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Number Of Distinct Topologies On Finite Set With R-Open Sets

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Abstract:
In this paper, we have studied the sequences of distinct topologies on n-set with r-open sets [2]. Here we have applied the concept of repeated ratios proposed by Dasre and Gujarathi [3] to these sequences. After applying the repeated ratios to these sequences, we observed that the repeated ratios follow the same pattern for all sequences. So the method of repeated ratios can be used for finding the better bounds for the number of topologies. Using the repeated ratios, one can approximate the large numbers for the sequences as in [3, 4]. We also observed that the sequence of repeated ratios oscillates around one.

AMS Subject Classification: 40A15, 54A99.

Key Words and Phrases: Topology, Repeated Ratio, Sequences.

1. Introduction

In literature very few approaches are available for finding number of topologies on larger finite set. The traditional method for finding number of topologies on finite sets are found insufficient for large n. The approaches by V. Krishnamoorthy [5], G. H. Patil and M. S. Chaudhary [1] have tried to give bounds but still these bounds are not efficient for large n. The method introduced by Dasre and Gujarathi of repeated ratios in [3] is applicable for large n. Also by the same approach in [4] the method was applied to partially ordered set with n-labelled elements and have given the approximate bounds. In this paper, we have applied the method of repeated ratios to the series of topologies on n-sets with r-open sets.

2. Repeated Ratios

Let $\{x_n\}$ be the series. We define the repeated ratios [3] as below:

$$a_n = \frac{X_{n+1}}{X_n} \qquad \ldots.(1)$$

$$b_n = \frac{a_{n+1}}{a_n} = \frac{X_{n+2}X_n}{X_{n+1}^2} \qquad \ldots.(2)$$

$$c_n = \frac{b_{n+1}}{b_n} = \frac{X_{n+3}X_{n+1}^3}{X_{n+2}^3X_n} \qquad \ldots.(3)$$

and so on. In this paper, we are considering the series A281773, A281774, A281775, A281776, A281777, A281778, A281779, A281780 of topologies on sets of n-elements with r-open sets by N. J. Sloane[2]. The repeated ratios $a_n, b_n, c_n, \ldots, j_n$ are as defined in [3]. These repeated ratios are calculated for series of distinct topologies on n-sets with exactly r-open sets. We have tabulated the repeated ratios for each of the above series [2] as below:
The series A281773: 0, 0, 1, 9, 43, 165, 571, 1869, 5923, 18405, 56491, 172029, 521203, 1573845, 4742011, 14266989, 42882883, 128812485, 386765131, 1160950749, 3484162963, 10455110325,

31370573851, 94122207309, 282387593443, 847204723365, 2541698056171, 7625261940669 is a series of Number of distinct topologies on an n-set that have exactly 4 open sets. Table 1 shows repeated ratios of the non-zero terms of the series A281773.

Table 1: The repeated ratios for the series **A281773**

x_n	a_n	b_n	c_n	d_n	e_n	f_n	g_n	h_n	i_n	j_n
1	9	0.53086	1.51288	0.74223	1.25833	0.83046	1.16808	0.87527	1.12347	0.90186
9	4.77777	0.80313	1.12291	0.93397	1.04500	0.97004	1.02239	0.98334	1.01322	0.98950
43	3.83720	0.90185	1.04878	0.97600	1.01370	0.99176	1.00536	0.99635	1.00259	0.99809
165	3.46060	0.94584	1.02361	0.98938	1.00535	0.99709	1.00170	0.99894	1.00068	0.99953
571	3.27320	0.96818	1.01275	0.99468	1.00243	0.99879	1.00064	0.99963	1.00022	0.99986
1869	3.16907	0.98053	1.00736	0.99710	1.00122	0.99943	1.00027	0.99985	1.00008	0.99995
5923	3.10737	0.98775	1.00445	0.99833	1.00066	0.99971	1.00013	0.99993	1.00003	0.99998
18405	3.06932	0.99215	1.00277	0.99899	1.00038	0.99984	1.00006	0.99997	1.00001	0.99999
56491	3.04524	0.99490	1.00176	0.99937	1.00022	0.99991	1.00003	0.99998	1.00000	0.99999
172029	3.02973	0.99666	1.00114	0.99960	1.00014	0.99994	1.00002	0.99999	1.00000	0.99999
521203	3.019639	0.99780	1.00074	0.99974	1.00008	0.99996	1.00001	0.99999	1.00000	0.99999
1573845	3.01301	0.99854	1.00049	0.99983	1.00005	0.99998	1.00000	0.99999	1.00000	1
4742011	3.00863	0.99903	1.00032	0.99989	1.00003	0.99998	1.00000	0.99999	1.00000	1
14266989	3.00574	0.99936	1.00021	0.99992	1.00002	0.99999	1.00000	0.99999	1	1
42882883	3.003820	0.99957	1.00014	0.99995	1.00001	0.99999	1.00000	0.99999	1	1
128812485	3.00254	0.99971	1.00009	0.99996	1.00001	0.99999	1.00000	1	1	1
386765131	3.00169	0.99981	1.00006	0.99997	1.00000	0.99999	1.00000	1	1	
1160950749	3.00112	0.99987	1.00004	0.99998	1.00000	0.99999	1.00000	1		
3484162963	3.00075	0.99991	1.00002	0.99999	1.00000	0.99999	1			
10455110325	3.000505	0.99994	1.000019	0.999994	1.000002	0.999999				
31370573851	3.00033	0.999963	1.000012	0.999996	1.000001					
94122207309	3.00022	0.99997	1.00000	0.99999						
282387593443	3.00014	0.99998	1.00000							
847204723365	3.00009	0.99998								
2541698056171	3.00006									
7625261940669										

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The series A281774: 0, 0, 0, 6, 72, 630, 4680, 31206, 193032, 1131990, 6386760, 35025606, 188061192, 993760950, 5187840840, 26831095206, 137770476552, 703455087510, 3576115150920, 18117222864006, 91536570671112, 461496288791670, 2322770028381000, 11675109032796006 is a series of Number of distinct topologies on an n-set that have exactly 6 open sets. Table 2 shows repeated ratios of the non-zero terms of the series A281774.

Table 2: The repeated ratios for the series **A281774**

x_n	a_n	b_n	c_n	d_n	e_n	f_n	g_n	h_n	i_n	j_n
6	12.00000	0.72917	1.16431	0.90807	1.07647	0.93969	1.05656	0.95152	1.04635	0.95936
72	8.75000	0.84898	1.05728	0.97751	1.01155	0.99284	1.00534	0.99562	1.00383	0.99659
630	7.42857	0.89761	1.03350	0.98881	1.00431	0.99814	1.00094	0.99943	1.00041	0.99967
4680	6.66795	0.92768	1.02193	0.99307	1.00244	0.99908	1.00037	0.99984	1.00008	0.99996
31206	6.18573	0.94803	1.01485	0.99550	1.00152	0.99945	1.00021	0.99992	1.00003	0.99999
193032	5.86426	0.96211	1.01028	0.99701	1.00097	0.99966	1.00013	0.99995	1.00002	0.99999
1131990	5.64206	0.97200	1.00726	0.99797	1.00063	0.99979	1.00008	0.99997	1.00001	1.00000
6386760	5.48410	0.97906	1.00522	0.99860	1.00042	0.99986	1.00005	0.99998	1.00001	1.00000
35025606	5.36925	0.98417	1.00381	0.99902	1.00028	0.99991	1.00003	0.99999	1.00000	1.00000
188061192	5.28424	0.98792	1.00282	0.99930	1.00019	0.99994	1.00002	0.99999	1.00000	1.00000
993760950	5.22041	0.99071	1.00212	0.99949	1.00013	0.99996	1.00001	1.00000	1.00000	1.00000
5187840840	5.17192	0.99281	1.00160	0.99962	1.00010	0.99997	1.00001	1.00000	1.00000	0.00000
26831095206	5.13473	0.99440	1.00123	0.99972	1.00007	0.99998	1.00001	1.00000	0.00000	
137770476552	5.10599	0.99562	1.00094	0.99979	1.00005	0.99999	1.00000	0.00000		
703455087510	5.08364	0.99656	1.00073	0.99984	1.00004	0.99999	0.00000			
3576115150920	5.06617	0.99729	1.00057	0.99988	1.00003	0.00000				
18117222864006	5.05246	0.99786	1.00045	0.99990	0.00000					
91536570671112	5.04166	0.99831	1.00035	0.00000						
461496288791670	5.03313	0.99866	0.00000							
2322770028381000	5.02637	0.00000								
11675109032796006										

The series A281775: 0, 0, 0, 0, 54, 780, 7830, 67620, 535374, 3992940, 28483110, 196316340, 1317106494, 8650141500, 55853351190, 355770438660, 2241509994414, 13998294536460, 86795899256070, 535048203626580, 3282628800655134, 20061393719417820,

122212221633141750 is a series of Number of distinct topologies on an n-set that have exactly 7 open sets. Table 3 shows repeated ratios of the non-zero terms of the series A281775.

Table 3: The repeated ratios for the series **A281775**

x_n	a_n	b_n	c_n	d_n	e_n	f_n	g_n	h_n	i_n	j_n
54	14.44444	0.69497	1.23788	0.86088	1.12000	0.91504	1.07372	0.94360	1.04942	0.96005
780	10.03846	0.86029	1.06567	0.96419	1.02485	0.98249	1.01316	0.99023	1.00749	0.99429
7830	8.63602	0.91679	1.02751	0.98815	1.00691	0.99542	1.00326	0.99764	1.00174	0.99872
67620	7.91739	0.94201	1.01533	0.99497	1.00230	0.99866	1.00089	0.99937	1.00045	0.99967
535374	7.45823	0.95644	1.01022	0.99725	1.00096	0.99955	1.00026	0.99983	1.00012	0.99991
3992940	7.13337	0.96622	1.00744	0.99821	1.00051	0.99982	1.00009	0.99995	1.00003	0.99998
28483110	6.89238	0.97341	1.00564	0.99872	1.00033	0.99990	1.00004	0.99998	1.00001	0.99999
196316340	6.70910	0.97890	1.00435	0.99905	1.00023	0.99994	1.00002	0.99999	1.00000	1.00000
1317106494	6.56753	0.98316	1.00339	0.99927	1.00017	0.99996	1.00001	1.00000	1.00000	1.00000
8650141500	6.45693	0.98649	1.00266	0.99944	1.00013	0.99997	1.00001	1.00000	1.00000	
55853351190	6.36972	0.98912	1.00211	0.99957	1.00010	0.99998	1.00001	1.00000		
355770438660	6.30044	0.99121	1.00167	0.99966	1.00007	0.99998	1.00000			
2241509994414	6.24503	0.99286	1.00134	0.99974	1.00006	0.99999				
13998294536460	6.20046	0.99419	1.00107	0.99979	1.00004					
86795899256070	6.16444	0.99526	1.00086	0.99984						
535048203626580	6.13520	0.99612	1.00070							
3282628800655134	6.11138	0.99681								
20061393719417820	6.09191									
1222122216331411750										

The series A281776: 0, 0, 0, 1, 54, 955, 11760, 122941, 1175034, 10595215, 91506420, 763624081, 6194818014, 49084747075, 381338401080, 2914184784421, 21965095364994, 163656285828535, 1207613518375740, 8838842878371961, 64253768864671974, 464416229729871595, 3340518964319750400 is a series of Number of distinct topologies on an n-set that have exactly 8 open sets. Table 4 shows repeated ratios of the non-zero terms of the series A281776.

Table 4: The repeated ratios for the series **A281776**

x_n	a_n	b_n	c_n	d_n	e_n	f_n	g_n	h_n	i_n	j_n
54	17.68519	0.69630	1.21925	0.88326	1.08486	0.94645	1.03925	0.97224	1.02188	0.98268
955	12.31414	0.84896	1.07691	0.95821	1.02677	0.98360	1.01040	0.99351	1.00418	0.99722
11760	10.45417	0.91425	1.03191	0.98386	1.00993	0.99383	1.00385	0.99767	1.00139	0.99919
122941	9.55771	0.94342	1.01526	0.99364	1.00370	0.99765	1.00151	0.99906	1.00058	0.99966
1175034	9.01694	0.95782	1.00880	0.99731	1.00134	0.99915	1.00056	0.99963	1.00023	0.99985
10595215	8.63658	0.96624	1.00608	0.99865	1.00050	0.99971	1.00019	0.99987	1.00009	0.99994
91506420	8.34503	0.97212	1.00473	0.99915	1.00021	0.99991	1.00006	0.99996	1.00003	0.99998
763624081	8.11239	0.97672	1.00387	0.99935	1.00012	0.99997	1.00002	0.99999	1.00001	0.99999
6194818014	7.92352	0.98050	1.00322	0.99947	1.00008	0.99999	1.00000	1.00000	1.00000	1.00000
49084747075	7.76898	0.98365	1.00269	0.99956	1.00007	0.99999	1.00000	1.00000	1.00000	
381338401080	7.64199	0.98630	1.00225	0.99963	1.00006	0.99999	1.00000	1.00000		
2914184784421	7.53730	0.98852	1.00187	0.99969	1.00005	0.99999	1.00000			
21965095364994	7.45074	0.99037	1.00156	0.99974	1.00004	0.99999				
163656285828535	7.37896	0.99191	1.00130	0.99978	1.00004					
1207613518375740	7.31926	0.99320	1.00108	0.99982						
8838842878371961	7.26948	0.99427	1.00090							
64253768864671974	7.22784	0.99517								
464416229729871595	7.19294									
3340518964319750400										

The series A281777: 0, 0, 0, 0, 20, 800, 14260, 189280, 2181060, 23241120, 235737620, 2308206560, 21979728100, 204477713440, 1864504348980, 16707856095840, 147469451067140, 1284607771225760, 11063319237792340, 94343562846289120, 797685042851814180, 6694943490279586080 is a series of Number of distinct topologies on an n-set that have exactly 9 open sets. Table 6 shows repeated ratios of the non-zero terms of the series A281777.

Table 5: The repeated ratios for the series **A281777**

x_n	a_n	b_n	c_n	d_n	e_n	f_n	g_n	h_n	i_n	j_n
20	40.00000	0.44563	1.67104	0.69765	1.30976	0.80740	1.19415	0.85894	1.14248	0.88834
800	17.82500	0.74466	1.16579	0.91375	1.05750	0.96416	1.02571	0.98133	1.01491	0.98799
14260	13.27349	0.86812	1.06524	0.96629	1.01960	0.98894	1.00655	0.99596	1.00272	0.99801
189280	11.52293	0.92475	1.02933	0.98523	1.00833	0.99543	1.00249	0.99867	1.00073	0.99958
2181060	10.65588	0.95188	1.01413	0.99343	1.00371	0.99790	1.00115	0.99940	1.00030	0.99985
23241120	10.14313	0.96533	1.00746	0.99712	1.00161	0.99905	1.00055	0.99970	1.00016	0.99992
235737620	9.79142	0.97253	1.00456	0.99872	1.00066	0.99960	1.00025	0.99986	1.00008	0.99996
2308206560	9.52243	0.97696	1.00327	0.99937	1.00025	0.99984	1.00010	0.99994	1.00004	0.99998
21979728100	9.30301	0.98015	1.00264	0.99963	1.00009	0.99994	1.00004	0.99997	1.00002	
204477713440	9.11837	0.98274	1.00227	0.99972	1.00004	0.99998	1.00001	0.99999		
1864504348980	8.96102	0.98497	1.00199	0.99976	1.00002	1.00000	1.00000			
16707856095840	8.82635	0.98693	1.00175	0.99978	1.00002	1.00000				
147469451067140	8.71101	0.98866	1.00153	0.99980	1.00002					
1284607771225760	8.61222	0.99017	1.00134	0.99982						
11063319237792340	8.52760	0.99150	1.00116							
94343562846289120	8.45511	0.99265								
797685042851814180	8.39297									
6694943490279586080										

The series A2817778 0, 0, 0, 0, 24, 900, 18030, 276570, 3680964, 45065160, 523292010, 5859909990, 63862084704, 680829769620, 7122705252390, 73284607133010, 742843170653244, 7429450873589280, 73416173732059170, 717721593866613630, 6949589106333898584, 66721599431782204140 is a series of Number of distinct topologies on an n-set that have exactly 10 open sets. Table 7 shows repeated ratios of the non-zero terms of the series A281778.

Table 6: The repeated ratios for the series **A281778**

x_n	a_n	b_n	c_n	d_n	e_n	f_n	g_n	h_n	i_n	j_n
24	37.50000	0.53422	1.43329	0.79060	1.18339	0.87844	1.11030	0.91672	1.07639	0.93875
900	20.03333	0.76570	1.13316	0.93559	1.03954	0.97533	1.01783	0.98675	1.01046	0.99181
18030	15.33943	0.86766	1.06017	0.97258	1.01390	0.99273	1.00434	0.99707	1.00219	0.99831
276570	13.30934	0.91986	1.03110	0.98610	1.00652	0.99704	1.00140	0.99925	1.00050	0.99962
3680964	12.24276	0.94847	1.01676	0.99253	1.00354	0.99843	1.00065	0.99974	1.00011	0.99993
45065160	11.61190	0.96437	1.00916	0.99604	1.00197	0.99908	1.00039	0.99986	1.00004	0.99999
523292010	11.19816	0.97321	1.00517	0.99800	1.00104	0.99947	1.00025	0.99990	1.00003	0.99999
5859909990	10.89813	0.97824	1.00315	0.99904	1.00051	0.99972	1.00015	0.99993	1.00003	0.99999
63862084704	10.66094	0.98132	1.00219	0.99955	1.00023	0.99986	1.00008	0.99996	1.00002	
680829769620	10.46180	0.98347	1.00174	0.99978	1.00009	0.99994	1.00004	0.99998		
7122705252390	10.28887	0.98518	1.00152	0.99987	1.00003	0.99998	1.00002			
73284607133010	10.13641	0.98668	1.00138	0.99989	1.00001	0.99999				
742843170653244	10.00137	0.98804	1.00128	0.99990	1.00000					
7429450873589280	9.88178	0.98930	1.00117	0.99990						
73416173732059170	9.77607	0.99046	1.00107							
717721593866613630	9.68285	0.99153								
6949589106333898584	9.60080									
66721599431782204140										

The series A2817779: 0, 0, 0, 0, 0, 500, 16980, 342160, 5486040, 77926380, 1031160060, 13047426920, 160124426880, 1921105846660, 22632779709540, 262513678889280, 3002768326532520, 33914184260797340, 378596540805849420, 4181330954328313240, 45727913513193402960, 495618273676457274420 is a series of Number of distinct topologies on an n-set that have exactly 11 open sets. Table 8 shows repeated ratios of the non-zero terms of the series A281779.

Table 7: The repeated ratios for the series **A281779**

x_n	a_n	b_n	c_n	d_n	e_n	f_n	g_n	h_n	i_n	j_n
500	33.96000	0.59337	1.34096	0.83032	1.13742	0.90874	1.07775	0.94108	1.05189	0.95785
16980	20.15077	0.79568	1.11342	0.94441	1.03361	0.97939	1.01425	0.98991	1.00755	0.99429
342160	16.03355	0.88592	1.05153	0.97616	1.01231	0.99335	1.00401	0.99739	1.00180	0.99873
5486040	14.20449	0.93157	1.02646	0.98818	1.00558	0.99733	1.00139	0.99919	1.00053	0.99963
77926380	13.23249	0.95622	1.01432	0.99369	1.00289	0.99872	1.00058	0.99972	1.00016	0.99989
1031160060	12.65315	0.96992	1.00792	0.99656	1.00161	0.99929	1.00029	0.99988	1.00005	0.99997
13047426920	12.27249	0.97760	1.00446	0.99817	1.00090	0.99959	1.00017	0.99993	1.00002	0.99999
160124426880	11.99758	0.98196	1.00262	0.99907	1.00049	0.99976	1.00011	0.99996	1.00001	
1921105846660	11.78112	0.98453	1.00168	0.99955	1.00025	0.99987	1.00006	0.99997		
22632779709540	11.59883	0.98618	1.00123	0.99980	1.00011	0.99993	1.00004			
262513678889280	11.43852	0.98739	1.00103	0.99991	1.00004	0.99997				
3002768326532520	11.29431	0.98841	1.00094	0.99995	1.00001					
33914184260797340	11.16337	0.98933	1.00089	0.99996						
378596540805849420	11.04429	0.99021	1.00085							
4181330954328313240	10.93621	0.99106								
45727913513193402960	10.83842									
495618273676457274420										

The series A2817780: 0, 0, 0, 0, 12, 660, 20400, 445620, 7977732, 126860580, 1873839000, 26381789940, 359484471852, 4784481401700, 62538498859200, 805447464281460, 10241415118476372, 128722997969290020, 1600670708273985000, 19705915838479512180, 240330009637668935292 is a series of Number of distinct topologies on an n-set that have exactly 12 open sets. Table 8 shows repeated ratios of the non-zero terms of the series A281780.

Table 8: The repeated ratios for the series **A281780**

x_n	a_n	b_n	c_n	d_n	e_n	f_n	g_n	h_n	i_n	j_n
660	30.90909	0.70672	1.15966	0.93459	1.03241	0.98504	1.00666	0.99779	0.99985	1.00139
20400	21.84412	0.81956	1.08381	0.96488	1.01697	0.99160	1.00444	0.99764	1.00124	0.99937
445620	17.90254	0.88824	1.04575	0.98126	1.00843	0.99600	1.00207	0.99888	1.00061	0.99967
7977732	15.90184	0.92888	1.02614	0.98953	1.00440	0.99806	1.00095	0.99949	1.00028	0.99985
126860580	14.77085	0.95316	1.01540	0.99389	1.00246	0.99901	1.00044	0.99977	1.00013	0.99992
1873839000	14.07901	0.96784	1.00919	0.99633	1.00147	0.99945	1.00021	0.99990	1.00005	0.99997
26381789940	13.62624	0.97674	1.00549	0.99779	1.00091	0.99966	1.00012	0.99996	1.00002	
359484471852	13.30929	0.98210	1.00327	0.99870	1.00057	0.99978	1.00008	0.99998		
4784481401700	13.07111	0.98532	1.00197	0.99927	1.00035	0.99985	1.00005			
62538498859200	12.87923	0.98726	1.00125	0.99962	1.00020	0.99991				
805447464281460	12.71519	0.98849	1.00087	0.99982	1.00011					
10241415118476372	12.56887	0.98935	1.00069	0.99993						
128722997969290020	12.43500	0.99003	1.00062							
1600670708273985000	12.31104	0.99064								
19705915838479512180	12.19583									
240330009637668935292										

From the above tables, one can observe that repeated ratios for all above series follow the same pattern $b_n > 1$, $c_n < 1$, $d_n > 1$, $e_n < 1$ and so on. Also one can observe that the sequence of repeated ratios $\{b_n, c_n, d_n, ...\}$ oscillates around 1 for each series. After approximating these repeated ratios to 1, we can find better upper and lower bounds for each series as in [3, 4].

Conclusion

In this paper, we have calculated the repeated ratios for the series of topologies defined on n-sets with exactly r-open sets. We observed that the sequence of repeated ratios $\{a_n, b_n, c_n, d_n, ...\}$ oscillates around 1. Hence we propose the conjecture that the sequence of repeated ratios converges to 1 for the series of topologies defined on n-sets with exactly r-open sets.

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