

Title：Analysis of the star nodes with stronger social capabilities into a new network based on BA model

Lecture: EE6605 Complex network

Department：Electrical Engineering

Name:XuFangkai

Student ID:57003443

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**1)Abstract**:According to the research of complex network,BA model shows some advantage in describe the distribution of normal social network in Internet. Here we control the variables of number of initial nodes, final nodes to analysis how those network situation will perform in different situation when star node with stronger social capabilities into a new network based on BA model.

**2)Introduction**

Nowadays,we are living in a networked world.It brings us with benefit as well as damages.In that case, we need some appreciate tool to analysis and to do some damage-prevention work and quality improvement work .

Then complex networks got on the stage. Research of complex network is pervading sciences and engineering from physical,technological,biological,to social sciences.Their impacts on engineering and technology,in particular, are prominent and their influence is deemed to be far-reaching. There also many meaningful topic about the Internet,the World Wide Web,wireless communication networks and social relation.

The prominent feature of the Internet era is the breakup of the worldwide proliferation of information predicated on the concept of national territory. And social networks for this point plays a further role for human beings, which network can expand your global scope of human relations network he will have a further advantage. Since the Internet has turned the world into a non-geographical concept, everyone's information is spread around the world. You can build your own social relationships through valuable social networks, you can find the most valuable information in the best systems, and you can search the world for organizations and individuals who can provide the services needed to start business activities in a mutually beneficial way, instead of being limited to the narrow concept of regional nature.

In that case,we will research in the simplified social network in World Wide Web,and focus on the various parameters of social network roughly conforms to the model of the BA to observe whether the pattern of its distribution still follow the power-law and its changes in average path length,clustering coefficient and average degree after changing the conditions.

1. **Problem formulation**

The simplified social network in World Wide Web follows the BA model,then we can easily assume those nodes with larger degree are people with obvious strong social skill,in other word, those stars in the social networks.But if we put these people into the social network following BA mode,how the conditions will appear?

Suppose that there will be a number of social stars(which means final number of nodes) entering the network.If everyone has same strong social skills,and make an number of N socialization attempts (in the simulation it means operation of )when entering a new environment with aboriginal people(where means different number of initial nodes).

Our motivation is to research in above situation how the parameters such as average path length,clustering coefficient and average degree will change after changing the conditions,and explain the some reality meaning in our assumptions.

1. Model or Method description

It basic on the BA model,so we will start from some principle of BA generate.

Start with a connected network having m0>=1 nodes  
(i) Add new nodes:  
Add 1 new node into the network:  
This node is connected to (m<=m0)existing nodes simultaneously  
(ii) The way to add the m new edges into the network: Every existing node is to be chosen with probability:



And here some assumptions about the realistic meaning of nodes in our experiment:

* Isolated point : people completely unknown to each other
* Fully connected:A group of people who know each other
* Partially connected: a group of people who know each other randomly

To facilitate the calculation of the mean path,here we take the second situation,”Fully connected” to simulation in the program.And that means before new nodes who add into a network,here are some aboriginal people who know each other (of different number)

Now we will simulation in three situation and in different number of added edge for three times.

6) Simulation

Here we can get the result from the simulation.

Tips:In the simulation in different growth of nodes,we add different number of edges every time in different situation.

In the case of situation 1：the nodes grow from 10 to 100.

And the first condition is that Number of added edges is 2 every time.We can get the fig1 to fig3.

Then the second condition is that Number of added edges is 5 every time.We can get the fig4 to fig6.

Finally the third condition is that Number of added edges is 10 every time.We can get the fig7 to fig9.

In the case of situation 2 (the nodes grow from 10 to 200)and situation3 (the nodes grow from 20 to 100),we take the same way in situation1 to process the simulation,and we can get the fig10 to fig18 which contained by situation 2 in order(Every three figures in a group), and fig19 to fig27 which contained by situation 3 in the same way.

Following are the figure of simulation.

|  |  |
| --- | --- |
| 1-1-1 | Situation1  Number of initial nodes=20  Final number of nodes=100  Added edge=2 |
| Fig1.network graph |  |
| 1-1-2 | 1-1-3 |
| Fig2.degree size distribution | Fig3.Probability distribution of degree |

|  |  |
| --- | --- |
| 1-2-1 | Situation1  Number of initial nodes=20  Final number of nodes=100  Added edge=5 |
| Fig4.network graph |  |
| 1-2-2 | 1-2-3 |
| Fig5.degree size distribution | Fig6.Probability distribution of degree |

|  |  |
| --- | --- |
| 1-3-1 | Situation1  Number of initial nodes=20  Final number of nodes=100  Added edge=10 |
| Fig7.network graph |  |
| 1-3-2 | 1-3-3 |
| Fig8.degree size distribution | Fig9.Probability distribution of degree |
| 2-1-1 | Situation2  Number of initial nodes=10  Final number of nodes=200  Added edge=2 |
| Fig10.network graph |  |
| 2-1-2 | 2-1-3 |
| Fig11.degree size distribution | Fig12.Probability distribution of degree |

|  |  |
| --- | --- |
| 2-2-1 | Situation2  Number of initial nodes=10  Final number of nodes=200  Added edge=5 |
| Fig13.network graph |  |
| 2-2-2 | 2-2-3 |
| Fig14.degree size distribution | Fig15.Probability distribution of degree |
| 2-3-1 | Situation2  Number of initial nodes=10  Final number of nodes=200  Added edge=10 |
| Fig16.network graph |  |
| 2-3-2 | 2-3-3 |
| Fig17.degree size distribution | Fig18.Probability distribution of degree |

|  |  |
| --- | --- |
| 3-1-3 | Situation3  Number of initial nodes=20  Final number of nodes=100  Added edge=2 |
| Fig19.network graph |  |
| 3-1-2 | 3-1-1 |
| Fig20.degree size distribution | Fig21.Probability distribution of degree |

|  |  |
| --- | --- |
| 3-2-1 | Situation3  Number of initial nodes=20  Final number of nodes=100  Added edge=5 |
| Fig22.network graph |  |
| 3-2-2 | 3-2-3 |
| Fig23.degree size distribution | Fig24.Probability distribution of degree |

|  |  |
| --- | --- |
| 3-3-1 | Situation3  Number of initial nodes=20  Final number of nodes=100  Added edge=10 |
| Fig25.network graph |  |
| 3-3-2 | 3-3-3 |
| Fig26.degree size distribution | Fig27.Probability distribution of degree |

And here in Table1we can view the parameters of average path length,clustering coefficient and average degree of these cases.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| BA model | Number of initial nodes | Final number of nodes | Number of added edges | average path length | clustering coefficient | average degree |
| situation1 | 10 | 100 | 2 | 2.7651 | 0.33418 | 4.44 |
|  |  |  | 5 | 2.2303 | 0.26758 | 9.18 |
|  |  |  | 10 | 1.8899 | 0.27084 | 16.78 |
| situation2 | 10 | 200 | 2 | 3.1011 | 0.18459 | 4.19 |
|  |  |  | 5 | 2.4858 | 0.13936 | 9.54 |
|  |  |  | 10 | 2.0829 | 0.17808 | 17.93 |
| situation3 | 20 | 100 | 2 | 2.4877 | 0.60923 | 6.84 |
|  |  |  | 5 | 2.1745 | 0.4745 | 11.38 |
|  |  |  | 10 | 1.8608 | 0.37886 | 18.36 |

Table1

**7) Analysis and comparisons**

It is assumed here that each person has similar social skills and chooses a completely random target, which may differ in the actual social network.

Ⅰ.From the distribution figure,we can find that it’s not obvious to observe these distribution figure through direct in if we translate the probability distribution and the degree distribution along the x-axis,then these result will follow Power-Law Distributions.It means if we put some newcomers into a social network,it more likely suggests that the redistribution of the social stars into new networks somehow also verifies that the distribution is a power-law distribution, which intuitively toward to the 20-80 Law.

Ⅱ.Compared with different number of added edges,we can find that larger number of added edges bring lower average path length which means in reality, if newcomers to a social network have a greater willingness and ability to socialize, the average cost of communication across the network will be lower.And we can also find there will be lower clustering coefficient,which means Social resources are more evenly distributed across the network with the development of each person's social ability and willingness to socialize.

Ⅲ.Compared with situation1 and situation2,we can find that if we keep other conditions constant, in the case of final node change，The average degree remains almost unchanged, but the distribution of node degrees is more concentrated towards the initial nodes, which means that the "average social resource" remains unchanged，but the social resources brought about by the growth in numbers of new people are taken up by the indigenous people, in other words, the people with the first-mover advantage.

Ⅳ.Compared with situation1 and situation3,we can find that in the case of more aborigines (assuming that they are more connected to each other compared to newcomers), the higher aggregation would show that the resources would be concentrated on the aborigines and only a small part would be on the newcomers.Although thanks to the full connectivity of the aborigines the average cost of communication (average path length) could be reduced, but the aggregation of resources is more obvious.

**Limitation:**The -BA model is the most simplified and principled model, and its main initial purpose is to portray the basic mechanism of the formation of scale-free characteristics, for the actual network system there are other characteristics to be considered, such as directedness, the disappearance of nodes, etc.Here we just talked in simple situation.

1. **Conclusions**

We can get some simple conculsions:

1. **First come, first served:**

star node are usally those who first to join a social network ,and they have a social advantage in owning greater social skills and share stronger willingness to socialize from others.Meanwhile,it will bring larger degree to the social network,so the gap between “star”and “farmer”will be deeper.

2.**More communication brings more equity：**

We can find that when each person's strong social skills and willingness to socialize increases, it promotes a more even distribution of resources.

3.**The Wall of Sighs between old money and newcomers:**

The distribution shows that even though stronger communication promotes a more even distribution, the advantage of the natives over the newcomers is absolute, the evenness is only the evenness of the majority (80%) of the resources on the pioneers and the evenness of the minority (20%) on the newcomers ,although the resources are brought by the newcomers and the number of newcomers is in the majority.

1. **The less,the better:**

Fewer the native in the social networks, the greater the chance that newcomers will have a greater share of the resources, although the resource will still end up concentrated in the hands of a small number of people.

1. **References**

[1] G. Chen, Lecture Nodes, EE6605, CityU, 2020

[2] L. Henneberg, Die graphische Statik der starren Systeme, Leipzig, 1911

[3] [ALBERT-LÁSZLÓ BARABÁSI](https://www.science.org/doi/full/10.1126/science.286.5439.509" \l "pill-con1) AND [RÉKA ALBERT](https://www.science.org/doi/full/10.1126/science.286.5439.509" \l "pill-con2),Emergence of Scaling in Random Networks,1999

1. Appendix (optional, e.g., program codes or method proof)

Matlab codes:

1.BA-net:

function A=BA\_net()

%%% 从已有的m0个节点的网络开始，采用增长机制与优先连接的机制生成BA无标度网络

%% A ——————返回生成网络的邻接矩阵

m0=input('未增长前的网络节点个数m0: ');

m=input(' 每次引入的新节点时新生成的边数m： ');

N=input('增长后的网络规模N： ');

disp('初始网络时m0个节点的连接情况：1表示都是孤立；2表示构成完全图；3表示随机连接一些边');

pp=input('初始网络情况1，2或3： ');

if m>m0

disp('输入参数m不合法');

return;

end

x=100\*rand(1,m0);

y=100\*rand(1,m0);

switch pp

case 1

A=zeros(m0);

case 2

A=ones(m0);

for i=1:m0

A(i,i)=0;

end

case 3

for i=1:m0

for j=i+1:m0

p1=rand(1,1);

if p1>0.5

A(i,j)=1;A(j,i)=0;

end

end

end

otherwise

disp('输入参数pp不合法');

return;

end

for k=m0+1:N

M=size(A,1);

p=zeros(1,M);

x0=100\*rand(1,1);y0=100\*rand(1,1);

x(k)=x0;y(k)=y0;

if length(find(A==1))==0

p(:)=1/M;

else

for i=1:M

p(i)=length(find(A(i,:)==1))/length(find(A==1));

end

end

pp=cumsum(p); %求累计概率

for i=1:m %利用赌轮法从已有的节点中随机选择m个节点与新加入的节点相连

random\_data=rand(1,1);

aa=find(pp>=random\_data);jj=aa(1); % 节点jj即为用赌轮法选择的节点

A(k,jj)=1;A(jj,k)=1;

end

end

plot(x,y,'ro','MarkerEdgeColor','g','MarkerFaceColor','r','markersize',8);

hold on;

for i=1:N

for j=i+1:N

if A(i,j)~=0

plot([x(i),x(j)],[y(i),y(j)],'linewidth',1.2);

hold on; %% 画出BA无标度网络图

end

end

end

axis equal;

hold off

[C,aver\_C]=Clustering\_Coefficient(A);

[DeD,aver\_DeD]=Degree\_Distribution(A);

[D,aver\_D]=Aver\_Path\_Length(A);

disp(['该随机图的平均路径长度为：',num2str(aver\_D)]); %%输出该网络的特征参数

disp(['该随机图的聚类系数为：',num2str(aver\_C)]);

disp(['该随机图的平均度为：',num2str(aver\_DeD)]);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%2.Clustering\_Coefficient:

function [C,aver\_C]=Clustering\_Coefficient(A)

%% 求网络图中各节点的聚类系数及整个网络的聚类系数

%% 求解算法：求解每个节点的聚类系数，找某节点的所有邻居，这些邻居节点构成一个子图

%% 从A中抽出该子图的邻接矩阵，计算子图的边数，再根据聚类系数的定义，即可算出该节点的聚类系数

%A————————网络图的邻接矩阵

%C————————网络图各节点的聚类系数

%aver———————整个网络图的聚类系数

N=size(A,2);

C=zeros(1,N);

for i=1:N

aa=find(A(i,:)==1); %寻找子图的邻居节点

if isempty(aa)

disp(['节点',int2str(i),'为孤立节点，其聚类系数赋值为0']);

C(i)=0;

else

m=length(aa);

if m==1

disp(['节点',int2str(i),'只有一个邻居节点，其聚类系数赋值为0']);

C(i)=0;

else

B=A(aa,aa); % 抽取子图的邻接矩阵

C(i)=length(find(B==1))/(m\*(m-1));

end

end

end

aver\_C=mean(C);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%3.Degree\_Distribution

function [DeD,aver\_DeD]=Degree\_Distribution(A)

%% 求网络图中各节点的度及度的分布曲线

%% 求解算法：求解每个节点的度，再按发生频率即为概率，求P(k)

%A————————网络图的邻接矩阵

%DeD————————网络图各节点的度分布

%aver\_DeD———————网络图的平均度

N=size(A,2);

DeD=zeros(1,N);

for i=1:N

% DeD(i)=length(find((A(i,:)==1)));

DeD(i)=sum(A(i,:));

end

aver\_DeD=mean(DeD);

if sum(DeD)==0

disp('该网络图只是由一些孤立点组成');

return;

else

figure;

bar([1:N],DeD);

xlabel('节点编号n');

ylabel('各节点的度数K');

title('网络图中各节点的度的大小分布图');

end

figure;

M=max(DeD);

for i=1:M+1; %网络图中节点的度数最大为M,但要同时考虑到度为0的节点的存在性

N\_DeD(i)=length(find(DeD==i-1));

end

P\_DeD=zeros(1,M+1);

P\_DeD(:)=N\_DeD(:)./sum(N\_DeD);

bar([0:M],P\_DeD,'r');

xlabel('节点的度 K');

ylabel('节点度为K的概率 P(K)');

title('网络图中节点度的概率分布图');