2.48	3.4	5.74	6.56
PRUCC$_2$	3.72	5.2	4.28	4.88	2.08	3.66	5.58	6.5

Table 129: Heuristics ranking - Dataset Domino

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Domino	3.88	4.64	4.44	4.96	3.72	5.2	4.28	4.88

Table 130: Heuristics ranking on $\mathcal{R}$ - Dataset Domino

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Domino	2.48	3.4	5.74	6.56	2.08	3.66	5.58	6.5

Table 131: Heuristics ranking on WSC - Dataset Domino

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Domino	3.8	4.76	3.96	4.76	4.6	4.76	4.6	4.76

Table 132: Heuristics ranking on *time* - Dataset Domino

3.7 Customer

			PRUCC_1				PRUCC_2			
mpr	mru		OF	OR	UF	UR	OF	OR	UF	UR
2	13	$\|\mathcal{R}\|$	594	610	595	616	620	626	619	625
		WSC	45981	46011	46017	46079	46062	46071	46090	46108
		time	628	621	654	678	591	596	647	639
2	16	$\|\mathcal{R}\|$	417	427	418	427	427	427	426	426
		WSC	46027	46037	46056	46084	46042	46038	46083	46081
		time	589	626	634	634	574	593	614	621
2	19	$\|\mathcal{R}\|$	351	353	351	353	356	357	352	354
		WSC	45991	45983	46027	46033	45999	46010	46031	46039
		time	598	604	627	623	575	589	614	612
2	22	$\|\mathcal{R}\|$	300	298	297	297	301	299	298	297
		WSC	45982	45972	46007	46007	45981	45989	46010	46008
		time	604	584	646	628	570	568	602	612
2	24	$\|\mathcal{R}\|$	290	290	288	288	290	290	288	288
		WSC	45957	45968	46002	46002	45974	45962	46002	46002
		time	608	583	634	637	582	569	619	600
8	4	$\|\mathcal{R}\|$	4303	4366	4305	4365	4377	4469	4381	4469
		WSC	49738	50016	49743	49998	50551	50969	50581	50937
		time	3397	3380	3454	3483	3599	3914	3708	3792
8	9	$\|\mathcal{R}\|$	1401	1506	1411	1522	1453	1562	1461	1570
		WSC	46968	47392	47023	47497	47450	47865	47492	47934
		time	808	817	828	848	795	807	829	858
8	14	$\|\mathcal{R}\|$	440	440	439	439	443	446	441	444
		WSC	46153	46153	46197	46192	46202	46201	46241	46244
		time	595	605	629	631	591	580	622	619
8	19	$\|\mathcal{R}\|$	318	322	317	319	320	324	316	320
		WSC	45963	45986	46005	46021	45981	45999	46011	46034
		time	591	598	626	635	573	578	612	609
8	24	$\|\mathcal{R}\|$	282	282	279	279	282	281	279	279
		WSC	45945	45930	45984	45984	45941	45943	45984	45984
		time	590	588	634	630	555	581	599	611
14	2	$\|\mathcal{R}\|$	5370	5374	5371	5374	5372	5375	5372	5375
		WSC	50450	50466	50450	50466	50479	50470	50478	50475
		time	5567	5494	5491	5481	5478	5399	5249	5249
14	7	$\|\mathcal{R}\|$	1798	1801	1805	1808	1800	1803	1806	1807
		WSC	48509	48539	48555	48577	48548	48557	48582	48580
		time	999	990	1038	1057	1014	982	1009	1019
14	12	$\|\mathcal{R}\|$	501	503	502	503	503	505	503	505
		WSC	46340	46362	46385	46391	46367	46367	46414	46420
		time	628	607	670	661	592	600	639	644
14	17	$\|\mathcal{R}\|$	333	334	332	333	335	338	332	333
		WSC	46021	46023	46057	46054	46030	46039	46078	46078
		time	598	602	630	638	573	575	617	617
14	24	$\|\mathcal{R}\|$	281	281	278	278	281	280	278	278
		WSC	45945	45944	45982	45982	45937	45949	45982	45982
		time	594	594	630	633	569	568	619	630
20	2	$\|\mathcal{R}\|$	5328	5330	5329	5330	5328	5330	5329	5330
		WSC	50412	50416	50412	50415	50411	50412	50412	50414
		time	5550	5455	5431	5444	5437	5286	5181	5129
20	7	$\|\mathcal{R}\|$	1760	1759	1766	1766	1759	1760	1765	1765
		WSC	48492	48482	48523	48524	48471	48483	48519	48519
		time	998	989	1014	1026	971	958	976	957
20	12	$\|\mathcal{R}\|$	463	463	463	463	462	462	462	462
		WSC	46321	46299	46353	46353	46315	46323	46351	46351
		time	600	594	630	619	565	553	604	601
20	17	$\|\mathcal{R}\|$	312	313	311	311	312	312	310	309
		WSC	46011	46013	46048	46048	46014	46013	46046	46043
		time	576	577	632	630	550	572	644	626
20	24	$\|\mathcal{R}\|$	280	281	278	278	280	280	278	278
		WSC	45944	45939	45982	45982	45951	45950	45982	45982
		time	594	596	636	645	585	568	607	620

Table 133: Role-set size, WSC, and time value - Dataset Customer

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
24	2	$\|\mathcal{R}\|$	5323	5322	5324	5323	5323	5322	5324	5323
		WSC	50402	50399	50402	50400	50402	50400	50402	50400
		time	5553	5494	5471	5473	5418	5333	5236	5127
24	7	$\|\mathcal{R}\|$	1754	1755	1760	1760	1755	1753	1759	1759
		WSC	48477	48484	48511	48511	48485	48468	48507	48507
		time	977	967	996	992	928	923	974	973
24	12	$\|\mathcal{R}\|$	457	456	457	457	456	457	456	456
		WSC	46305	46294	46341	46341	46286	46296	46339	46339
		time	594	582	621	610	567	576	593	605
24	17	$\|\mathcal{R}\|$	306	308	305	305	307	307	304	304
		WSC	46002	45976	46036	46036	45993	45990	46034	46034
		time	574	593	627	614	569	566	609	584
24	24	$\|\mathcal{R}\|$	279	280	277	277	280	280	277	277
		WSC	45940	45915	45980	45980	45937	45937	45980	45980
		time	570	578	595	622	559	559	592	598

Table 134: Role-set size, WSC, and time value - Dataset Customer

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	11	4	13	10	14	12	2	0
PRUCC$_2$	9	3	16	11	16	11	0	1

	$\|\mathcal{R}\|$	WSC
better	9	20
equal	11	0
worse	5	5

Table 135: Minumum values - Dataset Customer

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	14	9	1	0	1	16	5	2	1	1
OR	21	3	0	0	1	22	2	0	0	1
UF	12	2	10	0	1	9	5	9	1	1
UR	15	0	9	0	1	14	2	7	1	1

Table 136: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Customer

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	11	11	3	0	0	9	14	2	0	0
OR	13	11	1	0	0	14	8	3	0	0
UF	23	0	2	0	0	25	0	0	0	0
UR	25	0	0	0	0	24	0	1	0	0

Table 137: Number of times variants reached minumum value for WSC - Dataset Customer

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	3.72	5.22	3.36	4.48	2.32	2.22	5.4	6.16
PRUCC$_2$	5.04	5.98	3.62	4.58	3.34	3.76	6.3	6.5

Table 138: Heuristics ranking - Dataset Customer

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Customer	3.72	5.22	3.36	4.48	5.04	5.98	3.62	4.58

Table 139: Heuristics ranking on $\mathcal{R}$ - Dataset Customer

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Customer	2.32	2.22	5.4	6.16	3.34	3.76	6.3	6.5

Table 140: Heuristics ranking on WSC - Dataset Customer

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Customer	4.18	3.98	6.8	7.1	2.14	2.02	4.92	4.86

Table 141: Heuristics ranking on *time* - Dataset Customer

3.8 Firewall 1

			PRUCC_1				PRUCC_2			
mpr	mru		OF	OR	UF	UR	OF	OR	UF	UR
2	309	$\lvert\mathcal{R}\rvert$	408	422	407	418	408	422	408	419
		WSC	17981	18183	17935	18052	17981	18104	17944	18140
		time	73	68	62	68	70	69	67	78
2	386	$\lvert\mathcal{R}\rvert$	391	403	390	400	391	402	390	400
		WSC	17963	18083	17910	18082	17961	18199	17909	18014
		time	77	83	77	69	83	76	76	73
2	463	$\lvert\mathcal{R}\rvert$	391	402	390	400	390	401	390	400
		WSC	17954	18216	17898	18143	17959	18108	17913	18069
		time	66	68	60	62	71	70	73	67
2	540	$\lvert\mathcal{R}\rvert$	391	401	390	400	391	403	390	401
		WSC	17957	18101	17913	18062	17963	18209	17911	18047
		time	63	65	60	62	64	69	64	66
2	616	$\lvert\mathcal{R}\rvert$	390	402	390	402	391	402	390	400
		WSC	17953	17992	17907	18110	17963	18210	17902	18028
		time	76	66	58	63	66	72	62	68
100	7	$\lvert\mathcal{R}\rvert$	101	105	106	111	109	117	109	118
		WSC	4944	5439	4959	5515	5883	6675	5637	6529
		time	29	31	27	31	40	42	46	52
100	159	$\lvert\mathcal{R}\rvert$	68	68	71	71	68	68	71	71
		WSC	3304	3304	3280	3281	3304	3303	3281	3281
		time	15	15	15	16	15	16	15	16
100	311	$\lvert\mathcal{R}\rvert$	68	68	71	71	68	68	71	71
		WSC	3304	3304	3279	3280	3304	3304	3281	3280
		time	15	16	15	16	15	16	15	15
100	463	$\lvert\mathcal{R}\rvert$	68	68	71	71	68	68	71	71
		WSC	3303	3303	3280	3282	3303	3304	3280	3281
		time	16	15	16	16	16	16	15	17
100	616	$\lvert\mathcal{R}\rvert$	68	68	71	71	68	68	71	71
		WSC	3303	3303	3282	3281	3303	3304	3281	3281
		time	16	16	15	20	15	16	17	19
198	4	$\lvert\mathcal{R}\rvert$	92	92	93	93	94	95	95	95
		WSC	6221	6221	6230	6231	6792	6818	6798	6805
		time	46	47	46	48	110	130	103	96
198	157	$\lvert\mathcal{R}\rvert$	66	66	69	69	66	66	69	69
		WSC	3299	3300	3277	3276	3299	3300	3277	3277
		time	20	20	15	17	20	19	15	17
198	310	$\lvert\mathcal{R}\rvert$	66	66	69	69	66	66	69	69
		WSC	3300	3300	3278	3277	3300	3299	3277	3277
		time	18	15	18	16	18	15	17	17
198	463	$\lvert\mathcal{R}\rvert$	66	66	69	69	66	66	69	69
		WSC	3299	3300	3277	3277	3299	3300	3277	3277
		time	16	15	16	18	15	16	16	16
198	616	$\lvert\mathcal{R}\rvert$	66	66	69	69	66	66	69	69
		WSC	3300	3300	3276	3276	3300	3300	3276	3276
		time	20	17	16	15	19	16	15	17
296	3	$\lvert\mathcal{R}\rvert$	87	87	89	89	87	87	89	89
		WSC	6952	6952	6960	6963	6952	6952	6960	6959
		time	44	43	42	42	109	96	98	94
296	156	$\lvert\mathcal{R}\rvert$	66	66	69	69	66	66	69	69
		WSC	3300	3301	3278	3277	3301	3301	3276	3277
		time	14	15	15	16	15	15	17	15
296	309	$\lvert\mathcal{R}\rvert$	66	66	69	69	66	66	69	69
		WSC	3300	3300	3278	3277	3299	3300	3276	3277
		time	15	15	15	15	15	15	15	15
296	462	$\lvert\mathcal{R}\rvert$	66	66	69	69	66	66	69	69
		WSC	3299	3301	3277	3276	3300	3301	3277	3275
		time	15	14	15	15	15	15	15	15
296	616	$\lvert\mathcal{R}\rvert$	66	66	69	69	66	66	69	69
		WSC	3300	3299	3276	3277	3301	3300	3276	3277
		time	15	15	14	15	15	15	15	15

Table 142: Role-set size, WSC, and time value - Dataset Firewall 1

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
394	2	$\|\mathcal{R}\|$	90	90	91	92	90	90	91	91
		WSC	7116	7116	7122	7123	7116	7116	7121	7120
		time	42	42	43	43	96	103	93	95
394	155	$\|\mathcal{R}\|$	65	65	68	68	65	65	68	68
		WSC	3298	3297	3276	3276	3297	3298	3276	3274
		time	15	15	15	15	15	15	15	15
394	308	$\|\mathcal{R}\|$	65	65	68	68	65	65	68	68
		WSC	3297	3299	3273	3274	3297	3297	3275	3275
		time	15	15	15	15	16	15	15	14
394	461	$\|\mathcal{R}\|$	65	65	68	68	65	65	68	68
		WSC	3297	3298	3275	3276	3297	3298	3276	3275
		time	15	15	15	16	15	15	15	18
394	616	$\|\mathcal{R}\|$	65	65	68	68	65	65	68	68
		WSC	3298	3298	3276	3275	3298	3299	3274	3274
		time	16	15	16	16	16	15	17	18

Table 143: Role-set size, WSC, and time value - Dataset Firewall 1

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	21	19	5	0	4	3	14	10
PRUCC$_2$	22	18	6	0	3	2	18	12

	$\|\mathcal{R}\|$	WSC
better	3	8
equal	22	9
worse	0	8

Table 144: Minumum values - Dataset Firewall 1

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	4	1	20	0	0	3	1	21	0	0
OR	6	0	19	0	0	7	0	18	0	0
UF	20	4	1	0	0	19	3	3	0	0
UR	25	0	0	0	0	25	0	0	0	0

Table 145: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Firewall 1

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	21	1	3	0	0	22	1	2	0	0
OR	22	0	3	0	0	23	0	2	0	0
UF	11	11	3	0	0	7	10	8	0	0
UR	15	7	3	0	0	13	4	8	0	0

Table 146: Number of times variants reached minumum value for WSC - Dataset Firewall 1

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	2.54	3.42	5.24	6.24	4.9	6.08	2.74	3.86
PRUCC$_2$	2.82	3.82	5.52	6.4	5.34	6.72	2.78	3.58

Table 147: Heuristics ranking - Dataset Firewall 1

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 1	2.54	3.42	5.24	6.24	2.82	3.82	5.52	6.4

Table 148: Heuristics ranking on $\mathcal{R}$ - Dataset Firewall 1

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 1	4.9	6.08	2.74	3.86	5.34	6.72	2.78	3.58

Table 149: Heuristics ranking on WSC - Dataset Firewall 1

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 1	4.4	3.88	3.12	4.36	5.22	5.12	4.52	5.38

Table 150: Heuristics ranking on *time* - Dataset Firewall 1

3.9 Firewall 2

			PRUCC_1				PRUCC_2			
mpr	mru		OF	OR	UF	UR	OF	OR	UF	UR
2	295	$\lvert\mathcal{R}\rvert$	298	308	298	298	298	308	298	298
		WSC	19233	19271	19233	19234	19233	19271	19233	19234
		time	153	189	149	172	255	251	220	247
2	368	$\lvert\mathcal{R}\rvert$	297	303	297	297	297	304	297	297
		WSC	19321	19651	19321	19321	19321	19672	19321	19321
		time	83	100	91	92	95	97	90	92
2	441	$\lvert\mathcal{R}\rvert$	297	304	297	297	297	303	297	297
		WSC	19321	19672	19321	19321	19321	19651	19321	19322
		time	86	105	89	106	85	116	91	117
2	514	$\lvert\mathcal{R}\rvert$	297	303	297	297	297	303	297	297
		WSC	19321	19621	19321	19322	19321	19643	19321	19322
		time	83	106	78	84	104	100	80	99
2	589	$\lvert\mathcal{R}\rvert$	297	304	297	297	297	303	297	297
		WSC	19321	19702	19321	19321	19321	19632	19321	19323
		time	81	104	97	87	93	114	101	99
78	8	$\lvert\mathcal{R}\rvert$	17	17	17	17	19	19	19	19
		WSC	1589	1589	1611	1611	1747	1747	1769	1769
		time	31	35	37	35	77	78	69	80
78	153	$\lvert\mathcal{R}\rvert$	16	16	16	16	16	16	16	16
		WSC	1863	1863	1885	1885	1863	1863	1885	1885
		time	10	13	10	11	13	12	10	10
78	298	$\lvert\mathcal{R}\rvert$	16	16	16	16	16	16	16	16
		WSC	1863	1863	1885	1885	1863	1863	1885	1885
		time	10	11	12	12	10	12	11	11
78	443	$\lvert\mathcal{R}\rvert$	16	16	16	16	16	16	16	16
		WSC	1863	1863	1885	1885	1863	1863	1885	1885
		time	11	10	9	10	14	10	9	10
78	589	$\lvert\mathcal{R}\rvert$	16	16	16	16	16	16	16	16
		WSC	1863	1863	1885	1885	1863	1863	1885	1885
		time	10	10	12	12	11	11	11	10
154	4	$\lvert\mathcal{R}\rvert$	15	15	14	14	15	15	16	16
		WSC	1522	1522	1450	1450	1663	1663	1630	1630
		time	32	29	33	37	78	73	78	72
154	150	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1649	1649	1671	1671	1649	1649	1671	1671
		time	10	9	9	9	11	9	9	13
154	296	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1649	1649	1671	1671	1649	1649	1671	1671
		time	9	9	9	10	11	9	10	11
154	442	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1649	1649	1671	1671	1649	1649	1671	1671
		time	9	9	10	10	9	9	9	11
154	589	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1649	1649	1671	1671	1649	1649	1671	1671
		time	10	9	9	9	8	9	9	9
230	3	$\lvert\mathcal{R}\rvert$	13	13	13	13	14	14	14	14
		WSC	1371	1371	1371	1371	1613	1613	1613	1613
		time	31	38	35	35	78	78	90	72
230	149	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1649	1649	1671	1671	1649	1649	1671	1671
		time	9	9	9	10	9	9	12	10
230	295	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1649	1649	1671	1671	1649	1649	1671	1671
		time	10	11	8	9	11	8	8	9
230	441	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1649	1649	1671	1671	1649	1649	1671	1671
		time	8	9	8	9	8	8	9	9
230	589	$\lvert\mathcal{R}\rvert$	12	12	12	12	12	12	12	12
		WSC	1649	1649	1671	1671	1649	1649	1671	1671
		time	8	9	8	9	8	9	8	9

Table 151: Role-set size, WSC, and time value - Dataset Firewall 2

mpr	mru		PRUCC$_1$				PRUCC$_2$			
			OF	OR	UF	UR	OF	OR	UF	UR
306	2	$\|\mathcal{R}\|$	12	12	12	12	12	12	12	12
		WSC	1541	1541	1541	1541	1552	1552	1552	1552
		time	29	29	30	30	64	64	66	65
306	149	$\|\mathcal{R}\|$	10	10	10	10	10	10	10	10
		WSC	1542	1542	1564	1564	1542	1542	1564	1564
		time	8	8	8	8	8	8	8	8
306	296	$\|\mathcal{R}\|$	10	10	10	10	10	10	10	10
		WSC	1542	1542	1564	1564	1542	1542	1564	1564
		time	8	8	8	8	8	8	8	8
306	443	$\|\mathcal{R}\|$	10	10	10	10	10	10	10	10
		WSC	1542	1542	1564	1564	1542	1542	1564	1564
		time	8	8	8	8	8	8	8	8
306	589	$\|\mathcal{R}\|$	10	10	10	10	10	10	10	10
		WSC	1542	1542	1564	1564	1542	1542	1564	1564
		time	8	8	8	8	8	8	8	8

Table 152: Role-set size, WSC, and time value - Dataset Firewall 2

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	24	19	25	25	24	19	8	6
PRUCC$_2$	25	20	24	24	24	19	8	4

	$\|\mathcal{R}\|$	WSC
better	3	4
equal	22	21
worse	0	0

Table 153: Minumum values - Dataset Firewall 2

$\mathcal{R}$	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	1	0	0	5	19	0	0	1	5	19
OR	6	0	0	0	19	5	0	1	0	19
UF	0	0	1	5	19	1	0	0	5	19
UR	0	0	1	5	19	1	0	0	5	19

Table 154: Number of times variants reached minumum value for $\mathcal{R}$ - Dataset Firewall 2

WSC	PRUCC$_1$					PRUCC$_2$				
	0	1	2	3	4	0	1	2	3	4
OF	1	0	19	3	2	1	0	21	1	2
OR	6	0	17	0	2	6	0	17	0	2
UF	17	0	3	3	2	17	0	5	1	2
UR	19	0	1	3	2	21	0	1	1	2

Table 155: Number of times variants reached minumum value for WSC - Dataset Firewall 2

	$\|\mathcal{R}\|$				WSC			
	OF	OR	UF	UR	OF	OR	UF	UR
PRUCC$_1$	4.14	4.96	4.02	4.02	2.58	3.5	5.14	5.38
PRUCC$_2$	4.46	5.24	4.58	4.58	3.22	4.14	5.78	6.26

Table 156: Heuristics ranking - Dataset Firewall 2

$\mathcal{R}$	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 2	4.14	4.96	4.02	4.02	4.46	5.24	4.58	4.58

Table 157: Heuristics ranking on $\mathcal{R}$ - Dataset Firewall 2

WSC	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 2	2.58	3.5	5.14	5.38	3.22	4.14	5.78	6.26

Table 158: Heuristics ranking on WSC - Dataset Firewall 2

time	PRUCC_1				PRUCC_2			
	OF	OR	UF	UR	OF	OR	UF	UR
Firewall 2	3.16	4.54	3.52	4.7	4.98	5.1	4.54	5.46

Table 159: Heuristics ranking on *time* - Dataset Firewall 2

3.10 Heuristics' rank when fixing *mpr*

In the following tables, we synthesize the results of our experiments when the first value we assign to *mpr* is equal to 2 and the fifth (and last) is equal to $\overset{max}{ppr} - 1$. The other three values are equally spaced between 2 and the fifth value. Having fixed *mpr*, we let *mru* take, if possible, five values such that $mru \cdot mpr \geq \max\#P$. In particular, the first value is set to $\lceil \max\#P/mpr \rceil$, while the last one is equal to $\max\#P - 1$. The other three values, if any, are equally spaced between the first value and the last one. The data used to fill in the following tables are the ones contained in the previous sections. In all three tables, for each dataset, the best results are highlighted in boldface.

Dataset	$PRUCC_1$				$PRUCC_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	2.52	5.12	3.54	6.42	**2.26**	5.72	3.54	6.88
Americas small	**2.62**	3.82	4.96	5.86	2.66	4.02	5.48	6.58
Apj	**2.30**	3.74	5.72	6.26	**2.30**	3.74	5.68	6.26
Customer	3.72	5.22	**3.36**	4.48	5.04	5.98	3.62	4.58
Domino	3.88	4.64	4.44	4.96	**3.72**	5.20	4.28	4.88
Emea	3.50	5.36	**3.08**	6.02	3.50	5.50	3.12	5.92
Firewall 1	**2.54**	3.42	5.24	6.24	2.82	3.82	5.52	6.40
Firewall 2	4.14	4.96	**4.02**	**4.02**	4.46	5.24	4.58	4.58
Healthcare	4.94	4.56	**3.66**	4.20	4.98	4.98	3.84	4.84

Table 160: Heuristics ranking on $|\mathcal{R}|$ - fixed *mpr*

From Table 160 one can see that, for any fixed variant, heuristic $PRUCC_1$ performs, in more than 80% of the cases, better than $PRUCC_2$. For heuristics $PRUCC_1$, variants OF and UF produce smaller role-sets in most cases and, for both heuristics, variant OF is better than OR, as well as, UF is better than UR. Similarly to what happens when we fix the parameter *mru*, if we compute the average of all rankings, we get that variant OF of heuristic $PRUCC_1$ performs better than the others, while variant UR of $PRUCC_2$ is the worse. Since we used in our tests real-world dataset, this occurrence might be related to role's semantic (i.e., when creating permission in an organization, managers tend to deploy related permission in subsequent order). Moreover, from Table 160, one can see that, for the dataset *Emea*, for any fixed variant, there is almost no difference in the quality of the returned solutions. This outcome depends on the structure of the dataset *Emea*. More in general, from the data available in the previous sections, we can see that, when $mpr = 2$, both heuristics compute role-sets bigger than the *optimal* ones computed without considering any constraint. Next table summarizes the average growing factor of the role-set size computed by our heuristics when $mpr = 2$. Notice that the dataset *Customer* is not listed as the optimal solutions were made available, on the web-page at HP Labs of one of the authors of *Fast exact and heuristic methods for role minimization problems* - SACMAT 2008, for all datasets except for the *Customer* one.

Dataset	GF	Dataset	GF
Americas large	16	Emea	55
Americas small	6	Firewall 1	6
Apj	2	Firewall 2	30
Domino	7	Healthcare	2

Table 161: Computed solution vs optimal *unconstrained* solution ratio

A large role-set returned by our heuristics, for $mpr = 2$, is not a surprise at all. It depends on the structure of the UPA matrix. Several users have much more than two permissions, so we need many roles to cover all of them. For instance, users in the dataset *Emea* have assigned 3046 distinct permissions. So, independently of the selected heuristic and variant, when $mpr = 2$, we need at least 1523 different roles to cover them. When the value assigned to *mpr* increases, we notice that the number of generated roles decreases, in some cases to a large extent. This reduction was expected, as larger roles, usually, can cover larger parts of the UPA matrix. Therefore, less roles have to be generated. If we compute the average of all rankings, we get that variant OF of heuristic $PRUCC_1$ performs better than the others, while variant UF of $PRUCC_2$ is the worse.

Dataset	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	3.44	6.72	2.56	5.28	3.16	7.24	**2.50**	5.10
Americas small	**2.00**	3.68	5.56	6.1	2.14	4.18	5.64	6.70
Apj	6.08	6.50	2.36	3.26	6.38	6.08	**2.16**	3.18
Customer	2.32	**2.22**	5.40	6.16	3.34	3.76	6.30	6.50
Domino	2.48	3.40	5.74	6.56	**2.08**	3.66	5.58	6.50
Emea	3.50	5.66	**3.08**	5.58	3.50	5.88	3.12	5.68
Firewall 1	4.90	6.08	2.74	3.86	5.34	6.72	**2.78**	3.58
Firewall 2	**2.58**	3.50	5.14	5.38	3.22	4.14	5.78	6.26
Healthcare	5.90	5.36	**2.56**	3.04	5.98	6.24	2.92	4.00

Table 162: Heuristics ranking on WSC - fixed mpr

Since the WSC measure depends also on the number of generated roles, the results in Table 162 reflect, in large part, the ones in Table 160. Indeed, for any fixed variant, heuristic PRUCC$_1$ returns, in more than 70% of the cases, a lower WSC value than that returned by PRUCC$_2$. For both heuristics, variant OF is better than OR, as well as, UF is better than UR. We notice that, for the dataset *Healthcare*, variants UF and UR return a better solution, in terms of both role-set size and WSC value, than variants OF and OR. This is due to the fact that such dataset is quite dense. Indeed, UPA's entries are set to one in 70% of the cases. All but one users have more than 20 permissions, one third of the users has the same 45 permissions out of 46, and a large majority of the remaining users have distinct permissions. Recall that variants UF and UR generate roles selecting permissions that have not yet been covered by some already generated roles. This way of constructing roles and the structure of the UPA matrix of the dataset *Healthcare* allow the generation of a small number of role with the maximum number of possible permissions, while assigning them to few user. This lowers both $|\mathcal{R}|$ and WSC.

Dataset	PRUCC$_1$				PRUCC$_2$			
	OF	OR	UF	UR	OF	OR	UF	UR
Americas large	**2.50**	5.20	3.92	6.68	2.64	5.34	3.22	6.5
Americas small	2.88	3.16	6.00	6.36	**2.64**	2.70	5.82	6.44
Apj	6.72	6.76	5.58	6.12	2.78	3.28	**1.96**	2.80
Customer	4.18	3.98	6.80	7.10	2.14	**2.02**	4.92	4.86
Domino	**3.80**	4.76	3.96	4.76	4.60	4.76	4.60	4.76
Emea	2.86	6.34	2.28	6.36	2.56	6.56	**2.46**	6.58
Firewall 1	4.40	3.88	**3.12**	4.36	5.22	5.12	4.52	5.38
Firewall 2	**3.16**	4.54	3.52	4.70	4.98	5.10	4.54	5.46
Healthcare	**4.02**	4.18	**4.02**	**4.02**	5.12	5.04	4.80	4.80

Table 163: Heuristics ranking on *time* - fixed mpr

If we consider the execution time, we see that heuristic PRUCC$_1$ is faster than heuristic PRUCC$_2$ for most datasets. Execution time essentially depends of the UPA dimensions and its density. Anyway, from the data available in the previous sections, we can see that, when $mpr = 2$, the execution time of both heuristics is much greater than that for the other cases (i.e., when mpr is much larger than 2). This depends on the fact that, to cover users' permissions, both heuristics have to generate more roles, spending then more time.

4 Synthetic Datasets

4.1 Paper's experiments data

Set 1	nr	nu	np	mru	mpr
d1	20	200	40	2	5
d2	40	400	80	4	5
d3	80	800	160	8	5
d4	100	1000	200	10	5

Set 2	nr	nu	np	mru	mpr
d1	20	200	40	5	2
d2	40	400	80	5	4
d3	80	800	160	5	8
d4	100	1000	200	5	10

Figure 1: Datasets' parameters fixing mpr (left) and fixing mru (right)

Heuristics' results for the datasets described in the left side of Figure 1.

Dataset		PRUCC_1				PRUCC_2			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\lvert\mathcal{R}\rvert$	60	58	87	86	66	64	92	99
	WSC	586	570	708	690	617	599	745	763
	accuracy	91%	93%	83%	80%	88%	88%	73%	74%
	similarity	86%	85%	82%	81%	84%	84%	80%	78%
	time	3	3	5	5	4	3	6	6
d2	$\lvert\mathcal{R}\rvert$	198	232	390	448	211	253	380	441
	WSC	2005	2161	2913	3184	2082	2277	2917	3203
	accuracy	84%	75%	59%	54%	82%	73%	56%	53%
	similarity	77%	72%	71%	67%	76%	71%	70%	67%
	time	13	14	30	34	15	18	32	34
d3	$\lvert\mathcal{R}\rvert$	736	750	1331	1640	773	797	1275	1562
	WSC	7570	7628	10459	12131	7782	7901	10324	11856
	accuracy	76%	75%	49%	38%	76%	76%	51%	43%
	similarity	70%	66%	63%	56%	70%	66%	64%	57%
	time	81	77	192	266	91	93	199	235
d4	$\lvert\mathcal{R}\rvert$	1112	1229	2091	2540	1146	1321	1990	2376
	WSC	11551	12218	16455	18938	11771	12753	16158	18279
	accuracy	75%	74%	45%	40%	75%	73%	47%	44%
	similarity	68%	64%	61%	55%	68%	63%	62%	56%
	time	143	156	400	500	157	207	386	470

Heuristics' results for the datasets described in the right side of Figure 1.

Dataset		PRUCC_1				PRUCC_2			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\lvert\mathcal{R}\rvert$	47	45	60	62	49	48	64	66
	WSC	759	751	814	827	764	758	825	840
	accuracy	97%	94%	92%	89%	95%	92%	90%	86%
	similarity	85%	84%	80%	79%	83%	82%	79%	77%
	time	3	3	3	3	3	4	4	4
d2	$\lvert\mathcal{R}\rvert$	212	259	367	456	233	279	349	437
	WSC	2150	2328	2754	3142	2251	2422	2713	3083
	accuracy	80%	73%	67%	53%	80%	74%	64%	53%
	similarity	75%	71%	71%	65%	74%	70%	70%	66%
	time	17	16	26	40	17	18	31	41
d3	$\lvert\mathcal{R}\rvert$	596	622	1187	1301	618	638	1139	1264
	WSC	6859	7061	10800	11533	7055	7215	10790	11626
	accuracy	74%	73%	50%	40%	73%	73%	47%	39%
	similarity	71%	68%	66%	61%	71%	68%	66%	61%
	time	58	60	171	184	71	71	154	181
d4	$\lvert\mathcal{R}\rvert$	834	870	1549	1634	870	901	1511	1638
	WSC	10540	10885	16175	16837	10932	11206	16428	17475
	accuracy	71%	69%	48%	46%	70%	69%	42%	38%
	similarity	70%	66%	66%	62%	69%	66%	65%	61%
	time	111	117	267	294	123	120	253	285

4.2 Constant nu/nr, varying permissions, and $mpr = np \cdot nr/nu$

Set 1	nr	nu	np	mru	mpr
d1	20	200	40	4	4
d2	40	400	80	4	8
d3	80	800	160	4	16
d4	100	1000	200	4	20

Dataset		PRUCC_1				PRUCC_2			
		OF	OR	UF	UR	OF	OR	UF	UR
Data1	$\|\mathcal{R}\|$	91	82	152	174	96	86	150	167
	WSC	890	837	1123	1210	909	856	1130	1195
	accuracy	77%	81%	73%	56%	76%	82%	66%	56%
	similarity	76%	77%	73%	68%	76%	76%	72%	68%
Data2	$\|\mathcal{R}\|$	229	305	451	452	235	317	474	495
	WSC	2636	3180	3976	3912	2690	3282	4295	4412
	accuracy	75%	65%	57%	64%	75%	65%	43%	38%
	similarity	75%	69%	71%	69%	74%	69%	68%	64%
Data3	$\|\mathcal{R}\|$	535	480	1082	1074	555	484	1129	1121
	WSC	9085	8198	15399	15015	9376	8287	16421	16113
	accuracy	74%	78%	65%	63%	73%	78%	38%	38%
	similarity	72%	71%	70%	68%	72%	71%	67%	65%
Data4	$\|\mathcal{R}\|$	674	781	1379	1371	683	797	1435	1429
	WSC	13274	15080	23398	23143	13466	15402	24807	24598
	accuracy	75%	69%	65%	66%	75%	69%	40%	41%
	similarity	72%	69%	70%	68%	72%	68%	67%	66%

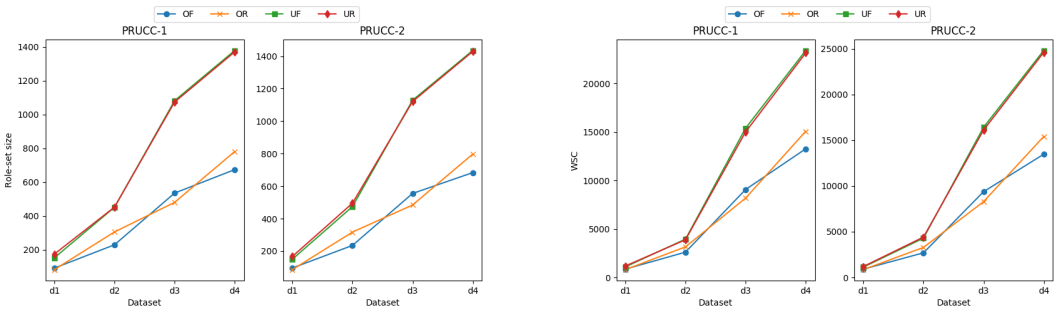

Figure 2: Role-set Size (left) - WSC (right)

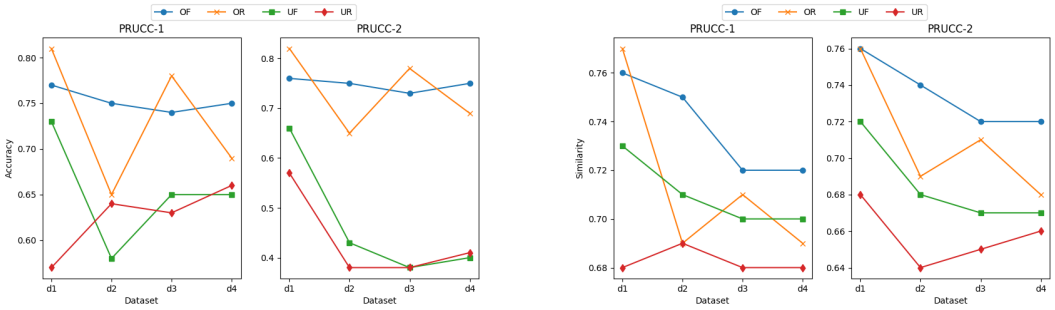

Figure 3: Similarity (left) - Accuracy (right)

4.3 Constant nu/nr and np/nr, $mru = nr/10$, $mpr = 5$, and $mru \cdot mpr = np/4$

Set 2	nr	nu	np	mru	mpr
d1	20	200	40	2	5
d2	40	400	80	4	5
d3	80	800	160	8	5
d4	100	1000	200	10	5

Dataset		PRUCC_1				PRUCC_2			
		OF	OR	UF	UR	OF	OR	UF	UR
Data1	$\lvert\mathcal{R}\rvert$	58	59	86	92	60	64	96	109
	WSC	571	574	695	717	582	596	757	810
	accuracy	90%	86%	86%	82%	87%	83%	73%	65%
	similarity	86%	84%	82%	81%	85%	83%	80%	76%
Data2	$\lvert\mathcal{R}\rvert$	209	238	384	479	226	256	366	470
	WSC	2059	2196	2852	3356	2154	2299	2821	3379
	accuracy	80%	74%	62%	55%	78%	74%	57%	49%
	similarity	76%	72%	72%	67%	75%	72%	71%	65%
Data3	$\lvert\mathcal{R}\rvert$	729	814	1402	1699	779	863	1342	1595
	WSC	7543	8036	10887	12459	7837	8326	10740	12085
	accuracy	75%	73%	45%	40%	75%	73%	49%	45%
	similarity	70%	66%	62%	56%	69%	65%	63%	57%
Data4	$\lvert\mathcal{R}\rvert$	1045	1281	2049	2470	1099	1348	1949	2352
	WSC	11214	12465	16225	18516	11552	12879	15918	18088
	accuracy	77%	74%	48%	40%	77%	73%	52%	45%
	similarity	69%	64%	62%	55%	68%	64%	63%	56%

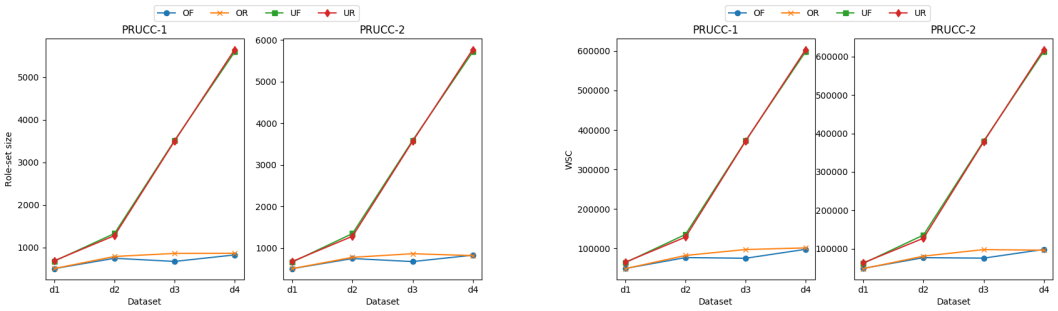

Figure 4: Role-set Size (left) - WSC (right)

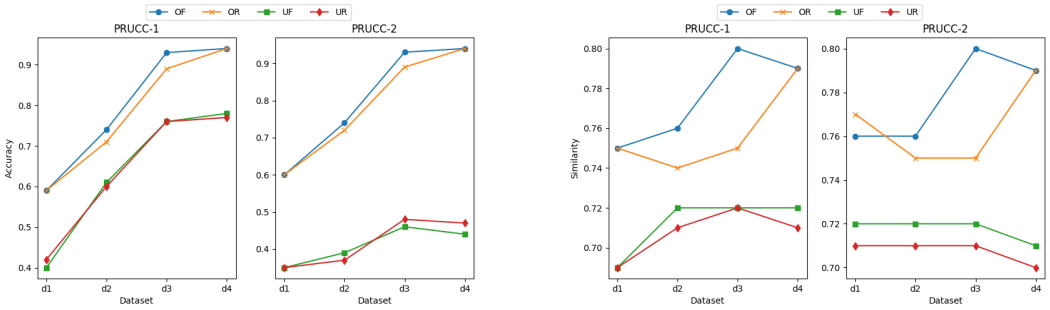

Figure 5: Similarity (left) - Accuracy (right)

4.4 Constant nu/nr and np/nr, $mru = nr/10$, $mru = 5$, and $mru \cdot mpr = np/4$

Set 3	nr	nu	np	mru	mpr
d1	20	200	40	5	2
d2	40	400	80	5	4
d3	80	800	160	5	8
d4	100	1000	200	5	10

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
Data1	$\|\mathcal{R}\|$	40	48	63	62	43	51	65	67
	WSC	741	773	832	822	749	785	832	834
	accuracy	96%	92%	88%	91%	97%	92%	86%	86%
	similarity	86%	82%	78%	79%	86%	82%	77%	77%
Data2	$\|\mathcal{R}\|$	223	276	365	467	232	293	366	454
	WSC	2180	2428	2744	3209	2226	2510	2788	3174
	accuracy	78%	71%	69%	51%	79%	73%	64%	51%
	similarity	74%	70%	72%	65%	74%	70%	70%	65%
Data3	$\|\mathcal{R}\|$	538	643	1214	1303	555	667	1142	1235
	WSC	6394	7180	11112	11661	6554	7390	10879	11471
	accuracy	78%	73%	44%	41%	78%	72%	46%	41%
	similarity	72%	68%	65%	61%	72%	67%	66%	61%
Data4	$\|\mathcal{R}\|$	762	813	1564	1576	773	840	1525	1551
	WSC	9892	10329	16325	16196	10041	10616	16554	16619
	accuracy	76%	72%	50%	49%	76%	72%	45%	41%
	similarity	71%	67%	66%	63%	71%	67%	66%	61%

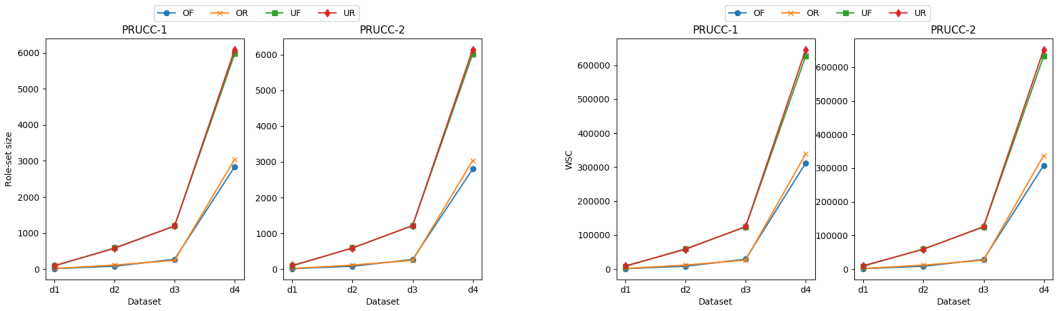

Figure 6: Role-set Size (left) - WSC (right)

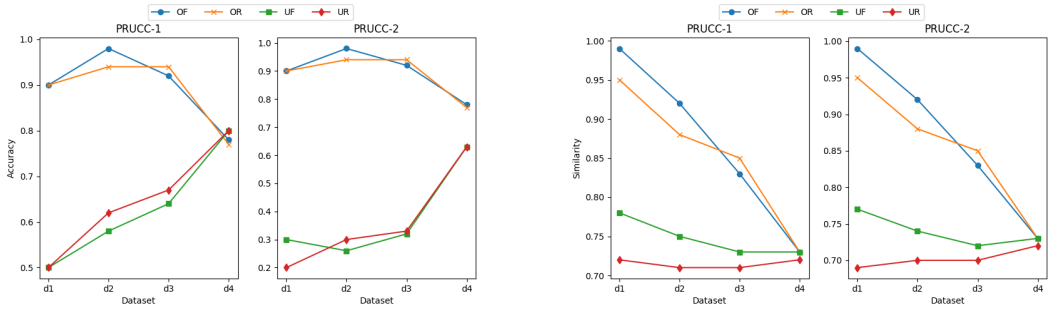

Figure 7: Similarity (left) - Accuracy (right)

4.5 Constant number of ratio users/roles and varying permissions

Set 4	nr	nu	np	mru	mpr
d1	100	2000	100	3	10
d2	100	2000	500	3	50
d3	100	2000	1000	3	100
d4	100	2000	2000	3	200

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	1429	1472	1760	1799	1552	1601	1990	2100
	WSC	16217	16304	18301	18150	17549	17675	21201	21673
	accuracy	68%	68%	91%	90%	60%	60%	54%	52%
	similarity	73%	72%	77%	75%	72%	70%	71%	69%
d2	$\|\mathcal{R}\|$	481	516	2134	2206	484	521	2218	2318
	WSC	21505	22865	79968	82357	21684	23100	84233	87679
	accuracy	90%	89%	75%	75%	90%	89%	43%	41%
	similarity	77%	75%	73%	71%	77%	75%	72%	69%
d3	$\|\mathcal{R}\|$	301	323	2157	2197	302	324	2224	2278
	WSC	24521	26448	154306	157379	24592	26478	159685	163975
	accuracy	94%	94%	73%	73%	94%	94%	37%	34%
	similarity	83%	79%	74%	71%	83%	79%	72%	70%
d4	$\|\mathcal{R}\|$	231	176	2195	2266	231	177	2253	2344
	WSC	34167	25652	306028	317055	34187	25793	313653	329474
	accuracy	96%	98%	72%	70%	96%	98%	28%	26%
	similarity	88%	93%	73%	71%	88%	93%	72%	69%

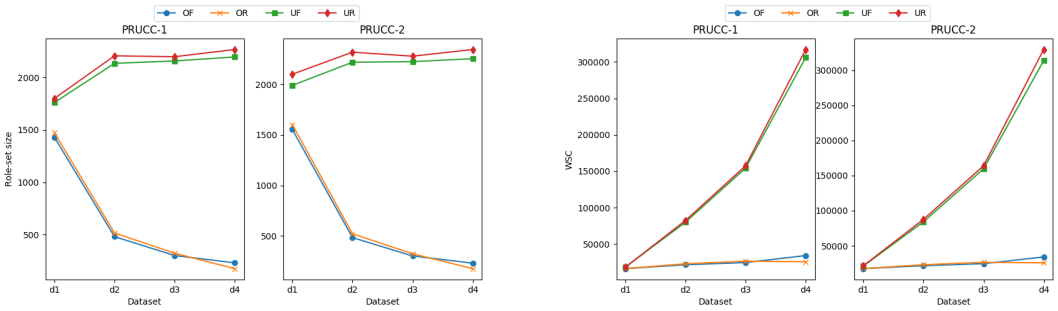

Figure 8: Role-set Size (left) - WSC (right)

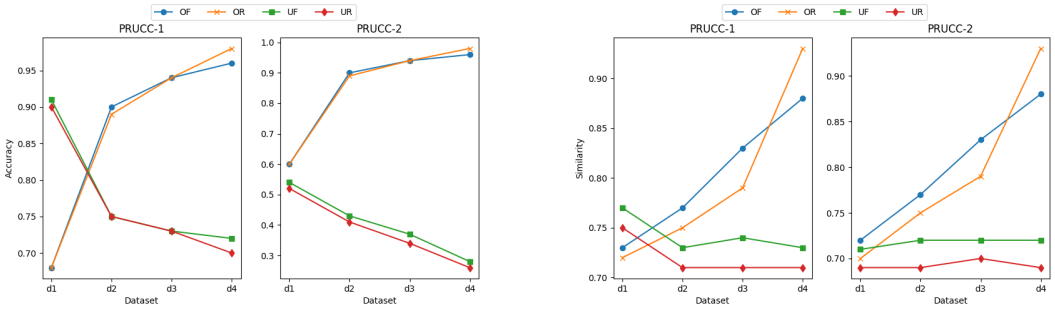

Figure 9: Similarity (left) - Accuracy (right)

4.6 Constant number of the ratio permissions/roles and varying users

Set 5	nr	nu	np	mru	mpr
d1	200	500	1500	3	150
d2	200	1000	1500	3	150
d3	200	3000	1500	3	150
d4	200	5000	1500	3	150

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	504	507	680	690	505	506	663	678
	WSC	49416	49078	64223	65356	48910	48238	61975	63335
	accuracy	59%	59%	40%	42%	60%	60%	35%	35%
	similarity	75%	75%	69%	69%	76%	77%	72%	71%
d2	$\|\mathcal{R}\|$	747	789	1329	1279	747	776	1347	1282
	WSC	77011	82368	135580	128726	76745	80718	135690	127313
	accuracy	74%	71%	61%	60%	74%	72%	39%	37%
	similarity	76%	74%	72%	71%	76%	75%	72%	71%
d3	$\|\mathcal{R}\|$	673	861	3515	3501	674	863	3582	3561
	WSC	75310	97433	372589	371760	75510	97689	379924	378051
	accuracy	93%	89%	76%	76%	93%	89%	46%	48%
	similarity	80%	75%	72%	72%	80%	75%	72%	71%
d4	$\|\mathcal{R}\|$	826	864	5595	5651	827	817	5708	5767
	WSC	97991	101500	598720	603666	98142	96238	613283	618525
	accuracy	94%	94%	78%	77%	94%	94%	44%	47%
	similarity	79%	79%	72%	71%	79%	79%	71%	70%

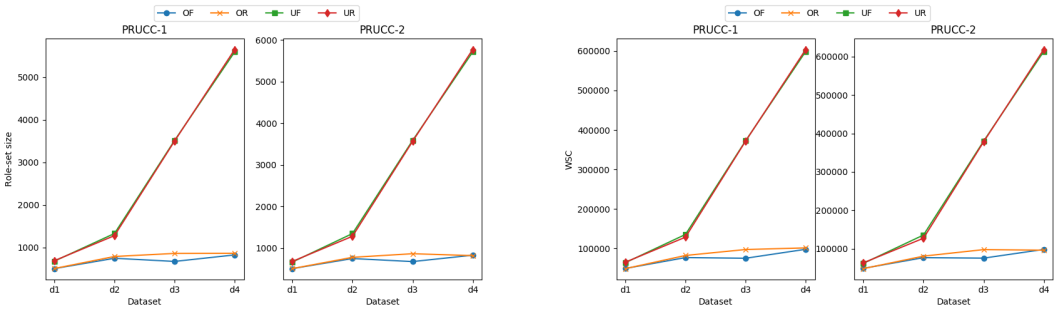

Figure 10: Role-set Size (left) - WSC (right)

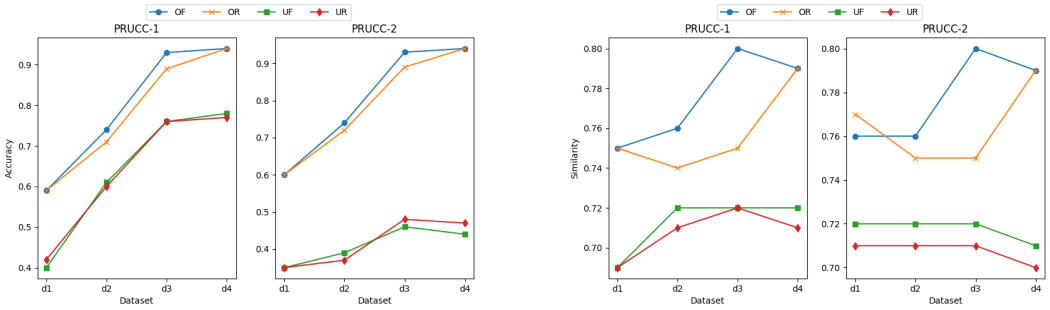

Figure 11: Similarity (left) - Accuracy (right)

4.7 Constant number of permissions and varying ratio users/roles

Set 6	nr	nu	np	mru	mpr
d1	10	100	1500	3	150
d2	50	500	1500	3	150
d3	100	1000	1500	3	150
d4	500	5000	1500	3	150

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	11	13	84	94	11	13	88	100
	WSC	1097	1458	7627	9158	1097	1458	8285	9863
	accuracy	90%	90%	50%	50%	90%	90%	30%	20%
	similarity	99%	95%	78%	72%	99%	95%	77%	69%
d2	$\|\mathcal{R}\|$	77	110	585	573	77	110	591	585
	WSC	7948	11519	59503	58094	7965	11550	59585	58783
	accuracy	98%	94%	57%	62%	98%	94%	26%	30%
	similarity	92%	88%	75%	71%	92%	88%	74%	70%
d3	$\|\mathcal{R}\|$	271	241	1194	1195	267	241	1213	1218
	WSC	28931	26181	123709	124840	28400	26183	124875	126057
	accuracy	92%	94%	64%	67%	92%	94%	32%	33%
	similarity	83%	85%	73%	71%	83%	85%	72%	70%
d4	$\|\mathcal{R}\|$	2839	3047	5974	6092	2800	3035	6022	6146
	WSC	312202	338525	626903	646308	308120	337470	633122	652863
	accuracy	78%	77%	80%	80%	78%	77%	63%	63%
	similarity	73%	73%	73%	72%	73%	73%	73%	72%

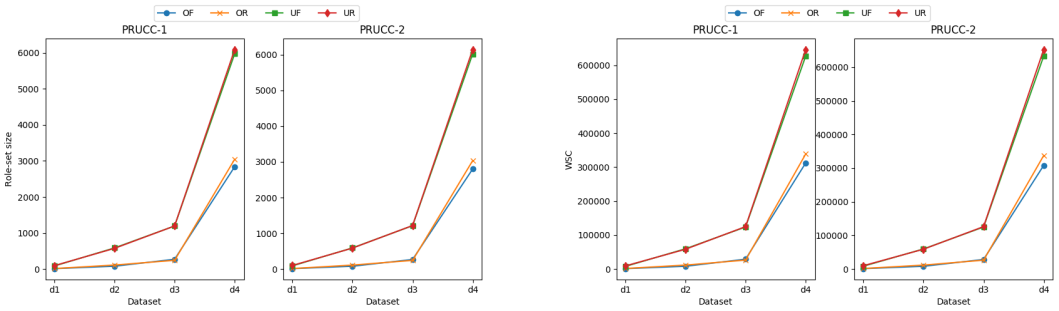

Figure 12: Role-set Size (left) - WSC (right)

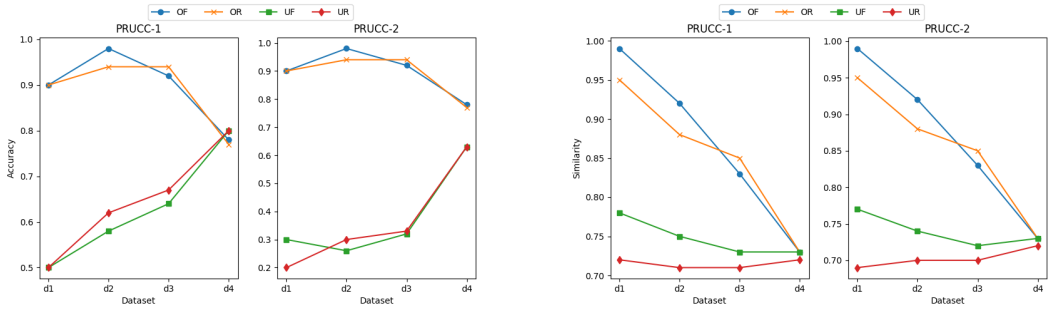

Figure 13: Similarity (left) - Accuracy (right)

4.8 Low UPA density - case 1

Datasets having low UPA density as the HP's dataset *Americas Large* (about 0.5%), but with a larger number of users and permissions.

Set 1	nr	nu	np	mru	mpr
d1	400	3500	10000	4	40
d2	400	4500	12000	5	40
d3	400	5500	14000	6	40
d4	400	7000	16000	7	40

Set 2	nr	nu	np	mru	mpr
d1	400	3500	10000	5	35
d2	400	4500	12000	5	40
d3	400	5500	14000	5	45
d4	400	7000	16000	5	55

Figure 14: Datasets' parameters fixing mpr (left) and fixing mru (right)

Heuristics' results for the datasets described in the left side of Figure 14

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	691	574	3819	3690	690	574	3543	3430
	WSC	27170	23083	127187	122800	27129	23083	119189	115283
	accuracy	97%	98%	64%	65%	97%	98%	68%	69%
	similarity	90%	89%	76%	67%	90%	89%	77%	67%
	time	759	715	2318	2103	700	672	2429	2367
d2	$\|\mathcal{R}\|$	589	649	5429	5601	589	649	5043	5220
	WSC	28628	30969	189988	194078	28615	30969	177896	182664
	accuracy	99%	98%	64%	62%	99%	98%	68%	65%
	similarity	92%	85%	76%	64%	92%	85%	76%	64%
	time	1014	1001	4415	4618	1000	1013	4280	4422
d3	$\|\mathcal{R}\|$	516	653	7702	7689	517	633	7228	7267
	WSC	32086	36833	278187	275571	32100	36138	263122	262472
	accuracy	99%	99%	59%	63%	99%	99%	63%	65%
	similarity	94%	85%	75%	62%	94%	86%	75%	62%
	time	1346	1454	8180	7942	1219	1251	8455	7770
d4	$\|\mathcal{R}\|$	749	641	11161	11614	750	641	10524	10656
	WSC	49069	45445	417277	426227	49096	45445	396567	395263
	accuracy	99%	99%	61%	59%	99%	99%	63%	62%
	similarity	88%	85%	75%	60%	88%	85%	75%	60%
	time	1968	1974	14485	14876	1841	2177	15341	15040

Heuristics' results for the datasets described in the right side of Figure 14

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	671	744	4222	4463	672	744	3846	4108
	WSC	26303	28372	130512	137153	26327	28377	120091	127656
	accuracy	97%	97%	67%	64%	97%	97%	70%	68%
	similarity	90%	82%	75%	64%	90%	82%	76%	65%
	time	772	780	2453	2476	745	754	2361	2466
d2	$\|\mathcal{R}\|$	664	634	5620	5589	665	633	5261	5232
	WSC	31356	30074	196749	194304	31370	30073	185672	183320
	accuracy	98%	98%	61%	63%	98%	98%	65%	65%
	similarity	90%	86%	75%	64%	90%	86%	75%	64%
	time	1009	992	3848	3803	982	959	4095	3871
d3	$\|\mathcal{R}\|$	782	611	7187	7411	782	612	6851	6868
	WSC	41062	34524	282094	287187	41093	34525	270875	268612
	accuracy	98%	98%	57%	56%	98%	98%	60%	61%
	similarity	87%	87%	75%	63%	87%	87%	75%	63%
	time	1415	1306	5999	6149	1273	1249	6726	6378
d4	$\|\mathcal{R}\|$	654	631	9119	9679	654	631	8636	9091
	WSC	44368	43693	429151	451873	44387	43695	409907	428079
	accuracy	99%	99%	55%	54%	99%	99%	56%	56%
	similarity	90%	87%	75%	63%	90%	87%	75%	63%
	time	1648	1717	9737	10461	1722	1635	10492	11468

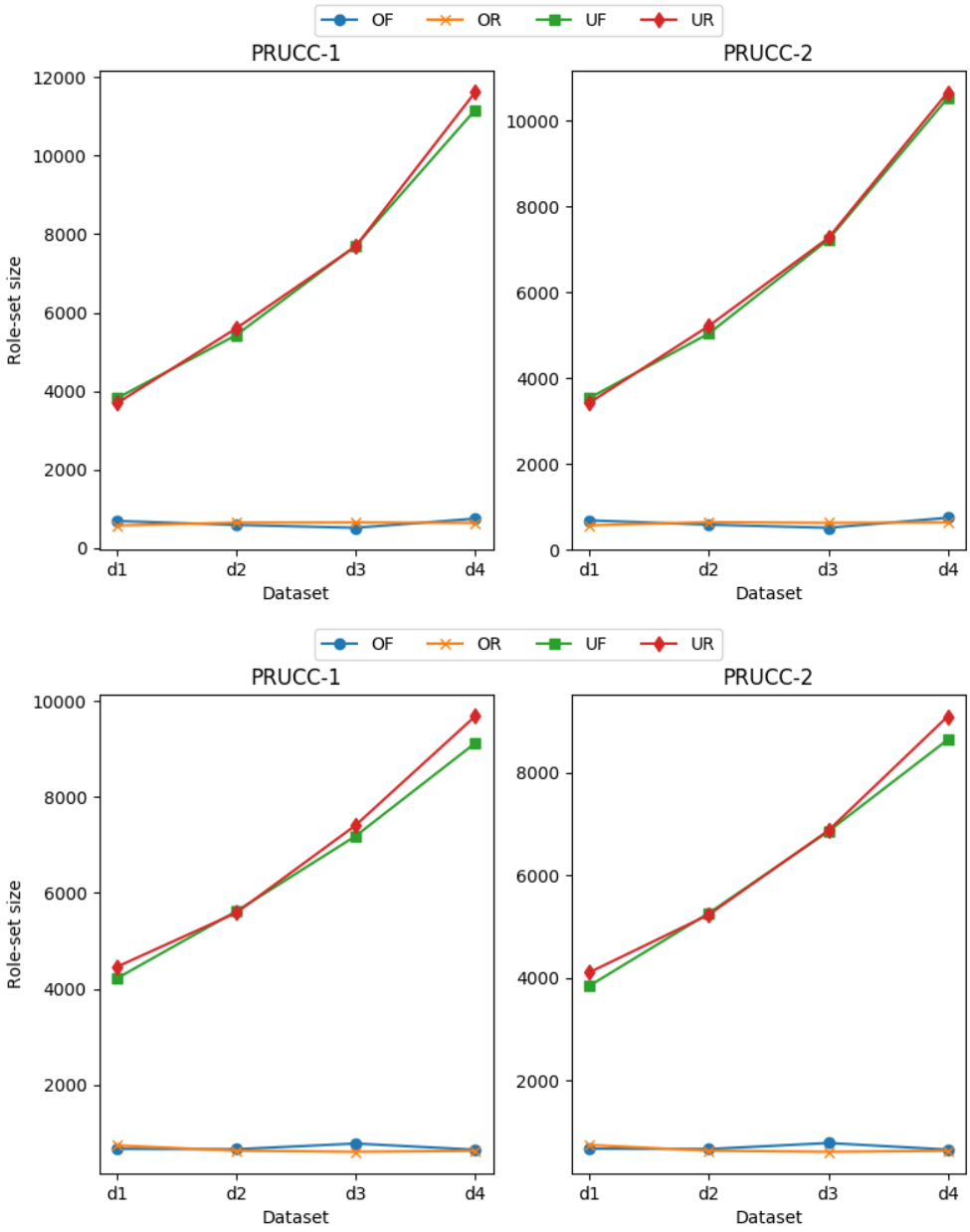

Figure 15: Role-set Size: Set 1 (upper) and Set 2 (lower)

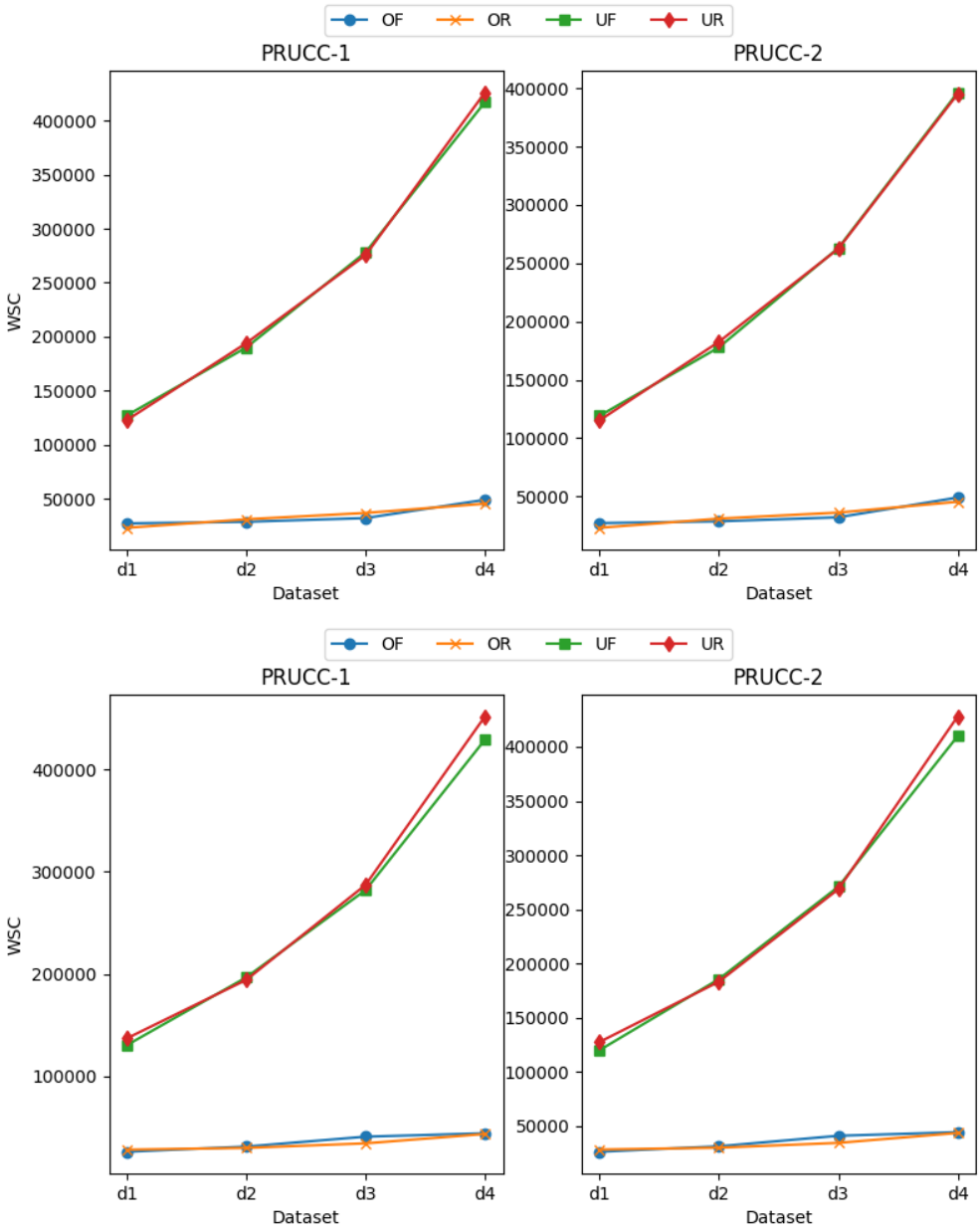

Figure 16: WSC: Set 1 (upper) and Set 2 (lower)

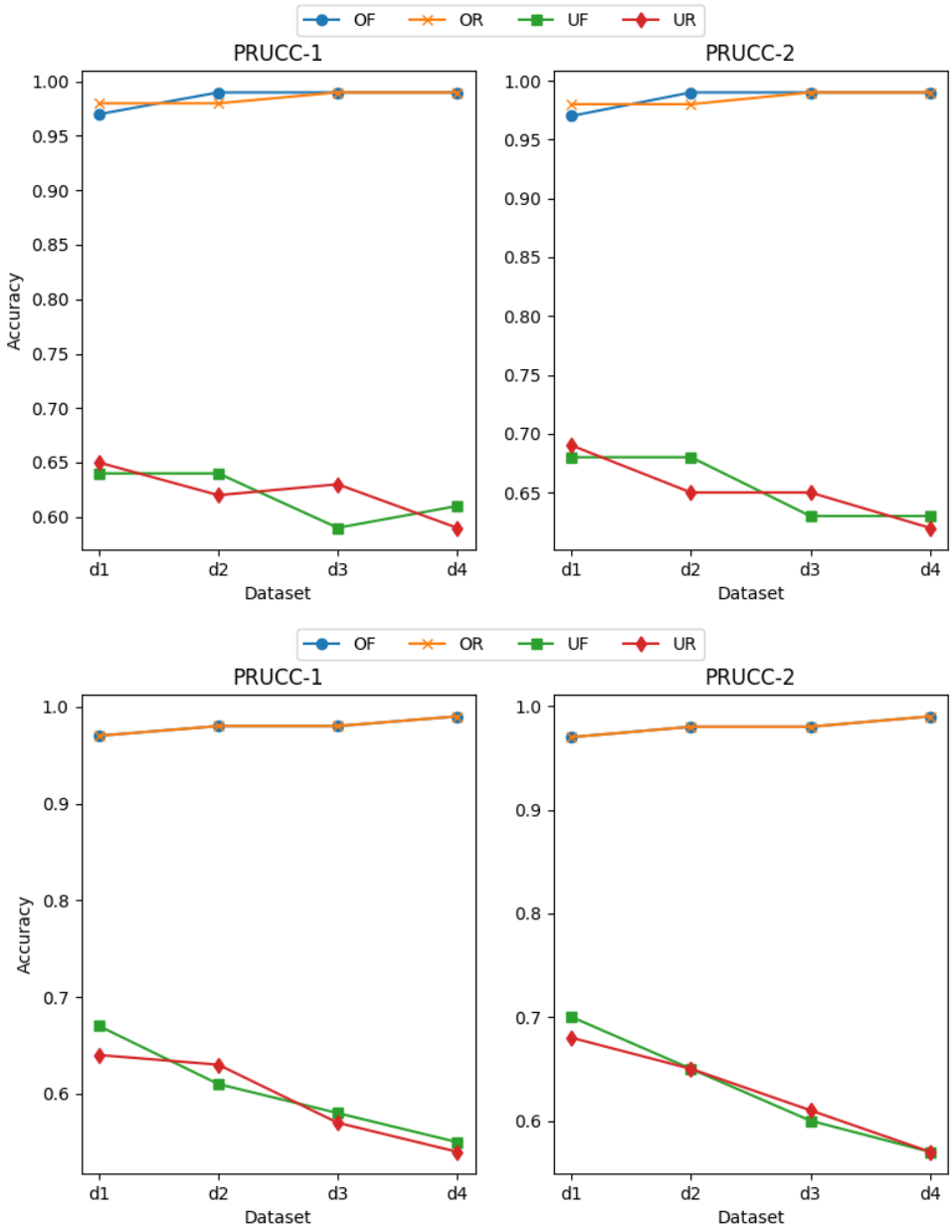

Figure 17: Accuracy: Set 1 (upper) and Set 2 (lower)

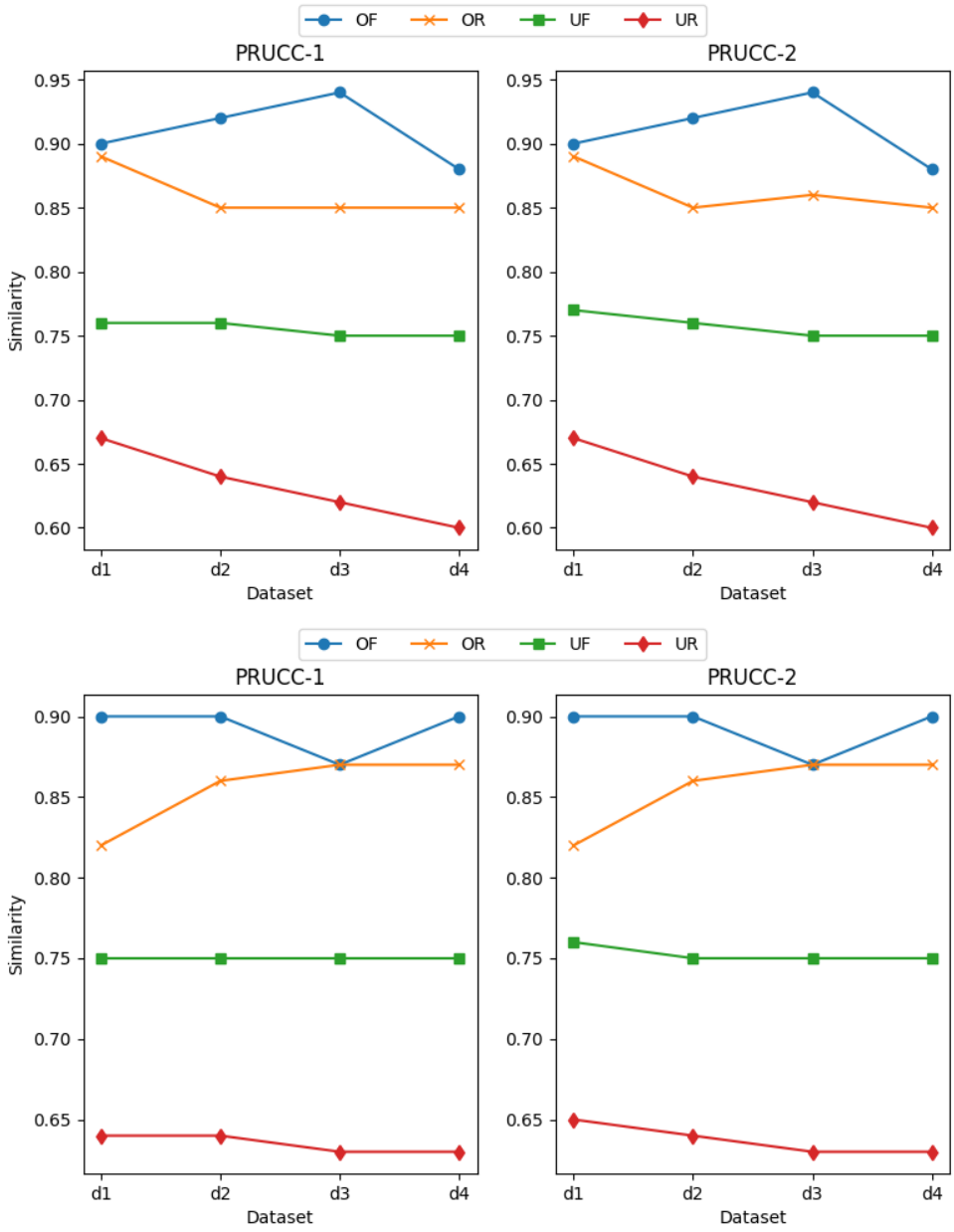

Figure 18: Similarity: Set 1 (upper) and Set 2 (lower)

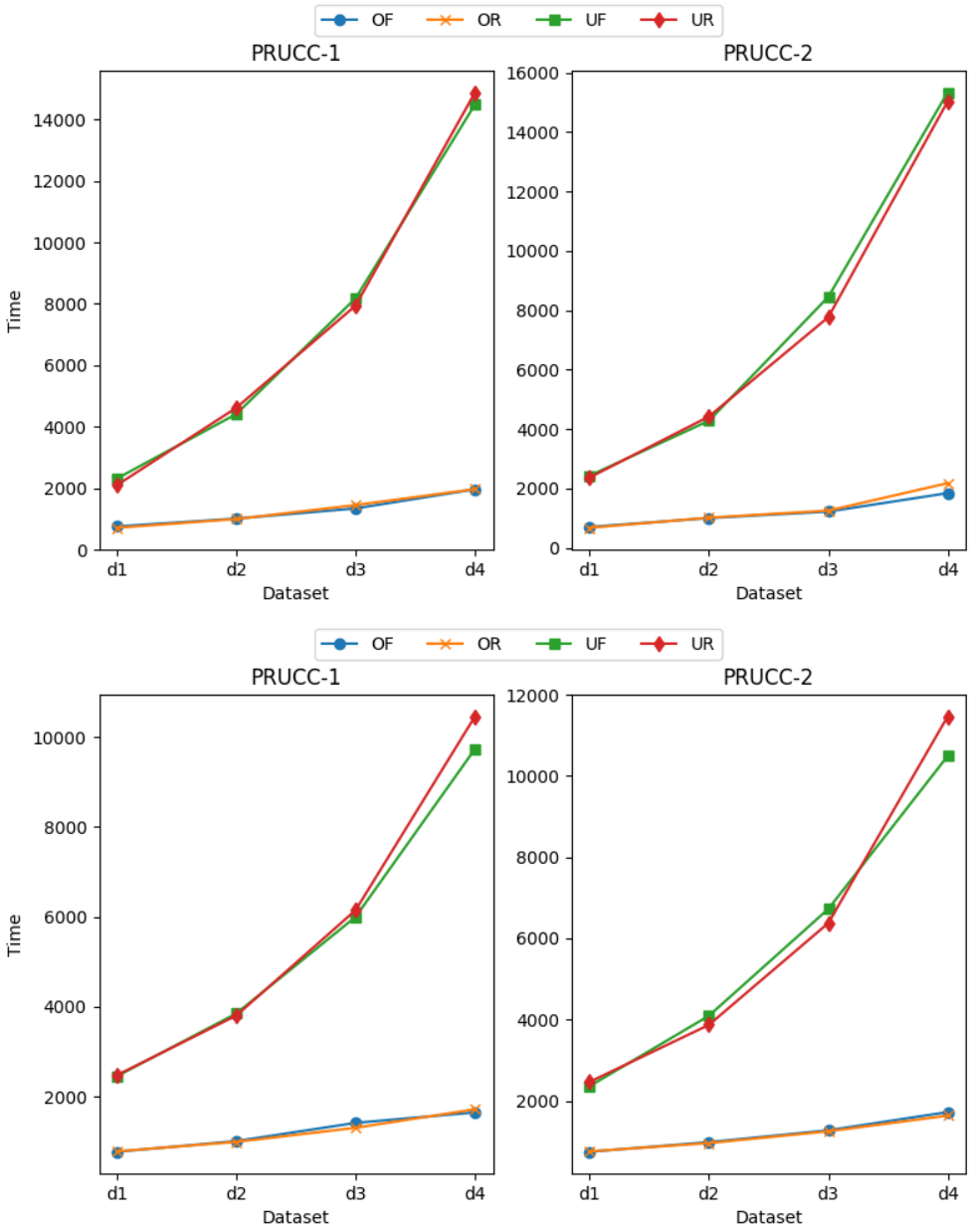

Figure 19: Time: Set 1 (upper) and Set 2 (lower)

4.9 Low UPA density - case 2

Similar to First Scenario, but with number of users and permissions interchanged. UPA density increased to about 1.3%.

Set 1	nr	nu	np	mru	mpr
d1	400	10000	3500	4	40
d2	400	12000	4500	5	40
d3	400	14000	5500	6	40
d4	400	16000	7000	7	40

Set 2	nr	nu	np	mru	mpr
d1	400	10000	3500	5	35
d2	400	12000	4500	5	40
d3	400	14000	5500	5	45
d4	400	16000	7000	5	55

Figure 20: Datasets' parameters fixing mpr (left) and fixing mru (right)

Heuristics' results for the datasets described in the left side of Figure 20

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	1854	1935	13724	13714	1861	1942	13449	13377
	WSC	83334	85161	454584	444461	83595	85421	453026	441967
	accuracy	95%	94%	56%	55%	95%	94%	42%	44%
	similarity	75%	73%	70%	66%	75%	73%	70%	65%
	time	2648	2901	24534	23420	2875	2954	28451	27671
d2	$\|\mathcal{R}\|$	2556	1902	18538	19831	2565	1904	18001	19143
	WSC	119282	97218	638923	675457	119651	97301	633382	665110
	accuracy	94%	96%	53%	48%	94%	96%	43%	39%
	similarity	73%	70%	70%	63%	73%	70%	69%	62%
	time	3595	3394	45957	50164	4034	3408	52812	57493
d3	$\|\mathcal{R}\|$	1975	2182	24712	25556	1979	2185	23544	24354
	WSC	114118	120524	884023	897891	114268	120634	857159	871394
	accuracy	97%	96%	46%	44%	97%	96%	46%	42%
	similarity	76%	67%	69%	61%	76%	67%	69%	61%
	time	4169	4580	83703	85944	4246	4707	92927	95319
d4	$\|\mathcal{R}\|$	2991	2216	31301	32822	3001	2353	29728	30921
	WSC	166224	138480	1157255	1188388	166659	143451	1114116	1133712
	accuracy	96%	97%	43%	43%	96%	97%	43%	44%
	similarity	74%	67%	69%	59%	74%	66%	69%	59%
	time	5603	5317	152250	143447	5897	5940	162444	160534

Heuristics' results for the datasets described in the right side of Figure 20

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	1963	2018	15714	16499	1972	2021	15041	15882
	WSC	85459	87627	477455	495735	85785	87747	467381	487844
	accuracy	94%	95%	50%	49%	94%	95%	45%	42%
	similarity	75%	69%	69%	63%	75%	69%	68%	62%
	time	2815	3227	32637	33858	2968	3159	35282	38341
d2	$\|\mathcal{R}\|$	1947	2372	18846	19680	1950	2375	18450	18960
	WSC	97975	112851	651402	669929	98098	112934	649577	660527
	accuracy	95%	94%	51%	50%	95%	94%	43%	41%
	similarity	75%	68%	69%	63%	75%	68%	69%	62%
	time	3223	3918	49835	48145	3708	4172	53390	54606
d3	$\|\mathcal{R}\|$	2054	1619	21993	21885	2058	1619	21407	21059
	WSC	115905	99508	848998	826093	116104	99553	840374	810874
	accuracy	96%	97%	47%	47%	96%	97%	41%	42%
	similarity	75%	71%	70%	63%	75%	71%	70%	63%
	time	4146	3769	64473	60317	4175	3786	75269	70234
d4	$\|\mathcal{R}\|$	2312	1641	25742	25943	2314	1642	24867	25488
	WSC	150882	118946	1200355	1178062	150975	119002	1180365	1182633
	accuracy	96%	97%	45%	49%	96%	97%	38%	38%
	similarity	73%	71%	70%	63%	73%	71%	70%	62%
	time	4960	4589	91424	88969	5216	4797	104117	107557

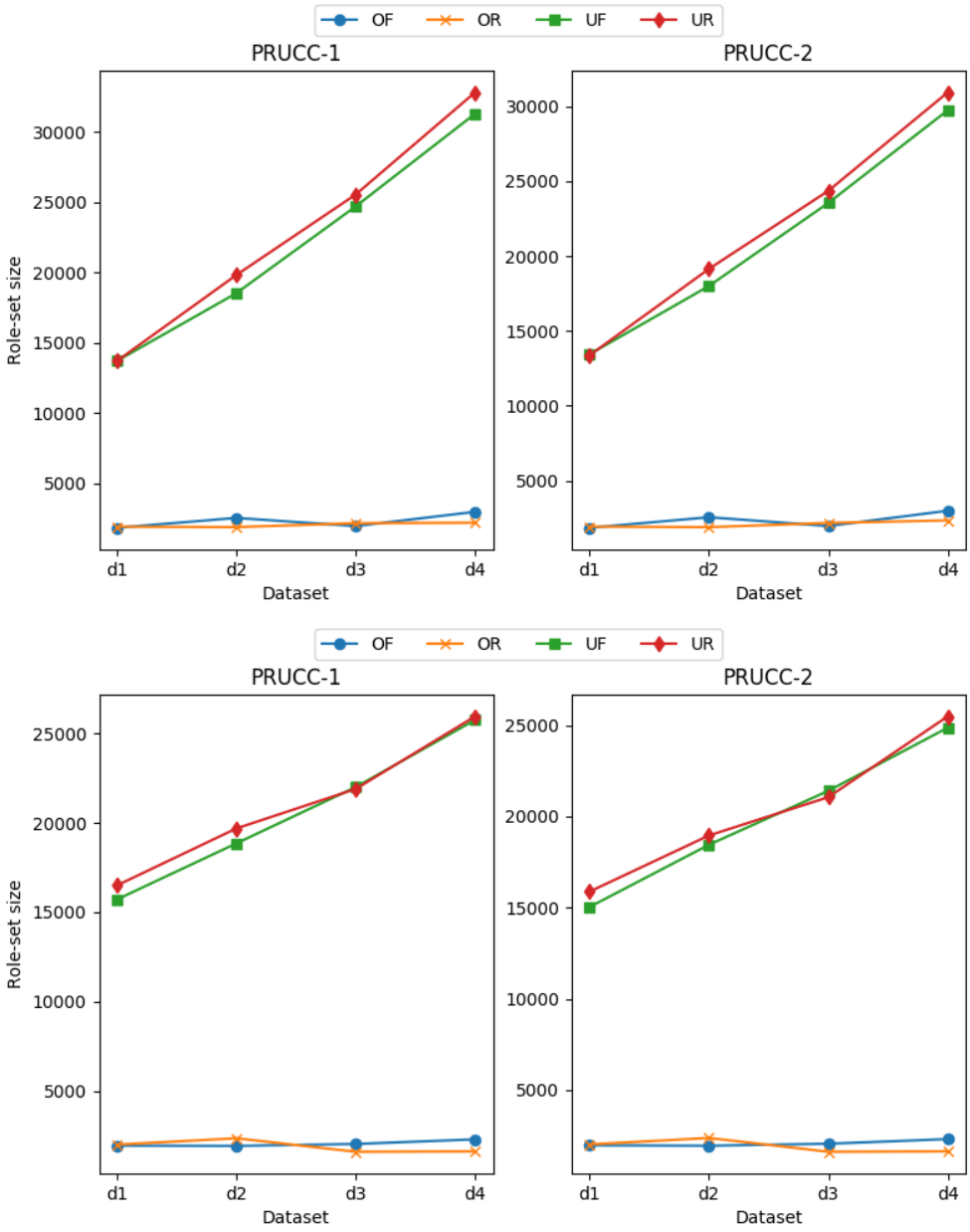

Figure 21: Role-set Size: Set 1 (upper) and Set 2 (lower)

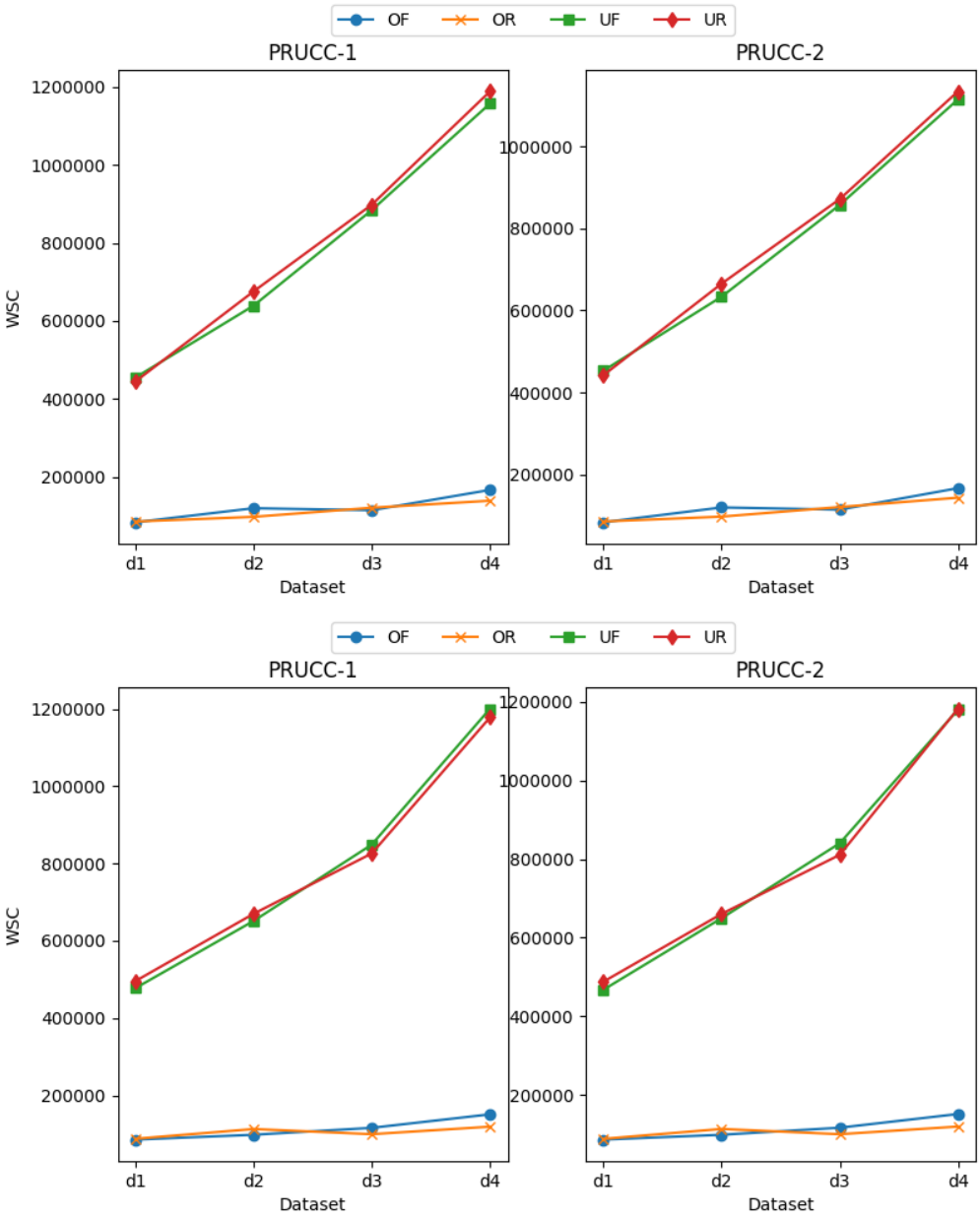

Figure 22: WSC: Set 1 (upper) and Set 2 (lower)

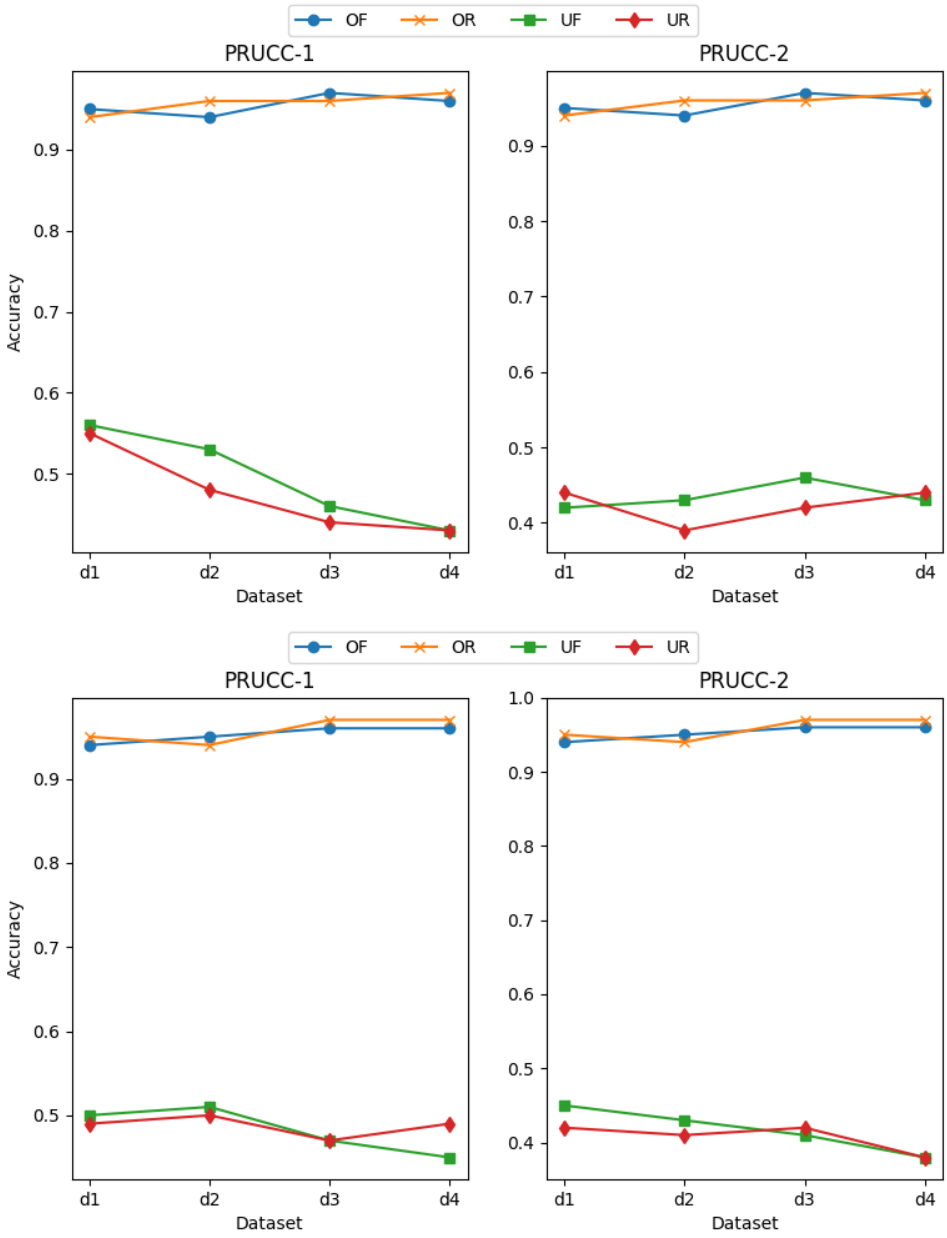

Figure 23: Accuracy: Set 1 (upper) and Set 2 (lower)

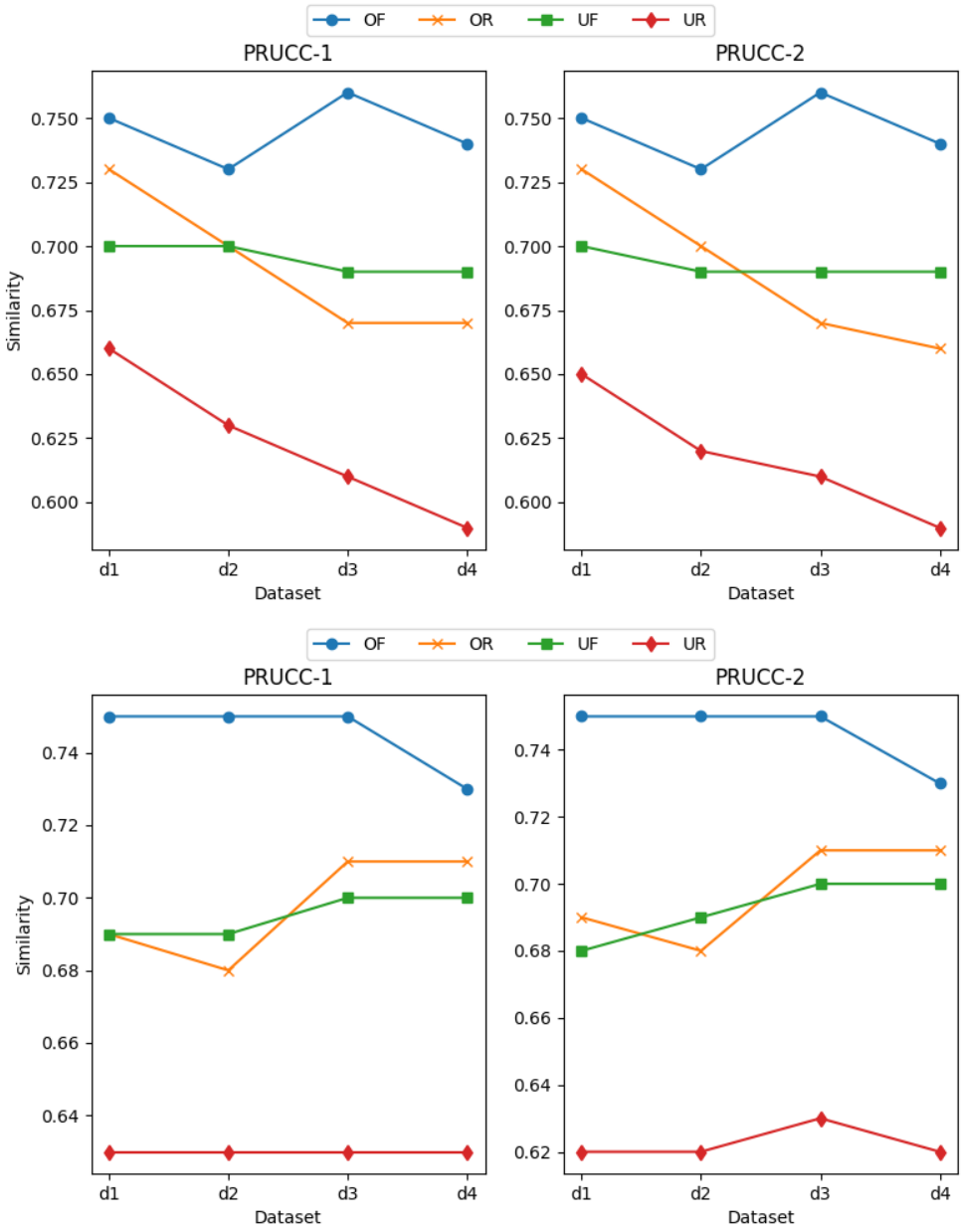

Figure 24: Similarity: Set 1 (upper) and Set 2 (lower)

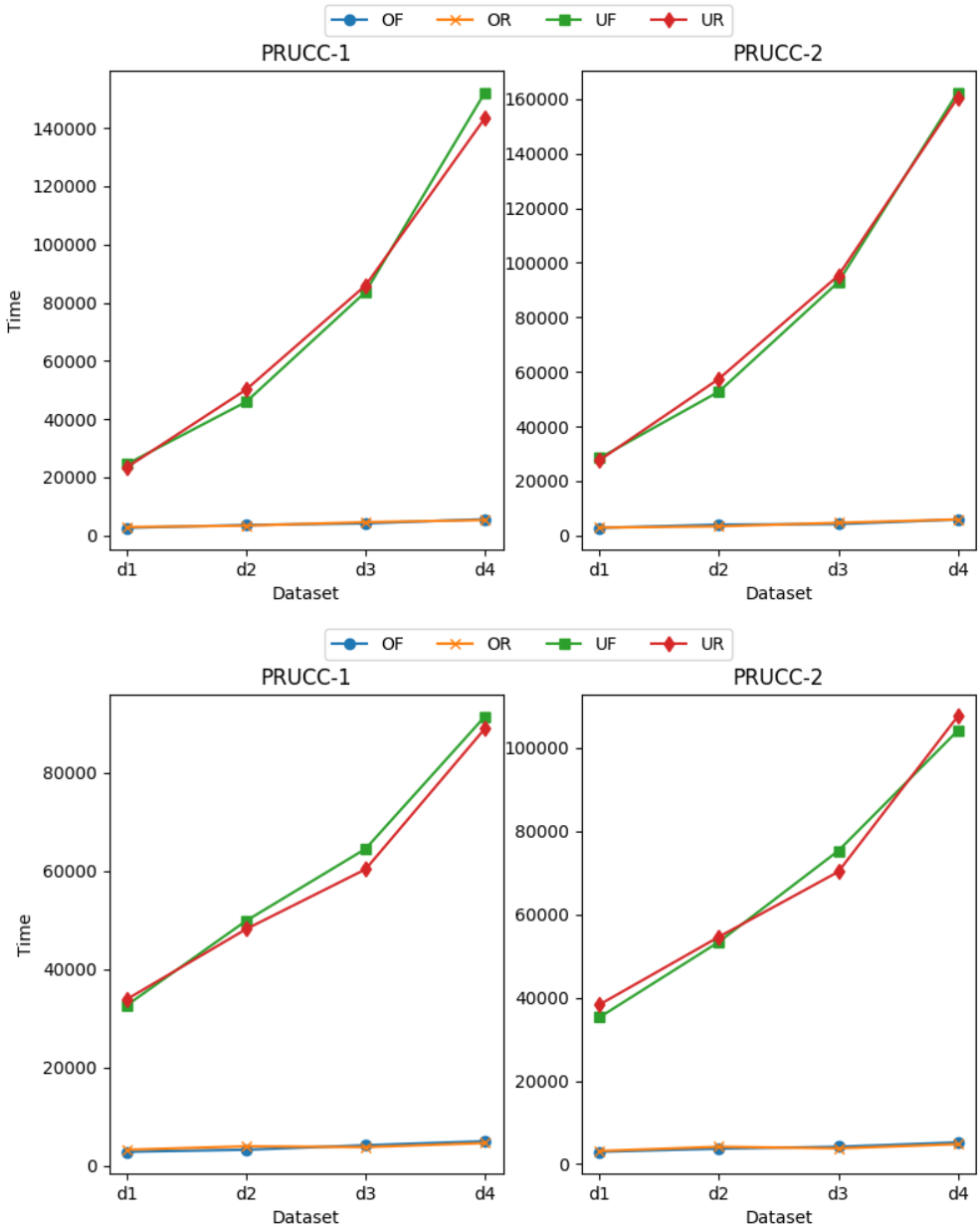

Figure 25: Time: Set 1 (upper) and Set 2 (lower)

4.10 Increasing (UPA density, from 1% to 4%)

Set 1	nr	nu	np	mru	mpr
d1	180	3500	1500	10	5
d2	180	3500	1500	20	5
d3	180	3500	1500	30	5
d4	180	3500	1500	40	5

Set 2	nr	nu	np	mru	mpr
d1	180	3500	1500	5	10
d2	180	3500	1500	5	20
d3	180	3500	1500	5	30
d4	180	3500	1500	5	40

Figure 26: Datasets' parameters fixing mpr (left) and fixing mru (right)

Heuristics' results for the datasets described in the left side of Figure 26

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	1296	1295	3672	5441	1341	1322	3566	5322
	WSC	26530	26540	39777	49680	26799	26683	39331	49145
	accuracy	94%	93%	84%	72%	94%	93%	85%	75%
	similarity	77%	71%	73%	62%	77%	71%	73%	62%
	time	474	461	1406	2183	457	461	1483	2217
d2	$\|\mathcal{R}\|$	2224	2462	6443	11300	2238	2320	6402	11691
	WSC	49323	50822	73210	102183	49353	50035	73200	104504
	accuracy	91%	94%	81%	70%	92%	94%	81%	71%
	similarity	74%	65%	69%	59%	74%	65%	69%	59%
	time	770	824	3246	7259	785	839	3703	8271
d3	$\|\mathcal{R}\|$	3300	4214	7986	14646	3462	4081	7961	14709
	WSC	73400	78682	100226	138971	74317	78029	100218	139873
	accuracy	91%	93%	79%	75%	92%	93%	80%	76%
	similarity	72%	62%	68%	57%	72%	62%	68%	57%
	time	1238	1397	4179	11333	1374	1473	4649	12249
d4	$\|\mathcal{R}\|$	4152	6576	9022	16308	4538	7033	9044	17467
	WSC	95469	110106	123908	166144	97803	112718	124099	173233
	accuracy	93%	91%	81%	75%	92%	91%	81%	75%
	similarity	71%	61%	67%	57%	70%	61%	67%	57%
	time	1612	2670	4883	13908	1934	3102	5659	17259

Heuristics' results for the datasets described in the left side of Figure 26

Dataset		PRUCC$_1$				PRUCC$_2$			
		OF	OR	UF	UR	OF	OR	UF	UR
d1	$\|\mathcal{R}\|$	986	872	3254	4175	998	851	3125	3927
	WSC	19606	18281	40832	48978	19741	18107	39731	46864
	accuracy	92%	93%	72%	62%	92%	93%	74%	66%
	similarity	79%	72%	74%	63%	78%	72%	74%	64%
	time	363	330	1234	1633	360	422	1255	1543
d2	$\|\mathcal{R}\|$	677	846	5209	5483	679	849	4855	5139
	WSC	21472	24532	98792	101815	21521	24589	94558	97556
	accuracy	95%	94%	50%	46%	95%	94%	51%	49%
	similarity	79%	70%	70%	62%	79%	70%	70%	62%
	time	372	402	2765	2852	383	425	2765	3908
d3	$\|\mathcal{R}\|$	774	1034	5307	5693	776	1040	5051	5513
	WSC	29048	35561	137953	146038	29110	35747	135358	145386
	accuracy	94%	91%	52%	49%	94%	91%	46%	41%
	similarity	76%	69%	69%	63%	76%	69%	69%	62%
	time	422	474	3081	3736	435	519	3600	3945
d4	$\|\mathcal{R}\|$	754	612	5380	5905	755	613	5309	5762
	WSC	34560	29601	177637	194381	34614	29629	179937	194885
	accuracy	95%	96%	53%	51%	95%	96%	39%	36%
	similarity	75%	73%	69%	64%	75%	73%	68%	62%
	time	485	574	3525	4082	541	536	4005	4610

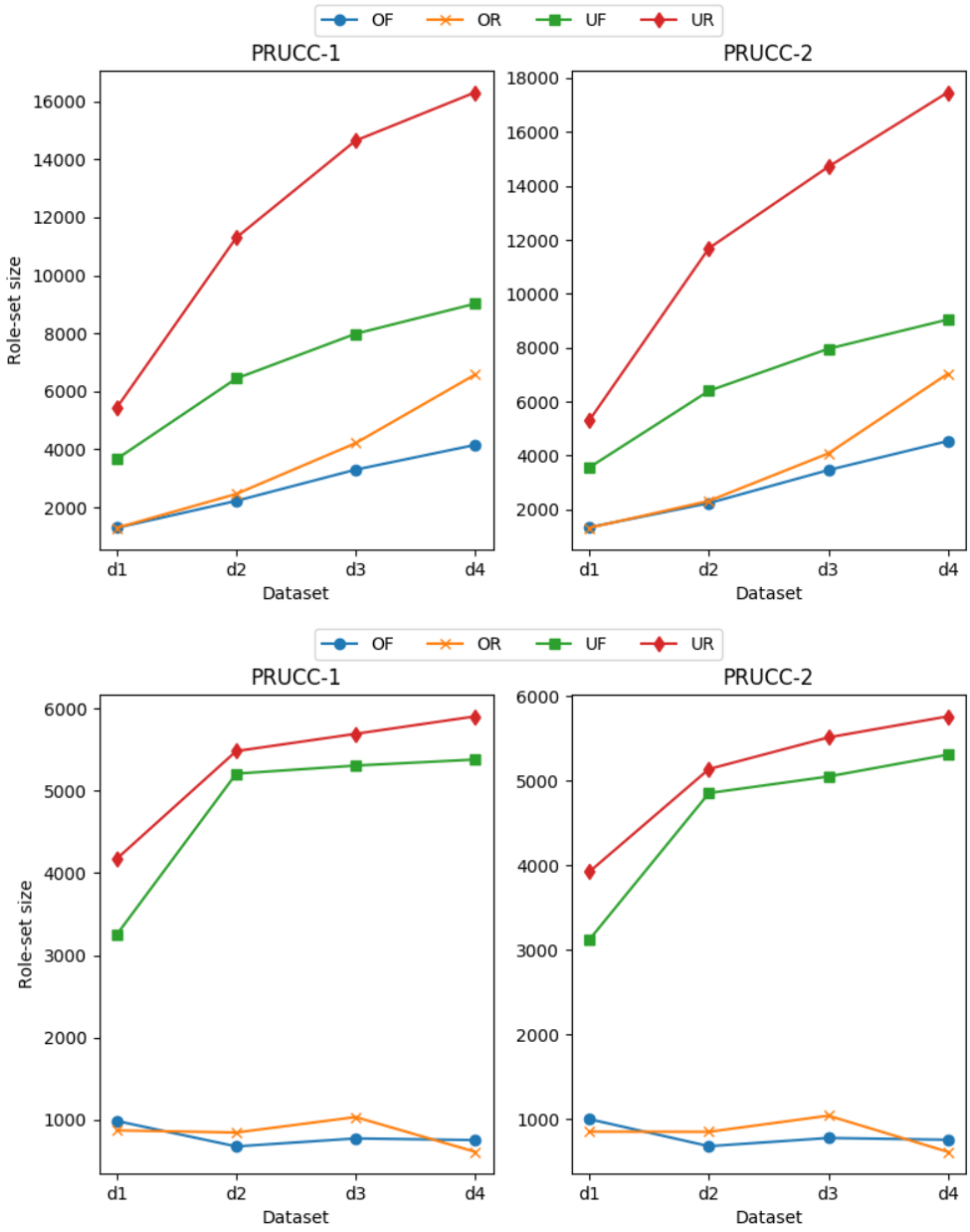

Figure 27: Role-set Size: Set 1 (upper) and Set 2 (lower)

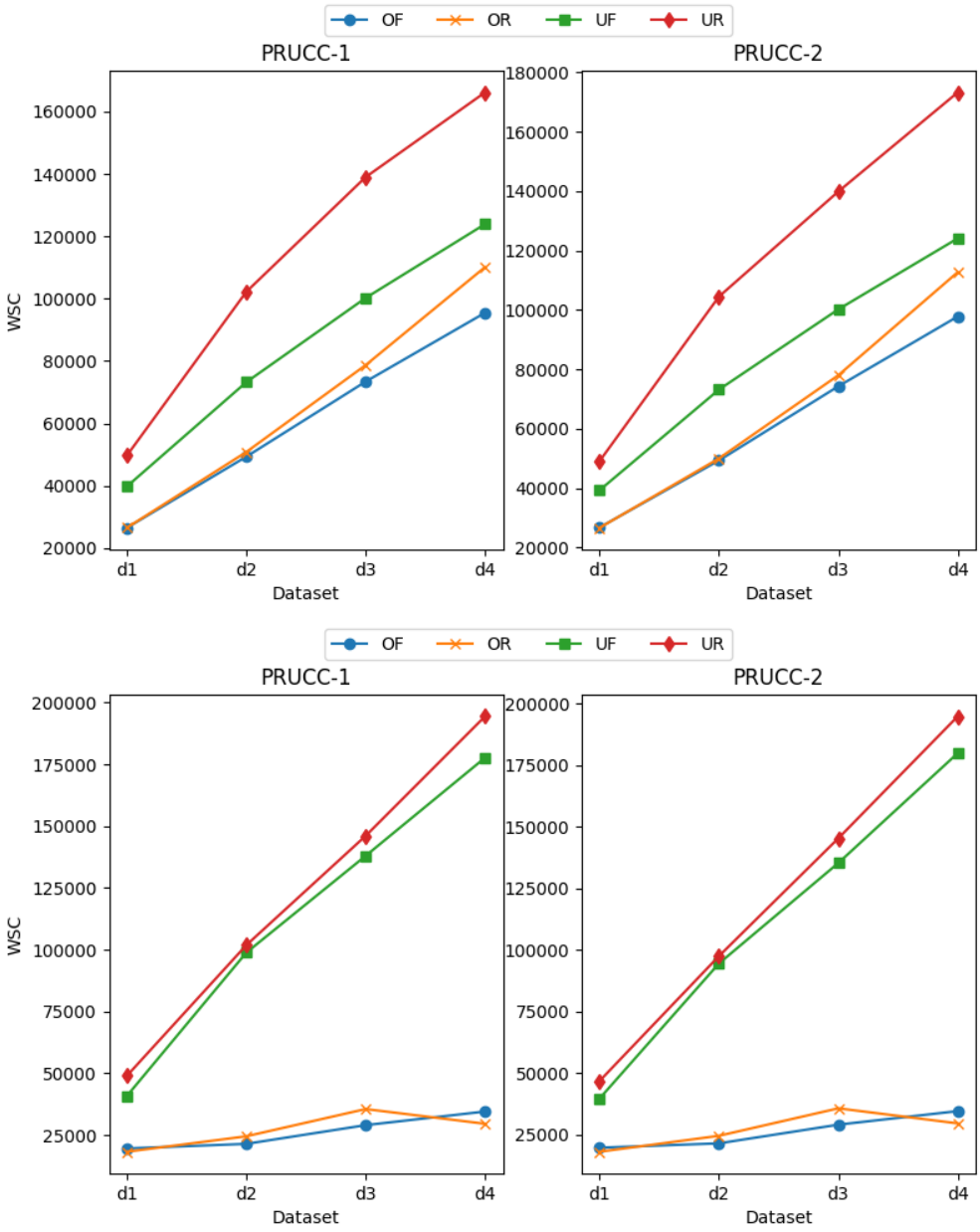

Figure 28: WSC: Set 1 (upper) and Set 2 (lower)

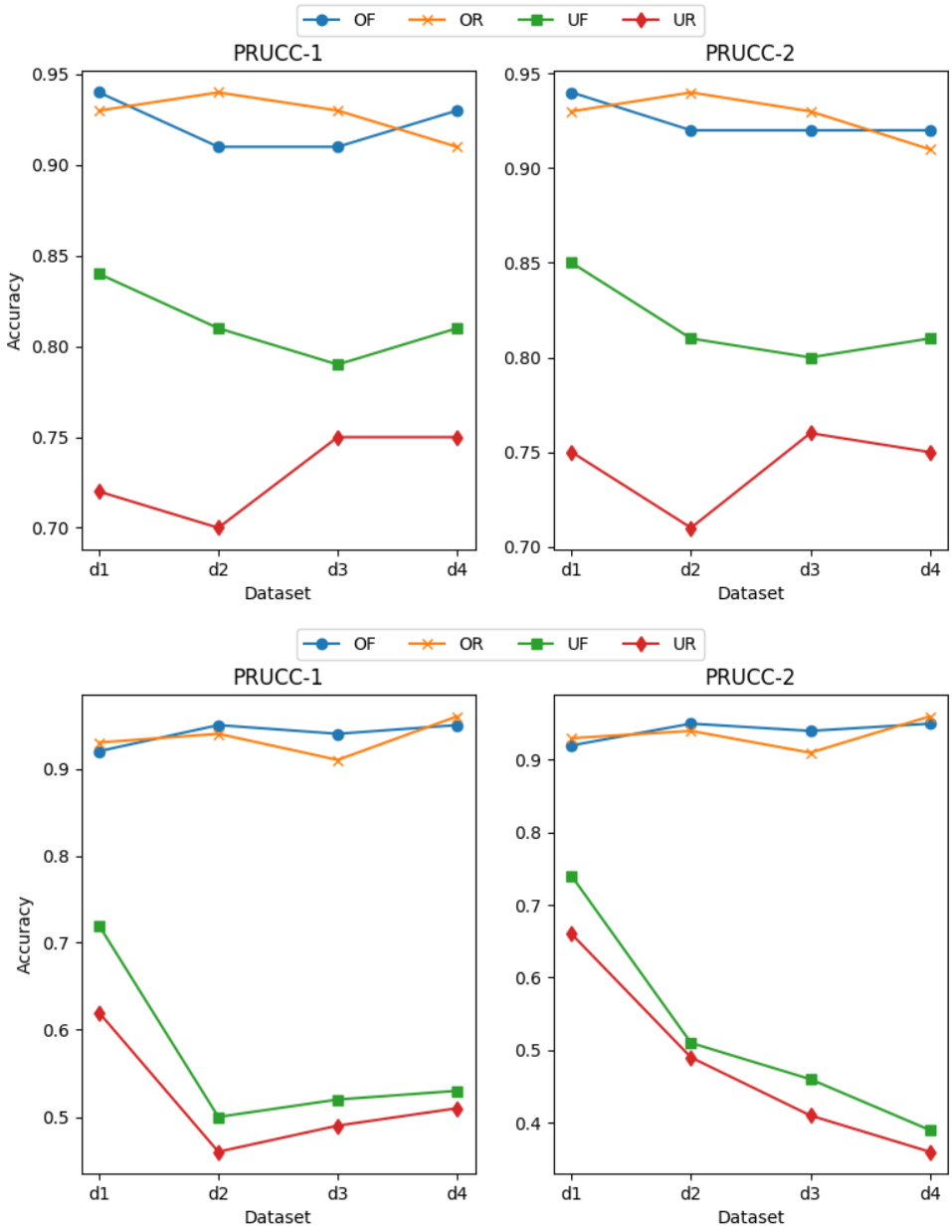

Figure 29: Accuracy: Set 1 (upper) and Set 2 (lower)

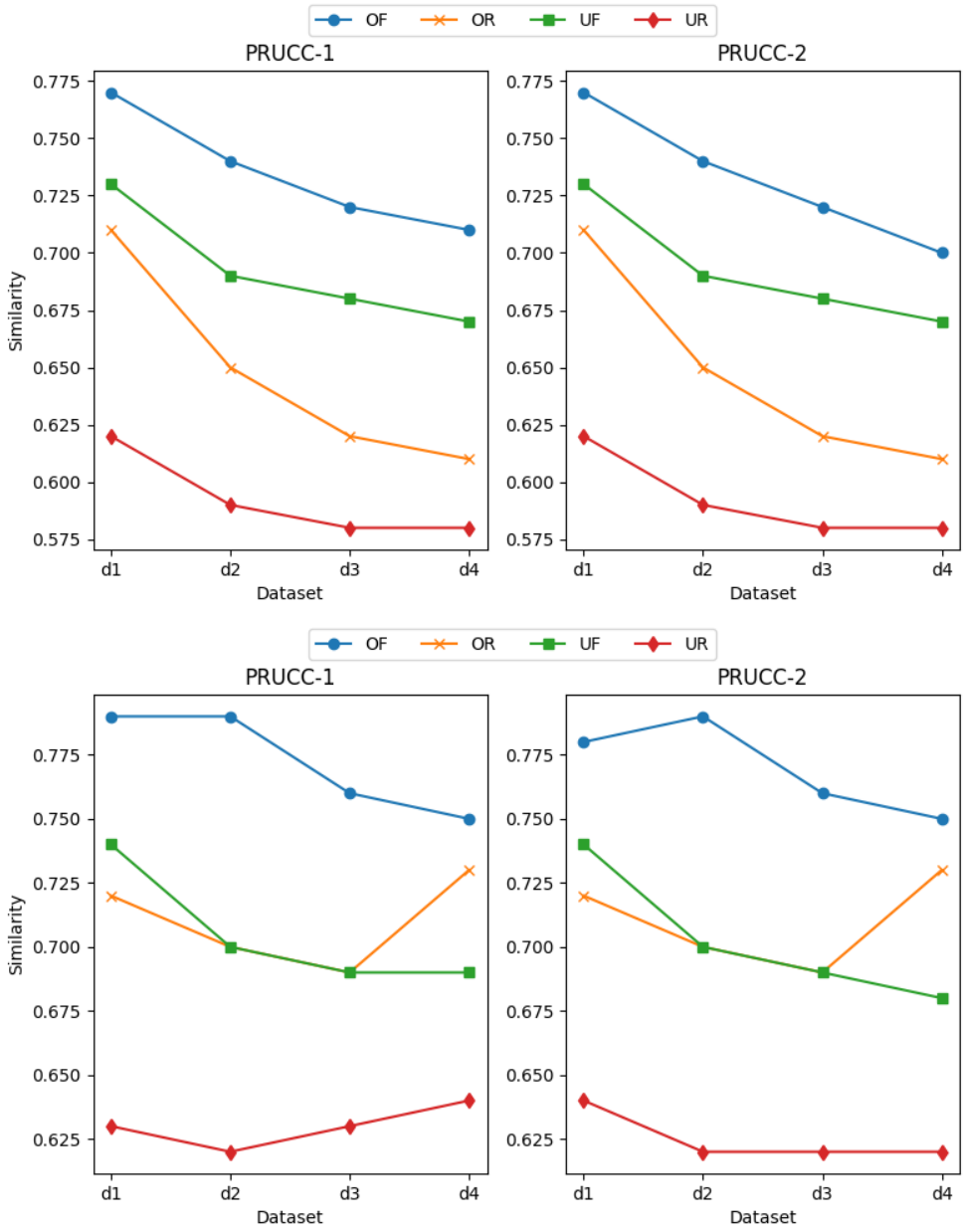

Figure 30: Similarity: Set 1 (upper) and Set 2 (lower)

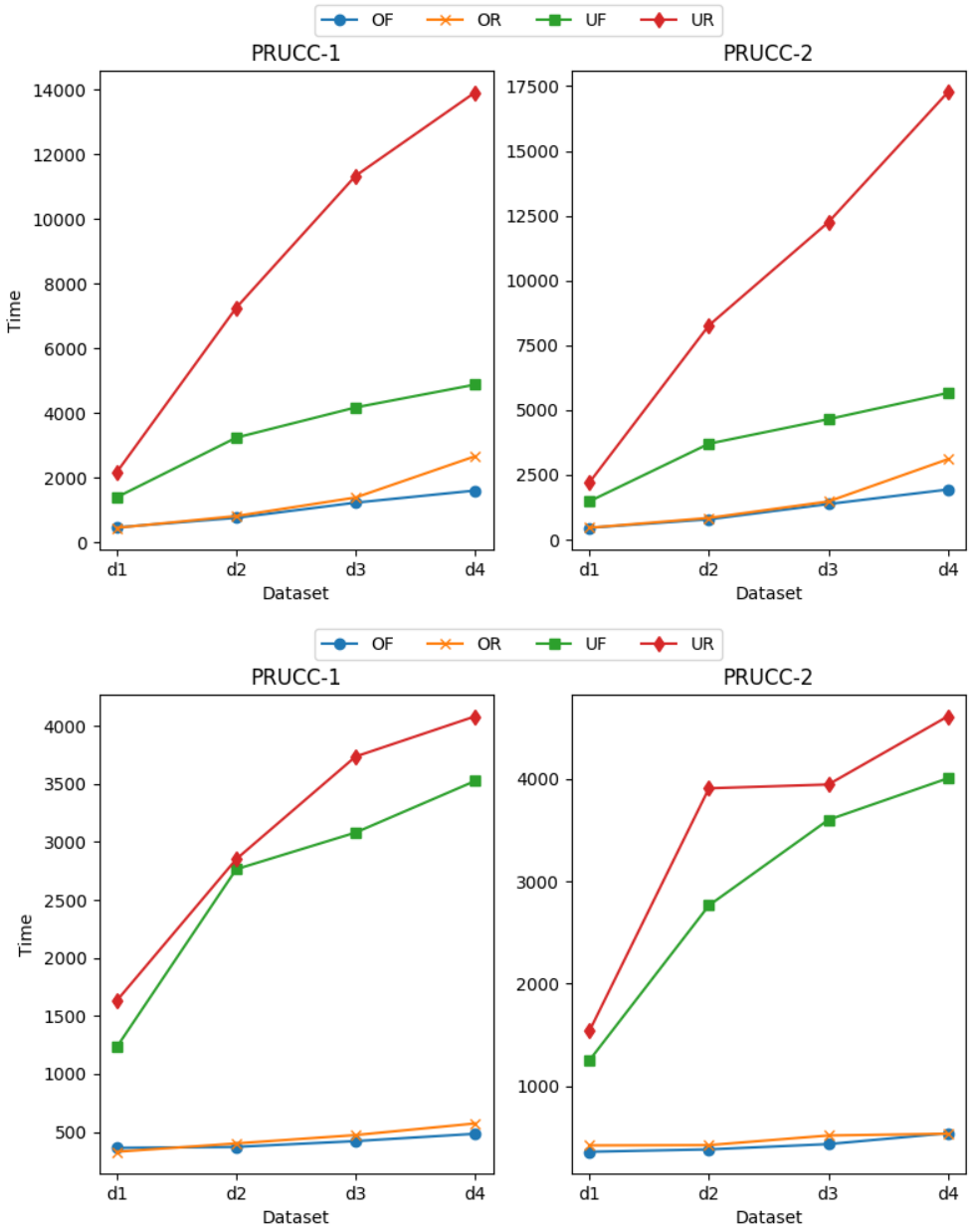

Figure 31: Time: Set 1 (upper) and Set 2 (lower)

5 Reducing PRUCC to RUCC or PUCC

Dataset	Heuristic	Role-set Size			WSC		
		20%	50%	100%	20%	50%	100%
Americas large	$C_{RM}-RUCC_R$	3485	432	432	192264	107585	107585
	$C_{RM}-RUCC_C$	3485	548	453	192264	99599	106561
	ERUC	432	429	415	479	98323	94095
	$PRUCC_1$-OF	414	421	413	93199	101201	94943
	$PRUCC_1$-OR	413	422	413	93208	101246	95008
	$PRUCC_1$-UF	415	422	415	93143	101021	94139
	$PRUCC_1$-UR	415	422	415	93143	101026	94121
	$PRUCC_2$-OF	415	422	413	93263	101311	94943
	$PRUCC_2$-OR	415	420	414	93258	101180	95063
	$PRUCC_2$-UF	415	422	415	93138	101026	94134
	$PRUCC_2$-UR	415	422	415	93125	101021	94134
Americas small	$C_{RM}-RUCC_R$	259	259	259	25488	25488	25488
	$C_{RM}-RUCC_C$	417	353	249	25930	21849	17827
	ERUC	258	244	224	22723	18532	13984
	$PRUCC_1$-OF	259	250	236	25168	22219	19030
	$PRUCC_1$-OR	259	250	236	25059	22219	19032
	$PRUCC_1$-UF	259	260	270	25342	23235	20692
	$PRUCC_1$-UR	259	260	270	25342	23242	20691
	$PRUCC_2$-OF	259	249	229	25054	22213	18080
	$PRUCC_2$-OR	259	249	229	25054	22218	18086
	$PRUCC_2$-UF	260	255	242	25344	22708	18361
	$PRUCC_2$-UR	260	255	242	25344	22708	18350
Apj	$C_{RM}-RUCC_R$	2044	564	564	10929	6129	6129
	$C_{RM}-RUCC_C$	2044	486	**456**	10929	**5299**	5223
	ERUC	**564**	**470**	457	**6129**	5372	**5160**
	$PRUCC_1$-OF	564	478	460	6129	5722	5261
	$PRUCC_1$-OR	564	478	460	6129	5746	5270
	$PRUCC_1$-UF	564	481	459	6129	5787	5211
	$PRUCC_1$-UR	564	481	459	6129	5787	5208
	$PRUCC_2$-OF	564	478	460	6129	5746	5272
	$PRUCC_2$-OR	564	478	460	6129	5746	5261
	$PRUCC_2$-UF	564	481	459	6129	5787	5218
	$PRUCC_2$-UR	564	481	459	6129	5787	5221
Emea	$C_{RM}-RUCC_R$	35	35	35	7290	7290	7290
	$C_{RM}-RUCC_C$	35	35	35	7290	7290	7290
	ERUC	**34**	**34**	**34**	**7280**	**7280**	**7280**
	$PRUCC_1$-OF	34	34	34	7280	7280	7280
	$PRUCC_1$-OR	34	34	34	7280	7280	7280
	$PRUCC_1$-UF	34	34	34	7280	7280	7280
	$PRUCC_1$-UR	34	34	34	7280	7280	7280
	$PRUCC_2$-OF	34	34	34	7280	7280	7280
	$PRUCC_2$-OR	34	34	34	7280	7280	7280
	$PRUCC_2$-UF	34	34	34	7280	7280	7280
	$PRUCC_2$-UR	34	34	34	7280	7280	7280

Table 164: RUCC Scenario

Dataset	Heuristic	Role-set Size			WSC		
		20%	50%	100%	20%	50%	100%
Healthcare	$C_{RM}-RUCC_R$	46	18	18	1578	563	563
	$C_{RM}-RUCC_C$	46	35	35	1578	503	521
	ERUC	**18**	**15**	**15**	**563**	**263**	**298**
	$PRUCC_1$-OF	18	15	15	563	381	344
	$PRUCC_1$-OR	18	15	15	563	381	344
	$PRUCC_1$-UF	18	15	15	563	381	344
	$PRUCC_1$-UR	18	15	15	563	381	344
	$PRUCC_2$-OF	18	15	15	563	381	344
	$PRUCC_2$-OR	18	15	15	563	381	344
	$PRUCC_2$-UF	18	15	15	563	381	344
	$PRUCC_2$-UR	18	15	15	563	381	344
Domino	$C_{RM}-RUCC_R$	79	23	23	888	**739**	**739**
	$C_{RM}-RUCC_C$	79	21	**20**	888	757	755
	ERUC	**23**	**20**	**20**	**739**	762	761
	$PRUCC_1$-OF	23	20	20	739	749	761
	$PRUCC_1$-OR	23	20	20	739	749	747
	$PRUCC_1$-UF	23	20	20	739	762	761
	$PRUCC_1$-UR	23	20	20	739	762	761
	$PRUCC_2$-OF	23	20	20	739	762	752
	$PRUCC_2$-OR	23	20	20	739	762	761
	$PRUCC_2$-UF	23	20	20	739	762	761
	$PRUCC_2$-UR	23	20	20	739	762	761
Customer	$C_{RM}-RUCC_R$	5655	5655	5655	**49761**	49761	49761
	$C_{RM}-RUCC_C$	8984	4403	956	62456	53557	46692
	ERUC	**5027**	**2495**	**657**	51138	**48928**	**46674**
	$PRUCC_1$-OF	3098	458	280	50229	46307	45959
	$PRUCC_1$-OR	3100	457	279	50218	46305	45904
	$PRUCC_1$-UF	3101	457	276	50242	46341	45978
	$PRUCC_1$-UR	3101	457	276	50242	46341	45978
	$PRUCC_2$-OF	3089	456	279	50207	46315	45943
	$PRUCC_2$-OR	3089	457	280	50207	46308	45951
	$PRUCC_2$-UF	3101	456	276	50242	46339	45978
	$PRUCC_2$-UR	3101	456	276	50242	46339	45978
Firewall 1	$C_{RM}-RUCC_R$	365	90	90	32681	7190	7190
	$C_{RM}-RUCC_C$	365	90	**65**	32681	**5807**	**4426**
	ERUC	**90**	**85**	71	**7190**	7207	4646
	$PRUCC_1$-OF	90	85	72	7190	6986	5354
	$PRUCC_1$-OR	90	85	72	7190	6986	5354
	$PRUCC_1$-UF	90	86	77	7190	6991	5828
	$PRUCC_1$-UR	90	86	77	7190	6991	5828
	$PRUCC_2$-OF	90	85	72	7190	6986	5359
	$PRUCC_2$-OR	90	85	72	7190	6986	5354
	$PRUCC_2$-UF	90	86	76	7190	6993	5831
	$PRUCC_2$-UR	90	86	76	7190	6990	5826
Firewall 2	$C_{RM}-RUCC_R$	325	325	11	37078	37078	1510
	$C_{RM}-RUCC_C$	325	325	**10**	37078	37078	**1466**
	ERUC	**11**	**11**	11	**1510**	**1510**	1548
	$PRUCC_1$-OF	10	11	12	1542	1510	1519
	$PRUCC_1$-OR	10	11	12	1542	1510	1519
	$PRUCC_1$-UF	10	11	11	1564	1510	1494
	$PRUCC_1$-UR	10	11	11	1564	1510	1494
	$PRUCC_2$-OF	10	11	11	1542	1510	1505
	$PRUCC_2$-OR	10	11	11	1542	1510	1505
	$PRUCC_2$-UF	10	11	11	1564	1510	1505
	$PRUCC_2$-UR	10	11	11	1564	1510	1505

Table 165: RUCC Scenario

Dataset	Heuristic	Role-set Size			WSC		
		20%	50%	100%	20%	50%	100%
Americas large	$C_{RM}-PUCC_C$	757	659	612	120369	122824	99913
	$C_{RM}-PUCC_R$	617	509	430	62439	79198	107610
	CRM	669	**464**	415	**48429**	74184	**92293**
	$PRUCC_1$-OF	604	494	416	59199	73661	93381
	$PRUCC_1$-OR	780	535	415	85223	90860	93267
	$PRUCC_1$-UF	608	498	415	59542	74312	93138
	$PRUCC_1$-UR	789	539	415	86962	89781	93138
	$PRUCC_2$-OF	603	494	414	59040	73933	93256
	$PRUCC_2$-OR	790	538	415	86827	90956	93256
	$PRUCC_2$-UF	607	499	415	59395	74666	93143
	$PRUCC_2$-UR	801	539	415	88181	90091	93143
Americas small	$C_{RM}-PUCC_C$	248	216	206	24538	24125	23242
	$C_{RM}-PUCC_R$	227	217	226	11814	15740	21650
	CRM	232	209	209	11533	**10550**	**10550**
	$PRUCC_1$-OF	208	196	196	10991	11198	11111
	$PRUCC_1$-OR	212	196	196	11348	11121	11106
	$PRUCC_1$-UF	217	207	207	11621	11674	11669
	$PRUCC_1$-UR	217	207	208	11629	11613	11665
	$PRUCC_2$-OF	208	196	196	11001	11134	11111
	$PRUCC_2$-OR	215	196	196	11428	11112	11112
	$PRUCC_2$-UF	218	207	206	11672	11680	11621
	$PRUCC_2$-UR	217	207	207	11618	11609	11602
Apj	$C_{RM}-PUCC_C$	505	478	466	11019	10980	10683
	$C_{RM}-PUCC_R$	492	480	475	5215	5747	5927
	CRM	487	**459**	455	**5146**	**5065**	**5063**
	$PRUCC_1$-OF	479	459	455	5201	5167	5151
	$PRUCC_1$-OR	478	458	454	5222	5178	5169
	$PRUCC_1$-UF	478	459	455	5154	5122	5110
	$PRUCC_1$-UR	479	459	455	5175	5118	5118
	$PRUCC_2$-OF	479	459	454	5201	5165	5169
	$PRUCC_2$-OR	479	458	455	5226	5169	5158
	$PRUCC_2$-UF	478	459	455	5153	5121	5112
	$PRUCC_2$-UR	479	459	455	5164	5118	5109
Emea	$C_{RM}-PUCC_C$	88	52	40	11820	11014	7677
	$C_{RM}-PUCC_R$	80	**45**	**34**	6848	6750	7280
	CRM	100	50	**34**	**4900**	**5938**	7280
	$PRUCC_1$-OF	78	45	34	6531	6750	7280
	$PRUCC_1$-OR	85	47	34	7264	7306	7280
	$PRUCC_1$-UF	78	45	34	6531	6750	7280
	$PRUCC_1$-UR	84	47	34	7255	7306	7280
	$PRUCC_2$-OF	78	45	34	6531	6750	7280
	$PRUCC_2$-OR	83	47	34	7048	7181	7280
	$PRUCC_2$-UF	78	45	34	6531	6750	7280
	$PRUCC_2$-UR	83	47	34	7137	7181	7280

Table 166: Role-set size and WSC for the PUCC case

Dataset	Heuristic	Role-set Size			WSC		
		20%	50%	100%	20%	50%	100%
Healthcare	C_{RM}−$PUCC_C$	22	19	16	549	636	605
	C_{RM}−$PUCC_R$	**18**	**15**	16	**494**	**383**	499
	CRM	86	39	**14**	858	651	**351**
	$PRUCC_1$-OF	18	15	14	551	431	385
	$PRUCC_1$-OR	18	15	14	544	431	385
	$PRUCC_1$-UF	18	15	14	521	401	369
	$PRUCC_1$-UR	18	15	14	516	401	355
	$PRUCC_2$-OF	18	15	14	551	431	385
	$PRUCC_2$-OR	18	15	14	551	431	385
	$PRUCC_2$-UF	18	15	14	521	401	355
	$PRUCC_2$-UR	18	15	14	528	401	355
Domino	C_{RM}−$PUCC_C$	29	26	23	1333	1414	1212
	C_{RM}−$PUCC_R$	**27**	24	**20**	631	667	758
	CRM	30	**22**	**20**	781	**577**	761
	$PRUCC_1$-OF	25	23	20	545	753	761
	$PRUCC_1$-OR	27	23	20	608	767	761
	$PRUCC_1$-UF	27	23	20	594	753	747
	$PRUCC_1$-UR	28	23	20	648	767	761
	$PRUCC_2$-OF	27	23	20	594	753	747
	$PRUCC_2$-OR	27	23	20	606	753	747
	$PRUCC_2$-UF	27	23	20	608	767	761
	$PRUCC_2$-UR	28	23	20	636	757	761
Customer	C_{RM}−$PUCC_C$	289	278	**276**	133091	134387	134367
	C_{RM}−$PUCC_R$	664	1122	1154	**43256**	**44604**	**45100**
	CRM	**277**	**277**	277	45963	45963	45963
	$PRUCC_1$-OF	278	278	277	45955	45945	45955
	$PRUCC_1$-OR	280	280	279	45896	45932	45948
	$PRUCC_1$-UF	276	276	276	45978	45978	45978
	$PRUCC_1$-UR	276	276	276	45978	45978	45978
	$PRUCC_2$-OF	278	278	279	45957	45941	45946
	$PRUCC_2$-OR	279	281	279	45946	45933	45892
	$PRUCC_2$-UF	276	276	276	45978	45978	45978
	$PRUCC_2$-UR	276	276	276	45978	45978	45978
Firewall 1	C_{RM}−$PUCC_C$	84	77	75	7181	6696	6510
	C_{RM}−$PUCC_R$	77	73	72	**3161**	4745	5233
	CRM	74	69	68	3250	**3192**	**3190**
	$PRUCC_1$-OF	71	66	65	3354	3301	3299
	$PRUCC_1$-OR	71	66	65	3358	3301	3299
	$PRUCC_1$-UF	73	69	68	3317	3278	3276
	$PRUCC_1$-UR	73	69	68	3315	3275	3278
	$PRUCC_2$-OF	71	66	65	3349	3301	3299
	$PRUCC_2$-OR	71	66	65	3358	3296	3299
	$PRUCC_2$-UF	73	69	68	3312	3275	3273
	$PRUCC_2$-UR	73	69	68	3312	3278	3273
Firewall 2	C_{RM}−$PUCC_C$	21	14	11	2831	2752	2444
	C_{RM}−$PUCC_R$	**18**	**12**	**10**	**1793**	**1472**	**1365**
	CRM	22	14	**10**	2219	1942	1564
	$PRUCC_1$-OF	18	12	10	1970	1649	1542
	$PRUCC_1$-OR	18	12	10	1970	1649	1542
	$PRUCC_1$-UF	18	12	10	1992	1671	1564
	$PRUCC_1$-UR	18	12	10	1992	1671	1564
	$PRUCC_2$-OF	18	12	10	1970	1649	1542
	$PRUCC_2$-OR	18	12	10	1970	1649	1542
	$PRUCC_2$-UF	18	12	10	1992	1671	1564
	$PRUCC_2$-UR	18	12	10	1992	1671	1564

Table 167: Role-set size and WSC for the PUCC case