HW1

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Q1

iv – Generating the types a – d networks and calculate their stats:

Type A:

network stats:

network 1 {'degrees_avg': 9.96, 'degrees_std': 2.8492806109613005, 'degrees_min': 4, 'degrees_max': 18, 'spl': 2.231313131313131, 'diameter': 4}

network 2 {'degrees_avg': 9.6, 'degrees_std': 2.668332812825266, 'degrees_min': 4, 'degrees_max': 17, 'spl': 2.2654545454545456, 'diameter': 4}

network 3 {'degrees_avg': 9.84, 'degrees_std': 3.170867389217026, 'degrees_min': 4, 'degrees_max': 18, 'spl': 2.2387878787878788, 'diameter': 4}

network 4 {'degrees_avg': 9.56, 'degrees_std': 2.8924729903665463, 'degrees_min': 3, 'degrees_max': 15, 'spl': 2.2652525252525253, 'diameter': 4}

network 5 {'degrees_avg': 10.2, 'degrees_std': 2.9017236257093817, 'degrees_min': 4, 'degrees_max': 18, 'spl': 2.216767676767677, 'diameter': 4}

network 6 {'degrees_avg': 10.12, 'degrees_std': 2.6278508329050947, 'degrees_min': 4, 'degrees_max': 16, 'spl': 2.2187878787878788, 'diameter': 4}

network 7 {'degrees_avg': 9.98, 'degrees_std': 2.792776396348266, 'degrees_min': 3, 'degrees_max': 18, 'spl': 2.2311111111111113, 'diameter': 4}

network 8 {'degrees_avg': 9.54, 'degrees_std': 2.7474351675699276, 'degrees_min': 3, 'degrees_max': 17, 'spl': 2.266868686868687, 'diameter': 4}

network 9 {'degrees_avg': 10.18, 'degrees_std': 3.037696495701965, 'degrees_min': 3, 'degrees_max': 18, 'spl': 2.212121212121212, 'diameter': 4}

network 10 {'degrees_avg': 9.66, 'degrees_std': 2.7539789396435115, 'degrees_min': 4, 'degrees_max': 17, 'spl': 2.2593939393939393, 'diameter': 4}

network 11 {'degrees_avg': 10.02, 'degrees_std': 3.1936812614911982, 'degrees_min': 3, 'degrees_max': 19, 'spl': 2.2248484848484846, 'diameter': 4}

network 12 {'degrees_avg': 9.76, 'degrees_std': 2.891781457856039, 'degrees_min': 3, 'degrees_max': 19, 'spl': 2.249090909090909, 'diameter': 4}

network 13 {'degrees_avg': 10.1, 'degrees_std': 3.4539832078341086, 'degrees_min': 4, 'degrees_max': 23, 'spl': 2.222828282828283, 'diameter': 4}

network 14 {'degrees_avg': 10.06, 'degrees_std': 2.8872824593378463, 'degrees_min': 3, 'degrees_max': 21, 'spl': 2.2147474747474747, 'diameter': 4}

network 15 {'degrees_avg': 10.08, 'degrees_std': 2.9721372781215885, 'degrees_min': 3, 'degrees_max': 18, 'spl': 2.243838383838384, 'diameter': 4}

network 16 {'degrees_avg': 9.5, 'degrees_std': 2.826658805020514, 'degrees_min': 4, 'degrees_max': 17, 'spl': 2.2814141414141416, 'diameter': 4}

network 17 {'degrees_avg': 9.46, 'degrees_std': 2.7144796923167425, 'degrees_min': 3, 'degrees_max': 16, 'spl': 2.2753535353535352, 'diameter': 4}

network 18 {'degrees_avg': 9.9, 'degrees_std': 2.913760456866693, 'degrees_min': 3, 'degrees_max': 16, 'spl': 2.2454545454545456, 'diameter': 4}

network 19 {'degrees_avg': 8.78, 'degrees_std': 3.015228017911745, 'degrees_min': 3, 'degrees_max': 16, 'spl': 2.3444444444444446, 'diameter': 4}

network 20 {'degrees_avg': 10.22, 'degrees_std': 2.7297618943783357, 'degrees_min': 4, 'degrees_max': 16, 'spl': 2.205656565656566, 'diameter': 4}

average networks stats:

average type a networks stats: {'degrees_avg': 9.826, 'degrees_std': 2.902058489619155, 'degrees_min': 3.45, 'degrees_max': 17.65, 'spl': 2.2456767676767675, 'diameter': 4.0}

Type B:

network stats:

network 1 {'degrees_avg': 60.18, 'degrees_std': 4.297394559497651, 'degrees_min': 48, 'degrees_max': 75, 'spl': 1.392121212121212, 'diameter': 2}

network 2 {'degrees_avg': 60.96, 'degrees_std': 5.027762922016113, 'degrees_min': 48, 'degrees_max': 72, 'spl': 1.3842424242424243, 'diameter': 2}

network 3 {'degrees_avg': 59.38, 'degrees_std': 5.405145696463696, 'degrees_min': 47, 'degrees_max': 70, 'spl': 1.4002020202020202, 'diameter': 2}

network 4 {'degrees_avg': 58.88, 'degrees_std': 5.000559968643512, 'degrees_min': 46, 'degrees_max': 70, 'spl': 1.4052525252525252, 'diameter': 2}

network 5 {'degrees_avg': 59.98, 'degrees_std': 4.547482820198445, 'degrees_min': 50, 'degrees_max': 71, 'spl': 1.3941414141414141, 'diameter': 2}

network 6 {'degrees_avg': 58.36, 'degrees_std': 5.348869039339064, 'degrees_min': 44, 'degrees_max': 68, 'spl': 1.4105050505050505, 'diameter': 2}

network 7 {'degrees_avg': 58.62, 'degrees_std': 4.316897033750052, 'degrees_min': 50, 'degrees_max': 70, 'spl': 1.407878787878788, 'diameter': 2}

network 8 {'degrees_avg': 59.58, 'degrees_std': 4.839793384019611, 'degrees_min': 44, 'degrees_max': 71, 'spl': 1.3981818181818182, 'diameter': 2}

network 9 {'degrees_avg': 59.22, 'degrees_std': 4.546603127610764, 'degrees_min': 50, 'degrees_max': 73, 'spl': 1.4018181818181819, 'diameter': 2}

network 10 {'degrees_avg': 58.8, 'degrees_std': 4.866210024238577, 'degrees_min': 47, 'degrees_max': 69, 'spl': 1.406060606060606, 'diameter': 2}

network 11 {'degrees_avg': 60.26, 'degrees_std': 5.045037165373508, 'degrees_min': 48, 'degrees_max': 74, 'spl': 1.3913131313131313, 'diameter': 2}

network 12 {'degrees_avg': 60.36, 'degrees_std': 5.098078069233543, 'degrees_min': 45, 'degrees_max': 73, 'spl': 1.3903030303030304, 'diameter': 2}

network 13 {'degrees_avg': 59.52, 'degrees_std': 4.721186291600873, 'degrees_min': 51, 'degrees_max': 72, 'spl': 1.3987878787878787, 'diameter': 2}

network 14 {'degrees_avg': 59.82, 'degrees_std': 5.485216495271632, 'degrees_min': 44, 'degrees_max': 74, 'spl': 1.3957575757575758, 'diameter': 2}

network 15 {'degrees_avg': 57.74, 'degrees_std': 4.959072493924645, 'degrees_min': 45, 'degrees_max': 68, 'spl': 1.4167676767676767, 'diameter': 2}

network 16 {'degrees_avg': 59.42, 'degrees_std': 5.274808053379763, 'degrees_min': 46, 'degrees_max': 69, 'spl': 1.3997979797979798, 'diameter': 2}

network 17 {'degrees_avg': 60.1, 'degrees_std': 4.222558466143482, 'degrees_min': 45, 'degrees_max': 69, 'spl': 1.392929292929293, 'diameter': 2}

network 18 {'degrees_avg': 58.14, 'degrees_std': 4.447516160735114, 'degrees_min': 48, 'degrees_max': 70, 'spl': 1.4127272727272728, 'diameter': 2}

network 19 {'degrees_avg': 59.8, 'degrees_std': 5.394441583704469, 'degrees_min': 45, 'degrees_max': 72, 'spl': 1.395959595959596, 'diameter': 2}

network 20 {'degrees_avg': 59.52, 'degrees_std': 4.856912599584226, 'degrees_min': 46, 'degrees_max': 70, 'spl': 1.3987878787878787, 'diameter': 2}

average networks stats:

average type b networks stats: {'degrees_avg': 59.431999999999995, 'degrees_std': 4.885077297736437, 'degrees_min': 46.85, 'degrees_max': 71.0, 'spl': 1.3996767676767676, 'diameter': 2.0}

Type C:

network stats:

network 1 {'degrees_avg': 99.656, 'degrees_std': 9.959400785187817, 'degrees_min': 67, 'degrees_max': 131, 'spl': 1.9002882882882883, 'diameter': 3}

network 2 {'degrees_avg': 99.97, 'degrees_std': 9.32507908813647, 'degrees_min': 74, 'degrees_max': 135, 'spl': 1.899995995995996, 'diameter': 3}

network 3 {'degrees_avg': 100.176, 'degrees_std': 9.224371198081739, 'degrees_min': 69, 'degrees_max': 132, 'spl': 1.8997597597597597, 'diameter': 3}

network 4 {'degrees_avg': 99.39, 'degrees_std': 9.341086660555083, 'degrees_min': 70, 'degrees_max': 130, 'spl': 1.9005545545545546, 'diameter': 3}

network 5 {'degrees_avg': 99.246, 'degrees_std': 9.52289262776809, 'degrees_min': 70, 'degrees_max': 127, 'spl': 1.9007047047047048, 'diameter': 3}

network 6 {'degrees_avg': 99.652, 'degrees_std': 9.537656735278325, 'degrees_min': 71, 'degrees_max': 131, 'spl': 1.9003043043043044, 'diameter': 3}

network 7 {'degrees_avg': 100.104, 'degrees_std': 9.392613267882375, 'degrees_min': 72, 'degrees_max': 129, 'spl': 1.8998298298298297, 'diameter': 3}

network 8 {'degrees_avg': 100.328, 'degrees_std': 9.134682041538175, 'degrees_min': 74, 'degrees_max': 129, 'spl': 1.8995975975975976, 'diameter': 3}

network 9 {'degrees_avg': 100.308, 'degrees_std': 9.522874355991464, 'degrees_min': 71, 'degrees_max': 130, 'spl': 1.8996376376376376, 'diameter': 3}

network 10 {'degrees_avg': 100.546, 'degrees_std': 8.950189048282725, 'degrees_min': 71, 'degrees_max': 127, 'spl': 1.8994014014014013, 'diameter': 3}

average networks stats:

average type c networks stats: {'degrees_avg': 99.9376, 'degrees_std': 9.391084580870226, 'degrees_min': 70.9, 'degrees_max': 130.1, 'spl': 1.9000074074074078, 'diameter': 3.0}

Type D:

network stats:

network 1 {'degrees_avg': 599.504, 'degrees_std': 15.656627478483353, 'degrees_min': 550, 'degrees_max': 650, 'spl': 1.3998958958958958, 'diameter': 2}

network 2 {'degrees_avg': 600.122, 'degrees_std': 15.343112982703353, 'degrees_min': 549, 'degrees_max': 648, 'spl': 1.3992772772772772, 'diameter': 2}

network 3 {'degrees_avg': 598.02, 'degrees_std': 15.580038510863837, 'degrees_min': 554, 'degrees_max': 641, 'spl': 1.4013813813813814, 'diameter': 2}

network 4 {'degrees_avg': 600.822, 'degrees_std': 15.02412446700303, 'degrees_min': 552, 'degrees_max': 650, 'spl': 1.3985765765765765, 'diameter': 2}

network 5 {'degrees_avg': 599.846, 'degrees_std': 15.50890982629018, 'degrees_min': 535, 'degrees_max': 644, 'spl': 1.3995535535535535, 'diameter': 2}

network 6 {'degrees_avg': 599.666, 'degrees_std': 15.762437755626513, 'degrees_min': 550, 'degrees_max': 648, 'spl': 1.3997337337337337, 'diameter': 2}

network 7 {'degrees_avg': 598.512, 'degrees_std': 16.067976101550563, 'degrees_min': 548, 'degrees_max': 654, 'spl': 1.4008888888888889, 'diameter': 2}

network 8 {'degrees_avg': 600.166, 'degrees_std': 16.042270537551712, 'degrees_min': 547, 'degrees_max': 649, 'spl': 1.3992332332332333, 'diameter': 2}

network 9 {'degrees_avg': 600.572, 'degrees_std': 15.742579712359639, 'degrees_min': 543, 'degrees_max': 648, 'spl': 1.398826826826827, 'diameter': 2}

network 10 {'degrees_avg': 599.24, 'degrees_std': 15.46604021719845, 'degrees_min': 551, 'degrees_max': 650, 'spl': 1.40016016016016, 'diameter': 2}

average networks stats:

average type d networks stats: {'degrees_avg': 599.647, 'degrees_std': 15.619411758963063, 'degrees_min': 547.9, 'degrees_max': 648.2, 'spl': 1.3997527527527525, 'diameter': 2.0}

v – Analyses of the networks statistics:

The result I discovered from running the network statistics functions are:

- We can see that the result of the **average degree** is close to **multiply the p parameter with the number of nodes** as the **size** of the nodes goes **bigger**.
- As the **size** of the **nodes** goes **bigger** the **diameter** goes **smaller**.
- The **Spl** is **similar** when we **increase** the number of **nodes**.

Q2

IV – Finding optimal p parameter for the first network in the list and running hypothesis test with bigger p parameter:

optimal p: 0.3

hypothesis test with 10% bigger therotical_p (p = 0.33): (1.2956123498389325e-54, 'reject')

hypothesis test with 100% bigger therotical_p (p = 0.6): (2e-323, 'reject')

As we can see the **optimal P** for **network 1** in the list is **p = 0.3**

When I ran the **hypothesis** test with **10% bigger p (0.33)** the result was a **rejection** of **H0**.

When I ran the **hypothesis** test with **100% bigger p (0.6)** the result was also a **rejection** of **H0**.

Q3

iii – Opt gamma for given networks

network 1 opt gamma: 2.2851782981197157

network 2 opt gamma: 2.403213704721938

network 3 opt gamma: 2.4853647652132134

network 4 opt gamma: 2.163677553908027

network 5 opt gamma: 2.2801675656482177

network 6 opt gamma: 2.559219269607702

network 7 opt gamma: 2.1813709039286877

network 8 opt gamma: 1.9479469550242525

network 9 opt gamma: 2.278629148703332

network 10 opt gamma: 2.7783898546176165

iv– Comparing stats between scale free and random network from Q1

I created a random network with the same number of nodes and similar number of edges to the first scale free network I received in the scale free networks list.

scale free stats: {'degrees_avg': 7.123867069486405, 'degrees_std': 15.889718259776625, 'degrees_min': 1, 'degrees_max': 163, 'spl': 2.5881900576764627, 'diameter': 6}

random stats: {'degrees_avg': 7.13595166163142, 'degrees_std': 2.534881832951777, 'degrees_min': 1, 'degrees_max': 19, 'spl': 3.152229241050993, 'diameter': 6}

The result I discovered from running the network statistics functions are:

- Degree average is **similar** between the two networks.
- Degree **STD** is **much higher** in the scale free then the random, a reasonable explanation for that is that the random network has **Poisson distributio**n of degrees and the Scale free has the **Power-Law** distribution.
- **Degree max** is much **higher** in the Scale free network because we have **Hubs** with high degrees.
- **SPL** is **smaller** in the Scale free because its the distances between nodes get smaller as they pass threw the **Hubs**.

Q4

iii – Classify if network is random or scale free (1 in case it classified it as a random network, 2 in case it classified it as a scale-free network.)

Network 1 classified: 1

Network 2 classified: 2

Network 3 classified: 1

Network 4 classified: 1

Network 5 classified: 1

Network 6 classified: 1

Network 7 classified: 1

Network 8 classified: 1

Network 9 classified: 2

Network 10 classified: 1

Network 11 classified: 2

Network 12 classified: 1

Network 13 classified: 1

Network 14 classified: 2

Network 15 classified: 2

Network 16 classified: 2

Network 17 classified: 1

Network 18 classified: 2

Network 19 classified: 1

Network 20 classified: 1