



Complex Networks Homework 2

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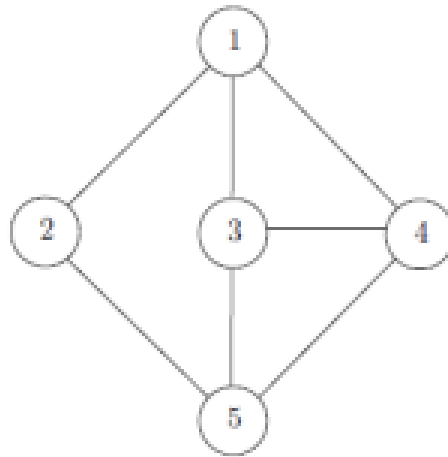
1 Exercise 1

2 Exercise 2

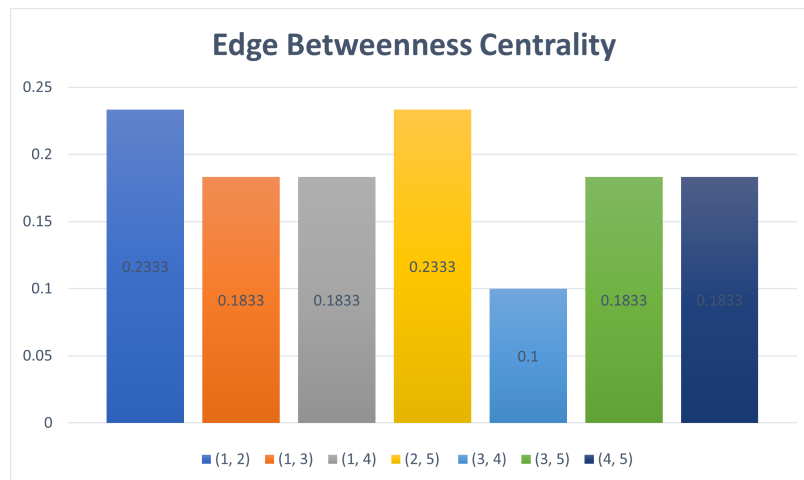
The Shortest-Path Node Betweenness centrality c_i of nodes and edges of a network are related as follows:

$$C_B(i) = \sum_{i < l} \frac{g_{il}(i)}{g_{il}} = \frac{1}{2} \sum_{i < l} a_{il} \frac{g_{il}(e)}{g_{il}} \Rightarrow$$
$$C_B(i) = \frac{1}{2} \sum_{i < l} a_{il} \frac{g_{il}(e)}{g_{il}} - 2(N-1) = \frac{1}{2} \sum_{l=1} a_{il} C_B(e_{il}) - 2(N-1)$$

3 Exercise 3



The Edge Betweenness Centrality of each edge from above is:

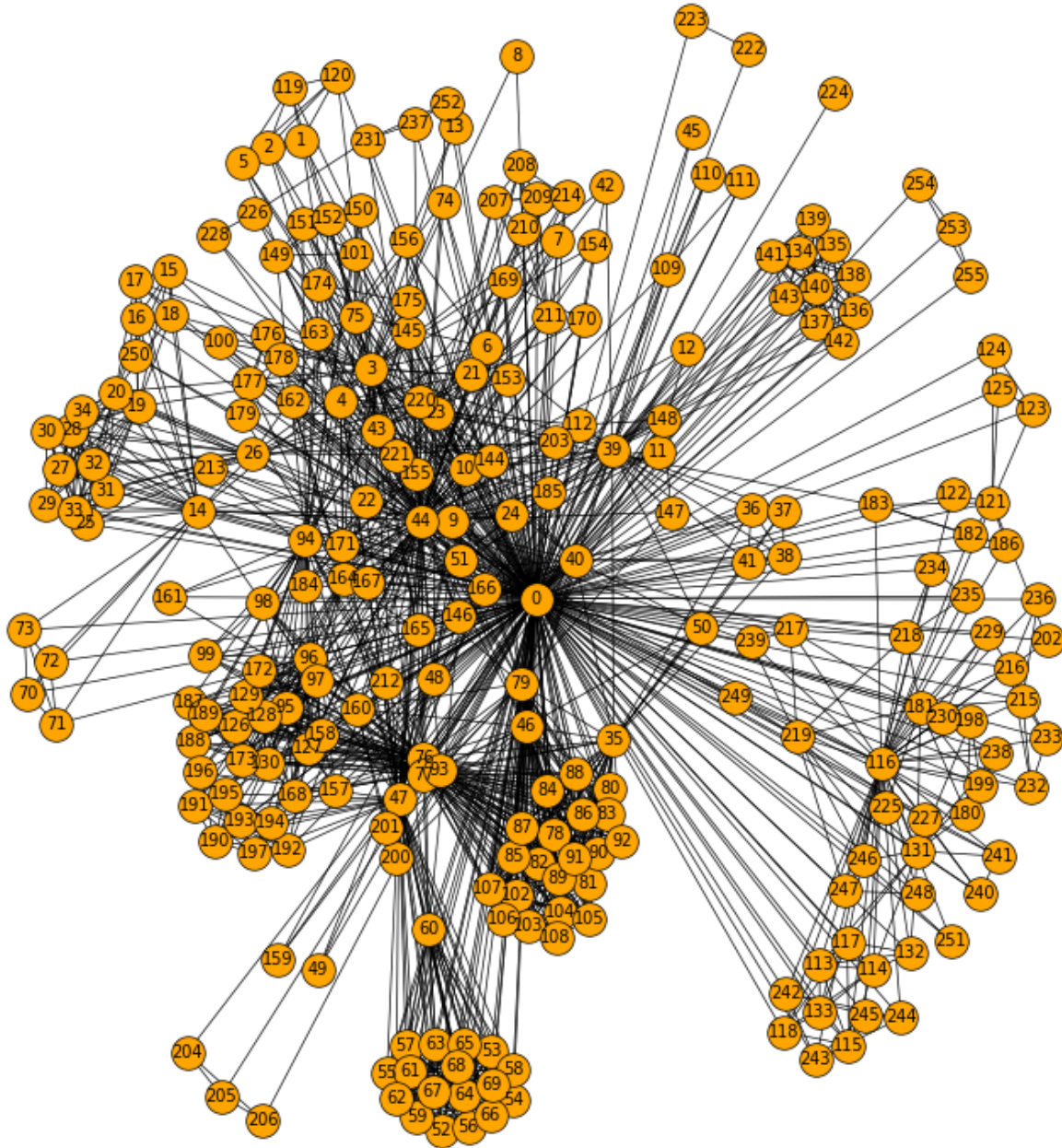


Calculating the sortest paths of each node:

- **Node 1:** 1: [1], 2: [1, 2], 3: [1, 3], 4: [1, 4], 5: [1, 2, 5]
- **Node 2:** 2: [2], 1: [2, 1], 5: [2, 5], 3: [2, 1, 3], 4: [2, 1, 4]
- **Node 3:** 3: [3], 1: [3, 1], 4: [3, 4], 5: [3, 5], 2: [3, 1, 2]
- **Node 4:** 4: [4], 1: [4, 1], 3: [4, 3], 5: [4, 5], 2: [4, 1, 2]
- **Node 5:** 5: [5], 2: [5, 2], 3: [5, 3], 4: [5, 4], 1: [5, 2, 1]

4 Graph

4.1 Authors and Co-authors Graph



4.2 Node index and author's name

0	Thanasis Korakis	65	Alexandros G. Fragkiadakis	130	Eduard Escalona	197	Henrik Lundgren
1	Valentina Nejtkovic	66	Pavlos Charalampidis	131	Pei Liu 0001	198	Francesco Verde
2	Filip Jelenkovic	67	Nicolas Seydoux	132	Theodore S. Rappaport	199	Anna Scaglione
3	Nikos Makris	68	Christelle Ecrepont	133	Parisa Amiri-Eliasi	200	George Parisis
4	Virgilios Passas	69	Mengxuan Zhao	134	Hyunwoo Lee 0001	201	Dirk Trossen
5	Milorad Tosic	70	Emmanouil Pissadakis	135	Donghyun Kim	202	Chen Dong
6	Christos Zarafetas	71	Nikolaos Alachiotis	136	Junho Suh	203	Maximilian Ott
7	Alexandros Valantasis	72	Dimitris Theodoropoulos	137	Ted Taekyoung Kwon	204	Hongbin Li
8	Theodoros Tsourdinis	73	Dionisios N. Pnevmatikatos	138	Pedro Martinez-Julia	205	Phuoc Tran-Gia
9	Panagiotis Tzimotoudis	74	Pavlos Basaras	139	Antonio F. Skarmeta	206	Hong-Shik Park
10	Giannis Kazdaridis	75	Navid Nikaein	140	Taewan You	207	Giovanni Di Stasi
11	Nikos Sidiroopoulos	76	Anna Tzanakaki	141	Loic Baron	208	Roberto Bifulco
12	Ioannis Zografopoulos	77	Markos P. Anastasopoulos	142	Serge Fdida	209	Stefano Avallone
13	Christos Nanis	78	Ignacio Berberana	143	JongWon Kim	210	Roberto Canonico
14	Panagiotis Skrimponis	79	Dimitris Syrivelis	144	Harris Niavis	211	Nikolaos Giallalis
15	Sheila Borges Rajguru	80	Ilker Demirkol	145	Ioannis Igoumenos	212	Adamantios Fiamegkos
16	Karen Cheng	81	Jesús Gutiérrez Terán	146	Max Ott	213	Georgios Kyriakou
17	Jonatan Ostrometzky	82	Eckhard Grass	147	Dimosthenis Delimpasis	214	Francesco Paolo D'Elia
18	Emily Ford	83	Qing Wei 0001	148	Konstantinos Chounos	215	Özgü Alay
19	Zoran Kostic	84	Emmanouil Pateromichelakidis	149	Eryk Schiller	216	Yao Wang 0001
20	Gil Zussman	85	Nikola Vucic	150	Islam Alyafawi	217	Feilu Liu
21	Vasileios Miliotis	86	Albrecht J. Fehske	151	Zhongliang Zhao	218	Jian Lin
22	Kostas Chounos	87	Michael Grieger	152	Torsten Braun	219	Zhifeng Tao
23	Apostolos Apostolaras	88	Michael Eiselt	153	Vasilis Maglogiannis	220	Angelos-Christos G. Anagnostou
24	Polychronis Symeonidis	89	Jens Bartelt	154	Dries Naudts	221	Luis Rodriguez
25	Dipankar Raychaudhuri	90	Gerhard P. Fettweis	155	Ingrid Moerman	222	Giovanni Pau 0001
26	Ivan Seskar	91	George L. Lyberopoulos	156	Spyros Kechagias	223	Ryuji Wakikawa
27	Dan Kilper	92	Eleni Theodoropoulou	157	Yi Shu	224	Sung-Ju Lee
28	Tingjun Chen	93	Dimitra Simeonidou	158	Georgios Zervas	225	Michael E. Knox
29	Jakub Kolodziejcki	94	Kostas Katsalis	159	Constantine Dovrolis	226	George Athanasiou
30	Michael Sherman	95	Bijan Rahimzadeh Rofaee	160	Vasilis Sourlas	227	Shashi Raj Singh
31	Xiaoxiong Gu	96	Giada Landi	161	Thanasis Papapioannou	228	Özgür Erçetin
		97	Jordi Ferrer Riera	162	Raymond Knopp	229	Ozgu Alay
				163	Antonio Maria Cipriano		
32	Harish Krishnaswamy	98	Kostas Kousias	164	Iordanis Koutsopoulos	230	Yao Wang
33	Sumit Maheshwari	99	L. Kiraly	165	Thierry Rakotoarivelo	231	Ioannis Broustis
34	Craig Gutterman	100	Agorastos Dimitrios Samal	166	Thierry Parmentelat	232	Caleb Li
35	Daniel Camps-Mur	101	Romain Favraud	167	Giannis Igoumenos	233	Anurag Rai
36	Ferran Cañellas	102	Nebojsa Maletic	168	Joan Antoni Garcia Espin	234	Xiao Wang
37	Azahar Machwe	103	Eduard Garcia Villegas	169	Spyros Lalis	235	Shunyuan Ye
38	Jorge Paracuellos	104	Vaia Kalokidou	170	Stavros Ioannidis 0002	236	Zhe Xu
39	Kostas Choumas	105	Peter Legg	171	Wei Liu 0019	237	Gentian Jakllari
40	Dimitris Giatsios	106	Dusan Markovic	172	Y. Yan	238	Yuanpeng Liu
41	Hadi Razzaghi Kouchaksaraei	107	Jay Kant Chaudhary	173	Joan A. Garcia-Espin	239	Jinyun Zhang
42	Panagiotis Karamichailidis	108	Jim Zou	174	Katerina Pechlivanidou	240	Ankit Sharma
43	Donatos Stavropoulos	109	Georgios S. Paschos	175	Dimitrios Katsaros 0001	241	Vikas Gelara
44	Leandros Tassioulas	110	Chih-Ping Li	176	Mahmoud Hadeef	242	Kaustubh Sinkar
45	Marios Karatsoglou	111	Eytan H. Modiano	177	Jim O'Reilly	243	Amit Jagirdar
46	Paris Flegkas	112	George Iosifidis	178	Alain Mourad	244	Hang Liu
47	Stratos Keranidis	113	C. Nicolas Barati	179	Belkacem Mouhouche	245	Saurabh Mathur
48	Ilias Syrigos	114	S. Amir Hosseini	180	Chun Nie	246	Sathya Narayanan
49	Nikos Sakellariou	115	Marco Mezzavilla	181	Elza Erkip	247	Salik Makda
50	Joan Josep Aleixendri Cruel	116	Shivendra S. Panwar	182	Cong Wang 0014	248	Boris Gitelman
51	Ioannis Zographopoulos	117	Sundeep Rangan	183	Michael Zink	249	Yevgeniy B. Slutskiy
52	Luis Sánchez	118	Michele Zorzi	184	Lieven Hollevoet	250	Andreas Pitsillides
53	Jorge Lanza	119	Nenad Milosevic 0001	185	Antonios Argyriou	251	Abhijit Bagri
54	Juan Ramón Santana	120	Zorica B. Nikolic	186	Yong Liu 0013	252	Srikanth V. Krishnan
55	Rachit Agarwal 0002	121	Fraida Fund	187	Dora Christofi	253	Nikos I. Passas
56	Pierre-Guillaume Raverdy	122	Regina Lin	188	Michael Georgiades	254	Evangelos Zervas
57	Tarek Elsaleh	123	Vicraj Thomas	189	Renaud Larsen	255	Lazaros F. Merakos
58	Yasmin Fathy	124	Niky Riga	190	Konstantinos Choumas		
59	SeungMyeong Jeong	125	Sarah Edwards	191	Felix Juraschek		
60	Aris Dadoukis	126	Shuping Peng	192	Mesut Günes		
61	Philip O'Brien	127	Yan Yan 0019	193	Emmanuel Baccelli		
62	Jerry Horgan	128	Giacomo Bernini	194	Pawel Misiorek		
63	Antonio Sacchetti	129	Nicola Ciulli	195	Andrzej Szwabe		
64	Giuseppe Mastandrea			196	Theodoros Salonidis		

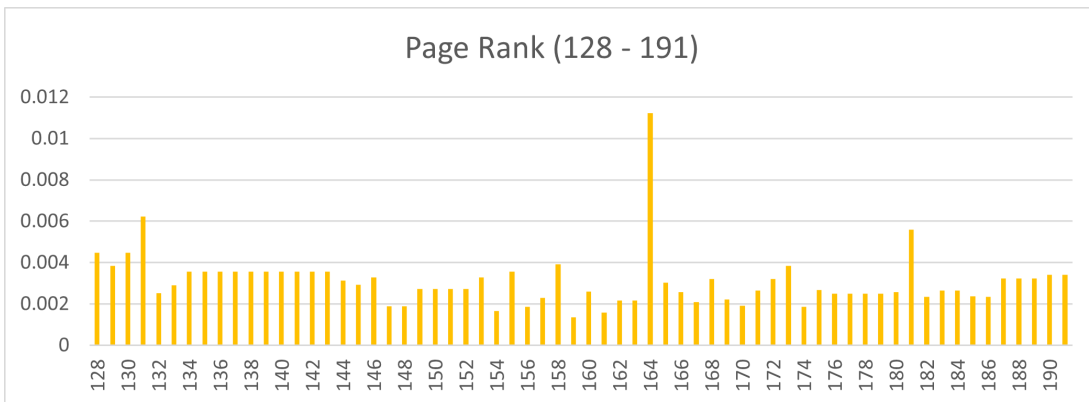
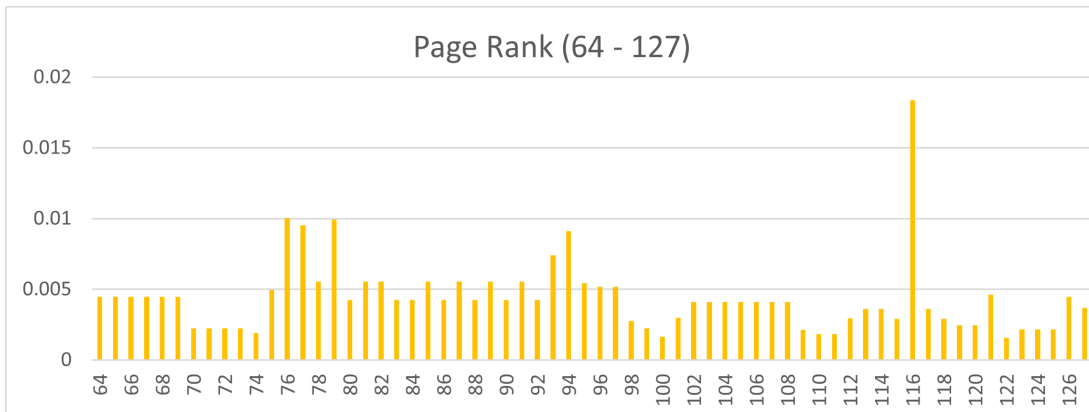
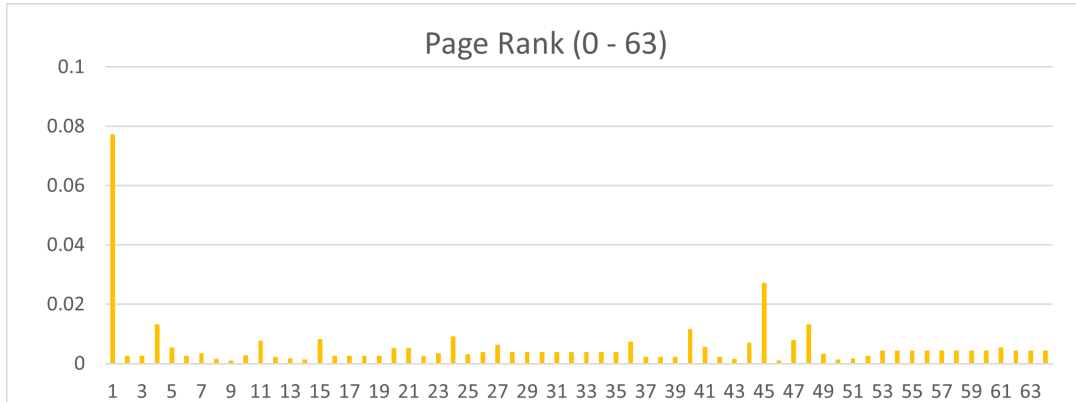
5 Exercise 4

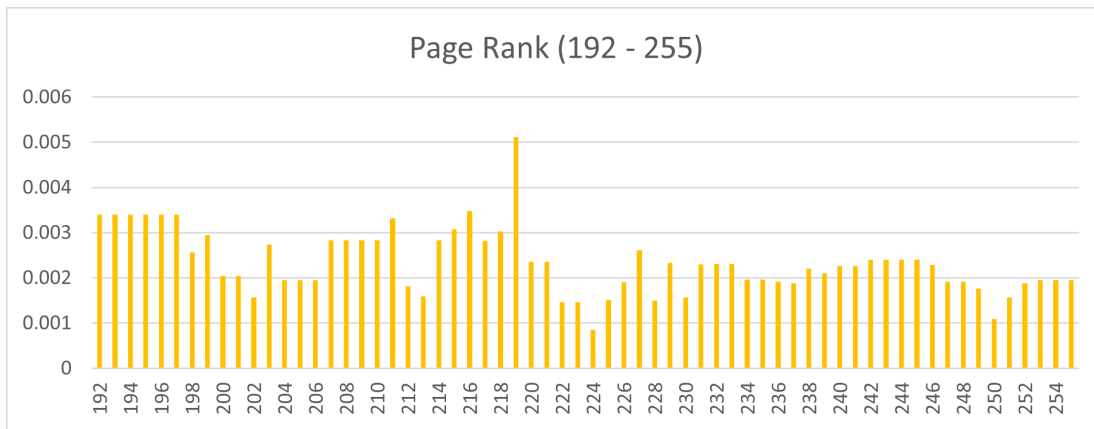
To calculate the nearest-neighbor edge centrality used a python script (4.py) But because the solution is too large, the solution is on exec4.xlsx

$$DC(e = (a, b)) = \frac{DC(a) - DC(b) - 2}{|DC(a) - DC(b)| + 1}$$

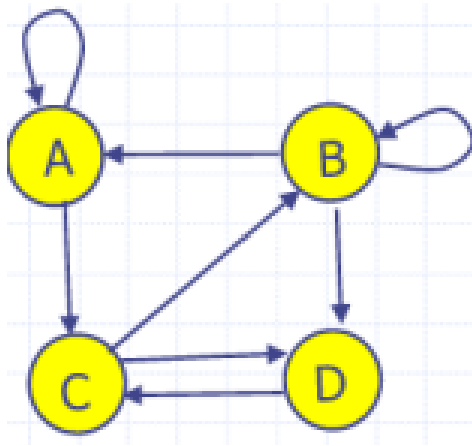
6 Exercise 5

The Page Rank of the Author-Co authors directive graph of Thanasis Korakis is:





7 Exercise 6



We do not take into account of damping factor because the Graph is:

- **Stochastic**
- **Irreducible**
- **Aperiodic**

And solving the following system, we pass the following results:

$$x_A = \frac{x_A}{2} + \frac{x_B}{3} \quad (1)$$

$$x_B = \frac{x_B}{3} + \frac{x_C}{2} \quad (2)$$

$$x_C = \frac{x_A}{2} + x_D \quad (3)$$

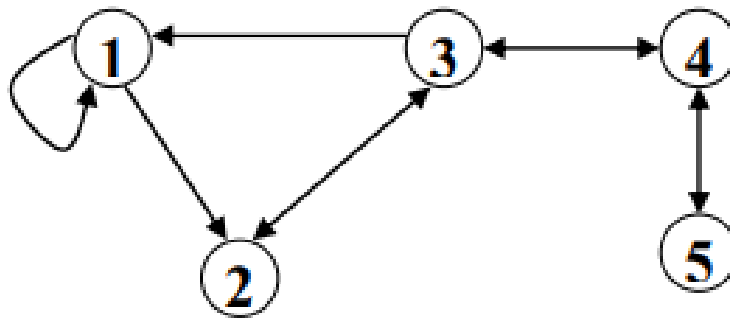
$$x_D = \frac{x_B}{3} + \frac{x_C}{2} \quad (4)$$

$$x_A + x_B + x_C + x_D = 1 \quad (5)$$

Solution:

$$x_A = 0.16, x_B = 0.25, x_C = 0.33, x_D = 0.25$$

8 Exercise 7



The Page Rank for a different damping factor of the above Graph is:

